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Preface

The Fourth International Conference on Information Technology Convergence & Services (ITCS-2015) was held in Zurich, Switzerland, during January 02 ~ 03, 2015. Second International Conference on Foundations of Computer Science & Technology (CST-2015), Fourth International Conference on Software Engineering and Applications (JSE-2015), The Fourth International Conference on Signal and Image Processing (SIP-2015), Second International Conference on Artificial Intelligence & Applications (ARIA-2015) and Sixth International conference on Database Management Systems (DMS-2015). The conferences attracted many local and international delegates, presenting a balanced mixture of intellect from the East and from the West.

The goal of this conference series is to bring together researchers and practitioners from academia and industry to focus on understanding computer science and information technology and to establish new collaborations in these areas. Authors are invited to contribute to the conference by submitting articles that illustrate research results, projects, survey work and industrial experiences describing significant advances in all areas of computer science and information technology.

The ITCS-2015, CST-2015, JSE-2015, SIP-2015, ARIA-2015, DMS-2015 Committees rigorously invited submissions for many months from researchers, scientists, engineers, students and practitioners related to the relevant themes and tracks of the workshop. This effort guaranteed submissions from an unparalleled number of internationally recognized top-level researchers. All the submissions underwent a strenuous peer review process which comprised expert reviewers. These reviewers were selected from a talented pool of Technical Committee members and external reviewers on the basis of their expertise. The papers were then reviewed based on their contributions, technical content, originality and clarity. The entire process, which includes the submission, review and acceptance processes, was done electronically. All these efforts undertaken by the Organizing and Technical Committees led to an exciting, rich and a high quality technical conference program, which featured high-impact presentations for all attendees to enjoy, appreciate and expand their expertise in the latest developments in computer network and communications research.

In closing, ITCS-2015, CST-2015, JSE-2015, SIP-2015, ARIA-2015, DMS-2015 brought together researchers, scientists, engineers, students and practitioners to exchange and share their experiences, new ideas and research results in all aspects of the main workshop themes and tracks, and to discuss the practical challenges encountered and the solutions adopted. The book is organized as a collection of papers from the ITCS-2015, CST-2015, JSE-2015, SIP-2015, ARIA-2015, DMS-2015.

We would like to thank the General and Program Chairs, organization staff, the members of the Technical Program Committees and external reviewers for their excellent and tireless work. We sincerely wish that all attendees benefited scientifically from the conference and wish them every success in their research. It is the humble wish of the conference organizers that the professional dialogue among the researchers, scientists, engineers, students and educators continues beyond the event and that the friendships and collaborations forged will linger and prosper for many years to come.

David C. Wyld
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SCRAPING AND CLUSTERING TECHNIQUES FOR THE CHARACTERIZATION OF LINKEDIN PROFILES

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ABSTRACT

The socialization of the web has undertaken a new dimension after the emergence of the Online Social Networks (OSN) concept. The fact that each Internet user becomes a potential content creator entails managing a big amount of data. This paper explores the most popular professional OSN: LinkedIn. A scraping technique was implemented to get around 5 Million public profiles. The application of natural language processing techniques (NLP) to classify the educational background and to cluster the professional background of the collected profiles led us to provide some insights about this OSN's users and to evaluate the relationships between educational degrees and professional careers.

KEYWORDS

Scraping, Online Social Networks, Social Data Mining, LinkedIn, Data Set, Natural Language Processing, Classification, Clustering, Education, Professional Career.

1. INTRODUCTION

The influence of Online Social Networks (OSNs) [1,2,3] on our daily lives is nowadays deeper according to the amount and quality of data, the number of users, and also to the technology enhancement, especially related to the concurrence in the smartphones' market. In this sense, companies but also researchers are attracted by the cyberspace's data and the huge variety of different challenges that the analysis of the data collected from social media opens: capturing public opinion, identifying communities and organizations, detecting trends or obtaining predictions in whatever area a big amount of user-provided data is available.

Taking professional careers as focus area, LinkedIn is undoubtedly one of these massive repositories of data. With 300 million subscribers announced in April 2014 [4], LinkedIn is the most popular OSN for professionals [5], and it is distinctly known as a powerful professional networking tool that enables its users to display their curricular information and to establish connections with other professionals. Given this huge amount of valuable data about education and professional careers, it is possible to explore it for capturing successful profiles, identifying professional groups, and more ambitiously detecting trends in education and professional careers and even predicting how successful a LinkedIn user is going to be in their near future career.
Several web data collection techniques were developed especially related to OSNs. First, OSN APIs ("Application Programming Interface") [6], a win-win relationship between Web Services

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providers and applications, have emerged in the most popular OSNs such as Facebook, Twitter, LinkedIn, etc. OSN APIs enable the connection with specific endpoints and obtaining encapsulated data mostly by proceeding on users' behalf. Some considerable constraints when following this method arise which impact directly in the amount of collected data: the need of users' authorizations, the demanding processing and storage resources but especially, and in almost of the cases, the data access limitations. For instance, the Facebook Platform Policy only allows to obtain partial information from profiles and do not allow to exceed 100M API calls per day1. In LinkedIn, it is only possible to access the information of public profiles or, having a LinkedIn account, it is possible to access to users' private profiles that are related to us at least in the third grade2.

In this context, crawling techniques appear as an alternative. It basically consists in traversing recursively through hyperlinks of a set of webpages and downloading all of them [7]. With the growth of the cyberspace's size, generic crawlers were less adapted to recent challenges and more accurate crawling techniques were proposed such as topic-based crawlers [8], which consists of looking for documents according to their topics. In this sense, a more economical alternative, referred to as scrapping, gets only a set of predetermined fields of each visited webpage, which allows tackling not only with the increasingly size of cyberspace but also with the size of the retrieved data. Please, note that crawlers deal generally with small websites, whereas scrappers are originally conceived to deal with the scale of OSNs.

However, obtaining the data is only one part of the problem. Generally, once gathered, the data go through a series of analysis techniques. In this context, clustering techniques were widely applied in order to explore the available data by grouping OSNs' profiles to discover hidden aspects of the data and, on this basis, provide accurate recommendations for users' decision-support. For example, in [9] the authors use crawling methods to study the customers' behaviour in Taobao (the most important e-commerce platform in China). At best, the data to be grouped have some structure which allows to easily define some distance measure but, unfortunately, this is not always the case when users freely define their profiles. Such is the case for LinkedIn users. If so, discover/uncover hidden relationships involves applying some NLP (Natural Language Processing) Techniques.

The main contributions of this paper can be summarized in: (1) obtaining a LinkedIn dataset, which does not exist to our knowledge; and performing exploratory analysis to uncover (2) educational categories and their relative appearance in LinkedIn and (3) professional clusters in LinkedIn by grouping profiles according to the free summaries provided by LinkedIn users.
This paper is organized as follows: Next section provides the background of OSNs crawling strategies, natural language processing and clustering techniques. After briefly introducing LinkedIn (Section 3), we provide a descriptive analysis of the data collection process and the obtained dataset in Section 4. The classification of educational background and clustering of professional background are shown in Sections 5 and 6, respectively. Finally, we draw some conclusions and perspectives in the last section.

2. BACKGROUND

Since their emergence, Online Social Networks (OSNs) have been widely investigated due to the exponential growing number of their active users and consequently to their socio-economic impact. In this sense, the challenging issue of collecting data from OSNs was addressed by a multitude of crawling strategies. These strategies were implemented according to the specificities of each social network (topology, privacy restrictions, type of communities, etc.) but also

[1] https://www.facebook.com/about/privacy/your-info [Last access: 24 October 2014]
[2] https://www.linkedin.com/legal/privacy-policy [Last access: 24 October 2014]

regarding the aim of each study. One of the most known strategies is the Random Walk (RW) [10] which is based on a uniform random selection from a given node among its neighbours [11]. Other techniques, such as the Metropolis-Hasting Random Walk (MHRW) [12], Breadth First Search (BFS) [11], Depth First Search (DFS) [13], Snowball Sampling [11] and the Forest Fire [14] were also presented as graph traversal techniques and applied to address OSNs crawling issues. One of the aims of crawling strategies is profiles retrieval. After that, there are some techniques that allow us to match the different profiles of one user in the different OSNs [14]. As pointed out in the introduction, dealing with textual data leads inevitably to the application of NLP (Natural Language Processing) techniques which mainly depends on the language level we are dealing with.(pragmatic, semantic, syntax) [15]. A good review of all NLP techniques could be found in [16].

In our case, we have centred in the application of NLP techniques to Information Retrieval (IR) [17]. The main techniques in this field are: (i) Tokenization, that consists in divide the text into tokens (keywords) by using white space or punctuation characters as delimiters [18]; (ii) Stop-words removal [19], which lies in removing the words that are not influential in the semantic analysis, like articles, prepositions, conjunctions, etc.; (iii) Stemming, whose objective is mapping words to their base form ([20] presents some of the most important Stemming algorithms); (iv) Case-folding [18], which consists in reduce all letters to lowercase, in order to be able to compare two words that are the same, but one of them has some uppercase. Applying these NLP techniques allow us to obtain a Document-Term Matrix, a matrix that represents the number of occurrences of each term in each document.

The main objective of obtaining the Document-Term Matrix is to apply classification and clustering methods [21] over the matrix, in order to classify the user's profiles. Classification is a supervised technique, whose objective is grouping the objects into predefined classes. Clustering, on the contrary, is an unsupervised technique without a predefined classification. The objective of clustering is to group the data into clusters in base of how near (how similar) they are.

There are different techniques of clustering [22], which can mainly be labelled as partitional or hierarchical. The former obtains a single partition of the dataset. The latter obtains a dendrogram (rooted tree): a clustering structure that represents the nested grouping of patterns and similarity levels at which groupings change.

K-means [23] is the most popular and efficient partitional clustering algorithm and has important computational advantages for large dataset, as Lingras and Huang show in [24]. One of the problems of the K-means algorithm is that it is needed to establish the number of clusters in advance. Finally, the gap statistic method [25] allows estimating the optimal number of clusters in a set of data. This method is based on looking for the Elbow point [26], or the point where the graph that represents the number of cluster versus the percentage of variance explained by clusters starts to rise slower, giving an angle in the graph.

3. SUMMARY OF THE LINKEDIN EXPERIMENT

The primary contribution of this paper is obtaining an anonymized dataset by scrapping the public profile of LinkedIn users subject to the terms of LinkedIn Privacy Policy. LinkedIn public profile refers to the user's information that appears in a Web Page when the browser is external to LinkedIn (not logged in). Although users can hide their public profile to external search, it is exceptional in this professional OSN. In fact, what users normally do is hiding some sections. The profile's part in Fig. 1.(a) includes personal information and current position. To respect LinkedIn privacy policy, we discarded that part for the study and we anonymized profiles by unique identifiers. The profile's part in Fig. 1.(b) contains information about educational and

professional aspects of the user, being the most relevant data for our exploratory analysis of LinkedIn.

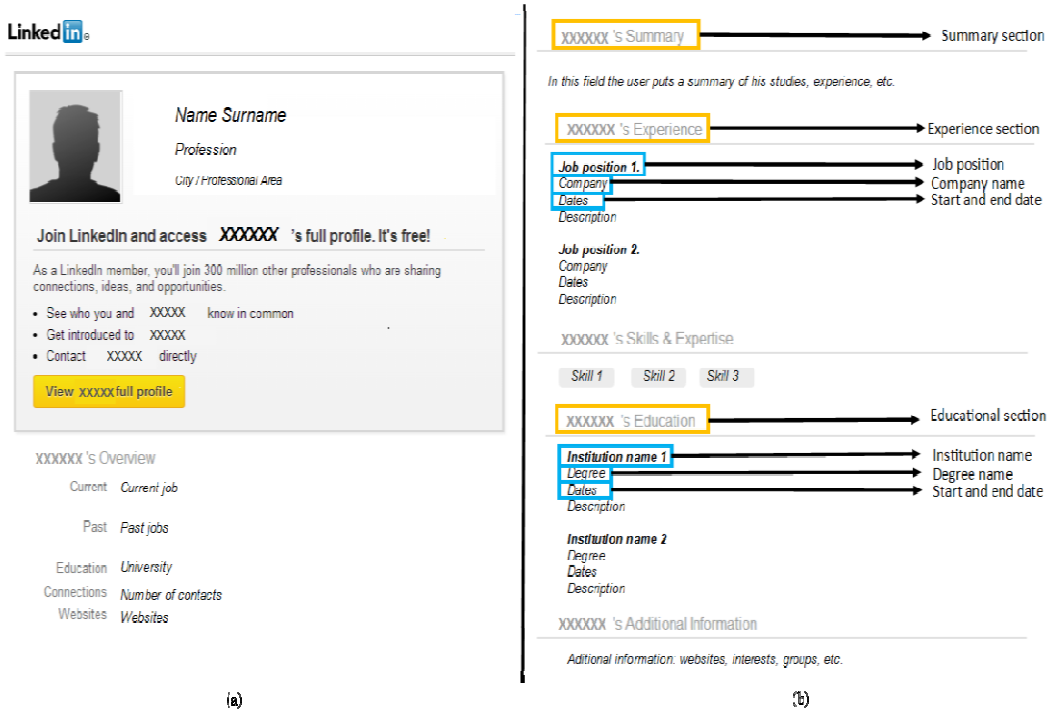

Fig.1. Example of a LinkedIn public profile

In this analysis, we grouped profiles according to the former dimensions in order to uncover potential relationships between groups. This grouping process may be done applying different techniques. As there is an established consensus around academic degrees, we apply classification as a supervised learning technique that assigns to each profile an educational level defined in advance. On the other hand, as this consensus is far to be present in the job market, we apply clustering as an unsupervised technique which groups profiles according to their professional similarity.

First, the experiment inspects the educational background to give response to a simple question: What academic backgrounds are exhibited for LinkedIn users? From that, we classify the educational levels in advance and assign each profile to its higher level by processing the text in the educational section of the profile (see Fig. 1.(b)).

Second, the experiment also inspects the professional background. For this, there is not a wide consensus in professionals' taxonomy or catalogue for professional areas or professional levels. Not having so in advance, clustering turns into an appropriate unsupervised technique to automatically establish the groups of professional profiles which are highly similar to each other (according to the content in the Summary (natural text) and Experience (structured text) sections of the profile (see Fig. 1.(b)).

4. OBTAINING A DATASET FROM LINKEDIN

One way to get users' profiles from LinkedIn is to take advantage of its APIs (mainly by using the JavaScript API which operates as a bridge between the users' browser and the REST API and it allows to get JSON responses to source's invocations) by using the "field selectors" syntax. In

this sense, and according to the user's permission grant, it is possible to get information such as the actual job position, industry, three current and three past positions, summary description, degrees (degree name, starting date, ending date, school name, field of study, activities, etc.), number of connections, publications, patents, languages, skills, certifications, recommendations, etc. However, this method depends on the permission access type (basic profile, full profile, contact information, etc.) and on the number of granted accesses. Thus, this data collection method is not the most appropriate for our approach, since a high number of profiles are needed in order to overcome profiles incompleteness.

Consequently, a scraping strategy was elaborated in order to get the maximum number of public profiles in a minimum of time. LinkedIn provides a public members' directory, a hierarchy taking into account the alphanumeric order3 (starting from the seed and reaching leafs that represent the public profiles). In this sense, we applied a crawling technique to this directory using the Scrapy framework on Python4 based on a random walk strategy within the alphabetic hierarchy of the LinkedIn member directory. Our technique relies on HTTP requests following an alphabetic order to explore the different levels starting from the seed and by reaching leafs which represent public profiles. During the exploitation phase, we dealt with regular expressions corresponding to generic XPaths5 that look into HTML code standing for each public profile and extract required items.

4.1. Data collection process

During the exploration phase, hyperlinks of the directory's webpages (may be another intermediate level of the directory or simply a public profile) are recursively traversed and added to a queue. Then, the selection of the next links to be visited is performed according to a randomness parameter. At each step, this solution checks if the actual webpage is a leaf (public profile) or only one of the hierarchy's levels. In the former case, the exploitation phase starts and consists of looking for predetermined fields according to their HTML code and extracting them to build up the dataset. Exploitation puts special emphasis in educational and professional backgrounds of public users' profiles, so it extracts the following fields: last three educational degrees, all actual and previous job positions, and the summary description. Table 1 shows a summary of the extracted data and their relations with the sections of the user's profile web page (Fig. 1). As it is shown in the following sections, the deployed technique showed its effectiveness in terms of the number of collected profiles.

Table 1. Description of the extracted fields

Field name	Field in user profile	Description
postions_Overview	Job positions (Experience section)	All actual and previous job positions.
summary_Description	Summary section.	Summary description.
education_Degree1	Degree (Educational section)	Last degree.
education_Degree2	Degree (Educational section)	Next-to-last degree.
education_Degree3	Degree (Educational section)	Third from last degree.

4.2. Filtering the Dataset

After obtaining the dataset, we apply some filters to deal with special features of LinkedIn. First, according to their privacy and confidentiality settings, LinkedIn public profiles are slightly

[3] http://www.linkedin.com/directory/people-a [Last access: 24 October 2014]
[4] http://scrapy.org [Last access: 24 October 2014]
[5] Used to navigate through elements and attributes in an XML document.

different from one user to another. Some users choose to display their information publicly (as it is the default privacy setting), others partially or totally not. This feature mainly impact on the completion level of profiles in the dataset, since the collected information obviously depends on its availability for an external viewer (logged off). To tackle this issue, we filter the original dataset (after scrapping) by only considering profiles with some professional experience and at least one educational degree. Second, LinkedIn currently support more than twenty languages from English to traditional Chinese. Users take advantage of this multilingual platform and fulfil their profiles information with their preferred language(s). Although multilingual support is part of our future work, we filter the dataset by only considering profiles written in English.

4.3. Description of the data set

As aforementioned, personal information such as users' names, surnames, locations, etc. are not scraped from public profiles. Thus, the collected data is anonymized and treated with respect to users' integrity. Originally, the total number of scrapped profiles was 5,702.544. After performing the first filter by keeping only profiles that mention at least a "job position" and an "educational degree", the total size of the data set became 920.837 profiles. Another filter is applied in order to get only profiles with a description of positions strictly in English. Finally, 217.390 profiles composed the dataset. Not all of these profiles have information in all fields. Table 2 shows the number of profiles that have each field.

Table 2. Profiles number with complete fields

Field name	Number of profiles
postions_Overview	217.390
Summary_Description	84.781
education_Degree1	205.595
education_Degree2	127.764
education_Degree3	45.002

5. CLASSIFICATION OF THE EDUCATIONAL BACKGROUND

As described in the previous section, after filtering, anonymizing and pre-processing the data, our dataset retains positions and degrees (with starting and ending dates) and the free summary if available. Despite of this fact, we merely rely on degree fields to establish the educational background. Probably, the profile's summary may literally refer to theses degrees but taking into account the results in section 4.3, we can consider that degree fields are included even in the most basic profiles.

Unfortunately, a simple inspection of our dataset uncovers some problems related with degrees harmonization across different countries. That is, the same degree's title may be used in different countries for representing different educational levels. For this particular reason we opted for a semi-automated categorization of the degree's titles. The UNESCO[6]'s ICSED[7] education degree levels classification presents a revision of the ISCED 1997 levels of education classification. It also introduces a related classification of educational attainment levels based on recognised educational qualifications. Regarding this standard and the data we have collected from LinkedIn, we can focus on four different levels which are defined in Table 3.

[6] United Nations Educational Scientific and Cultural Organization.
[7] Institute for Statistics of the United Nations Educational, Scientific and Cultural Organization (UNESCO): "International Standard Classification of Education: ISCED 2011" (http://www.uis.unesco.org/Education/Documents/isced-2011-en.pdf), 2011.

- **PhD or equivalent (level 8):** This level gathers the profiles that contain terms such as Ph.D. (with punctuation), PHD (without punctuation), doctorate, etc. As it is considered as the highest level, we have not any conflict with the other levels (profiles which belongs to this category may have other degrees title as Bachelor, Master, etc.) and we do not need to apply any constraint.
- **Master or equivalent (level 7):** This level includes the profiles which contain, in their degrees' fields description, one of the related terms evoking master's degree, engineering, etc. Profiles belonging to this category do not have to figure in the previous section so we obtain profiles with a master degree or equivalent as the highest obtained degree (according to LinkedIn users' description).
- **Bachelor or equivalent (level 6):** contains a selection of terms such as bachelor, license and so on. So obviously profiles here do not belong to any of the highest categories.
- **Secondary or equivalent (both levels 5 and 4):** contains LinkedIn profiles with the degrees' titles of secondary school.

Table 3. Keywords of the 4-levels classification.

Level	Keywords
PhD	*phd ph.d. dr. doctor dottorato doctoral drs dr.s juris pharmd pharm.d dds d.ds dmd postdoc resident doctoraal edd*
Master	*master masters msc mba postgraduate llm meng mphil mpa dea mca mdiv mtech mag Maîtrise maitrise master's mcom msw pmp dess pgse cpa mfa emba pgd pgdm masterclass mat msed msg postgrad postgrado mpm mts*
Bachelor	*bachelor bachelors bsc b.sc. b.sc licentiate bba b.b.a bcom b.com hnd laurea license licenciatura undergraduate technician bts des bsn deug license btech b.tech llb aas dut hbo bpharm b.pharm bsba bacharel bschons mbbs licenciada bca b.ca bce b.ce licenciado bachiller bcomm b.comm bsee bsee cpge bsw b.sw cess bachillerato bas bcs bcomhons bachalor bachlor bechelor becon bcompt bds bec mbchb licencjat bee bsme bsms bbs graduado prepa graduat technicians technicien tecnico undergrad bvsc bth bacharelado*
Secondary	*secondary sslc ssc hsc baccalaureate bac dec gcse mbo preuniversity hnc kcse ssce studentereksamen secondaire secundair igcse ossd vmbo htx*

Using the keywords in Table 3 as a criteria for the classification over the filtered data set, we obtain the distribution of levels in Fig. 2.

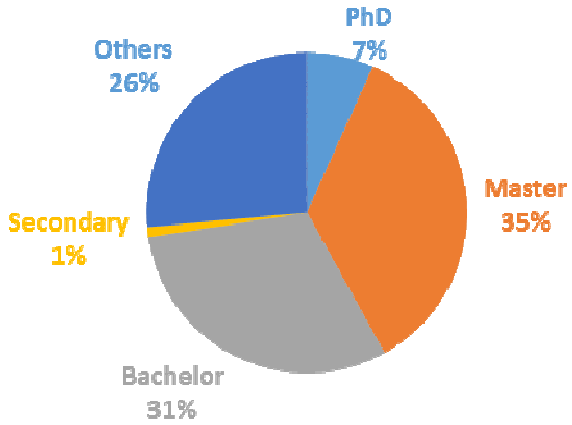

Fig.2. Classification of the educational background of our LinkedIn data set.

6. CLUSTERING THE PROFESSIONAL BACKGROUND

The purpose of this section is to analyse the professional background of the collected profiles. As mostly the rest of the fields of a typical LinkedIn profile, current and past job positions but also user's summary description can be managed freely and without special use of predefined items. In this sense, LinkedIn profile's fields are not conform to a specific standard (as the UNESCO one used for the classification of users according to their educational information). With the freedom given to users to present their job positions and especially their summaries' description, the possible adoption of the classification approach is clearly more difficult. Also, apart from the fact that some professional profiles are more multidisciplinary then others, we strongly believe that each professional profile is proper, and this by considering the career path as a whole. In this sense, we consider that applying clustering is more appropriate in this case. But before doing that, we must apply some transformations to our refined dataset.

6.1. Text Mining

In this context, we have to deal with a "corpus" which is defined as "a collection of written texts, especially the entire works of a particular author or a body of writing on a particular subject,[…], assembled for the purpose of linguistic research"8. In order to perform text mining operations on the data set, we need to build a corpus using the set of profile fields we are interested in. In this sense, the job positions and summary description of all profiles of the refined data set will be used to construct the so called corpus. Furthermore, a series of NLP functions must be applied on the corpus in order to build the Document Term Matrix (DTM) which represents the correspondence of the number of occurrence of each term (stands for a column) composing the corpus to each profile description (a document for each row).

First, the transformation of the corpus' content to lowercase is performed for terms comparison issues. Then, stop-words (such as: "too", "again", "also", "will", "via", "about", etc.), punctuations, and numbers are removed. Finally, white spaces are stripped in order to avoid some terms' anomalies. Stemming the corpus is avoided in this work because it didn't demonstrate better tokenization results with this data set.

The generation of the DTM can now be performed using the transformed corpus. With a 217.390 document, this DTM has high dimensions especially regarding the number of obtained terms. Analysing such a data structure become memory and run time consuming: we are dealing with the so called curse of dimensionality problem [27]. In order to tackle the latter, we opted to push our study forward and focus on profiles which belongs to only one educational category. As being the highest level, and with 14.650 profiles, the 8th category (PhD) seems to be the ideal candidate for this analysis.

In this sense, we subsetted the profiles of this category from the data set and applied the same NLP transformations described earlier in this section to a new corpus. Then, we generated the DTM by only considering terms' length more than 4 letters (simply because we get better results while inspecting the DTM terms). In fact, with its 14.650 document, this DTM is composed of 75.624 terms and it is fully sparse (100%). In such cases (high number of terms), the DTM may be reduced by discarding the terms which appears less than a predefined number of times in all DTM's documents (correspond to the DTM's columns sum) or by applying the TF-IDF (Term Frequency-Inverse Document Frequency) technique as described in [28]. By making a series of tests over our 14.650 document's DTM, 50 seemed to be the ideal threshold of occurrences' sum

[8] Definition of "Corpus" in Oxford dictionaries, (British & World English), *http://www.oxforddictionaries.com.* [Last access: 24 October 2014].

among all documents. After filtering the DTM, we obtained a matrix with only 1.338 term, which will be more manageable within the next steps of this analysis.

6.2. Clustering

Considering the size of the obtained DTM and as the efficiency and performance of K-means were widely demonstrated by the data mining community, we opted for the application of a heuristic-guided K-means clustering method. As the predetermined number of clusters “k” is a sensitive parameter for this clustering task (since it guides the algorithm to make the separation between the data points) and in order to address this issue, we applied the elbow method, as a heuristic, to guide the choice of the “k” parameter.

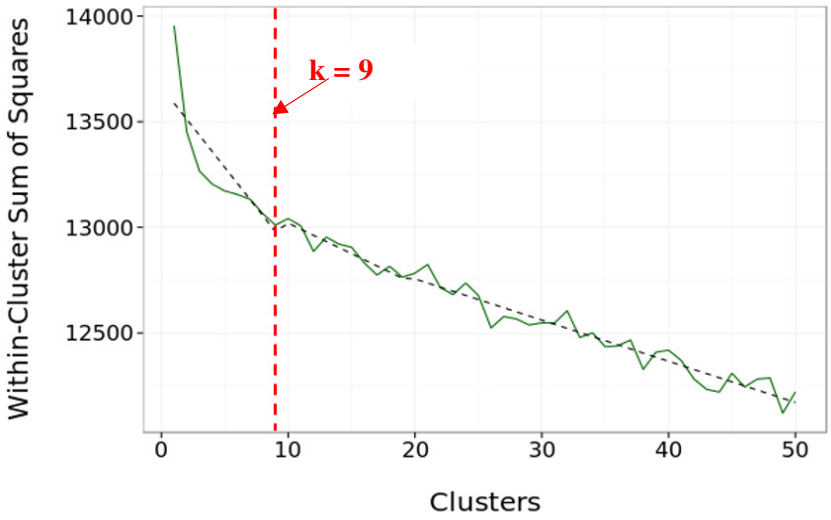

Fig.3. Reduction in cost for values of "k".

As shown in Figure 3, the elbow method is based on the computation of the squared distance’s total for each cluster. With the collection of the k-means’ results for different k-values (here from 1 to 50), the analysis of the generated graph allows us to determine the value k that should be considered by taking the breakpoint (marks the elbow point). In our case, and according to Figure 3, we selected 9 clusters.

In contrast with the educational background, classifying profiles according to their professional description become a complex task especially when we have to deal with multidisciplinary profiles. Depending on their positions’ history, working field(s), experience, etc., these aspects of the different career paths highlight the singularity of each profile. So, the application of a clustering technique rather than the semi-supervised classification as performed on the educational profiles’ description takes all its sense.

Actually, the aim of applying a clustering technique here is to group similar LinkedIn profiles within a restricted category (PhD level) according to their professional background, and thus, to build a methodology for groups’ detection. As pointed out earlier, 9 is the appropriate k value to perform k-means clustering. After running the algorithm, we have obtained the clusters distribution in Table 4.

Table I. Number of profiles for each cluster.

Cluster id	Number of profiles
1	199
2	2416
3	210
4	1846
5	374
6	5152
7	981
8	3090
9	75

Furthermore, we have decided to analyse the most frequent terms in the professional description of each cluster's profiles. We began by considering only terms associated to profiles belonging to each cluster. Then, we have sorted these terms according to their occurrence's frequency among all profiles. And finally, we have constructed a Tag Cloud for each cluster in order to enable the visualization of these results. Consequently, we have obtained the 9 tag clouds.

The existence of terms co-occurring among different tag clouds can be explained by the fact that there are some common terms used by the majority of profiles of this educational category (PhD level). So, encountering redundant terms such as "university", "professor", "teaching" etc., makes sense when considering this aspect. Indeed, scrutinizing each tag cloud can lead us to the characterization of the profiles' groups. This exercise must be performed regarding all the professional aspects of a profile description (such as the "job position(s)" and "working field(s)", etc.) but also by comparing each tag cloud to all others in order to spotlight its singularity.

Fig.4.1. Tag Cloud of cluster "1" profiles.

Fig.4.2. Tag cloud of cluster "2" profiles.

Fig.4.3. Tag cloud of cluster "3" profiles

Fig.4.4. Tag cloud of cluster "4" profiles

Fig.4.5. Tag cloud of cluster "5" profiles

Fig.4.6. Tag cloud of cluster "6" profiles

Fig.4.7. Tag cloud of cluster "7" profiles

Fig.4.8. Tag cloud of cluster "8" profiles

Fig.4.9. Tag cloud of cluster “9” profiles

Fig.4. Reduction in cost for values of "k".

7. RESULTS

The characterization of the obtained clusters by interpreting their correspondent tag clouds can lead us to draw some conclusions about the different professional groups inside the PhD level category. A scrutiny of the tag clouds lead us to distinguish between these different groups.
Administrative, technical, academic or business are the main discriminative aspects depicted here to characterize these profiles. Also, other major cross-cutting aspects must be considered as the working environment (private or public sector), field (health, technology, etc.) but also the position’s level (senior, director, assistant, etc.).

The characterization process takes into account the most relevant terms used in all the profiles (professional description) constituting each cluster. An eventual subtraction of common tags could be conducted but a general interpretation of the tag clouds’ results should firstly takes into account the most frequent terms.

Having 199 profiles, cluster number 1 (whose tag cloud is depicted in Fig 4.1) encompasses with the administrative public sector terminology (such as “public”, “county”, “district, etc.). The profiles of this group are related to the field of legal or juridical science. The second tag cloud describes high level academic researchers by the use of terms such as “university”, “professor”, “senior”, etc.
In contrast with the first one which is also dealing with administrative profiles in the field of legal sciences, the third tag cloud describes professional profiles working in the private sector (“clerk”). The fourth tag cloud describes more technical profiles’, characterized via terms such as “development”, “engineering”, “design”, etc.

Represented by its associated tag cloud, cluster 5 clearly spotlight academic profiles which are more involved in teaching experiences (“university”, “teaching”, “professor”, etc.) This aspect is consolidated by the existence of a terminology related to numerous fields of study (economics, technology, medical, etc.).

The sixth cluster represents the most common profiles of the PhD level category (by grouping 5.152 profiles). It is characterized by academic profiles of the range of “assistant professor”, “project manager” and they are more research oriented.

Tag cloud number 7 illustrates another group of profiles working in the academic field and mainly composed of "associate professor", which are involved in international projects and may have some administrative responsibilities in their research organizations. The jargon used in the eighth tag cloud clearly describes business profiles working in international settings. Finally, and compared to the previous tag clouds, the last one describes a multidisciplinary profile which takes advantage of all the discussed aspects. With its 75 profiles, the ninth cluster is composed by LinkedIn profiles that encompass different job positions in management, research, teaching, etc.

8. DISCUSSION AND FUTURE WORK

Very popular social networks, like Twitter or Facebook, have been intensively studied in the last years and it is reasonable easy to find available datasets. However, since LinkedIn is not as popular, there are not datasets gathering information (profiles and interactions) of this social network. In this paper, we have applied different social mining techniques to obtain our own dataset from LinkedIn which has been used as data source for our study. We consider that our dataset (composed of 5.7 million profiles) is representative of the LinkedIn activity for our study. Few proposals face analysis using this professional social network. In [29] the authors provide a statistical analysis of the professional background of LinkedIn profiles according to the job positions. Our approach also tackles profiles characterization, but focused on both the academic background and the professional background. Besides, our approach uses a really higher number of profiles instead of the 175 used in [29]. Clustering techniques were also applied in [30] with the aim of detecting groups or communities in this social network. They have also used as dataset a small group of 300 profiles. Finally, in [31] authors focus on detecting spammer's profiles. Their work on 750 profiles concludes a third of the profiles were identified as spammers.

For this study, we have collected more than 5.7 million LinkedIn profiles by scraping its public members' directory. Then, and after cleaning the obtained data set, we have classified the profiles according to their educational background into 5 categories (PhD, master, bachelor, secondary, and others) and by considering the 4 levels of the UNESCO educational classification. NLP techniques were applied for this task but also for clustering the professional background of the profiles belonging to the PhD category. In this context, we have applied the well-known K-means algorithm conjunctly with the elbow method as a heuristic to determine the appropriate k-value. Finally, and for each cluster, we have generated the tag cloud associated to the professional description of the profiles. This characterization enables us to provide more insights about the professional groups of an educational category.

Finally, and having established the former groups of educationally/professionally similar groups, we are currently working on given answers to the following questions: to what extent does educational background impact in the professional success? In how much time does this impact get its maximum level? Besides, and with the availability of temporal information in our data set (dates related to the job experience but also to the periods of studies or degrees), the application of predictive techniques is one of our highest priorities in order to provide career path recommendations according to the job market needs.

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INTENTIONAL BLANK

UNDERSTANDING PHYSICIANS' ADOPTION OF HEALTH CLOUDS

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ABSTRACT

Recently proposed health applications are able to enforce essential advancements in the healthcare sector. The design of these innovative solutions is often enabled through the cloud computing model. With regards to this technology, high concerns about information security and privacy are common in practice. These concerns with respect to sensitive medical information could be a hurdle to successful adoption and consumption of cloud-based health services, despite high expectations and interest in these services. This research attempts to understand behavioural intentions of healthcare professionals to adopt health clouds in their clinical practice. Based on different established theories on IT adoption and further related theoretical insights, we develop a research model and a corresponding instrument to test the proposed research model using the partial least squares (PLS) approach. We suppose that healthcare professionals' adoption intentions with regards to health clouds will be formed by their outweighing two conflicting beliefs which are performance expectancy and medical information security and privacy concerns associated with the usage of health clouds. We further suppose that security and privacy concerns can be explained through perceived risks.

KEYWORDS

Cloud Computing, Healthcare, Adoption, Physician, Security and Privacy Concerns

1. INTRODUCTION

Nowadays, healthcare and medical service delivery are on the way to be revolutionized ([7][7],[21]). Due to the recently proposed solutions, medical data can be easily shared and collaboratively used by healthcare professionals involved in the medical treatment [42][42], while novice surgeons can automatically be assisted in their surgical procedures [32][32] and physicians can be supported to make their therapy-related decisions [30][30]. The design of these apparently important innovative healthcare solutions is often enabled through the cloud computing model, which is known for providing adequate computing and storage resources on demand [33][33]. However, the immediate involvement of the cloud computing's third-party as well as communication via the open Internet landscape might lead to unexpected risks (e.g., legal problems) ([6][6],[35]) and therefore cause intense concerns among medical workers with respect to cloud computing companies' ability and willingness to protect disclosed medical information ([24], [36], [43]). While online medical service providers currently show interest in collecting medical information of their customers ([22][22],[25]), through the misuse of medical information the service users might get subject to harassment by marketers of medical products and services, and discrimination by employers, healthcare insurance agencies, and associates

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([3][3],[27]). The exposure of security and privacy concerns related to sensitive medical information could be a serious hurdle to successful adoption and consumption of cloud-based health services, as repeatedly demonstrated by prior empirical evidence in other healthcare settings ([1][1], [2], [3], [18], [15], [29], [6], [35], and [5]).

This research examines which determinants can explain the extent to which medical workers will be willing to adopt health clouds in their daily work. To conduct the research, we follow the guidelines proposed by [44][44], [38], [31] and [19]. We build on well-established theories and works on adoption of information technologies ([47], [48]) and existing theoretical insights into the factors influencing healthcare IT and cloud computing adoption. We further draw on utility maximization theory ([3], [12]) arguing that one tries to maximize his or her total utility. We suppose the utility function to be given by the trade-off between expected positive and negative outcomes in a healthcare professional's decision-making process with regards to the usage of health clouds.

The paper is divided into four sections. In Section 2, we introduce the background of our research, highlight main theoretical foundations and formulate research hypothesis. Section 3 proceeds with presenting the research model where we illustrate the hypothesized relations. It further deals with the instrument developed to test the proposed research model using the partial least squares (PLS) approach ([19][19], [20], [44]). We conclude by recapitulating the results of this work, extensively discussing its limitations and thus giving recommendations for further research.

2. BACKGROUND AND THEORETICAL FOUNDATIONS

The availability of medical data is of utmost importance to physicians during the medical service delivery [42][42]. The healthcare sector can further profit from modern data analysis techniques. Their application fields in the healthcare area range from disease detection, disease outbreak prediction, and choice of a therapy to useful information extraction from doctors' free-note clinical notes, and medical data gathering and organizing [21]. These techniques can also be applied to assessment of plausibility and performance of medical services and medical therapies development [7]. Recently, [32] introduced an interactive three-dimensional e-learning portal for novice surgeons. Under real time conditions, their surgical procedures are to be compared to the practice of experienced surgeons. [30] presented a decision support system aimed to assist physicians in finding a successful treatment for some certain illness based on the currently available best practices and the characteristics of a given patient.

By provisioning adequate capacities to store and process huge amounts of data, cloud computing facilitates the design of these innovative applications in the healthcare area. However, this technology is also known for users' concerns about their information security and privacy ([24], [36]). While the providers of healthcare-related websites are interested in collecting medical information ([22][22], [25]), the misuse of medical information might result in different harassment and discrimination scenarios for patients ([3],[27]). In the recent past, there were cases where, based on disclosed medical information, marketers of medical products and services sent their promotional offers; employers refused to hire applicants and even fired employees; insurance firms denied life insurances. The exposure of the concerns surrounding information security and privacy could therefore negatively affect adoption and consumption of cloud-based health services, as multiple empirical studies demonstrated this in the healthcare context ([1], [2], [3][3], [18], [15], [29], [6], [35] and [5]) and other settings ([13], [14] and [40]).

In the present work, we try to understand the predictors of behavioural intention of healthcare professionals to adopt health clouds in their work. In the research related to management of

information systems (MIS), a variety of theories have been applied to explain an individual's adoption of information technologies. Among others, these include theories of reasoned action (TRA), planned behaviour (TPB), technology acceptance model (TAM), and unified theory of acceptance and use of technology (UTAUT) ([47], [48]). In line with these theories, we suppose that healthcare professionals' adoption of health clouds is a product of beliefs surrounding the system. We additionally assume that medical workers' intentions are consistent with utility maximization theory ([3], [12]) which posits that an individual attempts to maximize his or her total utility. As usage of health clouds is associated with numerous risks for a healthcare professional, we suppose that his or her utility function in the presented context is given by the calculus of conflicting beliefs which involve performance expectancy of the services, on one side, and associated security and privacy concerns about medical information, on the other side. We further postulate that information security and privacy concerns result from perceived risks.

2.1 Performance Expectancy

In one of the recent works on information technology acceptance, Venkatesh et al. [47] defines performance expectancy as the extent to which individuals believe that using the information technology is helpful in attaining certain gains in their job performance. Performance expectancy and other factors that pertain to performance expectancy such as perceived usefulness are generally shown to be the strongest predictors of behavioural intention [47]. Previous work suggests that healthcare professionals tend to be higher willing to adopt technological advances in their practice the higher they perceive their usefulness ([17], [8], [46], [35]). Similarly, cloud computing is more likely to be adopted the more beneficial it appears to the decision maker ([23], [28], [29], [36]). Therefore, we hypothesize that:

Hypothesis 1. Performance expectancy will be positively associated with behavioural intention to accept health clouds.

2.2 Security and Privacy Concerns

Online companies rely on use of their customers' personal information to select their marketing strategies ([36], [25]). As a result of this, Internet users view their privacy as being invaded. A recent survey revealed that 90% of Americans and Britons felt concerned about their online privacy and over 70% of Americans and 60% of Britons were even higher concerned than in the previous year [43].

Healthcare professionals appear to be ones of the most anxious Internet users in terms of information privacy. Dinev and Hart [13] argue that Internet "*users with high social awareness and low Internet literacy tend to be the ones with the highest privacy concerns*". Although this group of users constitute the intellectual core of society, they are not able or willing to keep up with protecting technologies while using the Internet. Simon et al. [39] further state that physicians are worried about patient privacy even more than the patients themselves.

In this study, privacy concerns are related to healthcare professionals' beliefs regarding cloud computing companies' ability and willingness to protect medical information ([40], [4], [36]). The dimensions of privacy concerns involve errors, improper access, collection, and unauthorized secondary usage.

Due to the open Internet infrastructure vulnerable to multiple security threats [36], we further consider security concerns. They refer to healthcare professionals' beliefs regarding cloud computing companies' ability and willingness to safeguard medical information from security breaches ([4], [36]). The dimensions of security concerns include information confidentiality and

integrity, authentication (verification) of the parties involved and non-repudiation of transactions completed.

Similarly to [4], we distinguish six dimensions of the combined security and privacy concerns, where we consider the dimensions of errors and improper access to be equivalent to the expectancy are to be measured with items adapted from Venkatesh et al. ([47], [48]). Security and privacy concerns are to be explored at a more detailed level, as recommended by [1]. With regards to the concerns, we draw on the multi-dimensional view proposed by Bansal [4]. The dimensions of privacy-related concerns, i.e., collection, errors, unauthorized secondary use, and improper access, originate from the work by Smith et al. [40] and were validated in healthcare privacy studies ([15], [18]). To measure the factors associated with collection, integrity/errors, and confidentiality/improper access, the questions from [18] were adapted. For the secondary use construct, we took items from [12]. Measures for the remaining underlying factors, i.e., authentication and non-repudiation, were developed based on [4]. To measure perceived risks, we rely on the items by [16].

Table 1. Research Model Constructs and Related Questionnaire Items

Construct	**Items**
Behavioural Intention to Adopt Health Clouds (based on [47], [48])	Given I get the system offered in the future and the patient consent for medical information transmission over the system is given, … … I intend to use it whenever possible. … I plan to use it to the extent possible. … I expect that I have to use it.
Performance Expectancy (based on [47], [48])	Using the system would make it easier to do my job. I would find the system useful in my job. If I use the system, I will spend less time on routine job tasks.
Security and Privacy Concerns – Integrity / Errors (based on [4], [40], [18])	I would be concerned that in the system… … medical information can be modified (altered, corrupted). … medical information is not enough protected against modifications. … accurate medical information can hardly be guaranteed.
Security and Privacy Concerns – Confidentiality / Improper Access (based on [4], [40], [18])	I would be concerned that in the system… … medical information can be accessed by unauthorized people. … medical information is not enough protected against unauthorized access. … authorized access to medical information can hardly be guaranteed.
Security and Privacy Concerns – Authentication (based on [4])	I would be concerned that in the system… … transactions with a wrong user can take place in the system. … verifying the truth of a user in the system is not enough ensured. … transacting with the right user in the system can hardly be guaranteed.
Security and Privacy Concerns – Nonrepudiation (based on [4])	I would be concerned that transactions in the system … …. could be declared untrue. … are disputable. … are deniable.
Security and Privacy Concerns – Collection (based on [4], [40], [18])	I would be concerned that medical information transmitted over the system … … does not get deleted from the cloud. … is kept as a copy. … is collected by the cloud provider.
Security and Privacy Concerns – Unauthorized Secondary Use (based on [4], [40], [12])	I would be concerned that medical information transmitted over the system can be … … used in a way I did not foresee. … misused by someone unintended. … made available/sold to companies or unknown parties without your knowledge.

Perceived Risks (based on [16])	In general, it would be risky to transmit medical information over the system. Transmitting medical information over the system would involve many unexpected problems. I would not have a good feeling when transmitting medical information over the system.

The respondents are supposed to be presented one of the above mentioned scenarios. They further will be asked to provide their answers to the questions on a 7 Likert scale (e.g., 1: Not likely at all, 2: Highly unlikely, 3: Rather unlikely, 4: Neither likely nor unlikely, 5: Rather likely, 6: Highly likely, 7: Fully likely). Additionally, they will be asked about practice period [9], their workplace location (e.g. rural or urban) ([35], [9]), gender, and age, etc. [35]. These questions will mainly allow describing the sample.

3. CONCLUSION, LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

In this work, we defined a theoretical model aimed to explain behavioural intention of healthcare professionals to adopt health clouds in their clinical practice. We operationalized the research model and transferred it into a structural equation model to further analyse with the PLS approach.

Drawing on utility maximization theory and further related research, we suppose that healthcare professionals' adoption intentions with regards to health clouds will be formed by outweighing two conflicting beliefs. They involve expected performance expectancy and security and privacy concerns associated with the usage of health clouds. We further postulate that security and privacy concerns can be explained through perceived risks.

Our work implies some limitations. First, there might be some other possible casual relationships between the constructs proposed in the research model. For example, [46] hypothesize that EMR security/confidentiality influences its perceived usefulness, while [17] find a positive relationship between perceived importance of data security and perceived usefulness of electronic health services. As identified by [26], perceived privacy risk directly influences personal information disclosure in the context of online social networks. In our future research, we are going to verify all possible paths, as recommended by [20].

Second, we left some other factors out of consideration such as effort expectancy, social influence, and facilitating conditions which are often investigated and can extend the study in the future.

Venkatesh et al. [47] define effort expectancy as referring to the extent to which an individual finds the system easy to use. The factor is also captured by perceived ease of use specified in TAM. Perceived ease of use is important for potential cloud computing users ([28], [36]). Physicians view easy-to-use services as more useful and stronger intend to use them ([17], [6], [35], [6]). Contrary to these findings and other previous research assertions (e.g., [47], [48]), perceived ease of use did not exert any significant effects on perceived usefulness or attitude, when tested in the telemedicine context [8]. The authors suggest that physicians comprehend new information technologies more easily and quickly than other user groups do. Alternatively, the importance of perceived ease of use may be weakened by increases in general competence or staff assistance [8]. These aspects are implied in the concept of facilitating conditions which relates to the extent to which individuals believe in the existence of an organizational and technical

infrastructure to support their system use [47]. They were found to play a role in formation of behavioural intention to use cloud computing in hospital [29] and perceived usefulness of healthcare information technologies ([8], [34], [6], [35]).

Social influence refers to the degree to which individuals perceive that others' beliefs about their system use are important [47]. Being differently labelled across studies, social influence was found to have contradictory results when tested with regards to behavioural intention. Cloud computing users were significantly guided by the way they believe they are viewed by others as having used the cloud computing technology [28]. However, practicing physicians' intentions to use telemedicine technology were not significantly influenced by social norms [8]. Dinev and Hu [11] observe subjective norm influencing behavioural intention rather for IT aware groups. Dinev and Hu believe that the more IT knowledgeable the group are, the more they communicate about IT related issues and are willing to learn IT solutions their peers already use.

Finally, some variables which are to be used to describe the sample (e.g., workplace location) can further be controlled for their role. As observed by [35], urban hospitals could be expected to adopt innovative solutions rather than rural ones. Hospitals located outside cities and towns are the only alternative for people living nearby. So they do not have to compete with others in adopting new technologies. Furthermore, they are typically under-occupied and have little financial support.

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IMAGE RETRIEVAL USING VLAD WITH MULTIPLE FEATURES

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ABSTRACT

The objective of this paper is to propose a combinatorial encoding method based on VLAD to facilitate the promotion of accuracy for large scale image retrieval. Unlike using a single feature in VLAD, the proposed method applies multiple heterogeneous types of features, such as SIFT, SURF, DAISY, and HOG, to form an integrated encoding vector for an image representation. The experimental results show that combining complementary types of features and increasing codebook size yield high precision for retrieval.

KEYWORDS

VLAD, SIFT, SURF, DAISY, HOG

1. INTRODUCTION

Image retrieval is one of the classical problems in computer vision and machine intelligence. The challenge of image retrieval is mainly aimed at trade-off between computing costs and the precision of retrieval due to the large scale data, including the large size of a single image and the large number of all images. In this paper, we propose an combinatorial encoding algorithm based on VLAD[6,9] with multiple features to achieve the goal of large scale image retrieval. VLAD cluster all features descriptors extracted from training images to find a certain number of centroids. These centroids are treated as code words or visual words, and thus form a codebook. Each image from either testing dataset or training dataset can be further encoded to a vector with fixed dimension using the trained codebook. The VLAD encoding contributes a key concept that it encodes any image by a collection of code words encoding vector with a consensus dimension. The rest of this paper is organized as follows. Section 2 reviews the previous work VLAD algorithm, section 3 elaborates the proposed method, section 4 shows experimental results, and a conclusion is given in section 5.

2. RELATED WORK

2.1. VLAD Algorithm

VLAD(vector of locally aggregated descriptors) is proposed by Jegou[6] in 2010. Similar as BOF(bag-of-features)[10], VLAD aims at representing one single image by a fixed number of feature vectors aggregated by all feature descriptors extracted from this image. Such a

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representation is called a VLAD encoding for an image. Initially, VLAD takes all feature descriptors from all training images as inputs to cluster them and find a fixed number of centroids by K-means[7] as shown in Figure 1 and Figure 2. The collection of these centroids is referred to as the codebook. To encode an image using the codebook, the details of processing are elaborated as follows. Let N denote the total number of centroids, and $c_i(i=1\ldots N)$ denote the centroids.

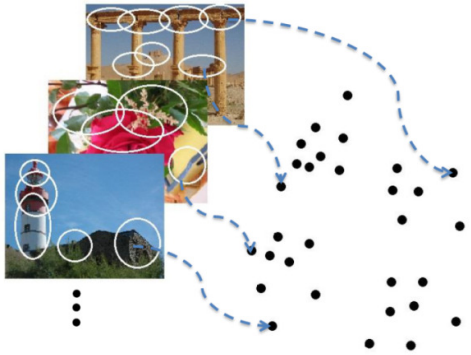

Figure 1. Features extraction from images.

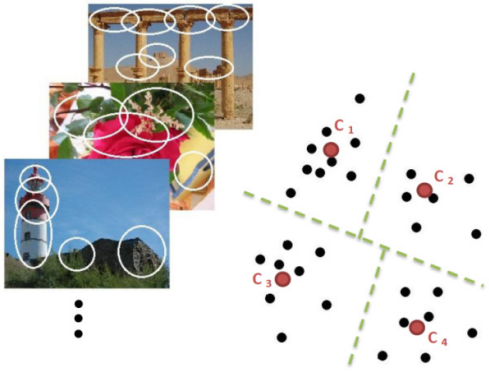

Figure 2. Clustering all features by K-means.

For encoding an image, we first extract all feature vectors from this image and denote them by $x_t(t=1\ldots T)$ as shown in Figure 3. Then, each feature finds the centroid closest to it, $NN(x_t)$, defined in eq. (1) as shown in Figure 4.

$$NN(x_t) = \arg\min ||x_t - c_i|| \qquad (1)$$

Let v_i denote the normalized vector sum of all difference between each feature vector x_t and the centroid $NN(x_t)$ which it belongs to, as defined in eq. (2) and eq. (3). Then $v_i(i=1\ldots N)$ can be seen as an aggregation of all feature vectors contained in the input image based on the codebook as illustrated in Figure 5 and Figure 6., and such an aggregation is called a VLAD encoding for this image.

$$v_i = \sum_{x_t:NN(x_t)=c_i}(x_t - c_i) \qquad (2)$$

$$v_i := v_i/||v_i||_2 \qquad (3)$$

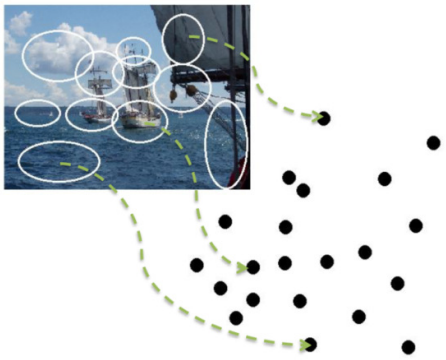

Figure 3. Features extraction for an image encoding.

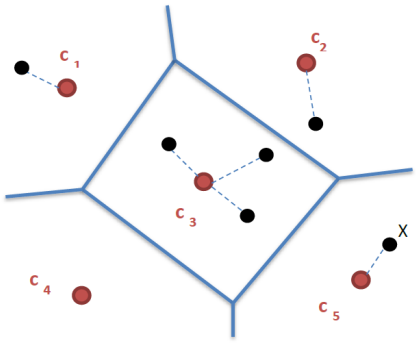

Figure 4. Each feature finds the centroid closest to it

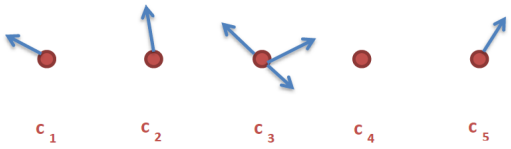

Figure 5. Distributing all features to centroids

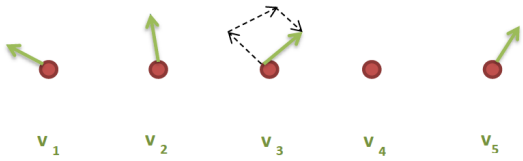

Figure 6. Vectors aggregation and normalization

3. PROPOSED METHOD

3.1. Multiple Feature Extraction

VLAD adopts SIFT as the feature descriptors for encoding. The state-of-the-art SIFT proposed by Lowe[1] is a well-known feature descriptor which is widely applied in computer vision, object recognition and machine intelligence due to its feature distinctness, robustness, and scale and rotation invariant. For achieving higher accuracy for large scale image retrieval, this paper proposes the scheme of integrating multiple types of feature into VLAD algorithm to enhance the distinctness between image objects. Thus, besides SIFT, we also adopt the well-known feature descriptors, including SURF, DAISY, and HOG. Detail of each feature descriptor is elaborated in the following.

SURF is proposed by Bay[4] which replaces the DoG in SIFT with Haar wavelets transform to generate the pyramid of scale space and approximates the determinant of Hessian blob detector by an integer evaluation for efficiency. It is feasible to be used on large scale image matching for the real-time concern. SURF descriptors can be extracted under various dimensions, for instance, SURF-64 or SURF-128 are the SURF descriptors with dimension 64 or 128, respectively.

DAISY is a local dense feature descriptor scheme proposed by Tola[2]. Similar with SIFT, it generates block-based orientation histogram but uses Gaussian convolution to aggregate these blocks for efficiency. It has been shown that DAISY is a feasible and efficient feature descriptor to be applied in wide base-line stereo matching. In this work, we uses dimension 200 to extract DAISY descriptors.

The HOG descriptor is proposed by Dalal and Triggs[8], is a well-known feature descriptor and widely applied in human or pedestrian detections due to its robustness of geometric shape and luminance. It consists of three hierarchical structures, naming cell, block, and window, respectively. The feature extraction starts by processing the image to a greyscale form, and divides the image into several cells. Each cell is partitioned into nine bins according to the orientation of gradients, and every four neighboring cells form a block. Then use a block to scan the window for each step, the length of one cell at a time. Eventually, a feature descriptor is generated by integrating feature vectors in all blocks. In this paper, we define that a cell consists of 8*8 pixels, and four cells form a block with 16*16 pixels. The block then scans a window consisting of 64*128 pixels for each step with length 8 pixels. Thus, every cell has nine orientation features, and each block contains 36 features. After window scanning is completed, we obtain (64-8)/8=7 scanning blocks in horizontal direction，and (128-8)/8=15 scanning blocks in vertical direction. Therefore, the dimension of such a HOG descriptor is 64*7*15=3780.

3.2. Codebook Training

As aforementioned, VLAD uses k-means to cluster all SIFT features extracted from all training images to find a certain number of centroids, the codebook. Similarly, we can extract other types of feature descriptors, such as SURF-64, SURF-128, DAISY, and HOG from all training images to compute the corresponding codebooks. Besides, the dimension of codebook, i.e., the number of centroids for K-means clustering is also a crucial effect upon the accuracy of recognition. In this paper, we train codebooks with 64 clusters, 128 clusters, and 256 clusters, respectively.

3.3. Combined VLAD Encoding

After finishing the codebooks generation, the encoding process for an image can be elaborated as follows. An image can be computed for its VLAD encoding vector with a specific codebook. The proposed encoding method is to combine several VLAD encoding vectors that are encoded by

different codebooks into a normalized encoding vector. For instance, if four types of features, SIFT, SURF-64, DAISY and HOG are adopted and the sizes of codebook are all set to 64, an image is firstly encoded by SIFT codebook, followed by a normalization process, to produce a VLAD encoding vector of SIFT with dimension 128*64=8192. Applying similar processes, we can compute the normalized VLAD encoding vector of SURF-64, DAISY, and HOG for this image, respectively. Dimensions of SURF-64, DAISY, and HOG for a single VLAD encoding vector are 64*64=4096, 200*64=12800, and 3780*64=241920, respectively. Thus, an image can be represented by a combined normalized VLAD encoding vector with dimension 8192+4096+12800+241920=267008.

4. EXPERIMENTAL RESULTS

The training and testing images adopted in this research are from INRIA Holiday dataset[5] ◦ The Holiday dataset contains 500 classes of images, and a total of 1491 images. We pick one image from each class for testing data, and the rest are for training data. Firstly, each training image is pre-processed by VLAD encoding with a specific combination of codebooks. The 500 testing image are then encoded by applying the same combination of codebook. To match the testing image with the training images, the KNN[3] algorithm is adopted to list the first 1000 ranks of encodings of training images for each encoding of testing image, and thus the mAP(mean average precision) value can be computed to reflect the precision of retrieval.

Table 1 shows the performance of encodings which combines different numbers of feature descriptors from one to four types. It is obviously that mAPs are noticeably promoted as the number of feature types and the number of centroids increases. In all combinations of any two types of feature descriptors as shown in table 2, the combination of SIFT and DAISY performs best. Our explanation is that SIFT and SURF are local descriptors, while DAISY and HOG preserves a certain portion of region description. Thus, the complementary between SIFT and DAISY can achieve more complete and detail representation of an image, and thus make each encoding more distinguishable from others. The combination of all four types of feature descriptors as shown in Table 3, SIFT, SURF(64), DAISY, and HOG, with 256 centroids yields the best result and significantly promotes the mAP to 0.72.

Table 1

Feature Descriptors	Dimension 64-centroids	mAP	Dimension 128-centroids	mAP	Dimension 256-centroids	mAP
SIFT	8192	0.528	16384	0.574	32768	0.604
SIFT+SURF(64)	12288	0.572	24576	0.597	49152	0.619
SIFT+SURF(64)+HOG	254208	0.637	508416	0.661	1016832	0.671
SIFT+SURF(64)+DAISY	25088	0.668	50176	0.679	100352	0.701
SIFT+SURF(64)+DAISY+HOG	267008	0.687	534016	0.707	1068032	**0.720**

Table 2

Feature Descriptors	Dimension 64-centroids	mAP	Dimension 128-centroids	mAP	Dimension 256-centroids	mAP
DAISY+HOG	254720	0.527	509440	0.526	1018880	0.538
SURF(128)+HOG	250112	0.566	500224	0.598	1000448	0.585
SURF(64)+HOG	246016	0.567	492032	0.585	984064	0.598
SIFT+SURF(128)	16384	0.571	32768	0.590	65536	0.607
SIFT+SURF(64)	12288	0.572	24576	0.597	49152	0.619
SURF(128)+DAISY	20992	0.594	41984	0.608	83968	0.609
SURF(64)+DAISY	16896	0.601	33792	0.607	67584	0.626
SIFT+HOG	250112	0.604	500224	0.646	1000448	0.658
SIFT+DAISY	20992	0.624	41984	0.641	83968	0.655

Table 3

Feature Descriptors	Dimension 64-centroids	mAP	Dimension 128-centroids	mAP	Dimension 256-centroids	mAP
SIFT+SURF(128)+HOG	258304	0.630	516608	0.666	1033216	0.662
SURF(64)+DAISY+HOG	258816	0.630	517632	0.642	1035264	0.654
SURF(128)+DAISY+HOG	262912	0.635	525824	0.647	1051648	0.645
SIFT+SURF(64)+HOG	254208	0.637	508416	0.661	1016832	0.671
SIFT+DAISY+HOG	262912	0.641	525824	0.667	1051648	0.675
SIFT+SURF(128)+DAISY	29184	0.661	58368	0.680	116736	0.686
SIFT+SURF(64)+DAISY	25088	0.668	50176	0.679	100352	**0.701**
SIFT+SURF(64)+DAISY+HOG	267008	0.687	534016	**0.707**	1068032	**0.720**
SIFT+SURF(128)+DAISY+HOG	271104	**0.692**	542208	**0.711**	1084416	**0.707**

5. CONCLUSIONS

In this paper, we show that a combinatorial encoding method with multiple features indeed enhance the distinctiveness among large number of image representations, and thus significantly promote the retrieval precision. On the other hand, encoding by using identical size of codebook equalizes the dimension of representation for each image, and efficiently facilitates the matching

process with KNN if compared to the traditional two-stage point-to-point and geometrical matching processes for every pair of images. The benefits of distinctiveness and efficient matching make it practical and feasible to apply on large scale image retrieval. Although the dimension of encoding might increase as multiple features are applied, the computing cost caused by large dimension can be alleviated by the novel technologies of parallel processing or distributive computing.

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THE EFFECT OF SOCIAL WELFARE SYSTEM BASED ON THE COMPLEX NETWORK

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ABSTRACT

With the passage of time, the development of communication technology and transportation broke the isolation among people. Relationship tends to be complicated, pluralism, dynamism. In the network where interpersonal relationship and evolved complex net based on game theory work serve respectively as foundation architecture and theoretical model, with the combination of game theory and regard public welfare as influencing factor, we artificially initialize that closed network system. Through continual loop operation of the program ,we summarize the changing rule of the cooperative behavior in the interpersonal relationship, so that we can analyze the policies about welfare system about whole network and the relationship of frequency of betrayal in cooperative behavior. Most analytical data come from some simple investigations and some estimates based on internet and environment and the study put emphasis on simulating social network and analyze influence of social welfare system on Cooperative Behavior .

KEYWORDS

Complex network, Welfare System, Game Theory, Cooperation

1. INTRODUCTION

At present, the game theory is widely applied in many fields such as economics, sociology and computer science .Scientists in various fields have put forward applicable game models, such as snowdrift game, coordination game and so on, and had good simulation results[1]. The prisoner's dilemma model is a typical model in game theory, which interpret the process of game simple and clear. But the prisoner's dilemma model show that individuals choose betrayal will get the highest interest, and betrayal of dominant. However, this does not accord with actual situation, most people need cooperation to complete something in reality. And only under the common cooperation and the long-term relationship, the individual will achieve maximum benefit. At the same time, because the real world not only have the individual game, but also usually a game between people. So people often research multi-player games[2].

Complex network[3] is the research focus in the academic field in the 21st century, and it is used in various fields to describe the relationships between all kinds of complicated things[4-5]. In today's society, the evolution of social welfare system in the developed countries, mainly experienced from residual welfare model to system of welfare model to hybrid welfare model transition[6], and China's social welfare system still exist many problems, and still in the process of perfecting. At present, most studies of social welfare system is in view of economics, there are also many people made comparison and research between structures of national welfare system,

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but no one study the application of complex network to the social welfare system. Today's society has formed a complex network with the person node. In this complex network, the social welfare system for the cooperative behavior of people will produce what kind of impact? In this paper, we combined with a complex network game model, simulate the behavior of the social individual performance through relevant features to analysis of network status.

This paper will use the complex network to set up a social group with some orders of magnitude. Under the natural development, Between people will influence each other and the implementation of the welfare system and changes will affect most people in this group. when everyone is affected and will feedback to the welfare system and affect other people around us, the people affected with the cooperation of others will also change, may betray partners, give up cooperation, and so on. In this big system of the dynamic and changeable, there are always Effect and feedback. We will study such a system, and establish a model. In this model, the node represents the individual and edge is abstracted as the relationship between the individual and eventually form a dynamic model, to reflect the change of the whole system. And analysis how the social welfare system based on the complex network effect on the cooperative behaviors. In this paper, we found that let all individuals in the system to balance as soon as possible by dynamically adjusting tax rate and the minimum guarantee of the welfare center value, and let the wave amplitude decreases, and the network of betrayal of inhibition.

2. THE INTRODUCTION OF RELEVANT CONCEPTS

Welfare system corresponding to the social group is a social network, social network and other natural network is also a complex system, from the social network also found the famous six degrees of separation phenomenon (also known as the ‘small world effect).In this paper we use the characteristics of small world network[2] to established the network model.

Welfare center: responsible for the management of the entire network, establish welfare system (including the tax rate and poor issuance rate) of the department.

Person: the individual in the network interact with each other, with the attribute of personal id, personal wealth, risk factor and the list of the contact.

Risk factor(SPIRIT): An individual's definition to investors, The greater the risk coefficient of individuals tend to invest more,($0 \leq SPIRIT \leq 100$).

The contact list: private property, divided into red list and white list. If the times of successful cooperation higher than that of the number of failed, we put it into the red list, whereas in the white list.

The blacklist: the list of the system, all people share, depositing a betrayal of people.

Rate(η): the proportion of the object charged.If the cooperation with the partner had been success, you must pay income tax according to the specified rate.

Poor issuance rate: the proportion of the funding for poor person. Refers to the property below the lowest life, welfare center according to its property status, issuance rate subsidies granted by poverty.

Earnings ratio: Profit ratio when the successful cooperation.

Percentage: the ratio When failed in the cooperation.

The minimum level of consumption (min): The minimum balance individual normal life. When individual wealth is lower than this value, welfare center will be given the allowance according to the level of poverty

General level of consumption(aver): the general consumption of the individual's normal life. In this article, we supposed that each traverse round the network through the time t, then every time t, the property of the general individual consumption value is Aver.

Minimum value: the lowest wealth welfare center give to the poor people.

Quick deduction (δ): quick deduction =the next higher level of the highest income×(the rate at this level -The higher tax rate) + the higher quick deduction.

3. THE INTRODUCTION OF THE SMALL WORD NETWORK MODEL

This paper uses the small world network model[2] to establish the network. Everyone can be regarded as nodes in complex networks. There are a large number of edges connecting to the network nodes, and two nodes connected by a line are regarded as persons who know each other. We assume that the network had N nodes, set up steps as follows:

Step 1: Each node should be connected to K / 2 neighbor nodes around (K is even), forming the regular net. We number N nodes of network for 1 ~ N and K lines connected to the node for 1~K.

Step 2: Whether Line 1 of node 1 would be reconnected depends on probability p (0<p<1). Node 1 of line 1 stays the same and on the other end is reconnected to other nodes of network. It meets only a line between two points.

Step 3: Line 1 of node 2 to node N repeats step 2 until finished.

Step 4: Line 2 of node 1 to node N repeats step 2 until finished.

Step 5: Processing Line 3 to Line K of node 1 to node N by iterating until finished.

The line will never happen reconnecting while p=0 and it will be homogeneous network. The line must be a reconnect while p=1 and it will be random network. By the introduction of Watts and Strogatz ' small world network[2] in 1998, we know that small world network have characteristic of short average path length and high degree of clustering. Let's call degree of clustering C(p)and average path length Iavg(P). Figure 1 shows degree of clustering and average path length is reduced with the increase of p value, but the decreasing degree is different. It can make degree of clustering high and average path length short while p=0.1, so this paper make p=0.1 to construct small world network.

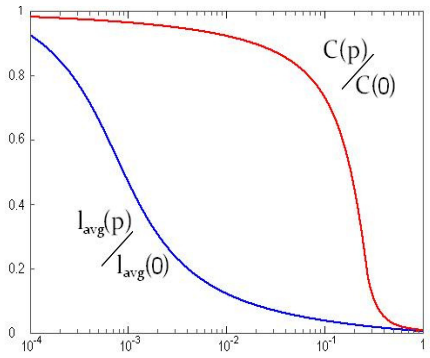

Figure 1. The image of degree of clustering C (red) and average path length L (blue) change with p.

4. THE THEORETICAL MODEL

The line will never happen reconnecting while p=0 and it will be homogeneous network. This paper is based on a small-world network to simulate real network. In the network, we define a welfare institution and many individuals. The welfare institution manages the entire network, so it sets rate and poor fund-issuance rate. Through simulate individual income tax in the real society, the welfare institution taxes on profitable individuals from cooperation. If the profit is lower than the threshold, the welfare institution wouldn't tax. Otherwise it taxes according to the following way

tax= taxable income × applicable tax rate quick calculation – deduction

Each time t, the welfare institution statistics its own wealth value and the wealth value it should give out the poor people next time. When the former is lower than the latter, it will reduce the minimum guarantee value. So this will reduce distribution of wealth value of the poor individual and raise tax. Otherwise, if the former exceeds the latter over the continuous time 10t, it will reduce tax and raise the minimum guarantee value. This paper starts with the minimum guarantee value to divide poverty levels into three levels, and set different poor fund-issuance rate with the different poverty levels. Poor fund-issuance rate is unchanged, and distribution of wealth value of the poor individual is linearity to changes of the minimum guarantee value.

In the model, we suppose that the interaction between individuals is through investment a comment project. Investment projects will have the risk, so according to the related factors, it may succeed or fail. When RISK changes, GAIN and LOST along with the change. We suppose M cooperate the same project, so

$$RISK = \sum SPIRIT_{\text{项目参与人}} / M + \omega_1$$

$$GAIN = (RISK + \omega_2) \times 0.01$$

$$LOST = (RISK + \omega_3 \% (RISK + 1)) \times 0.005$$

Figure 2. Formula 1

Among the above, the range of ω1 which is a random number is [-10,10], and the range of ω2 which is a random number is [0,100], and ω3 is a random number.

In this paper, we will combine the multi-player games model with single-player game. A person can choose to cooperate with other persons who have a connection with him, ask others to invest a project , or he can invest himself. However, individual investment would take bigger risks. In the multi-player game, Sponsor can ask all persons who exist in the red list, part of the white list for investing a project. But the requested people must ensure that their assets is greater than the half of sponsor. Then the requested people can decide whether agree to cooperate by their policy set. In the network, everyone has two alternative strategies, investment and non-investment. In the process of cooperation, μi represents the budget investment of Node i, Pi represents expected profit. Through the value of Pi determine whether agree to cooperation. When Pi > 0, individuals decide to invest, otherwise individuals declined to invest. α Represents the probability of success,

$$Pi = \alpha \times (\mu i \times GAIN \times (1-\eta) + \delta) - \mu i \times (1-\alpha) \times LOST$$

Figure 3. Formula 2

In order to maximize their own interests, individuals by their own the value of risk and the investment situation to make their own decisions. Whether individual invest and how invest is called the game process. The success of the investment is determined by probability. We generate a random number between [0,100] compared with value at risk, when its value is greater than the risk, investment success. On the other hand, investment failure. According to investment value and earnings ratio (or loss ratio)of each investor in the project, each investor charges (or pays) the corresponding amount. If investors cooperation successfully, investors will update their contact list. They will put the investors they do not know before in their white list, make investment cooperation times of investors who belong to red list to increase 1, put the investors belonging to white list in red list and delete them from white list. If investors cooperate unsuccessfully, they will make investment cooperation times of investors who belong to red list to decrease 1. What is more, if investment cooperation times of investors who belong to red list are equal to 1, they will put the investors belonging to red list in white list and delete them from red list. However, in the process of investment a project, it may exist individual betrayal, namely , the individual will take all the money investors invest away. Individual will be punished if they choose to betrayal. In a period of time T (T = kt (k > 10)), it exists in the black list, individuals in the network will not cooperate with people in the black list, and people cannot be a single investment in black list. After a period of time, betrayers cannot cooperate with others that lead to betrayers can only consume without income. When there is not enough wealth individuals supported the γ*t time consumption, If individual ensure the money of investment is greater than its β times the cost of investment and can support in T time consumption and can ensure the budget surplus amount S is enough for their minimum consumption in the next T time, they will choose to betray. So an individual judge whether betrayal by following condition:

$$①\ \mathrm{value(i)} < \gamma \times aver$$

$$②\ Total\_value \geqslant \beta \times \mathrm{value(i)}$$

$$③\ S_i = (Total\_value + \mathrm{Self\_value(i)}) - (\theta \times aver) \times k$$

$$S_i > min;$$

Figure 4. Formula 3

Total_value means the total wealth value of investment. value(i) means the investment cost of an individual, Self_value(i) means wealth value of an individual. Si means surplus wealth value after an individual is deleted from the black list. θ means positive integer.

Group of betrayal by following condition:

$$①\ Max\{\mathrm{value(i)}\} < \gamma \times aver \quad (i=1,2\ldots d)$$

$$②\ Total\_value \geqslant \beta \times \sum_{1 \leqslant i \leqslant t} \mathrm{value}(i)$$

$$③\ S = (Total\_value + \sum_{1 \leqslant i \leqslant t} \mathrm{Self\_value\ (i)}) - (\theta \times aver \times \mathrm{d}) \times \mathrm{k}$$

$$S > min \times d$$

Figure 5. Formula 4

d means d people choose to betrayal.

Each time after t, according to relation factor, welfare center adjusts the tax rate and the lowest guarantee value. Society's total wealth and welfare.

5. MODEL ANALYSIS

Network system was closed, in a closed system, Figure 6 show the interaction relationship:

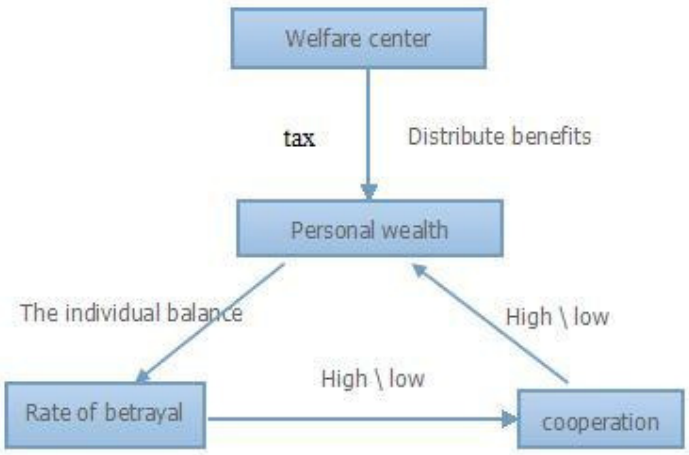

Figure 6 Relational model

(1)Balance of personal payments determines the betrayal, if the estimated income is lower than spending, the treachery must happened in the individual cooperation, and use the betrayal income to make up the difference between income and expenditure. If the estimated income is higher than spending, There is little possibility of individual betrayal.

(2)Betrayal can affect the cooperation of the result, When higher rate of betrayal of the whole system, all the individuals will worry about the partner's betrayal, and they select to reduce the cooperation or don't cooperate with others to avoid risk. On the contrary, if the times of the betrayal is less, less individual in cooperating with other individuals would be worried about the betrayal of partners and the possibility of cooperation will rise.

(3)Presence of ontogenesis of treason in the cooperation, cooperation success or failure will directly affect the individuals involved in cooperation of balance of payments. Failure and partner of betrayal will reduce other individual income, which can let the part of individual income lower than spending.

The above three relations influence each other and restrict each other. When one of them change and make the balance of the whole system destroyed, the other two relations will change accordingly with interdependent function. But the system will balance again, which is the ability of self-regulation. In a word ,the whole system vary like like is the cosine function and float up or down on both sides of the line of balance. But depend on the adjustment ability by the system itself, the amplitude of fluctuation is larger. Through the study we found that the system of all individual can achieve the balance of payments as soon as possible by dynamically adjusting the influence factors of welfare center, which is the welfare system. In this way, it can quickly close to the line of balance and make fluctuation amplitude decreases. So reasonable

welfare system can make the system to stabilize as soon as possible, keeping society stable state. If the welfare system is not reasonable or too light, it may have not good effect. If the welfare of the welfare center is too much, it may be effective in a short time. But can cause negative effects after some time, and make a lot of individuals depend on the welfare system and not participate in cooperation, which make the welfare system's pressure too large, and its benefits decrease. At this time, the rate of betrayal will rebound again. Figure 7 shows the relationship between them.

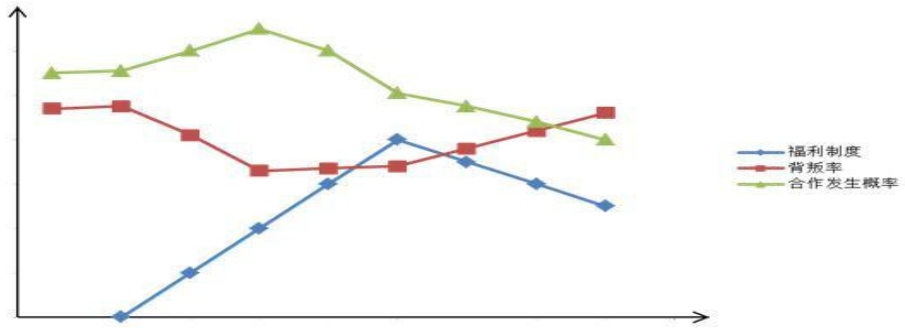

Figure 7 The influence of the relationship between factors

In this picture we can see that there is no influence of the welfare system in the first stage, and the betrayal rate of the system and the possibility of cooperation in near the equilibrium value. The welfare system join in in the second stage. The betray in the cooperation will reduce affected by the welfare system. Because of the reduce of the betray, the possibility of the cooperation may get higher. In the third stage, although the welfare system continues to increase, the rate of the betrayal reach a steady state instead of continuing to decline, the possibility of cooperation began to fall slowly. This is due to the influence of betrayal rate in cooperation reduced or even disappear, but the good welfare system make some individuals give up to participate in the cooperation and depend on the welfare system. In the fourth stage, because of the magnitude of the welfare system to achieve perfection and more people depend on the welfare system, the welfare system was forced to cut, which can cause betrayal rate rebound and the possibility of the cooperation will continue to decline. So a good welfare system can make the system to achieve balance as soon as possible, and make the system stable relatively.

6. CONCLUSIONS

Welfare system can affect the speed to the balance and the amplitude of fluctuations of the whole. Reasonable welfare system can make the overall balance quickly, reduce the amplitude of fluctuations, and contributes to the development of the whole. On the contrary, if the welfare system is not reasonable, it will lead to the change among the cooperation in the system larger or smaller impact on the system.

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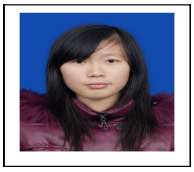

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INVENTIVE CUBIC SYMMETRIC ENCRYPTION SYSTEM FOR MULTIMEDIA

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ABSTRACT

Cryptography is a security technique that must be applied in both communication sides to protect the data during its transmission through the network from all kinds of attack. On the sender side, the original data will be changed into different symbols or shapes by using a known key; this is called encryption. On the other communication side, the decryption process will be done and the data will be returned to its former shape by using the agreed key. The importance of cryptography is to fulfil the communication security requirements. Real time applications (RTA) are vulnerable for the moment because of their big size. However, some of the current algorithms are not really appropriate for use with these kinds of information. In this paper, a novel symmetric block cipher cryptography algorithm has been illustrated and discussed. The system uses an 8x8x8 cube, and each cell contains a pair of binary inputs. The cube can provide a huge number of combinations that can produce a very strong algorithm and a long key size. Due to the lightweight and fast technique used in this idea, it is expected to be extremely rapid compared to the majority of current algorithms, such as DES and AES.

KEYWORDS

Home of keys, Shared secret key, Encryption key, symmetric, block size.

1. INTRODUCTION

Voice, video, images, and text are examples of real time applications that need to be transmitted quickly with a high level of security. Nowadays, there are many applications that provide real time services, such as Skype and Tango. On the other hand, there are many suggested algorithms that can be used to protect these applications and to guarantee that unauthorized persons cannot access these services. Cryptography is one of the important techniques used to protect the data during its transmit from sender to receiver by changing the situation of the message into another shape. This process can be done in right way if both the communication sides know the key used to encrypt/decrypt the message. DES, AES and Blowfish are examples of algorithms that deal with the symmetric technique that is used to protect real time applications. Some of these, like DES, are no longer used, and some of them will be broken in the coming years. Therefore, an alternative algorithm must be implemented with a guarantee that it will fulfil all security require ments, such as integrity, confidentiality, authentication, and non-repudiation [1]

There are two different types of cryptography: symmetric and asymmetric techniques. In this paper, symmetric cryptography will be used. Symmetric key encryption, commonly called secret or

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conventional encryption, refers to the type of encryption where the keys of encryption and decryption have the same values. Also, a symmetric key can contain a stream cipher and a block cipher; the block cipher will be used here. The concept of a block cipher is to divide the text into fairly bulky blocks, for instance, 128 bits, then encode every block individually[2][3].

The act of cracking or breaking a cipher involves extracting the plain text from the cipher text with no knowledge of the key and frequently with no encryption algorithm information. The strength of a cipher is evaluated according to the time required to break it, with the emphasis on the length of time it takes to break the cipher rather than whether it is possible to break it as, probably, all recognized ciphers except for some very few protocols, may be easily cracked or broken[6].

Strong ciphers are those that require an extended period of time to be broken; however, they are also likely to be more complicated and hard to apply. In contrast, weak ciphers tend to be broken quickly; nevertheless, they are generally quite simple and uncomplicated to use. Furthermore, it is important to take into consideration the fact that any cipher's use has some operating expenses concerning time and processing demands[6][7].

In recent years, a cube has been used to create some algorithms that can be used to encrypt a specific type of data (i.e. images). The main idea was to use the cube as a message container. Consequently, in this paper, an 8*8*8 cube is used to generate the key that will be used to encrypt the message.

2. LITERATURE REVIEW

The Rubik's cube was created in 1974 for entertainment purposes. In 1992, the cube was used in cryptography by writing and jumbling the message on the cube. It was very new technique in cryptography and it has given rise to further new suggested techniques[13].

As mentioned previously, recently, many cryptography solutions have been implemented that use a cube, and many of these algorithms were created for a specific type of data, that is, images. The majority of techniques wrote the messages on the cube and then scrambled the plain text to get the cipher text. However, the original message in this case can be obtained by anyone who can solve the cube if the arrangement faces of the cube are known. Another disadvantage is that writing the message on the cube will help to get the plain text by linguistic analysis. This can be done by looking for the most frequently used letter, which in the English language is 'E' as it is repeated around 12% [13][14].

A paper titled A Secure Image Encryption Algorithm based on Rubik's Principle [15] suggests two secret keys that are generated randomly and that take the same number of rows and columns (M x N) as the plain text image. The technique uses the concept of a Rubik's cube to shuffle the pixels and then the keys will be generated by applying the bitwise XoR operation into odd and then even rows and columns respectively, which encrypts the image. The main advantages of it are the extreme speed and the fact that two kinds of keys are used. On the other hand, it is easy to break because of the simple implementation. Another paper, namely, New Approach and Additional Security to Existing Cryptography Using Cubical Combinatorics [16], has a shared key that is generated from many aspects: arrangement of letters on cube slides, arrangement of faces, arrangement of colours, steps needed to reach a solved cube, and cube angle which is then exchanged using another existing technique. This algorithm is written with the original message on the cube faces. The Rubik's cube shuffles them randomly. After scrambling the cube, any known algorithm will be applied; the authors used SHA-1 Hash. The benefits of this algorithm are that it can be used to encrypt text and may be applied to other types of data, it is fast, and it can be combined with other current and tested algorithms. However, the SHA-1 algorithm used in this technique is no longer in use. Moreover, the technique that was used to generate the key is easy to

guess and break. The message is written on the face, and the plain text may obtained by anybody who knows how to solve the cube, especially with the 2*2*2 cube used in their experiment.

2.1 Advanced Encryption Standard (AES):

The AES based on the block cipher symmetric encryption technique was created in 2001 and is used by the US government as a standard. AES is considered secure and fast so most applications use it. Its block data size is 128-bits, and it has three different key sizes: 128, 192 and 256 bits. These different keys are generated by different numbers of rounds, that is, 10, 12 and 16 respectively[6].

3. THE SUGGESTED ALGORITHM

The suggested algorithm is symmetric block cipher cryptography that is more suitable for use with multimedia compared to the asymmetric technique because it is faster. The strongest feature of the suggested algorithm is not the key size, although it is long, but rather is the very complex technique used to generate the key. The possible combinations in this project are divided into two huge numbers. One is related to the cube itself and the other one is the key length. The suggested algorithm uses the cube to generate the key in a specific way that is completely different from the other current algorithms. Cube 8*8*8 has a 3.6×10^{217} possible number of permutations. Moreover, the number of bits in each single cell can be 1, 2, 4 and 8 bits. 2-bits will be used in this paper and can be represented as follows:

$$M: ([1;8] \cap \mathcal{N})^3 \rightarrow \{0,1\}^2.$$

The key will not be exchanged. The secret shared key will be exchanged instead. The master cube $8 \times 8 \times 8$ is a three-dimensional object limited by six square faces or sides (front, back, up, down, right, and left faces).

In this paper, each face consists of 128 bits, and the cube's centre facets contains of four faces with a total of 512 bits. The whole cube has 384 cells, and each cell has 2-bits so the maximum key length considered here is 768 or 1024 bits. The method used to mix up the home keys contains complex rounds that will be used to create the E_K. Actually, the rounds are divided into two groups, and the total number of rounds is 10. The first group states the first four rounds which are achieved by shifting the odd rows/columns by even numbers and vice versa. The second group carries out the remaining rounds by XoR-ing each pair of faces, and stores the result in a different face. Using fewer rounds means spending less time so all or some of the rounds can be applied.
The method of reading the cube means it is very important to specify the key length. Here, two different ways are considered. The first method uses a face by face process as a key, starting with 128-bits for the first face and ending with 768-bits. The second reading mechanism of the cube to obtain the 1024 bits is to read the cube's centre facets in horizontal and vertical directions. Each face's cells can be shifted in 12 different directions as follows:

No.	Direction	Name
1	→	Rightwards
2	←	Leftwards
3	↑	Upwards
4	↓	Downwards
5	↗	North East
6	↙	South West
7	↖	North West
8	↘	South East
9	↴	Right Down (apply in the same face)
10	↱	Right Up (apply in the same face)
11	↳	Left Down (apply in the same face)
12	↰	Left Up (apply in the same face)

Table 1: cube movement directions

Encryption Algorithm:

Encryption Algorithm: secret shared key to mix-up the key's home and apply the selected rounds.

Require 1: X is a selected block size and could be any values between 128 and 1024 bits.

Require 2: Shared Secret Key (SSK) to mix-up the key's home. $SSK = \{n \in Z\hat{} + \mid 1 \leq n \leq 7\}$.

Require 3: Pre-define place to hide the SSK.

1. Select the plain text (PT) size, which must be equal to the key length (K).
2. Agree shared secret key (SSK).
3. The keys' home cube will be jumbled up by the SSK and applied to the selected rounds (R).
4. The result of point 3 above will be the key (EK).
5. The generated key will be XoR-ed with the plain text. EK: $K \oplus P + R \rightarrow CT$
6. The result of (5) operation will be the ciphered text: CT
7. Then, the shared secret key in point 2 above will be injected into the ciphered text in a pre-known place: $C + SSK$
8. The result of 7 will be sent to the receiver: $CT + SSK \rightarrow Receiver$.

The figure below illustrates the algorithm.

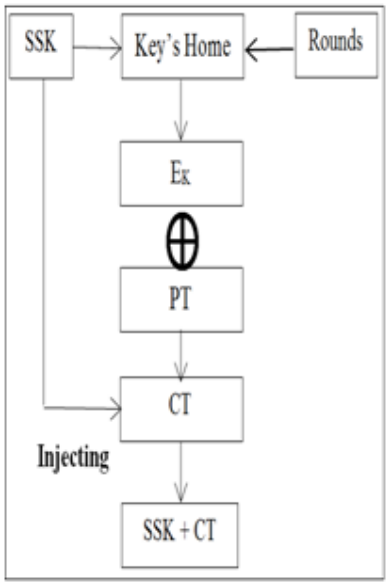

Figure 1: Encryption process.

Decryption Algorithm:

Decryption algorithm:

Require 1: Pre-defined place to hide the SSK

The decryption process will be done in the receiver side as the following steps:

1. The receiver will receive $CT + SSK$.
2. Then, the receiver will extract the SSK that has been hidden in a pre-defined place. As a result, the receiver will separate the SSK from CT.
3. The SSK that is obtained from the previous point will be used to shuffle the home of the keys.
4. The K will be produced.
5. $K \oplus C \rightarrow PT$

The figure shows the decryption process.

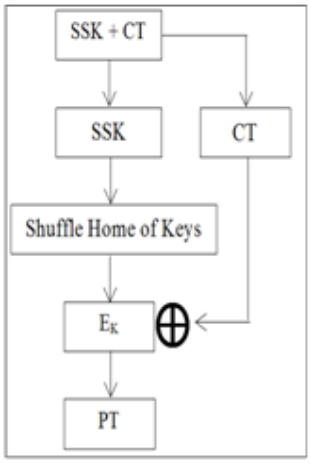

Figure 2: Decryption process.

4. RESULT AND EVALUATION

Using Java, the suggested algorithm has been tested in two different packet /key sizes of 128 and 512-bits. The tested file size is 10,000 bits. Only the first group of rounds has been applied, and the result was as follows:

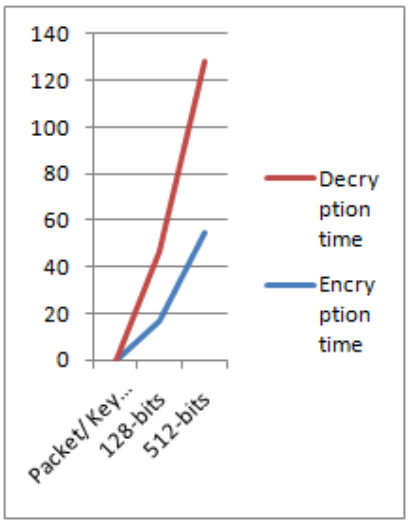

Figure 1: The experiment result

From the above result, it is clear that the time needed to encrypt and decrypt the files in the suggested algorithm referred to as ITU-T in its G114 recommendations was very reasonable. Moreover, it takes around a third of the time needed by AES to encrypt the files.

5. CONCLUSION

In this paper, a novel cubic symmetric block cipher technique is discussed. The greatest advantages of this technique are the length of the key, the technique used to generate the key, and that the suggested algorithm and tools are very lightweight and so are inexpensive. Moreover, the algorithm can be used with all different kinds of data because it will not cause any specific delay. Two keys are used to produce this strong algorithm. The first one is a shared key that will be used to scramble the home keys to get the key that will be XoR-ed with the plain text. Compared to the AES, less time is required to encrypt and decrypt the tested message. However, the delay will be affected by the number of rounds that will be used to generate the key so it is highly recommended that fewer rounds be used.

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SVHSIEVS FOR NAVIGATION IN VIRTUAL URBAN ENVIRONMENT

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ABSTRACT

Many virtual reality applications, such as training, urban design or gaming are based on a rich semantic description of the environment. This paper describes a new representation of semantic virtual worlds. Our model, called SVHsIEVs[1] should provide a consistent representation of the following aspects: the simulated environment, its structure, and the knowledge items using ontology, interactions and tasks that virtual humans can perform in the environment. Our first main contribution is to show the influence of semantic virtual objects on the environment. Our second main contribution is to use these semantic informations to manage he tasks of each virtual object. We propose to define each task by a set of attributes and relationships, which determines the links between attributes in tasks, and links between other tasks. The architecture has been successfully tested in 3D dynamic environments for navigation in virtual urban environments.

KEYWORDS

Virtual environments, semantic modeling, ontology, Virtual Human

1. INTRODUCTION

Nowadays, many applications use virtual environments in different contexts such as medicine [1], virtual heritage [2], education [3], Geographical Information Systems [4], scientific research [5], and WorldWide Web [6]. Current virtual environment representations describe models of environments so that browsers can effectively visualize their geometry and can support low-level interactivity in most of cases [7][8][9]. There is a gap between the low-level representation of the universe and how we conceptualize (and therefore how we think and talk about this universe). Thus, a high-level model's representation (including semantic descriptions of objects in the environment) is desirable in order to support user interactions which are richer in a more abstract level (querying for contents) and reasoning of deployed agents on the environments they inhabit.

[1]Semantic Virtual Humans In Virtual Environments

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We believe that the semantic information in virtual worlds should be considered as a component of the universe. Therefore, the construction of virtual environments should contain semantic annotations about the environment [7][10]. Modeling techniques are rooted in semantic information systems, namely databases, geographic information systems, etc. Data representation is a critical issue for these systems. Traditional approaches simply focus on techniques that support efficient storage and retrieval of data. Otherwise, semantic modeling makes the data meaningful, and therefore machine-readable [11]. The Semantic Web is a good example of what semantic modeling can provideby inserting machine-readable metadata, it allows the information stored in meaning web pages to be processed by algorithms and researches based on their content [6].

The role of the semantic modeling of virtual environments (VEs) is to provide an abstract, high-level and semantic description of different aspects of a VE: structure of the virtual environment, behaviors and interactions of entities, domain knowledge, etc.[8,9]. A main motivation for adding a semantic model is to ease the design of intelligent VEs. This intelligence of VEs mixed with artificial agents and users can be defined as the capacity of artificial agents to exhibit human-like behaviors and to be capable to assist users to solve a specific problem [12].

Ontologies have been used in virtual worlds as a relevant formalism to provide a conceptual representation of scene contents. The main idea has been a direct mapping between graphical contents and ontologies [8,11]. The concepts in an ontology can be the exact copy of the specific graphical resources, butthis leads to several inconveniences. First, ontologies are not able to represent entities with no graphical representation in VEs. Second, it is not possible to share common properties among a family of graphical resources. For instance, movable objects have some properties in common in comparison with unmovable objects.

In short, our model proposes that each virtual object in a particular virtual environment is geometrically considered as its minimum bounding-box, and corresponds to a particular type of object in a specific ontology. In addition, this model also establishes relationships between elements in the VE. This model (called SVHsIEVs) uses virtual humans in VE. Each virtual human uses both two techniques. The first technique: Guidelines, ensures coherence and sequence of tasks. The second technique: Querying ensures the communications between agents and ontology.

In the next section, we briefly review related works. A detail description of the proposed semantic modeling is given in section 3. Section 4 describes the definition and the role the ontology in VEs. The architecture of the proposed environment is illustrated in section 5. Section 6 concludes the paper and outlines some future works.

2. RELATED WORKS

Semantic modelling techniques are rooted in Information Systems, namely Databases, Geographical Information Systems, and World Wide Web. Data representation is a crucial issue for these systems. Traditional approaches merely focus on techniques that promote efficient storage and data retrieval. On the contrary, semantic modeling aims to make data meaningful and consequently compatible with machine-process able. The semantic web is a good example of what semantic modelling can provide. By inserting machine-readable metadata, it allows the meaningless information stored on web pages to be processed by algorithms, which perform researches based on their content.

This section describes several approaches and concrete works concerning the addition of a semantic level to a virtual world, and designing of VE along with the semantic model. The

metadata are added in the model as the objects are created. This technique has been used either for content-oriented and system-oriented approaches, building the VE based on a pre-existent semantic level. The main idea of this technique is to get benefits from an existing semantic model. For instance, one can use an existing Geographical Information System to build virtual urban environments, adding semantic annotations to the pre-existent VE[10]. The semantic annotations can be multimedia resources, such as texts, images, sounds, and Web links. In this case, the added information makes sense only for the user, but isnot semantically interpreted by the system.

Cavazza & Ian [14] present technical problem in the implementation of intelligent virtual worlds, theydeal with the need to find a knowledge representation layer. They recognize that in some virtual world applications there is a need for the simultaneous access to concrete and abstract information. These intelligent virtual worlds, based on theproposed common representation layer, offer advantages regarding adaptability and reusability.

Thalmann et al [15] present an informed environment that creates a database dedicated to urban life simulation. They introduce a method for building virtual scenes with semantic information for the exploitation of such scenes. The three-dimensional scene provided by the designer is divided into two parts, one for visualization and another for database construction. The database contains geometrical and semantic information for mobile entity simulation.

Doyle [10] introduces the concept of the annotated environment, so the structured representation of their content and their objectives are available to any agent in the environment. This description of an agent architecture gives the possibility to interact with an annotated virtual environment, with a structure for representing information in these environments.

Badawi& Donikian [16] describe the STARFISH (synoptic objects for tracking actions received from interactive surfaces and humanoids) architecture that uses synoptic objects to allow real-time object manipulation by autonomous agents in a virtual environment. A set of actions is defined. Then these actions are assigned to interactive surfaces that definethe geometry of an object and that are concerned by the action. The agent then uses these interactive surfaces to get the data specific to the object when it wants to manipulate it and to adapt its behavior accordingly.

The current trend is the use of ontologies to model the semantic information of virtual environments. Vanacken et al [17] introduce the use of semantic information, represented using ontologies, in conceptual modelling of interaction invirtual environments.

This semantic information itself is created during the design of the virtual world. More concretely, semantics is incorporated in NiMMiT (Notation for MultiModal interaction Techniques) [18], a diagram based notation intended to describe multimodal interaction. Some works have proposed complete architectures that include a semantic layer, which is the interface between the agents and the world. This layer usually models the world through a semantic representation defined according to a set of ontologies. Chang et al [19] present a framework that allows separating the agent mind from the environment. An ontology-based cognitive middle layer between agent minds and the environment manages semantic concepts. Ontologies are mapped onto the environment, through which characters understand the world as instances of interconnected concepts rather than numerical values, allowing them to infer the relation between objects. This layer also represents actions through causal rules whose effect is turning the target object into an instance of another concept.

With Grimaldo et al [20], an approach that uses ontologies as a basis to animate virtual environments inhabited by intelligent virtual agents is presented. The proposed architecture is a multi-agent framework, which can be divided into several parts: ontologies that define the world knowledge base; a semantic layer which is the interface between the agent and the world; planning based agents that receive sensorial information from the semantic layer and calculate the appropriate sequence of actions in order to achieve their goals; and a 3D Engine that extracts graphical information from the object database and performs visualization.

The ontology is consideredas a means for social relations between agents within an artificial society. These relations must be used into account in order to display socially acceptable decisions [21].

This approach has been used to simulate the virtual bar of a university, where groups of waiters and customers interact with both the objects in the scene and the other virtual agents finally displaying complex social behaviors [22].

Ibânêz et al [23] think that application approaches are necessary, and they are different from one another in nature. Thus, the model they proposed is situated at a lower level than approaches, which depend of applications. Their model does not intend to substitute to application dependent approaches, but to constitute a common lower level for all of them. The authors'intention was to create a useful model, that is, a model actually employed by the world creators. Thus, their principle was that it should not require a great annotation effort from the environment creators. As a result, the model consists of a reduced number of different features, and the majority of them can be automatically annotated.

Tutenel et al [24] introduced the Semantic Class Library to design semantic VEs, notably 3D games. After creating a 3D model, the designer associates the elements of the 3D model to existing classes in the library. Otherwise, the designer can create a new class with the desired properties. Beyond the 3D representations of objects within the game world, the Semantic Class Library provides additional semantics to the objects, such as physical attributes (e.g., the mass or material), functional information (e.g., how one can interact with an object).

3. VIRTUAL HUMAN

Lot of research has been done on behavioral animation of virtual agents over the last few years – see [25] for a good introduction to the field. The pioneer work of [26] showed how to design a framework to animate natural ecosystems. He simulated artificial fishes in the natural complexity of virtual underwater worlds. However, human behavior is clearly different and more complex to emulate. Possibly, the more relevant works in this field came from Thalmann's group [15]. The goal of these previous works was to design agents with a high degree of autonomy without losing control. Their agents are an extension of the BDI architecture described in [27], and they include internal states as emotions, reliability, trust and others. BDI-based agents have been also used in games such as Epic Game's Unreal [28].

Some research has been done about the questions of credibility of groups of synthetic characters, usually centered on the interactions either among a human user and a virtual character [29] or between virtual characters [30]

Creating Virtual Humans is a complex task, which involves several Computer Science domains: Geometric Modeling, Computer Graphics, Artificial Intelligence, and Multimodal Interfaces [31]. In his works, Gutierrez proposed a semantics-based approach in order toorganize the different kindsof data that constitute a Virtual Human.

The knowledge defined by the synthesis, functionalities and animation of VHs is formally specified by the way of ontology. This approach is similar to our purpose in the section 4.2.

4. ONTOLOGY IN VIRTUAL ENVIRONMENT

Virtual Humans are virtual entities with a rich set of functionalities and potential, present in a VE. One of the main instruments used to lay-down the foundations of a knowledge-based system are ontologies. Ontology defines a common vocabulary for domain-users (researchers or experts in a particular area) who need to share information in a particular domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among them. The semantics-based representation can be enhanced by means of knowledge-management techniques and tools. One of the main tools used to lay-down the foundations of a knowledge-based system is therefore an ontology. A first one focuses on the adaptive multimodal interfaces system and a second one formalizes the knowledge related to the creation of virtual humans and serves as a basis for a general ontology for Virtual Environments [32]. Many consider W3C'sWeb Ontology Language (OWL) the prospective standard for creating ontologies on the Semantic Web.

OWL has three species: OWL Lite, OWL DL and OWL Full, in ascending order according to expressiveness. We can divide the use of ontologies in thedomain of Virtual Environments into three uses; the first use: Ontologies in the context of Virtual Environments [33,34], the second use : Ontology for interactive Virtual Environments[35,36], the third use: Ontology for Virtual Humans [31,37].

5. OUR FRAMEWORK (SVHSIEVS)

In the framework SVHsIEVs, we attempt to apply the influence of the integration semantic layer in virtual worlds. This semantic layer is distributed according to two levels. The first level is global, in this level we can define semantic information on a more global way. The second level concerns the virtual objects; in this level, objects need to transcend the geometry concepts and more abstract information need to be incorporated into the object's description. Many properties of real-world objects should be represented in their virtual counterparts to allow an algorithm to perform some kind of reasoning on objects (e.g., the physical attributes define whether or not the object is too heavy to carry, or the functional information is necessary to decide if an AI character can use the object to reach a goal).

In our proposal semantic information use the ontology to describe the concepts used in the domain along with their properties and relations between them, in each two levels.

Our first contribution is to show the influence of adding semantic information (contextual attributes and relationships between concepts) to virtual objects and with the aim to use this information to define and redefine interaction with environment.

Our second contribution concerns the use in our modelofVirtual Humans two technics: Querying and Guidelines.

Our third contribution concerns the use of this semantic information in management of tasks for each virtual object; we propose to define each task by more attributes and set of relationships, this relationships determine on one side the links between the attributes in a task and on the other side they determine the relations between tasks.

As discussed earlier in this paper, the proposed framework is based on the integration of semantics information in virtual environment, and we show this integration in different layer.

Also, for each objet in the environment composed of two aspects: geometry and semantic, the aspect semantic is based on contextual information only but using the relationship between different concepts, these concepts are present information's semantics of different objects in virtual environment.

In this paper we present a Semantic Virtual Environment approach that uses ontologies as an appropriate basis to animate virtual environments inhabited by intelligent virtual Humans. Figure 1 show the architecture of our multi-agent framework, which can be divided into several parts:

Ontologies define the world knowledge base as well as the set of all possible relations among the agents and virtual humans. We distinguish two levels of representation: the SVE Core Ontology is a unique base ontology suitable for all virtual environments which can be extended by different Domain Specific Ontologies in order to model application-specific knowledge. Then, environments can be constructed by instantiating the classes of these ontologies. For example, in section Implementation we will create pedestrians a virtual city with a large number of objects – cars, crossroads, etc.

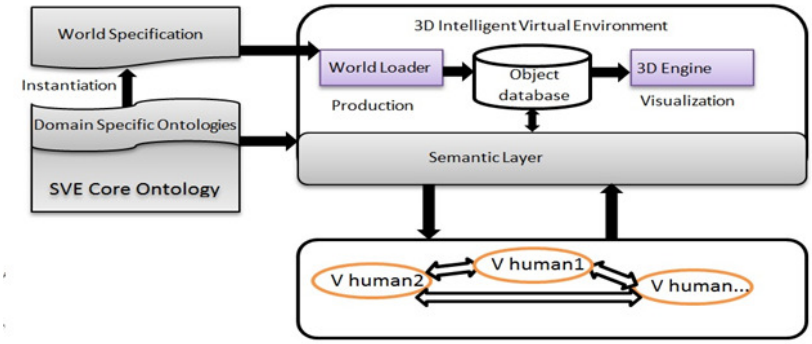

Figure 1. SVHsIEVs architecture

The Semantic Layer is the interface between the virtual human and the world. It uses the ontology so as to reduce the information flow; this layer is in charge of executing the actions requested by the agents as well as maintaining their semantic effects.

In the structure of Virtual Human we find the combination between three aspects: Virtual human intelligent (VHI), Querying and Guidelines. The VHI insures the intelligent interaction with world and the others VHI and the querying insures communication (asks and answers) with the world. The Guidelines insures the planning of different tasks.

5.1 Ontology of virtual environment

The goal of ontology design for virtual environment in this architecture is two parts. First, we would like to keep the information that exists in the virtual environment such as object geometry and transformation. Second, we use semantic information about the virtual objects can facilitate the computation of advanced reasoning procedures such as a navigation in the world.

Our ontology design of the virtual environment is shown in Figure 2. The root of the ontology is the environment node, which contains world information (environment) and all the virtual objects (object) in the environment. In order to retain the semantic information of the virtual objects, we have designed the base Info and Transform nodes; in this node we show sub-information as position and rotation. Each object also has some additional attributes such as name, weight, height and tag. All this attributes are designed for public properties for virtual objects. For example, the

urban environment, one can tag certain objects as s pedestrian area and car area such that these regions can be treated appropriately by the urban environment according to their meanings in the world. Each object in environment as (building, car and Column lights…) may also have the attribute of Approximation 3D, which is a polygon that can be used to define 3D approximation of obstacles in the environment for the navigation.

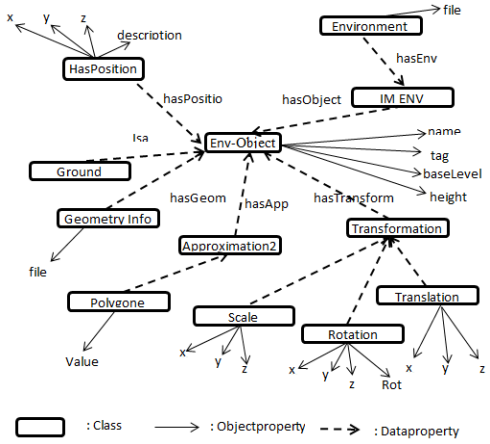

Figure 2. Ontology design for virtual environment

5.2. VHs architecture

The Virtual Human is based on three aspects; Virtual human intelligent (VHI), Querying and Guidelines. The VHI gives the intelligent interaction with world and other VHI and the querying gives asks and reception the answers with world. The Guidelines gives the pacification of different tasks.

The module gives the aspect querying, it is a communication module, and in this module we show two types of communication: the first protocol with other Virtual Human by message for example demand the service or information, the second protocol with environment by the queries. The answer of these queries is divided into two cases according to natural answer; if the answer is a static information like position or direction by example, in this case, the answer is simple processing; we take the query and search in the ontology of data information without treatment. In second case, we use different modules as reasoning module and ontology.

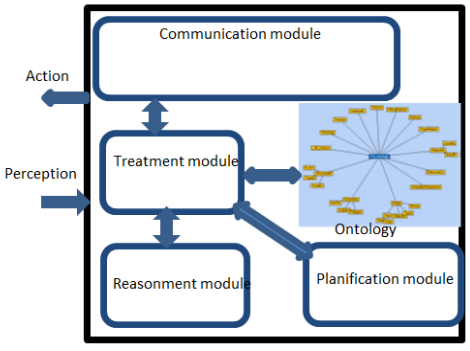

Figure 3. A Virtual Human architecture

We show the aspect of guidelines in planning module, this module is ensuring the planning of different tasks; in this part we using ontology for giving all information's of each task, because

each information, it is influence in the order between tasks. For example we have four tasks T1, T2, T3 T4, with the following planning.

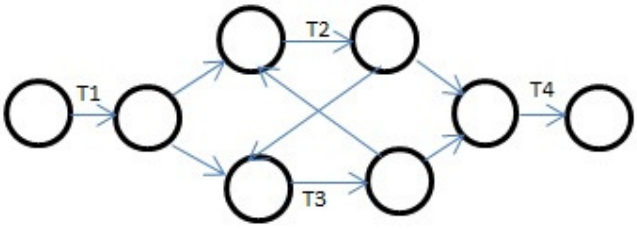

Figure 4. The sequence of tasks

We note that T2 and T3 are independent; in this case the order is not important. By adding more information as the nature task such as the time attribute for example, this task is joined with time or not; T2 is the task “buy in the store” and T3 is the task “buy in internet”; therefore, we run T2 before T3 because T2 depends on the opening of the store.

The reasoning module it is means of present the intelligent, this module likes with all reasoning tasks for each virtual human; we show the experience or information’s of finding the path between two points in the network of points after the Transformation the points network for VE into form « case base ».(as shown in Figure 5)

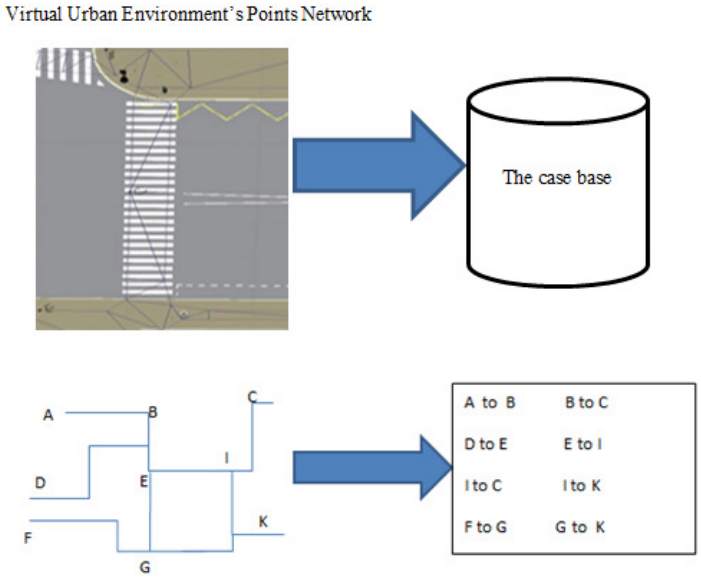

Figure 5. Transformation the points network for VE into form « case base »

The path between two points is the sequence of sub-paths, result of the induction algorithm on the case base.

In other case; if VH cannot get the solutions, because these information do not exist in his ontology, it sends the query to environment or other VH to get this information. This asks is assumed by the querying module. According to the following figure:

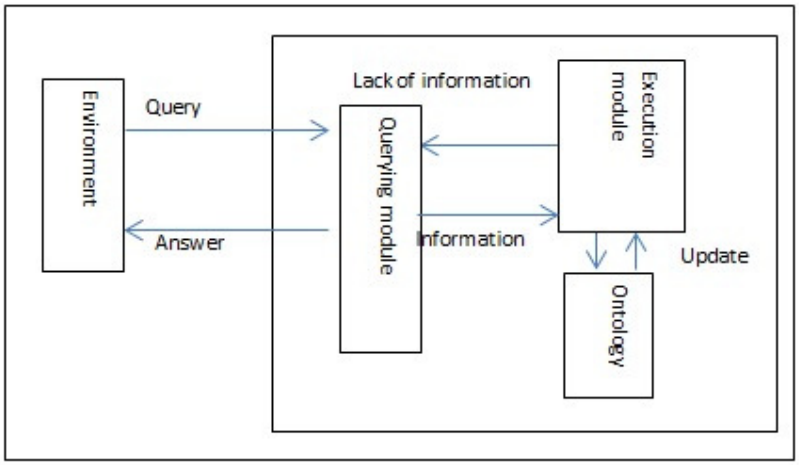

Figure 6. The internal handling of requests to VHs

5.3. Ontology design for Virtual Human

In our architecture, a VH has ontology, in this ontology we describe the basic ontology classes and attributes (as shown in Figure 7) that we have designed for the applications of the VH navigations. Although a VH is also an object in a virtual environment, they have more active and complicated roles to play. For example, a user in Anthropometry Description set attributes as Height, Wight, Age, Gender, Speed and Acuity. A VH may contain some basic attributes such as name, Transform, and status. We also take the Tired and stress for present the influence of these properties in speed and acuity of VH.

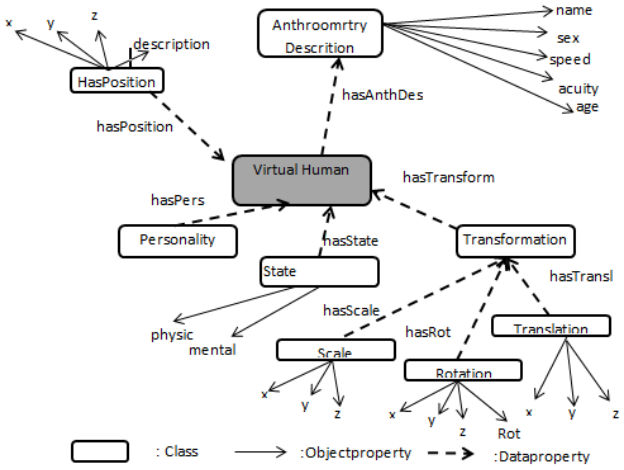

Figure 7. Ontology design for VH

5.4 Implementation and results

We have implemented our model in Unity3D; developed in C#. We built our ontologies using the Protégé and Jena for update. Access to the ontology is obtained by sending SPARQL queries. In this section, we will give two examples of using semantic information in the virtual world to enhance the functions and behaviors of the VH.

We distinguish that the navigation of a VH in virtual urban environment is based on more tasks, among these tasks are collision detection; avoidance of collisions and search of goals. In the two first tasks, we use the two attributes speed and acuity, dynamically changing, because they are in relation with other attributes (tired, stress, age, etc.).

In figures 8, we show the influence of age on speed and acuity. We distinguish three phases: the first phase increases the speed and acuity when the age increases. The second phase is almost stability of speed and acuity between 20 and 40 years. The last phase, after 40, decreases the two parameters.

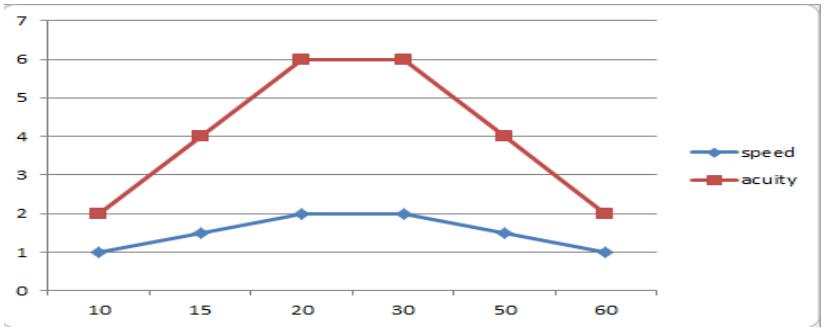

Figure 8. The influence of age factor on speed and acuity

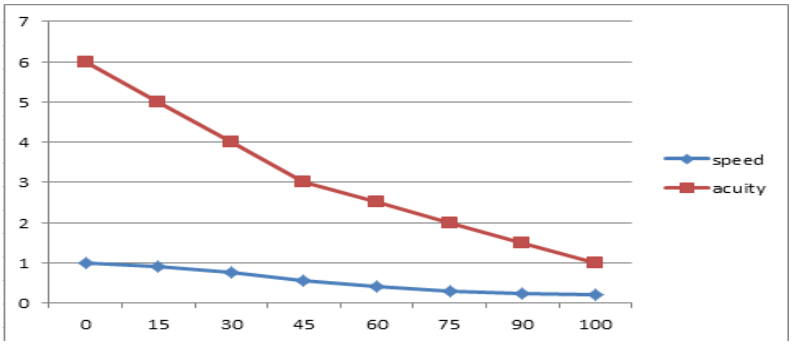

Figure 9. The influence of tiredness factor on speed and acuity

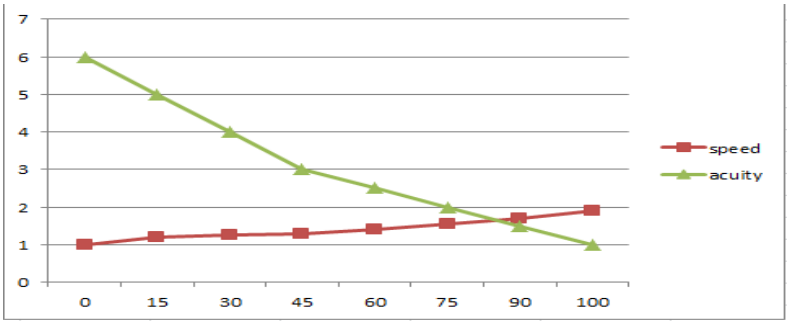

Figure 10. The influence of stress factor on speed and acuity

In figure 9, we add another factor, the tiredness to test the influence of this tiredness attribute on VH's speed and acuity. We show the inverse relationship between tiredness and speed; the speed and acuity decreases with increase of tiredness.

In figure 10, we add another factor, the stress to test the influence of this stress attribute on VH's speed and acuity. We show the inverse relationship between tiredness and acuity; the acuity decreases with the increase of stress, and the speed increases with the increase of stress.

In figure 11, we show a character called Zinab, she is a woman of 30 years old, 50% of stress and 50% of tiredness. With initial value of speed of 1 and acuity of 6, we show the stability of speed and the decrease of acuity (6 to 5.12), this decrease in acuity is the result of the influence of the stress factor. And the almost stability of speed; it is influenced due the two factors tiredness and stress.

Figure 11. The influence of tired and stress factor on speed and acuity

Each VH used the same steps to search the path but with their knowledge, these are found in ontology. In this task, there are three phases, the first phase is called localization; the input parameters of the phase is the position of the VH and the position of their goal. From this information and the positions of the points of the landmarks in the environment, the VH determines their position and the position of their goal by to graduations of environments. These graduations are saved in his ontology and all related information with other graduations such as graduations are neighbors, the distance between neighboring and between sub-paths graduations that you save a form as Figure 5.

The second step, which answers the question what kind of path I follow; (the usual path, the shortest path, the path is more popular, or compact), this choice is linked with several parameters such as physic state of VH, his personality, the overall goal is touristy, go to work or return to home). For example, we consider two VH, with identical physical state, identical positions and identical goal. In the first VH, the character is a tourist, in the second, the character goes to meet a friend. This last difference gives two different paths. The tourist chooses the most popular and security trajectory, unlike the second takes a more compact path

.

All factors are the result of influence several parameters. For example, the stress factor is the result of several elements, among these elements is the nature of the goal (important, necessary, compulsory ...). And all information related with objective, this relationship is direct or indirect; in the following example; we demonstrate the effects of new information arrives on stress factor. In our example two VH1 and VH2, VH2 event received at time = 3, giving an event of the influence of the stress factor, decreases the effect of the constraint value. This increase is the result of the relationship between the event and the goal of VH1. This relationship is defined in the ontology. The reverse with VH1 at time = 4 received another event that increases the value of the stress.

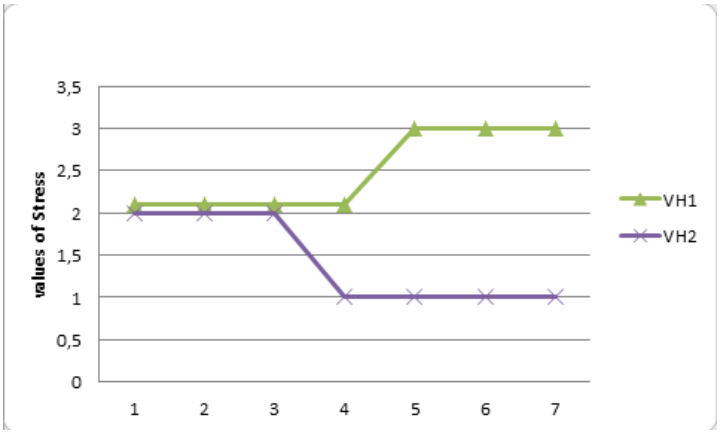

Figure 12. Evolution stress factor with time

6. CONCLUSION AND FUTURE WORKS

Using semantic information's is a key function for enabling richer contents and behaviors in the future development of virtual environment. The SVHsIEVshave presented a semantic-based framework for the virtual environment with Virtual Humans (VHs), our first parts integrated the VH in virtual environment with more semantic information, these information are helping of developing area of research that integrates computer graphics and artificial intelligence solutions. Our second parts to show the influence of adding semantic information (contextual attribute and relationships between their concepts) to virtual Human and using this influence for define and redefine his interaction with environment.

Throughout the paper, we showed the importance of semantics when modelling dynamic virtual environments. Furthermore, the VH extracted from the ontology allows the VHs to reuse their information in different contexts. We will add different animation components owned by different VHs to interact with each other, will integrate more semantic information for tasks and using these information in planning phase, will implementSVHsIEVswith other environment as theatre for example and using motions information's as mean of communication between VHs.

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Short Biography

Mezati Messaoud is a Ph student at University of Ouargla since 2009. He works in the LESIA Laboratory Biskra University. His current research interest is in artificial intelligence, artificial life, crowd simulation, behavioral animation and virtual characters.

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ON DIAGNOSIS OF LONGWALL SYSTEMS

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ABSTRACT

Nowadays we can observe the change of the structure of energy resources, which leads to the increasing fraction of a renewable energy sources. Traditional underground coal mining loses its significance in a total but there are countries, including Poland, which economy is still coal based. A decreasing coal resources imply an exploitation a becoming harder accessible coal beds what is connected with the increase of the safety of the operation. One of the most important technical factor of the safety of underground coal mining is the diagnostic state o a longwall powered roof support. It consists of dozen (or hundreds) of units working in a row. The diagnostic state of a powered roof supports depends on the diagnostic state of all units. This paper describes the possibility of unit diagnostic state analysis based on the biclustering methods.

KEYWORDS

Biclustering, Longwall Systems, Machine Diagnosis.

1. INTRODUCTION

In a coal mining industry – similarly as in the case of other industry branches – the growth of monitoring systems application. Initially, monitoring systems were designed just for the purpose of data acquisition and presentation. Over time, their abilities were extended in the direction of simple dangerous situations recognition and finally – to the advanced machine diagnostic status analysis and its prediction for the nearest future.

Longwall systems are the basis of the coal mining, because the longwall is the place in the process of mining from which we can say about the output. Mechanised longwall systems consist of longwall shearer (which tears off the output from the rock), longwall conveyor (transports the output from the longwall to the heading) and units of powered roof support (prop the roof after mining the output).

Longwall systems are very interesting objects from the collected data point of view. Its most important part is a power roof support. Its primary task is to protect the other elements of the longwall system, especially the coal shearer which is an essential part as of a coal mining process. Power roof support consists of units. In a particular moments of time – after shearer takes the another part of the longwall output – each unit has to move in the direction of the whole longwall face advance (treading), protecting the rock material, exposed by the shearer, from collapsing.
Unequal propping can be caused by leaks in the hydraulic system (pipes, valves) or leaks in legs of the unit. To long times of treading can point the wrong diagnostic state of the unit or be caused by the wrong usage (so called: moving with the contact of roof-bar with the roof). It is also dangerous to perform the treading too long as the roof is not propped. So it can be stated that the

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safety of coal mining is determined by the diagnostic state of all parts of the longwall mining system, including the diagnostic state of all units of power roof support.

In this article the ability of adaptation of biclustering method for the purpose of the analysis the data from longwall monitoring systems is presented. The paper is organized as follows: it starts from the brief description of monitoring systems with a special consideration of underground coal mining monitoring system is presented. Than the description of a construction, the role and a working cycle of a powered roof support is presented together with the proposed monitored (and extracted) parameters. Next part presents a wide group om continuous and binary data biclustering methods. The paper ends with a perspective of application of these methods in the longwall monitoring systems.

2. MONITORING SYSTEMS

Nowadays, software producers and monitoring systems users point the need of analysis of the data, collected in repositories of these systems. In particular, the definition of diagnostic models of monitored devices can be a goal of this analysis [1][10][19]. The process of a diagnostic model identification can be carried out by planned experiments or on the basis of a data from the past device operation.

The problem of a monitoring and diagnosing of a coal mine industry devices was raised recently in [1][6][8][16][17][19]. These topics are presented widely and review in [1][19]. In these works also new methods of extraction and processing of new diagnostic features in new diagnostic relations discovering are presented. Especially in [1] the diagnostic of conveyor belts is described. In [17] a current consumption and a temperature of roadheader cutting head. On the basis of these parameters three roadheader working states were defined. Two of them described different but correct underground mining conditions. In this paper also the parameter reflecting the roadheader cooling system efficiency was defined.

Longwall conveyors diagnostic was an aim of the following works [6][8][16][4][5][12]. In [6] the way of conveyor chute failures detection on the bottom side of a conveyor was presented. On the basis of the conveyor engines power consumption analysis the failure was detected with an accuracy to the one unit. In [8] the complex subassemblies management system was proposed, which allows to generate operational and analytical reports as well as summary statements.
In [16] the analysis of the motor driving the conveyor power consumption is described. As the result summary reports are presented and an association rules-based description of the motor operating parameters are described.

3. POWERED ROOF SUPPORT

The safety of underground coal mining depends on many of natural and technical factors, also including the human factor. From the technical factors the diagnostic state of powered roof support units must be acknowledged. It becomes more understandable when the construction and the working cycle of single unit is known. In this section the basics of the powered roof support unit structure and its working cycle description are presented.

3.1. Unit Structure

An unit consists of one or more hydraulic prop (legs), holding up an upper part of the unit (roof-bar). It also has and hydraulic shifting system that is responsible for shifting the unit with the

longwall advance simultaneously. The unit should prop the roof, assuring the safety of mining. From time to time – after the shearer passage – the unit must prop the newly bared roof.

Fig. 1 Single unit of powered roof support (www.joy.com).

3.1. Working cycle

A typical unit working cycle can be described from the moment of treading, when the pressure in the leg decreases. A 6000 second long leg pressure series is presented on the Fig. 2.

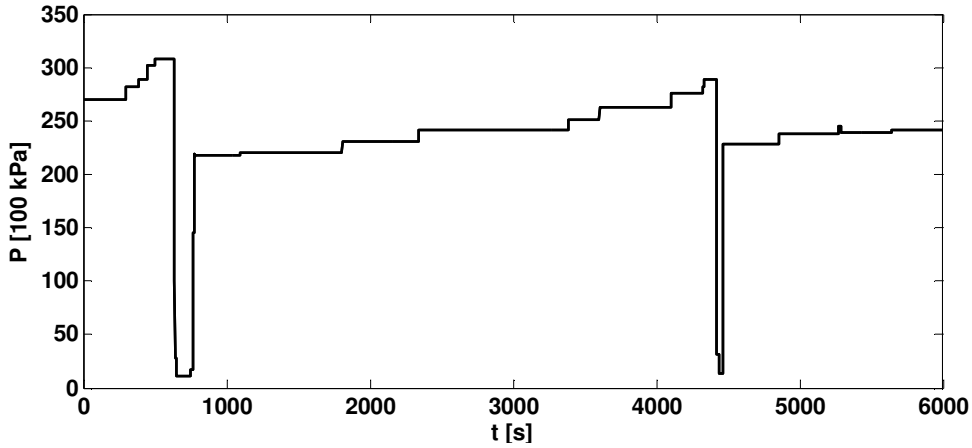

Fig. 2. A real time series of pressure in the unit leg.

It is typical to decrease the pressure as long as the roof-bar has the contact with the roof. This phase is very short – takes only several seconds – and is characterised by the rapid decrease of the pressure (light grey field between 635th and 648th second on the Fig. 3.). Then the phase of treading is performed (between 649th and 751st second on the Fig. 3.). It is characterised by the very low level of the pressure in the leg. Usually the time of treading should be constant as the wall web by shearer is also almost constant. But it happens that the duration of this phase increases with the malfunction of hydraulic system (the pressure in the leg remains on the low level) or due to the treading with the roof-bar touching the roof (treading with contact). The second situation is present with the rather high pressure in the leg (several or more times higher than in the treading without a contact). Next, the spragging – an initial, rather fast, pressure increase of the leg – is performed in order to assure the contact with the roof (dark grey field between 752nd and 772nd second on the Fig. 3.) and then as a result of roof work the slow increase of a pressure in the leg follows.

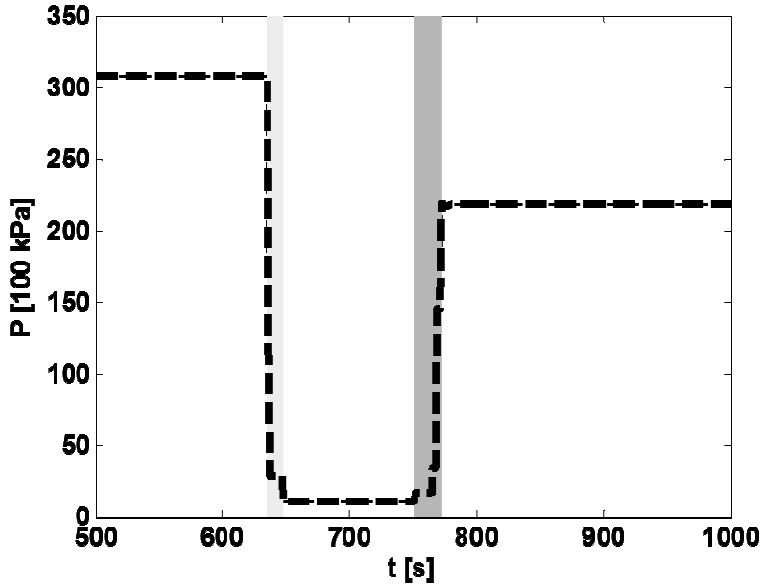

Fig.3. Phases of unit working cycle.

3. POWERED ROOF SUPPORT MONITORING

The most important element of powered roof support monitoring is the measuring legs pressures in each unit. This helps to determine the working cycle phase of unit. Following also the durations of all cycle phases can be calculated, including the treading time. For units equipped with more than one leg also the effective roof propping strength can be determined. Unequal roof-bar propping may have negative consequences influencing on the unit diagnostic state.

On the basis of measured pressures in all units in the longwall the detailed analysis of each unit work and even each leg in the unit work during the exploitation can be performed, including the following aspects:

- Durations of unit working cycle phases,
- Pressure statistics aggregated in time intervals (max, min, std)
- Inequality of propping (for units with two or more legs)
- Statistics of treads (durations, pressure level)

As all characteristics are time dependent (values are varying in the time) and all units can be treated as objects from the same population, every characteristic for the powered roof support can be present as the twodimensional matrix. A sample matrix is presented on the Fig. 3. It is intuitive that the time axis is the X axis we will assumed that following sections are rows and the column represents the state of all units at the selected time in the past.

This matrix can be interpreted as the image in the further analysis, but this assumption implies that two distant units which behave in the same inappropriate way should be considered separately. In our feeling this does not reflect the nature of the process. The other way of twodimensional data analysis is searching of subsets of rows which behave in the similar way on the subset of columns. This way of data analysis is called biclustering.

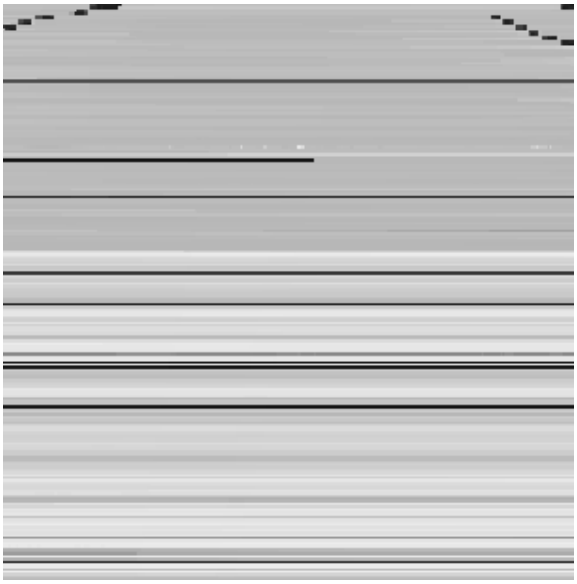

Fig. 3 Matrix representing a series of legs pressures in the powered roof support.

3. BICLUSTERING

Biclustering is the problem of unsupervised data analysis, where we are grouping scalars from the two-dimensional matrix. It called also as co-clustering, two-dimensional clustering or two mode clustering. This approach has been started in 70's in the last century [7] and is successfully applied in bioinformatics [5][14][19] or text mining [5]. The illustration of the main idea of biclustering is presented on Fig. 1.

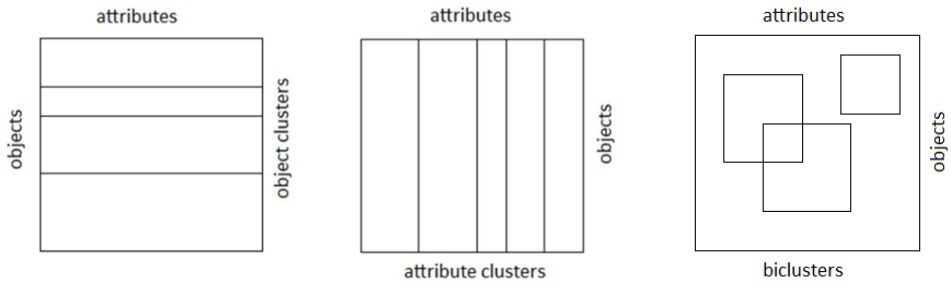

Fig. 4 Schematic representation of clustering (left, centre) and biclustering (right) [1].

In the literature there are a lot of algorithms of biclusters induction. In [5] authors define bicluster as a subset of rows under subset of columns, for which calculated parameter (mean squared residue score) is below threshold defined by the user. The minimum value of the considered parameter is 0. The algorithm consists of two steps. Initially the rows and columns are removed from input dataset, until the value of mean squared residue score is below assumed level. Then rows and columns, which were removed during the first step, are added to obtained in the previous step submatrix until its score fulfils the criterion of being bicluster. After each iteration, the founded bicluster has been hidden with random values. The extension of this algorithm proposed in [20] allows to avoid noise among input dataset, which was a consequence of masking discovered biclusters. The Order Preserving Submatrix Algorithm was presented in [3]. The

bicluster was defined as subset of rows, which preserves linear ordering across subset of conditions. The set of valid biclusters is identifying by algorithm based on stochastic model. This idea was also evolved in [9].

The algorithm X-Motif is dedicated to the extraction of conserved gene expression motifs from gene expression data and has been proposed in [13]. Bicluster is defined as subset of genes, which expression level belong to the same state across subset of conditions. The states are assigned to genes during preprocessing step. In order to find multiple biclusters an algorithm is running in an iterative way. Each iteration starts from different initial sets.

There exists also methods of biclustering dedicated for matrices with the binary values. Bimax [15] uses a simple divide-and-conquer approach for finding all inclusive maximal biclusters for a given minimal number of rows and columns. Bicluster, which is maximal in the sense of inclusion is defined as not entirely contained in any other bicluster. Such assumption allows to exclude from analysis individual cells equal to one, which can be considered as a single biclusters, however they provide no important information.

BicBin [18] is an algorithm dedicated for binary sparse matrices. It consists of three main components: the score function to evaluate a submatrix, the search algorithm to restrict the search space of all possible submatrices and an algorithm used to extract all biclusters in an ordered way from a dataset. BicBin is dedicated for finding inexact biclusters. Each run of BicBin may give different results, because algorithm finds set of random biclusters, which fulfil its restrictions and cover all ones in dataset.

A novel approach of the binary matrix biclustering is based on the rough sets theory [11], where non-exact biclusters are defined as the ordered pair of biclusters called a lower and an upper approximation. The lower approximation is the exact submatrix of the given one and the upper approximation is non-exact matrix that is the superset of a given one. The algorithm is hierarchic similarly as the Ward clustering algorithm. In every step two rough biclusters can be joined if the intersection of their lower approximations is nonempty. The generalisation of the data description allows to limit the number of final biclusters assuring the assumed level of the description accuracy.

The analogical hierarchical strategy can be also applied for classical biclusters (not considered as the rough bicluster) and was presented in [11].

4. PERSPECTIVES OF LONGWALL SYSTEMS MONITORING

As presented above it is very important to determine the diagnostic state of powered roof supports units. Due to the nature of units behaviour, which can be different in the close neighbourhood and similar for the distant ones, biclustering methods seem to be appropriate tools for detection of subsets of units behaving similarly in the same period of time.

A single measured value – the pressure level of leg (or legs) in the unit – can bring a lot of diagnostic features, which can describe a diagnostic state of a particular unit. Apart from the units diagnostic state of, also the level of proper longwall system operation quality can be measured.

All mentioned analysis requires data in two aspects. The first one aspect means the raw data, coming from the monitoring systems, which should help in the process of detection of unit working cycle phases. The second aspect means the technical expert knowledge, necessary for the purpose of a raw data interpretation.

ACKNOWLEDGEMENTS

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COMPARATIVE PERFORMANCE ANALYSIS OF MACHINE LEARNING TECHNIQUES FOR SOFTWARE BUG DETECTION

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ABSTRACT

Machine learning techniques can be used to analyse data from different perspectives and enable developers to retrieve useful information. Machine learning techniques are proven to be useful in terms of software bug prediction. In this paper, a comparative performance analysis of different machine learning techniques is explored for software bug prediction on public available data sets. Results showed most of the machine learning methods performed well on software bug datasets.

KEYWORDS

Machine Learning Methods, Software Bug Detection, Predictive Analytics.

1. INTRODUCTION

The advancement in software technology causes an increase in the number of software products, and their maintenance has become a challenging task. More than half of the life cycle cost for a software system includes maintenance activities. With the increase in complexity in software systems, the probability of having defective modules in the software systems is getting higher. It is imperative to predict and fix the defects before it is delivered to customers because the software quality assurance is a time consuming task and sometimes does not allow for complete testing of the entire system due to budget issue. Therefore, identification of a defective software module can help us in allocating limited time and resources effectively. A defect in a software system can also be named a bug.

A bug indicates the unexpected behaviour of system for some given requirements. The unexpected behaviour is identified during software testing and marked as a bug. A software bug can be referred to as" Imperfection in software development process that would cause software to fail to meet the desired expectation" [1]. Moreover, the finding of defects and correcting those results in expensive software development activities [2]. It has been observed that a small number of modules contain the majority of the software bugs [3, 4]. Thus, timely identification of software bugs facilitates the testing resources allocation in an efficient manner and enables

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developers to improve the architectural design of a system by identifying the high risk segments of the system [5, 6, 7].

Machine learning techniques can be used to analyse data from different perspectives and enable developers to retrieve useful information. The machine learning techniques that can be used to detect bugs in software datasets can be classification and clustering. Classification is a data mining and machine learning approach, useful in software bug prediction. It involves categorization of software modules into defective or non-defective that is denoted by a set of software complexity metrics by utilizing a classification model that is derived from earlier development projects data [8]. The metrics for software complexity may consist of code size [9], McCabe's cyclomatic complexity [10] and Halstead's Complexity [11].

Clustering is a kind of non-hierarchal method that moves data points among a set of clusters until similar item clusters are formed or a desired set is acquired. Clustering methods make assumptions about the data set. If that assumption holds, then it results into a good cluster. But it is a trivial task to satisfy all assumptions. The combination of different clustering methods and by varying input parameters may be beneficial. Association rule mining is used for discovering frequent patterns of different attributes in a dataset. The associative classification most of the times provides a higher classification as compared to other classification methods.

This paper explores the different machine learning techniques for software bug detection and provides a comparative performance analysis between them. The rest of the paper is organized as follows: Section II provides a related work on the selected research topic; Section III discusses the different selected machine learning techniques, data pre-process and prediction accuracy indicators, experiment procedure and results; Section VI provides the discussion about comparative analysis of different methods; and Section V concludes the research.

2. RELATED WORK

Lessmann et al. [12] proposed a novel framework for software defect prediction by benchmarking classification algorithms on different datasets and observed that their selected classification methods provide good prediction accuracy and supports the metrics based classification. The results of the experiments showed that there is no significant difference in the performance of different classification algorithms. The study did not cover all machine learning techniques for software bug prediction. Sharma and Jain [13] explored the WEKA approach for different classification algorithms but they did not explore them for software bug prediction. Kaur and Pallavi [14] explored the different data mining techniques for software bug prediction but did not provide the comparative performance analysis of techniques. Wang et al. [15] provided a comparative study of only ensemble classifiers for software bug prediction. Most of the existed studies on software defect prediction are limited in performing comparative analysis of all the methods of machine learning. Some of them used few methods and provides the comparison between them and others just discussed or proposed a method based on existing machine learning techniques by extending them [16, 17, 18].

3. MACHINE LEARNING TECHNIQUES FOR SOFTWARE BUG DETECTION

In this paper, a comparative performance analysis of different machine learning techniques is explored for software bug prediction on public available data sets. Machine learning techniques are proven to be useful in terms of software bug prediction. The data from software repository contains lots of information in assessing software quality; and machine learning techniques can be applied on them in order to extract software bugs information. The machine learning techniques

are classified into two broad categories in order to compare their performance; such as supervised learning versus unsupervised learning. In supervised learning algorithms such as ensemble classifier like bagging and boosting, Multilayer perceptron, Naive Bayes classifier, Support vector machine, Random Forest and Decision Trees are compared. In case of unsupervised learning methods like Radial base network function, clustering techniques such as K-means algorithm, K nearest neighbour are compared against each other.

3.1 Datasets & Pre-processing

The datasets from PROMISE data repository [20] were used in the experiments. Table 1 shows the information about datasets. The datasets were collected from real software projects by NASA and have many software modules. We used public domain datasets in the experiments as this is a benchmarking procedure of defect prediction research, making easier for other researcher to compare their techniques [12, 7]. Datasets used different programming languages and code metrics such as Halstead's complexity, code size and McCabe's cyclomatic complexity etc. Experiments were performed by such a baseline.

Waikato Environment for Knowledge Analysis (WEKA) [20] tool was used for experiments. It is an open source software consisting of a collection of machine learning algorithms in java for different machine learning tasks. The algorithms are applied directly to different datasets. Pre-processing of datasets has been performed before using them in the experiments. Missing values were replaced by the attribute values such as means of attributes because datasets only contain numeric values. The attributes were also discretized by using filter of *Discretize* (10-bin discretization) in WEKA software. The data file normally used by WEKA is in ARFF file format, which consists of special tags to indicate different elements in the data file (foremost: attribute names, attribute types, and attribute values and the data).

3.2 Performance indicators

For comparative study, performance indicators such as accuracy, mean absolute error and F-measure based on precision and recall were used. Accuracy can be defined as the total number of correctly identified bugs divided by the total number of bugs, and is calculated by the equations listed below:

Accuracy = (TP + TN) / (TP+TN+FP+FN)
Accuracy (%) = (correctly classified software bugs/ Total software bugs) * 100

Precision is a measure of correctness and it is a ratio between correctly classified software bugs and actual number of software bugs assigned to their category. It is calculated by the equation below:

Precision = TP /(TP+FP)

Table 1. Datasets Information

	CM1	JM1	KC1	KC2	KC3	MC1	MC2	MW1	PC1	PC2	PC3	PC4	PC5	AR1	AR6
Language	C	C	C++	C++	Java	C++	C	C	C	C	C	C	C++	C	C
LOC	20k	315k	43k	18k	18k	63k	6k	8k	40k	26k	40k	36k	164k	29k	29
Modules	505	10878	2107	522	458	9466	161	403	1107	5589	1563	1458	17186	121	101
Defects	48	2102	325	105	43	68	52	31	76	23	160	178	516	9	15

Table 2. Performance of different machine learning methods with cross validation test mode based on Accuracy

	Supervised learning								Unsupervised learning		
Datasets	**Naye Bayes**	**MLP**	**SVM**	**Ada Boost**	**Bagging**	**Decision Trees**	**Random Forest**	**J48**	**KNN**	**RBF**	**K-means**
AR1	83.45	89.55	91.97	90.24	92.23	89.32	90.56	90.15	65.92	90.33	90.02
AR6	84.25	84.53	86.00	82.70	85.18	82.88	85.39	83.21	75.13	85.38	83.65
CM1	84.90	89.12	90.52	90.33	89.96	89.22	89.40	88.71	84.24	89.70	86.58
JM1	81.43	89.97	81.73	81.70	82.17	81.78	82.09	80.19	66.89	81.61	77.37
KC1	82.10	85.51	84.47	84.34	85.39	84.88	85.39	84.13	82.06	84.99	84.03
KC2	84.78	83.64	82.30	81.46	83.06	82.65	82.56	81.29	79.03	83.63	80.99
KC3	86.17	90.04	90.80	90.06	89.91	90.83	89.65	89.74	60.59	89.87	87.91
MC1	94.57	99.40	99.26	99.27	99.42	99.27	99.48	99.37	68.58	99.27	99.48
MC2	72.53	67.97	72.00	69.46	71.54	67.21	70.50	69.75	64.49	69.51	69.00
MW1	83.63	91.09	92.19	91.27	92.06	90.97	91.29	91.42	81.77	91.99	87.90
PC1	88.07	93.09	93.09	93.14	93.79	93.36	93.54	93.53	88.22	93.13	92.07
PC2	96.96	99.52	99.59	99.58	99.58	99.58	99.55	99.57	75.25	99.58	99.21
PC3	46.87	87.55	89.83	89.70	89.38	89.60	89.55	88.14	64.07	89.76	87.22
PC4	85.51	89.11	88.45	88.86	89.53	88.53	89.69	88.36	56.88	87.27	86.72
PC5	96.93	97.03	97.23	96.84	97.59	97.01	97.58	97.40	66.77	97.15	97.33
Mean	83.47	89.14	89.29	88.59	89.386	88.47	89.08	88.33	71.99	88.87	87.29

Recall is a ratio between correctly classified software bugs and software bugs belonging to their category. It represents the machine learning method's ability of searching extension and is calculated by the following equation.

Recall = TP / (TP + FN)

F-measure is a combined measure of recall and precision, and is calculated by using the following equation. The higher value of F-measure indicates the quality of machine learning method for correct prediction.

F = (2 * precision * recall) / (Precision + recall)

3.3 Experiment Procedure & Results

For comparative performance analysis of different machine learning methods, we selected 15 software bug datasets and applied machine learning methods such as NaiveBayes, MLP, SVM, AdaBoost, Bagging, Decision Tree, Random Forest, J48, KNN, RBF and K-means. We employed WEKA tool for the implementation of experiments. The 10- fold cross validation test mode was selected for the experiments.

Table 3. Performance of different machine learning methods with cross validation test mode based on mean absolute error

	Supervised learning								Unsupervised learning		
Datasets	**NayeBayes**	**MLP**	**SVM**	**AdaBoost**	**Bagging**	**Decision Trees**	**Random Forest**	**J48**	**KNN**	**RBF**	**K-means**
AR1	0.17	0.11	0.08	0.12	0.13	0.12	0.13	0.13	0.32	0.13	0.11
AR6	0.17	0.19	0.13	0.22	0.24	0.25	0.22	0.23	0.25	0.22	0.17
CM1	0.16	0.16	0.10	0.16	0.16	0.20	0.16	0.17	0.16	0.17	0.14
JM1	0.19	0.27	0.18	0.27	0.25	0.35	0.25	0.26	0.33	0.28	0.23

KC1	0.18	0.21	0.15	0.22	0.20	0.29	0.19	0.20	0.18	0.23	0.17
KC2	0.16	0.22	0.17	0.22	0.22	0.29	0.22	0.23	0.21	0.23	0.21
KC3	0.15	0.12	0.09	0.14	0.14	0.17	0.14	0.13	0.39	0.15	0.12
MC1	0.06	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.31	0.01	0.01
MC2	0.27	0.32	0.28	0.39	0.37	0.40	0.35	0.32	0.35	0.41	0.31
MW1	0.16	0.11	0.08	0.12	0.12	0.15	0.12	0.12	0.18	0.12	0.13
PC1	0.11	0.11	0.07	0.11	0.10	0.14	0.09	0.10	0.12	0.12	0.08
PC2	0.03	0.01	0.00	0.01	0.01	0.02	0.01	0.01	0.18	0.01	0.01
PC3	0.51	0.14	0.10	0.16	0.15	0.21	0.15	0.15	0.36	0.18	0.13
PC4	0.14	0.12	0.11	0.15	0.14	0.16	0.14	0.12	0.43	0.20	0.13
PC5	0.04	0.03	0.03	0.04	0.03	0.06	0.03	0.03	0.33	0.05	0.03
Mean	0.16	0.14	0.10	0.15	0.15	0.18	0.14	0.14	0.27	0.16	0.13

Table 4. Performance of different machine learning methods with cross validation test mode based on F-measure

	Supervised learning								**Unsupervised learning**		
Datasets	**NayeBayes**	**MLP**	**SVM**	**AdaBoost**	**Bagging**	**Decision Trees**	**Random Forest**	**J48**	**KNN**	**RBF**	**K-means**
AR1	0.90	0.94	0.96	0.95	0.96	0.94	0.96	0.95	0.79	0.95	0.94
AR6	0.90	0.91	0.93	0.90	0.92	0.90	0.92	0.90	0.84	0.92	0.90
CM1	0.91	0.94	0.95	0.95	0.95	0.94	0.94	0.94	0.91	0.95	0.93
JM1	0.89	0.90	0.90	0.90	0.90	0.90	0.90	0.88	0.80	0.90	0.86
KC1	0.90	0.92	0.92	0.91	0.92	0.92	0.92	0.91	0.89	0.92	0.91
KC2	0.90	0.90	0.90	0.88	0.90	0.89	0.89	0.88	0.86	0.90	0.88
KC3	0.91	0.94	0.95	0.95	0.95	0.95	0.94	0.94	0.72	0.95	0.93
MC1	0.97	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.81	1.00	1.00
MC2	0.82	0.78	0.82	0.80	0.81	0.77	0.80	0.78	0.76	0.81	0.77
MW1	0.90	0.95	0.96	0.95	0.96	0.95	0.95	0.95	0.89	0.96	0.93
PC1	0.94	0.97	0.96	0.96	0.97	0.97	0.97	0.97	0.94	0.96	0.96
PC2	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	1.00	1.00
PC3	0.60	0.94	0.95	0.95	0.94	0.95	0.94	0.94	0.77	0.95	0.93
PC4	0.92	0.94	0.94	0.94	0.94	0.93	0.94	0.93	0.72	0.93	0.92
PC5	0.98	0.99	0.99	0.98	0.99	0.98	0.99	0.99	0.80	0.99	0.99
Mean	0.89	0.93	0.942	0.93	0.94	0.93	0.93	0.93	0.82	0.93	0.92

Experiment procedure:

Input:

i) The software bug repository datasets:

D= {AR1, AR6, CM1, JM1, KC1, KC2, KC3, MC1, MC2, MW1, PC1, PC2, PC3, PC4, PC5}

ii) *Selected machine learning methods*

M = {Nayes Bayes, MLP, SVM, AdaBoost, Bagging, Decision Tree, Random Forest, J48, KNN, RBF, K-means}

Data pre-process:

a) Apply Replace missing values to D

b) Apply Discretize to D

Test Model - cross validation (10 folds):

for each D do for each M do

Perform cross-validation using 10-folds

end for

Select accuracy

Select Mean Absolute Error (MAE) Select F-measure end for

Output:

a) Accuracy
b) Mean Absolute Error
c) F-measure

3.4 Experiment results

Table 2, 3 & 4 show the results of the experiment. Three parameters were selected in order to compare them such as Accuracy, Mean absolute error and F-measure. In order to compare the selected algorithms the mean was taken for all datasets and the results are shown in Figure 1, 2 & 3.

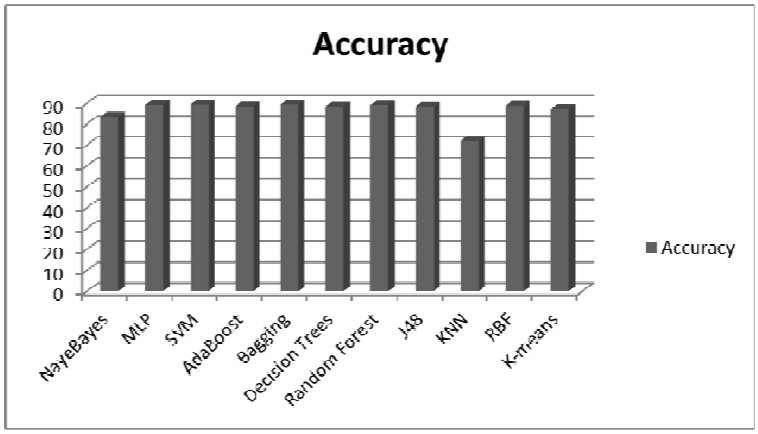

Figure 1. Accuracy results for selected machine learning methods

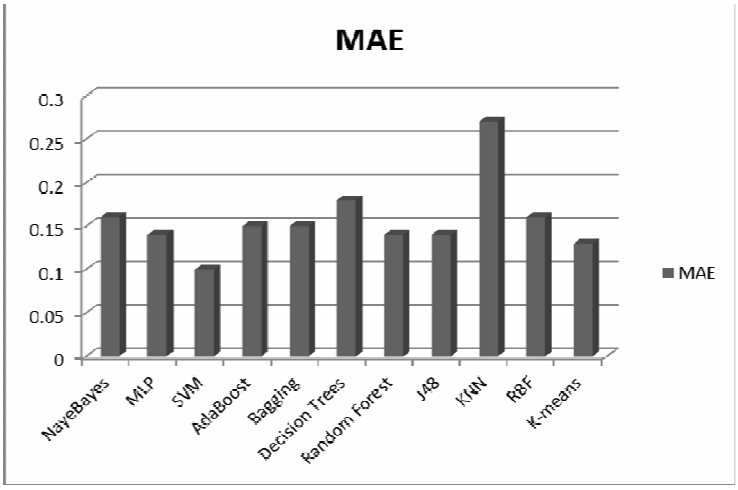

Figure 2. MAE results for selected machine learning methods

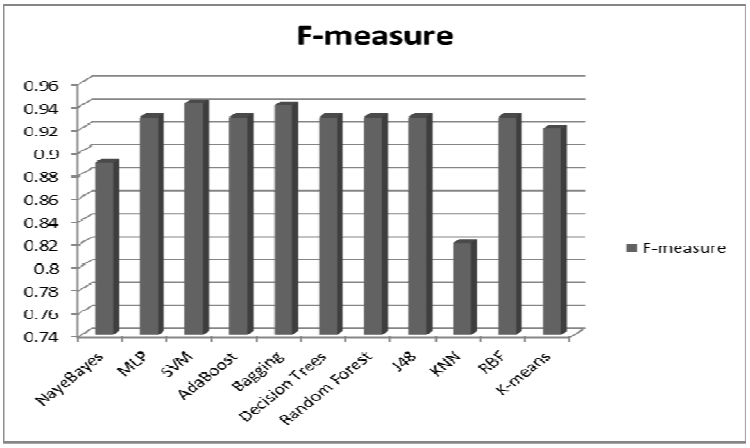

Figure 3. F-measure results for selected machine learning methods

4. DISCUSSION & CONCLUSION

Accuracy, F-measure and MAE results are gathered on various datasets for different algorithms as shown in Table 2, 3 & 4. The following observations were drawn from these experiment results:

NaiveBayes classifier for software bug classification showed a mean accuracy of various datasets 83.47. It performed really well on datasets MC1, PC2 and PC5, where the accuracy results were above 95%. The worst performance can be seen on dataset PC3, where the accuracy was less than 50%. MLP also performed well on MC1 and PC2 and got overall accuracy on various datasets 89.14 %. SVM and Bagging performed really well as compared to other machine learning methods, and got overall accuracy of around 89 %. Adaboost got accuracy of 88.59, Bagging got 89.386, Decision trees achieved accuracy around 88.47, Random Forest got 89.08, J48 got 88.33 and in the case of unsupervised learning KNN achieved 71.99, RBF achieved 88.87 and K-means achieved 87.29. MLP, SVM and Bagging performance on all the selected datasets was good as compared to other machine learning methods. The lowest accuracy was achieved by KNN method.

The best MAE achieved by SVM method which is 0.10 on various datasets and got 0.00 MAE for PC2 dataset. The worst MAE was for KNN method which was 0.27. K-means, MLP, Random Forest and J48 also got better MAE around 0.14. In the case of F-measure, higher is better. Higher F-measure was achieved by SVM and Bagging methods which were around 0.94. The worst F-measure as achieved by KNN method which was 0.82 on various datasets.

Software bugs identification at an earlier stage of software lifecycle helps in directing software quality assurance measures and also improves the management process of software. Effective bug's prediction is totally dependent on a good prediction model. This study covered the different machine learning methods that can be used for a bug's prediction. The performance of different algorithms on various software datasets was analysed. Mostly SVM, MLP and bagging techniques performed well on bug's datasets. In order to select the appropriate method for bug's prediction domain experts have to consider various factors such as the type of datasets, problem domain, uncertainty in datasets or the nature of project. Multiple techniques can be combined in order to get more accurate results.

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ANALYSING ATTRITION IN OUTSOURCED SOFTWARE PROJECT

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ABSTRACT

Information systems (IS) outsourcing has grown as a major business phenomenon, and widely accepted as a business tool. Software outsourcing companies provide expertise, knowledge and capabilities to their clients by taking up the projects both onsite and offsite. These companies face numerous challenges including attrition of project members. Attrition is a major challenge experienced by the outsourcing companies as it has severe impact on business, revenues and profitability. In this paper, attrition data of a major software outsourcing company was analysed and an attempt to find the reason for attrition is also made. The data analysis was based on the data collected by an outsourcing company over a period of two years for a major client. The results show that the client initiated attrition can have an impact on project and the members quit the outsourcing company due to client initiated ramp down without revealing the reason.

KEYWORDS

Software engineering, Project Management, Attrition, Software Outsourcing, Software Project.

1. INTRODUCTION

A successful software project can be attributed to rightly managing three critical factors – people, process and technology [1] While the process and technology used largely influences the schedule, the quality and the productivity of the project, the people factor directly impacts the revenue and profitability of the project [2]. People leave the project for various reasons and every project member leaving the project will result in 'attrition'. As people develop skills and gain knowledge when they work through the different life cycle stages of the project, the attrition in the project will result in loss of skills and knowledge [3]. It takes a great deal of effort and time to rebuild that skills and knowledge to ensure that the project keeps running smoothly. Hence many project managers will maintain a small buffer of people who will pitch in whenever there is attrition in the project so that the project schedule, quality and productivity will not get impacted. However, the buffer of people will bring down the profitability of the project.

The attrition process in a software project is common and needs to be carefully managed [1]. In large size projects (both in terms of the number of people and the duration), the attrition manifests itself in two forms – one is the attrition initiated by the client due to budget constraints or non-performance of employees, and the other is the attrition initiated by the project members themselves either because they want to move out of the current project or they want to leave the company he/she is working for. In either of the cases, it is important to understand the nature of attrition and its impact on the project [4].

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The project schedule and quality of project work largely depends on the stability of the project team members. If attrition in the project increases, there will be transference of knowledge from the outgoing project member to the incoming project member. This will introduce a delay in the project and if the transition is incomplete, the quality of the project work greatly suffers. Hence, the attrition factor in outsourced software project should be carefully considered while planning for a project.

The aim of this study is an attempt to understand whether there is any relationship between the client initiated attrition and the project member initiated attrition. It is also an attempt to understand whether the HR personnel are correctly capturing the reasons for any employee quitting the company during the exit interview. A large outsourcing organization of India was considered for the study from which a sample of 120 records over a period of 14 months was analysed.

2. LITERATURE REVIEW

According to Gopal et al. (2003), attrition largely impacts the profitability of a software project and hugely depends on the nature of the project contract signed. A project with a fixed price contract will impact the profitability due to higher attrition than a project with a time and material contract. The role of a person in the project also impacts profitability. A project manager leaving in the middle of a project with a fixed price contract will create more damage than a mere project member leaving the project. In a project with time and material contract, key software developers/leads can create more damage to the projects than the project manager himself.

According to Reel (1993) any of the key people leaving the project is a loss, as some of the crucial knowledge that has been gained till then is lost. If the project analysts quit the project, then the business requirement knowledge is lost. Similarly, if the project managers leave the project, the project process knowledge is lost. If the programmers quit, the pace of development will slow down. The best practices and lessons learnt during the project execution are largely held with the project team members. Unless all the knowledge that is gained during project execution is documented, this knowledge will be lost along with the people and takes a similar time period to be re-built [7].

According to Sundararajan et al. (2013) IT skills are very critical to the success of software projects. Companies spend a lot of money and time to build IT skills among its staff to prepare them to deliver successful software projects. Investing in FTEs (Full Time Employees) will bring stability to workforce and hence better quality of delivery. However, Jones (1994) highlights that the higher rate of attrition higher the risks associated with a project. Some companies choose to outsource a part of the project work to contractors or vendors. While outsourcing is one of the strategies for mitigating the risk related to attrition, the outsourced work will not automatically guarantee good quality of work. Accountability for the work done becomes a bigger issue to handle in such situations.

Knowledge management (KM) is one of the key aspects of handling the continuity of business, in wake of growing attrition in the software industry. It is one of the solutions to the problem arising out of the staff attrition. It also helps in improving re-usability and hence the productivity of the staff. Companies can also use KM to improve their profitability. But KM calls for huge investments in infrastructure and a continuous push by the management to ensure that people contribute to the KM repository [10].

Staffing decisions in software projects is quite complex and needs to go through a structured process. Software projects will have to be delivered within budget, within schedule and with very high quality [11]. Sharm et al. (2010) in their paper states that a staffing model should be defined

for each type of software project and 'what if' scenarios should be analyzed to cover possible risks due to staff attritions throughout the life cycle of the project. The most estimation models consider staff allocation as one of the key ingredients to arrive at the right effort estimation and hence the total cost of the project. Before the start of any project, the staff profile, their experience levels, roles and productivity of each staff should be analyzed in detail to cover the attrition risk in projects.

In their work by Lacity and Hirschheim (1993) have found that factors like cultural differences, time zone differences, the quality of the staff, their knowledge retention and reuse impacting the productivity of outsourced work. In fact, many organizations feel that they have not achieved the real benefits of true outsourcing due to the above factors.

3. RESEACRH QUESTION

All the above studies are based on small samples, single cases, specific industries and project types, generalization might not be possible. In this study, 'attrition' is defined as any project member leaving / quitting the client project. The reasons for leaving the project may be on account of client initiation or by the project member's desire to quit. The client can ask the outsourcing company to reduce the project members in a team due to financial budget constraints or non-performance of the team members. In such cases, the outsourcing company takes the members out of the project and deploys the engineers in some other project. From the outsourcing company perspective, this may not be considered as attrition. However, the company has to make a decision whether to retain these members in the same project, without billing the client or deploy them into other projects. This has an impact on the overall profitability of the project. In other cases, the project members working at the client site quit the company altogether due to better opportunities or some other reasons. This is considered as a true attrition for the outsourcing company.

The objective of the research is to analyse the reasons for leaving a project, whether client initiated or employee initiated, are similar in nature or not. In addition, an analysis is done on the reasons given by the project members while quitting the company are same or different. Since attrition in a large project can impact the revenues and profitability of the project, this analysis helps companies in proper resource planning and retention.

Hypothesis 1 (H10): There is no difference between the sample mean of attrition caused due to the client initiation and the project member initiation.

The objective was to statistically test the significance of attrition data. T-tests were performed to confirm that the means of attrition in client initiated data were similar to the means of the attrition in members initiated data.

Hypothesis 2 (H20): There is no difference between the sample mean of attrition of employees joining another company and for personal reasons.

The objective was to statistically test the significance of attrition data. T-tests were performed to confirm that the means of attrition in client initiated data were similar to means of the attrition of members initiated data.

4. METHODOLOGY

In this study, the attrition dataset from a major outsourcing company from India was analyzed. The company is a global leader in consulting, technology, and outsourcing solutions. It has a

client base with more than 250 clients across 30 countries and with an employee base of more than 100000. For the study, the attrition data from one client was analysed. The outsourcing company had deployed more than 300 engineers at the client's site for a project. Whenever an employee left the project, the reason for leaving was recorded and collated on a monthly basis. A total of 120 records were available in the dataset. Out of the 120 records, after some data cleaning, a total of 106 employee records were analysed. The data was collected over a period of 14 months. The project members who left the project were programmers, programmer analysts, project managers, translators and UI designers. Every month, the attrition data was captured by entering the pertinent information regarding the project member, including whether the member was ramped down by the client, or the member had resigned from the outsourcing company. If the member had resigned, then further data from the exit interview was also recorded. In this dataset, only one reason was recorded – whether the exit was for personal reasons or for joining another company. In this study, as per the outsourcing company norms, any member leaving the project before 18 month is considered as attrition.

The descriptive data was analyzed using Statistical Package for Social Science (SPSS) Version 17, the statistical software package by IBM. SPSS is commonly used in the Social Science and in the business world [14]. IBM SPSS allows in-depth data analysis and preparation, analytical reporting, graphics and modelling (ibm.com). It is a Windows based program that can be used to perform data analysis, create tables, graphs and statistical data analysis. It is capable of handling large amounts of data and can perform visualization, ANOVA, t-test, Chi-square tests, F-test, and other statistical analyses.

Further, in order to analyze the data at a micro level and test the difference between two groups at a time, t-tests were conducted. The null hypothesis assumes that there is no significant difference in the means of the two groups, in other words, the sample mean of attrition initiated either by the client or the project members is the same.

5. RESULTS

The results of descriptive data on the study of attrition are important for the following reasons:
1). It enables a company to determine the compatibility of client initiated attrition and project member initiated attrition. 2). It enables to determine the reasons for attrition by members are the same or different.

The first part of the analysis is to identify whether the attrition of client initiation and project members' initiation are the same or different. The analysis was performed between two groups of data – client initiated attrition and project members' initiated attrition. The following Table 1 presents the descriptive data analysis:

Table 1. Attrition Statistics: Client and Members Initiated

	Client Initiated	***Member Initiated***
Mean	3.285714286	2.571428571
Standard Error	0.834875601	0.561730898
Median	2	1.5
Standard Deviation	3.123818458	2.101804562
Sample Variance	9.758241758	4.417582418
Peasron Coefficient	0.63	0.63

From the Table 1, it can be noted that the mean of client initiated is 3.25 persons per month with a standard deviation of 3.12 whereas the members initiated is 2.57 persons per month with a

standard deviation of 2.10 and both the groups are independent. Further, t-tests were conducted to compare the behaviour between the two groups, whether they are same or different. Whether the reasons for client initiated attrition and member initiated attrition are the same or they are different. Further, correlation coefficient was found to be 0.63.

Table 2. T-test: Client and Members Initiated Attrition

Groups	**M**	**SD**	**t-value**	**p-value (two tailed)**	**Null Hypothesis**
Client Initiated	3.28	3.12	1.099	0.29*	Fail to Reject
Member Initiated	2.57	2.10			

*Significance level = 0.05

A paired-samples t-test was conducted to compare client initiated attrition and members initiated attrition conditions. As shown in the Table 2, there was no significant difference in the scores for client initiated (M=3.28, SD=3.12) and members initiated (M=2.57,SD=2.10) conditions with t-value of 1.099 and p = 0.29. These suggest that there is not enough evidence to show that the attrition due to client initiated and attrition due to members initiated are different.

The second part of the analysis is to identify the reasons given by the members who resign (attrition) was to join the other company or some other reasons which is unknown. The analysis was performed between the two sets of data – reasons joining the other company and reasons that is unknown. The following Table 3 presents the descriptive data analysis:

Table 3. Attrition reasons: Joining other company and Unknown

	Joining Other Company	***Unknown***
Mean	0.92	1.64
Standard Error	0,304	0.487
Median	0.5	1
Standard Deviation	1.141	1.823
Sample Variance	1.302	3.324

From the Table 3, it can be noted that the mean of Joining Other Company is 0.92 persons per month with a standard deviation of 1.14 whereas the Unknown is 1.64 persons per month with a standard deviation of 1.82 and both the groups are independent. Further, t-tests, as shown in Table 4, were conducted to compare the behaviour between the two groups are same or different. Whether reasons for Joining Other Company and Unknown are same or they are different.

Table 4: T-test: Joining Other Company and Unknown

Groups	**M**	**SD**	**t-value**	**p-value (two tailed)**	**Null Hypothesis**
Joining Other Company	0.92	1.14	1.21	0.24	Fail to Reject
Unknown	1.64	1.82			

*Significance level = 0.05

A paired-samples t-test was conducted to compare Joining Other Company and Unknown conditions. As shown in the Table 4, there was no significant difference in the scores for Joining Other Company (M=0.92, SD=1.14) and Unknown (M=1.64,SD=1.82) conditions with t-value of 1.21 and p = 0.24. These suggest that there is not enough evidence to show that the reasons for Joining Other Company and reasons for Unknown attrition by members initiated are different.

6. DISCUSSION

The results indicate that there is no significant difference in the sample mean of client initiated and members initiated attrition. It can be inferred from the results that the client initiated ramp down can have significant impact on team members working on the project. Client initiated ramp down can result in demotivating the team as the other team members do not feel secure about their places in the project and hence not contribute to the best of their ability to the project and on the personal side, not gain proper experience or skills which would help in their career. From the results, it can be also inferred that the reasons given by the employees when they quit the company is not properly captured. T-test shows that there is no significant difference in the sample means of reasons for leaving the company.

Employees normally tend to quote 'pursuing higher education' as one of the main reasons for members initiated attrition. The companies tend to go soft on this aspect and do not insist on serving sufficient notice before reliving them from their duty. In other cases, employees quote 'personal reasons' which cannot be drilled down further as it would mean intruding in their privacy. In case of client initiated attrition, some employees will treat it as an opportunity to move on to new projects. But many employees will feel demotivated as their learning opportunity in their current project got terminated due to ramp down in the account.

Hypothesis 1 (H10): There is no difference between the sample mean of attrition caused due to the client initiation and the project member initiation.

Fail to reject as there is not enough evidence to show that the attrition due to client initiated and attrition due to members initiated are different.

Hypothesis 2 (H20): There is no difference between the sample mean of attrition of employees joining another company and for personal reasons.

Fail to reject as there is not enough evidence to show that the reasons for Joining Other Company and reasons for Unknown attrition by members initiated are different.

6.1 Managerial Implications

From project management perspective, the impact of attrition on the project profitability will remain the same irrespective of whether the attrition was initiated by the client or the project member. The project manager will have to factor in the risk associated with the attrition on the project output and accordingly handle his staffing plan to mitigate the risk. In case of client initiated attrition, the project member has the option to come out of the current project and move on to another project. Hence this attrition will not impact the attrition of the company. In case of project member initiated attrition, both the project and the company will suffer and the cost of mitigating the risk will be very high and hence will impact the profitability both the company and its client.

7. CONCLUSIONS

The study analyses the attrition in a project from an outsourcing company's point of view and the reasons behind the attrition. Further, the study shows that there is no significant difference between the client initiated and members initiated attrition. Similarly, in the case of the members initiated attrition, the reasons for leaving the company is not extensively captured by the company and all these could have an impact on the overall project. The study was limited to only one client because of data availability. This can be further extended to data from multiple clients and multiple projects. Also in the next stage of the study, detail analysis of exit interview answers will be analysed once there is a significant amount of data.

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LSB STEGANOGRAPHY WITH IMPROVED EMBEDDING EFFICIENCY AND UNDETECTABILITY

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ABSTRACT

In this paper, we propose a new method of non-adaptive LSB steganography in still images to improve the embedding efficiency from 2 to 8/3 random bits per one embedding change even for the embedding rate of 1 bit per pixel. The method takes 2-bits of the secret message at a time and compares them to the LSBs of the two chosen pixel values for embedding, it always assumes a single mismatch between the two and uses the second LSB of the first pixel value to hold the index of the mismatch. It is shown that the proposed method outperforms the security of LSB replacement, LSB matching, and LSB matching revisited by reducing the probability of detection with their current targeted steganalysis methods. Other advantages of the proposed method are reducing the overall bit-level changes to the cover image for the same amount of embedded data and avoiding complex calculations. Finally, the new method results in little additional distortion in the stego image, which could be tolerated.

KEYWORDS

Steganography, Embedding efficiency, Probability of detection, Single Mismatch, LSB matching, LSB replacement

1. INTRODUCTION

Steganography is the art and the science of keeping the existence of messages secret rather than only their contents, as it is the case with cryptography. Both steganography and digital watermarking belong to information hiding, but they differ in their purpose. Digital watermarking is intended to protect the cover, whereas steganography is used to protect the message. So, steganography is considered broken when the existence of the secret message is detected. Hence, the most important property for every steganographic method is undetectability by the existing steganalysis techniques.

LSB steganography is the most widely used embedding method in pixel domain, since it is easy to implement, has reasonable capacity, and is visually imperceptible. Unfortunately, both methods of LSB steganography (LSB replacement and LSB matching) are detectable by the current steganalysis approaches discussed in later sections.

There are some methods proposed to improve the capacity of LSB replacement like[1,2], or to avoid changing the histogram of the cover image like [3] which reduce the embedding capacity by 50%. As mentioned earlier, the undetectability, or the probability of detection is the most important property for any steganographic method. In this paper a new method of non-adaptive

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LSB steganography is proposed to reduce the probability of detection for the same amount of data embedded with LSB replacement, LSB matching, and LSB matching revisited [4]by the current detection methods. The proposed method also results in fewer ENMPP (Expected Number of Modifications Per Pixel) in both pixel and bit-level to the cover image, and changes the histogram of the cover image in a different way without any complex calculation.

The paper is organized like the following; it starts with clarifying adaptive and non-adaptive steganography and the related embedding methods in the literature. Then, it starts analysing both LSB replacement and LSB matching in grey-scale images from different perspectives such as the embedding efficiency, histogram changes, and bit-level ENMPP. Then, the proposed method is explained and followed by the same analysis process. After that, the experimental results are shown for the proposed method against both steganalysis methods; LSB replacement and LSB matching. Finally, the conclusion and future work are discussed in the last section.

2. ADAPTIVE AND NON-ADAPTIVE LSB STEGANOGRAPHY IN IMAGE

The embedding process of LSB steganography relies on some methods for selecting the location of the change. In general, there are three selection rules to follow in order to control the location of change, which are either sequential, random, or adaptive [5].

A sequential selection rule modifies the cover object elements individually by embedding the secret message bits in a sequential way. For example, it is possible to embed the secret message by starting from the top-left corner of an image to the bottom-right corner in a row-wise manner. This selection rule, sequential, is very easy to implement, but has a very low security against detection methods.

A pseudo-random selection rule modifies the cover object by embedding the secret message bits into a pseudo randomly chosen subset of the cover object, possibly by using a secret key as a pseudo-random number generator (PRNG). This type of selection rule gives a higher level of security than sequential methods.

An adaptive selection rule modifies the cover object by embedding the secret message bits in selected locations based on the characteristics of the cover object. For example, choosing noisy and high textured areas of the image, which are less detectable than smooth areas for hiding data. This selection rule, adaptive, gives a higher security than sequential and pseudo-random selection rules in terms of detection.

So, the non-adaptive image steganography techniques are modifying the cover image for message embedding without considering its features (content). For example LSB replacement and LSB matching with sequential or random selection of pixels are modifying the cover image according to the secret message and the key of random selection of pixels without taking the cover image properties into account. Whereas, adaptive image steganography techniques are modify the cover image in correlation with its features [6]. In other words, the selection of pixel positions for embedding is adaptive depending on the content of the cover image. The bit-plane complexity segmentation (BPCS) proposed by Kawguchi[7] is an early typical method of adaptive steganography.

As adaptive steganographic schemes embed data in specific regions (such as edges), the steganographic capacity of such method is highly depend on the cover image used for embedding. Therefore, in general it is expected to have less embedding rate than non-adaptive schemes. However, steganographers have to pay this price in order to have a better security or less detectable stego image.

3. RELATED WORKS

The undetectability is the most important requirement of any steganographic scheme, which is affected by the choice of the cover object, the type of embedding method, the selection rule of modifying places, and the number of embedding changes which is directly related to the length of secret message[8].

If two different embedding methods share the same source of cover objects, the same selection method of embedding place, and the same embedding operation, the one with less number of embedding changes will be more secure (less detectable). This is because the statistical property of the cover object is less likely to be disrupted by smaller number of embedding changes[8].
The concept of embedding efficiency is introduced by westfeld[9], and then considered as an important feature of steganographic schemes[10,11], which is the expected number of embedded random message bits per single embedding change[12].

Reducing the expected number of modifications per pixel (ENMPP) is well studied in the literature considering the embedding rate of less than 1 , like westfeld's F5-algorithm[13], which could increase the embedding efficiency only for short messages. However, short messages are already challenging to detect. Also, the source coding-based steganography (matrix embedding) proposed by Fridrich et al.[8,12], which are extensions of F5-algorithm improved the embedding efficiency for large payloads but still with embedding rate of less than 1. The stochastic modulation proposed by Fridrich and Goljan[14], is another method of improving the security for the embedding rate of up to 0.8 bits/ pixel.

For the embedding rate of 1, there have been some methods for improving the embedding efficiency of LSB matching like Mielikainen[4], which reduced the ENMPP with the same message length from 0.5 to 0.375. The choice of whether to add or subtract one to/from a pixel value of their method relies on both the original pixel values and a pair of two consecutive secret bits. However, this method of embedding cannot be applied on saturated pixels (i.e. pixels with values 0 and 255), which is one of the drawbacks of this method. Then, the generalization method of LSB matching is proposed by Li et al.[15] with the same ENMPP for the same embedding rate using sum and difference covering set (SDCS). Another method of improving the embedding efficiency of LSB matching is proposed by Zhang et al.[16], using a combination of binary codes and wet paper codes, The embedding efficiency of this method can achieve the upper bound of the generalized ±1 embedding schemes.

However, no method could be found in the literature to improve the embedding efficiency of non-adaptive LSB replacement, which is 2 bits per embedding change, for the embedding rate of 1. So, developing such a method could be more useful than other adaptive methods in reusability perspective. Moreover, the non-adaptive LSB embedding methods with higher embedding efficiency can be used by existing adapted embedding methods to improve the steganographic capacity and reduce the probability of detection. A good example is the LSB matching revisited[4], which has been extended by[17,19].

Also, moving from non-adaptive to adaptive LSB embedding method does not mean that improving the non-adaptive methods are impossible or useless, as we mentioned earlier, the LSB matching revisited[4] is a very good example to support this fact.

4. ANALYSIS OF LSB REPLACEMENT

In this section, LSB replacement is analysed in three perspectives; the embedding process itself (with its embedding efficiency), its effect on the intensity histogram after embedding process, and

the bit-level ENMPP for each bit of the secret message. Also, the main weaknesses of this embedding method are highlighted with the steganalysis methods that can detect it.

LSB replacement steganography simply replaces the LSB of the cover image pixel value with the value of a single bit of the secret message. It leaves the pixel values unchanged when their LSB value matches the bit value of the secret message and changes the mismatched LSB by either incrementing or decrementing the even or odd pixel values by one respectively[4], as shown in Figure 1.

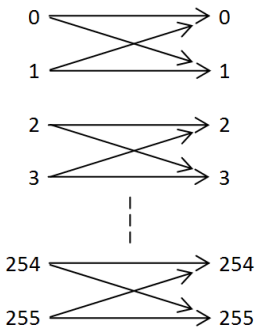

Figure1. Possible pixel value transitions with LSB replacement

The embedding algorithm of the LSB replacement can be formally described as follows:

$$P_s = \begin{cases} P_c + 1 & ,if\ b \neq LSB(P_c)\ and\ P_c\ is\ even \\ P_c - 1 & ,if\ b \neq LSB(P_c)\ and\ P_c\ is\ odd \\ P_c & ,if\ b = LSB(P_c) \end{cases}$$

To analyse the influence of the LSB replacement on the cover image intensity histogram, we should consider that there is a probability of 50% for the LSB of the cover image pixel value to already have the desired bit value. Therefore, the probability of modified pixel values will be (P/2) for an embedding rate of P and the unmodified pixel values will be (1-P/2) after embedding process, which means that embedding each message bit needs 0.5 pixel values to be changed. In other words, it has an embedding efficiency of 2 bits of the secret message per one embedding change. Hence, the intensity histogram of the stego image could be estimated as follows:

$$\mathrm{h_s(n)} = \left(1 - \frac{\mathrm{P}}{2}\right)\mathrm{h_c(n)} + \frac{\mathrm{P}}{2}\begin{cases}\mathrm{h_c(n+1)} & ,\mathrm{n\ is\ even} \\ \mathrm{h_c(n-1)} & ,\mathrm{n\ is\ odd}\end{cases}$$

Where n is a greyscale level which ranges from 0 to 255, and $\mathrm{h(n)}$ indicates the number of pixels in the image with greyscale value of n.

This type of embedding, LSB replacement, leads to an imbalance distortion and produces 'Pairs of Values' on the intensity histogram of the stego image. Since LSB replacement is inherently asymmetric, current steganalysis methods can detect it easily[20], like: RS[21], SP[22], and WS[23,24].

Another way of analysing LSB embedding is the bit-level ENMPP, which is the expected number of bit modifications per pixel. This would be important too, as there are some steganalysis methods that can detect the existence of the secret message based on calculating several binary similarity measures between the 7^{th} and 8^{th} bit planes like[25]. Hence, an embedding process with less bit-level ENMPP would be better and less detectable by such detection methods.

The overall bit-level ENMPP for LSB replacement could be estimated by multiplying the probability of having mismatched LSBs, $P_r(\overline{M})$, which is 0.5 by the number of bits that needs to be changed in each case, as shown below.

$$\text{bit} - \text{level ENMPP} = P_r(\overline{M}) \times \text{no. of modified bits}$$
$$\text{bit} - \text{level ENMPP} = 0.5 \times 1 = 0.5 \quad \text{bits per message bits}$$

Hence, the overall bit-level ENMPP for LSB replacement is 0.5 bits for each bit of the secret message.

5. ANALYSIS OF LSB MATCHING

To analyse LSB matching steganography, we again consider the embedding process (with its embedding efficiency), its effect on the intensity histogram of the cover image, and bit-level ENMPP.

LSB matching or ±1 embedding is a modified version of LSB replacement. Instead of simply replacing the LSB of the cover image, it randomly either adds or subtracts 1 from the cover image pixel value that has mismatched LSB with the secret message bit[26]. The possible pixel value transitions of ±1 embedding are shown in Figure 2.

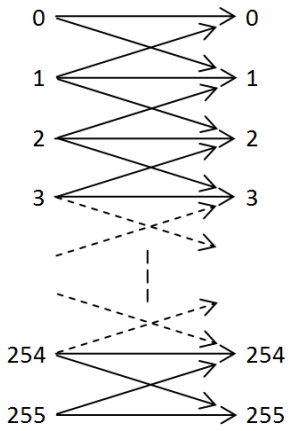

Figure 2. Possible pixel value transitions with LSB matching

The random increment or decrement in pixel values should maintain the boundary limitation and pixel values should always be between 0 and 255 [27]. In other words, the embedding process should neither subtract 1 from pixel values of 0 nor add 1 to the pixel values of 255.

This random ±1 change to the mismatched LSB pixel values avoids the asymmetry changes to the cover image, which is the case with LSB replacement. Hence, LSB matching is considered harder to detect than LSB replacement[4]. The embedding procedure of LSB matching can be formally represented as follows[28]:

$$P_s = \begin{cases} P_c + 1 & , \text{if } b \neq \text{LSB}(P_c) \text{ and } (K > 0 \; or \; P_c = 0) \\ P_c - 1 & , \text{if } b \neq \text{LSB}(P_c) \text{ and } (K < 0 \; or \; P_c = 255) \\ P_c & , \text{if } b = \text{LSB}(P_c) \end{cases}$$

Where K is an independent and identically distributed random variable with uniform distribution on $\{-1, +1\}$.

For the intensity histogram we consider an embedding rate of P. There is a chance of 50% that the clean image pixel value contains the desired LSB, which means that $(P/2)$ of the cover pixel values will change after the embedding process. Hence, the estimated unmodified pixel values will be $(1 - P/2)$, which means that embedding each message bit needs 0.5 pixel values to be changed. In other words, its embedding efficiency is 2 bits of the secret message per one embedding change. The intensity histogram of the stego image could be obtained as follows[28].

$$h_s(n) = \left(1 - \frac{P}{2}\right) h_c(n) + \frac{P}{4}[h_c(n+1) + h_c(n-1)]$$

As mentioned earlier, the LSB matching will avoid the asymmetric property in modifying the cover image. However, as claimed by[29], ±1 embedding is reduced to a low pass filtering of the intensity histogram. This implies that the cover histogram contains more high-frequency power than the histogram of the stego image [28], which offers an opportunity to steganalyzers to detect the existence of the secret message embedded with LSB matching.

Apart from the supervised machine learning detectors of ±1 embedding like[30-33], which usually have problems in choosing an appropriate feature set and measuring classification error probabilities[34], the methods of detecting LSB matching steganography could be divided into two categories; the centre of mass of the histogram characteristic function (HCF) and the amplitude of local extrema (ALE)[35].

A number of detection methods have been proposed based on the centre of mass of the histogram characteristic function (HCF-COM) like Harmsen and Pearlman[36], which has better performance on RGB images than grey-scale. This method is modified and improved by Ker[27], who applied the HCF in two novel ways: using the down sampled image and computing the adjacency histogram.

Based on the amplitude of local extrema (ALE), Zhang et al.[29] considered the sum of the amplitudes of all local extrema in the histogram to distinguish between stego and clean images. This method is improved by Cancelli et al. [32] after reducing the border effects noise in the histogram and extending it to the amplitude of local extrema in the 2D adjacency histogram.
The bit-level ENMPP of LSB matching is also important and should be considered for the same reason, binary similarity measures. Since the probability of having mismatched LSB is also 50%, the bit-level ENMPP would be as follows:

$$\text{bit} - \text{level ENMPP} = P_r(\overline{M}) \times \text{no. of modified bits}$$
$$\text{bit} - \text{level ENMPP} = 0.5 \times (\geq 1)$$
$$\text{bit} - \text{level ENMPP} \geq 0.5 \text{ (bits per message bits)}$$

Where P_r is the probability of having mismatched LSBs, which is 0.5. However, the number of modified bits would be more than 1, because of the random ±1 changes to the pixel values, as could be noted from the following examples:

$127\ (0111111)_2 + 1 = 128\ (10000000)_2$, 8-bits changed
$192\ (11000000)_2 - 1 = 191\ (10111111)_2$, 7-bits changed
$7\ (00000111)_2 + 1 = 8\ (00001000)_2$, 4-bits changed
$240\ (11110000)_2 - 1 = 239\ (11101111)_2$, 5-bits changed

Hence, the overall bit-level ENMPP for LSB matching is expected to be more than or equal to 0.5 bits for each bit of the secret message.

6. THE PROPOSED METHOD

Based on highlighting the weakest part of both LSB replacement and ±1 embedding, in this section we propose a new method of LSB embedding to improve the embedding efficiency and reduce the probability of detection by current steganalysis methods. Moreover, the new proposed method should also minimize the bit-level ENMPP to the cover image after embedding.

The new method, single mismatch LSB embedding (SMLSB), takes two bits of the secret message at a time and embeds them in a pair of selected pixel values of the cover image. The embedding method always assumes a single mismatch between the 2-bits of the secret message and the LSBs of the selected pair of pixel values. For each 2-bits of the secret message we consider two consecutive pixel values for simplicity. However, the selection could be based on other functions as well.

Since the proposed method embeds 2-bits at a time, there are four cases of having match (M) or mismatch ($\overline{M}$) between the LSBs of the selected two pixel values and the 2-bits of the secret message, as shown in Figure 3.

	LSB
Pixel value 1	M
Pixel value 2	M

	LSB
Pixel value 1	M
Pixel value 2	$\overline{M}$

	LSB
Pixel value 1	$\overline{M}$
Pixel value 2	M

	LSB
Pixel value 1	$\overline{M}$
Pixel value 2	$\overline{M}$

Figure 3. The possible cases of Match/ Mismatch

As the embedding method always assumes a single mismatch (M$\overline{\text{M}}$ or $\overline{\text{M}}$M) between pixel values and secret message bits, the 2nd LSB of the first pixel value should always refer to the index of the mismatch; 1 for M$\overline{\text{M}}$ and 0 for $\overline{\text{M}}$M. If the case is MM, then it changes one of the LSBs according to 2nd LSB of the first pixel value. If the 2nd LSB value was 0, then it flips the LSB of the first pixel value to create $\overline{\text{M}}$M. Otherwise, if it was 1, it flips the LSB of the second pixel value to create M$\overline{\text{M}}$. For the $\overline{\text{MM}}$ case, the embedding will also change one of the LSBs according to 2nd LSB of the first pixel value. But this time, if the 2nd LSB was 0, then it flips the LSB of the second pixel value to create $\overline{\text{M}}$M. Otherwise, if it was 1, it flips the LSB of the first pixel value to create M$\overline{\text{M}}$.

For the other two cases, M$\overline{\text{M}}$ and $\overline{\text{M}}$M, the embedding will be done by changing the 2nd LSB of the first pixel value based on the index of the mismatch. If it was M$\overline{\text{M}}$, then the 2nd LSB of the first pixel value will be set to 1. Otherwise, if it was $\overline{\text{M}}$M, then the 2nd LSB value of the first pixel value will be set to 0. Hence, after each embedding there is only M$\overline{\text{M}}$ or $\overline{\text{M}}$M with the right index in the 2nd LSB of the first pixel value. The embedding algorithm is shown in Figure .

input: two cover pixel values x_1, x_2, and two message bits b_1, b_2
output: stego pixel values y_1, y_2
$y_1 = x_1$
$y_2 = x_2$
if $LSB(x_1) = b_1$ *AND* $LSB(x_2) = b_2$
{
  if $2^{nd} LSB(x_1) = 0$
    $LSB(y_1) = \overline{b_1}$
  else
    $LSB(y_2) = \overline{b_2}$
}
else if $LSB(x_1) \neq b_1$ *AND* $LSB(x_2) \neq b_2$
{
  if $2^{nd} LSB(x_1) = 0$
    $LSB(y_2) = \overline{b_2}$
  else
    $LSB(y_1) = \overline{b_1}$
}
else if $LSB(x_1) = b_1$ *AND* $LSB(x_2) \neq b_2$
  $2^{nd} LSB(y_1) = 1$
else if $LSB(x_1) \neq b_1$ *AND* $LSB(x_2) = b_2$
  $2^{nd} LSB(y_1) = 0$
end

Figure 4. The embedding algorithm of SMLSB embedding

Table 1, shows some examples of the embedding process by the proposed method.

Table 1. Examples of SMLSB embedding process.

Clean pair of pixels	Two message bits	Stego pair of pixels
xxxxxx01 xxxxxxx1	11	xxxxxx0**0** xxxxxxx1
xxxxxx11 xxxxxxx0	10	xxxxxx11 xxxxxxx**1**
xxxxxx01 xxxxxxx1	00	xxxxxx01 xxxxxxx**0**
xxxxxx11 xxxxxxx0	01	xxxxxx1**0** xxxxxxx0
xxxxxx11 xxxxxxx0	11	xxxxxx11 xxxxxxx0
xxxxxx01 xxxxxxx1	10	xxxxxx**1**1 xxxxxxx1
xxxxxx11 xxxxxxx0	01	xxxxxx**0**1 xxxxxxx0
xxxxxx00 xxxxxxx0	10	xxxxxx00 xxxxxxx0

7. ANALYSIS OF SMLSB EMBEDDING

To analyse the proposed LSB embedding, just like other embedding methods mentioned earlier, we consider the embedding process itself (with its embedding efficiency), its effect on the intensity histogram of the image, and the bit-level ENMPP as well.

SMLSB embedding modifies the pixel values based on the match/mismatch cases between LSBs of the selected two pixel values and the 2-bits of the secret message. As it uses the 2nd LSB of the first selected pixel value to refer to the index of the mismatch, it modifies the first pixel value differently from the second one in the selected pair of pixels. The embedding algorithm could be formulated in two separate forms as follows.

$$p_s^{(2i)} = \begin{cases} p_c^{(2i)} + 2 & ,if\ b_{2i} = LSB\left(p_c^{(2i)}\right)\ AND\ b_{2i+1} \neq LSB\left(p_c^{(2i+1)}\right)\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 0 \\ p_c^{(2i)} - 2 & ,if\ b_{2i} \neq LSB\left(p_c^{(2i)}\right)\ AND\ b_{2i+1} = LSB\left(p_c^{(2i+1)}\right)\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 1 \\ p_c^{(2i)} + 1 & ,if\ b_{2i} = \left[LSB\left(p_c^{(2i)}\right) = 0\right] AND\ b_{2i+1} = LSB\left(p_c^{(2i+1)}\right)\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 0 \\ & OR\ b_{2i} \neq \left[LSB\left(p_c^{(2i)}\right) = 0\right]\ AND\ b_{2i+1} \neq LSB\left(p_c^{(2i+1)}\right)\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 1 \\ p_c^{(2i)} - 1 & ,if\ b_{2i} = \left[LSB\left(p_c^{(2i)}\right) = 1\right]\ AND\ b_{2i+1} = LSB\left(p_c^{(2i+1)}\right)\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 0 \\ & OR\ b_{2i} \neq \left[LSB\left(p_c^{(2i)}\right) = 1\right]\ AND\ b_{2i+1} \neq LSB\left(p_c^{(2i+1)}\right)\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 1 \\ p_c^{(2i)} & ,Otherwise \end{cases}$$

$$p_s^{(2i+1)} = \begin{cases} p_c^{(2i+1)} + 1\ ,if\ b_{2i} = LSB\left(p_c^{(2i)}\right)\ AND\ b_{2i+1} = \left[LSB\left(p_c^{(2i+1)}\right) = 0\right]\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 1 \\ \quad OR\ b_{2i} \neq LSB\left(p_c^{(2i)}\right)\ AND\ b_{2i+1} \neq \left[LSB\left(p_c^{(2i+1)}\right) = 0\right]\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 0 \\ p_c^{(2i+1)} - 1\ ,if\ b_{2i} = LSB\left(p_c^{(2i)}\right)\ AND\ b_{2i+1} = \left[LSB\left(p_c^{(2i+1)}\right) = 1\right]\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 1 \\ \quad OR\ b_{2i} \neq LSB\left(p_c^{(2i)}\right)\ AND\ b_{2i+1} \neq \left[LSB\left(p_c^{(2i+1)}\right) = 1\right]\ AND\ 2^{nd}LSB\left(p_c^{(2i)}\right) = 0 \\ p_c^{(2i+1)} \quad ,Otherwise \end{cases}$$

Where i is the index of the secret message bit. The $p_s^{(2i)}$ and $p_c^{(2i)}$ refer to the stego and clean pixel values respectively for the 2i[th] secret message bit embedding. The $p_s^{(2i+1)}$ and $p_c^{(2i+1)}$ are again refer to the stego and clean pixel values used for embedding 2i+1[th] secret message bit.
The possible pixel value changes with SMLSB embedding could be simplified by separating the first $p_s^{(2i)}$ and second $p_s^{(2i+1)}$ pixel values from the selected pair, as shown in Figure 5 and Figure 6.

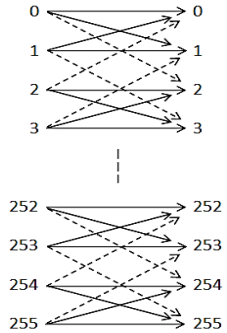

Figure 5. Possible pixel value transitions for $p_s^{(2i)}$ with SMLSB embedding

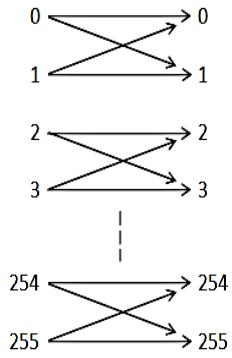

Figure 6. Possible pixel value transitions for $p_s^{(2i+1)}$ with SMLSB embedding

As could be noted from Figure and Figure , the pixel value transitions of $p_s^{(2i+1)}$ are like LSB replacement. While $p_s^{(2i)}$ is more complicated and has more transitions between clean and stego pixel values.

To analyse the impact of the SMLSB embedding on the intensity histogram, again we consider an embedding rate of P. Since the secret message is considered as a random sequence of 0 and 1, based on the fact that it will be close to its encrypted version [37], equal probabilities should be considered for match/mismatch cases. Hence, for each case of $(MM, M\overline{M}, \overline{M}M, \overline{MM})$ the probability of occurrence would be 0.25.

For MM and $\overline{MM}$, the embedding process will change one of the two selected pixel values according to the 2nd LSB of the $p_c^{(2i)}$ to get either $M\overline{M}$ or $\overline{M}M$. The change will be -1 or +1 for the odd and the even pixel values respectively. So, $(P/4)$ of the pixel values will be modified by adding or subtracting 1 according to their values, even or odd values respectively.

However, for $M\overline{M}$ and $\overline{M}M$ there is a probability of having 50% of the 2nd LSB of the $p_c^{(2i)}$ to have the desired value, which needs no change. The other 50% will be modified by flipping the 2nd LSB of the $p_c^{(2i)}$ only. In other word $(P/8)$ of the pixel values will either incremented or decremented by 2 according to their 2nd LSB value. Hence, the remaining $(1 - 3P/8)$ pixel values will stay unchanged after embedding the secret message with the embedding rate of P, which means that embedding each message bit needs 0.375 pixel values to be changed. This ENMPP, 0.375, is better than LSB replacement and LSB matching, which are 0.5 pixels per message bit. Hence, it improves the embedding efficiency from 2 to 8/3 bits per embedding change. The intensity histogram of the stego image could be estimated by the following:

$$h_s(n) = \left(1 - \frac{3P}{8}\right) h_c(n) + \frac{P}{8} \begin{cases} h_c(n+2) & , \text{if } 2^{nd}\ \text{LSB}(n) = 0 \\ h_c(n-2) & , \text{if } 2^{nd}\ \text{LSB}(n) = 1 \end{cases} + \frac{P}{4} \begin{cases} h_c(n+1) & , n \text{ is even} \\ h_c(n-1) & , n \text{ is odd} \end{cases}$$

Where, n is again the greys-cale level valued between 0 and 255. Both $h_s(n)$ and $h_c(n)$ refer to the number of pixels in the stego and clean image respectively with the greyscale value of n.

As only $(P/4)$ of the pixel values are modified like LSB replacement, it is expected to effectively reduce the probability of detection with LSB replacement steganalysis methods. Also, it is expected to reduce the probability of detection by LSB matching steganalysis methods as well, based on the dissimilarity in pixel value transitions and its influence on the intensity histogram after embedding.

The bit-level ENMPP for the proposed method could be calculated based on the match/mismatch cases, in which equal probabilities are considered.

$$\text{bit} - \text{level ENMPP} = \frac{\sum(\text{P}_\text{r}[\text{each case}] \times \text{no. of modified bits})}{2}$$

$$\text{bit} - \text{level ENMPP} = \frac{\text{P}_\text{r}(\text{MM}) \times 1 + \text{P}_\text{r}(\text{M}\overline{\text{M}}) \times 0.5 + \text{P}_\text{r}(\overline{\text{M}}\text{M}) \times 0.5 + \text{P}_\text{r}(\overline{\text{MM}}) \times 1}{2}$$

$$\text{bit} - \text{level ENMPP} = \frac{0.25 \times 1 + 0.25 \times 0.5 + 0.25 \times 0.5 + 0.25 \times 1}{2}$$

$$\text{bit} - \text{level ENMPP} = \frac{0.75}{2} = 0.375 \quad \text{bits per message bit}$$

The bit-level ENMPP is divided by two, as it embeds two bits of the secret message at a time. In this case the overall bit-level ENMPP for the proposed method will be 0.375 bits per message bit. Hence, the proposed method will result in fewer bit-level changes to the cover image after embedding the same amount of secret message.

8. EXPERIMENTAL RESULTS

To make the experimental results more reliable, two sets of images are considered. The first set is 3000 images from ASIRRA (Animal Species Image Recognition for Restricting Access) public corpus pet images from Microsoft research website[38], which are random with different sizes, compression rates, texture ...etc. The other group is a set of 3000 never compressed images from Sam Houston state university – Multimedia Forensics Group image database [39]. Both sets are used after converting them into grey-scale images.

To check the efficiency of the proposed LSB embedding, both detection methods are considered; the LSB replacement and LSB matching steganalysis methods. In all experiments, streams of pseudo random bits are considered as a secret message. This is due to the fact that it will have all statistical properties of encrypted version of the secret message according to[40]. Also, to eliminate the effect of choosing the embedding place (random or sequential embedding), the embedding rate of 1 bit per pixel (i.e. the images' total capacity) is considered. Then it is tested against both LSB replacement and matching steganalysis methods as shown in the following sections.

8.1 SMLSB against LSB replacement steganalysis methods

There are many methods for detecting LSB replacement steganography in the literature, this paper considers two structural steganalysis methods, the Sample Pair (SP) analysis[41] and Weighted Stego (WS)[24]. As mentioned earlier, for each case, the image is loaded with the maximum capacity of the random secret message twice; one with LSB replacement and the other with SMLSB embedding.

The experimental results showed that the proposed method effectively reduce the probability of detection for both detection methods over both sets of images compared to LSB replacement, as shown in Table 2.

Table 2. The overall reduction rates in probability of detection.

Image set	Detection method	The overall reduction in probability of detection
ASIRRA	WS	46.5%
Uncompressed	WS	48.4%
ASIRRA	SP	30.9%
Uncompressed	SP	39.8%

Also, there is a noticeable reduction in probability of detection for the threshold values that suits the LSB replacement by SMLSB embedding as shown in Figures 7-10.

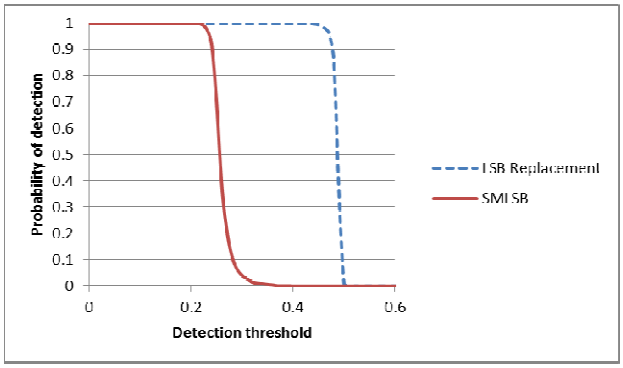

Figure 7. The probability of detection vs. detection threshold for ASIRRA images with WS.

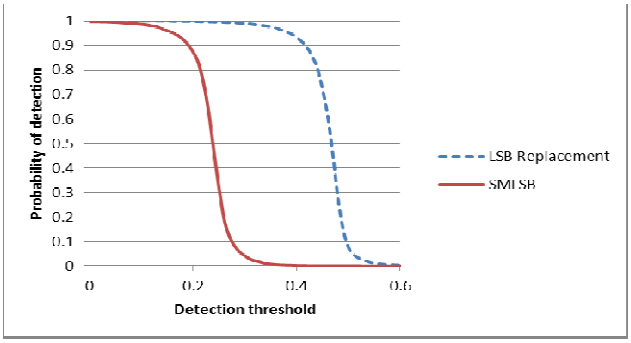

Figure 8. The probability of detection vs. detection threshold for uncompressed images with WS.

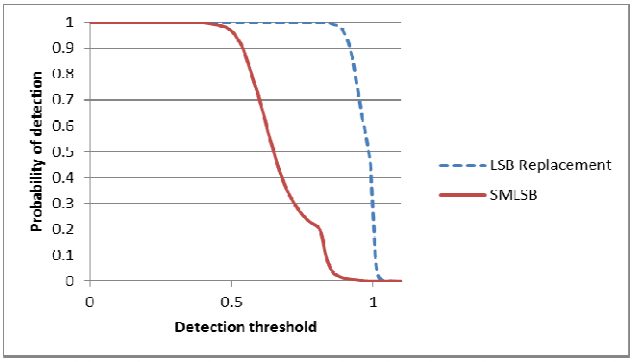

Figure 9. The probability of detection vs. detection threshold for ASIRRA images with SP.

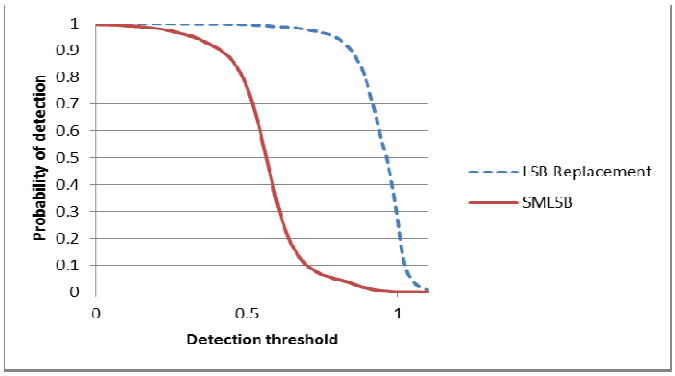

Figure 10. The probability of detection vs. detection threshold for uncompressed images with SP.

8.2 SMLSB against LSB matching steganalysis methods

As mentioned earlier, there are two main categories of LSB matching steganalysis methods. In this paper we use one detection method in each category. For the centre of mass of the histogram characteristic function (HCF-COM) we used Ker's method in[27], and for the amplitude of local extrema we used the method proposed by Zhang et al.[29].

The proposed method, SMLSB, outperforms both LSB matching and LSB matching revisited [4] embedding methods in terms of detection. Figures 11-14, show the ROC graph for each group of images with two different detection methods. As could be noticed from Figures 11 and 12, the ALE based steganalysis method is no more than a random classifier for the stego images embedded with SMLSB. Also, the performance of the HCF-COM based steganalysis method is considerably reduced by applying the SMLSB embedding method, as shown in Figures 13 and 14.

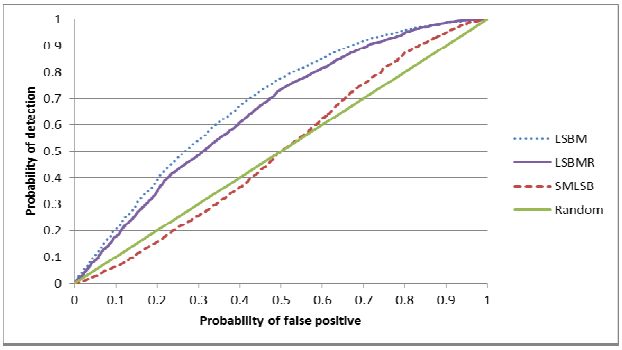

Figure 11. ROC graph of ALE steganalysis for LSB matching, LSB matching revisited, and SMLSB for ASIRRA images.

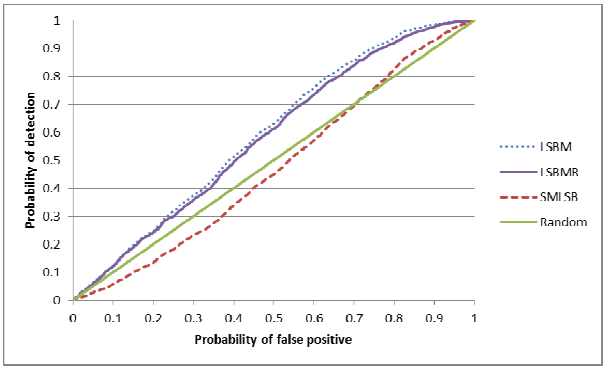

Figure 12. ROC graph of ALE steganalysis for LSB matching, LSB matching revisited, and SMLSB for Uncompressed images.

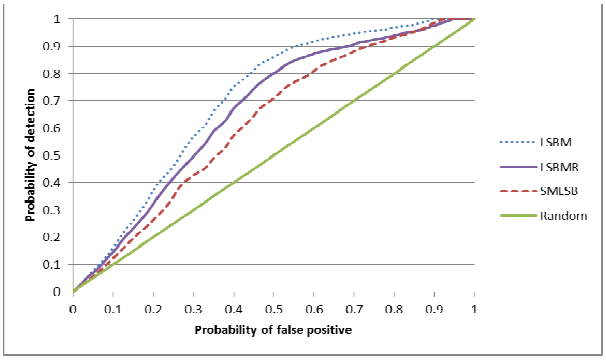

Figure 13. ROC graph of HCF-COM steganalysis for LSB matching, LSB matching revisited, and SMLSB for ASIRRA images.

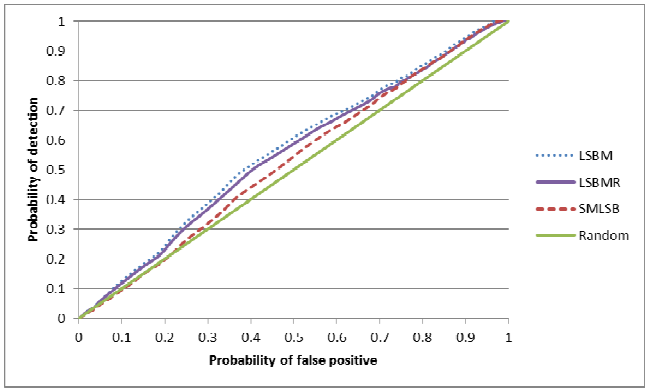

Figure 14. ROC graph of HCF-COM steganalysis for LSB matching, LSB matching revisited, and SMLSB for Uncompressed images.

Like any other steganography methods, the SMLSB cannot avoid all limitations and cannot totally defeat the detection methods. As could be noticed from Table 2 and Figures 7-14, it is not possible to entirely avoid the detection. Also, there is another weakness regarding the image quality measurement PSNR (Peak Signal to Noise Ratio) between the cover and a stego image. The proposed method results in a slightly lower PSNR than other methods; LSB replacement, LSB matching and LSB matching revisited, which is imperceptible and still very far from the lower limit value of PSNR (38 dB) according to [42, 43].

Table 3 shows the PSNR values for some standard images after embedding random binary streams with a maximum capacity using different embedding methods.

Table 13. PSNR values vs. embedding methods.

Images	LSB Replacement	LSB Matching	LSB Matching Revisited	SMLSB
Lena	50.88	50.88	52.13	49.12
Pepper	50.17	50.17	51.41	48.42
Baboon	50.28	50.28	51.53	48.52

9. EXTRACTION PROCESS

The extraction process is very simple, let $s_1 s_2$ denote the least significant bits of the first and second selected pixel values respectively. It looks at the 2nd LSB of the first pixel value in the pair of pixels. If it is 0, then the LSBs of the pair of pixels would be extracted in the form of $\bar{s_1} s_2$ as two secret message bits, since, in this case, the mismatched LSB is in the first pixel value. If, on the other hand, it is 1, then it takes $s_1 \bar{s_2}$ as an extracted message bits. Table 4, shows all different cases of extraction process.

Table 4. The extraction process.

The stego images pixel pair	Extracted message bits
$xxxxxx0s_1$ $xxxxxxxs_2$	$\bar{s_1} s_2$
$xxxxxx1s_1$ $xxxxxxxs_2$	$s_1 \bar{s_2}$

Table 5, shows some examples of message bits extracted from stego pixel values.

Table 5. Examples of SMLSB extraction process.

The stego images pixel pair	Extracted message bits
xxxxxx01 xxxxxxx1	01
xxxxxx00 xxxxxxx1	11
xxxxxx11 xxxxxxx1	10
xxxxxx10 xxxxxxx1	00

10. CONCLUSION

In this study, we have shown that the proposed SMLSB method can improve the embedding efficiency in compare to LSB replacement and LSB matching from 2 to 8/3 and reduce the probability of detection by the two LSB steganalysis methods; LSB replacement and LSB matching. It also leaves a higher rate of pixel values unchanged for embedding the same amount of secret messages compared with other two LSB steganography methods. Moreover, the proposed method outperforms the LSB matching revisited, which has the same embedding efficiency, in terms of detection. Also, it can be applied to any pixel without restricting the saturated values (0 and 255). All embedding methods are analysed in detail including SMLSB and highlighted the cause of reducing the probability of detection. As could be noticed, the

proposed method is very simple to implement with no complex calculation, less bit-level ENMPP on the cover image, and no reduction in the embedding capacity compared to other two LSB steganography methods, LSB replacement and LSB matching.

Finally, reducing the probability of detection by LSB replacement steganalysis methods is limited and the new method cannot totally avoid it. Also, it results in slightly more distortion in comparison to LSB replacement and LSB matching methods. As future work, it might be possible to modify the proposed method to give lower probability of detection and lower ENMPP for the same message length.

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ROBUST AND REAL TIME DETECTION OF CURVY LANES (CURVES) HAVING DESIRED SLOPES FOR DRIVING ASSISTANCE AND AUTONOMOUS VEHICLES

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ABSTRACT

One of the biggest reasons for road accidents is curvy lanes and blind turns. Even one of the biggest hurdles for new autonomous vehicles is to detect curvy lanes, multiple lanes and lanes with a lot of discontinuity and noise. This paper presents very efficient and advanced algorithm for detecting curves having desired slopes (especially for detecting curvy lanes in real time) and detection of curves (lanes) with a lot of noise, discontinuity and disturbances. Overall aim is to develop robust method for this task which is applicable even in adverse conditions. Even in some of most famous and useful libraries like OpenCV and Matlab, there is no function available for detecting curves having desired slopes, shapes, discontinuities. Only few predefined shapes like circle, ellipse, etc, can be detected using presently available functions. Proposed algorithm can not only detect curves with discontinuity, noise, desired slope but also it can perform shadow and illumination correction and detect/ differentiate between different curves.

KEYWORDS

Hough Probabilistic Transform, Bird eye view, weighted centroids, mean value theorem on Hough lines on curve, clustering of lines, Gaussian filter, shadow and illumination correction

1. INTRODUCTION

Nowadays, one of the biggest topics under research is self-driving vehicles or smart vehicles which generally based on GPS synchronization, Image processing and stereo vision. But these projects are only successful on well-defined roads and areas and it is very hard to localize vehicles in real time when lanes or boundaries of roads are not well defined or have sharply varying slopes, discontinuities and noise. Even in some of most famous and useful libraries like OpenCV and Matlab, there is no function available for detecting curves of desired slopes, shapes, discontinuities. Only few predefined shapes like circle, ellipse, etc, can be detected using presently available functions. Using color thresholding techniques for detecting lanes and boundaries is very bad idea because it is not a robust method and will fails in case of discontinuity of lanes, shadow/illumination disturbances and noise present on roads.

For proper localization of a vehicle in between the desired region of interest (like between lanes or boundaries), it is very important to detect lanes and boundaries efficiently and it is also

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important to develop feedback algorithm for auto correction of vehicle motion in synchro with varying slopes of lanes or boundaries. It is also very important to avoid confusion due to multiple lanes or shadow/illumination disturbances and noises which have similar features as lanes or boundaries.

For solving all the above mentioned problems, we developed algorithm which is combination of four important algorithms, out of which two algorithms are new and unique and very efficient. Four algorithms are:

1) Dissection of curves into large number of Hough lines (called Curve stitching) and then implementing Mean value theorem using weighted centroids to keep track of curves which works well in adverse conditions like discontinuous curves (lanes).
2) Differentiating various curves (lanes) based on slope of curves. This helps in developing algorithm for tracking varying slopes of lane and develops efficient feedback system for proper localization in between roads.
3) Clustering of Hough lines to avoid confusion due to other lane type noises present on road.
4) Shadow, illumination correction and noise filters implemented on HSV color frame.
5) Feedback algorithm to continuously compare parameters (road texture) of current image frame with previous frame of image to decide boundaries in case of missing lanes or well defined boundaries.

All the above algorithms are described below one by one.

2. Dissection Of Curve Into Infinite Hough Lines (Curve Stitching) To Implementing Mean Value Theorem Using Weighted Centroids.

Curve stitching is process of making curves and circles using straight lines. This means that a curve can be made using large number of tangent straight lines as shown in the figure 1.

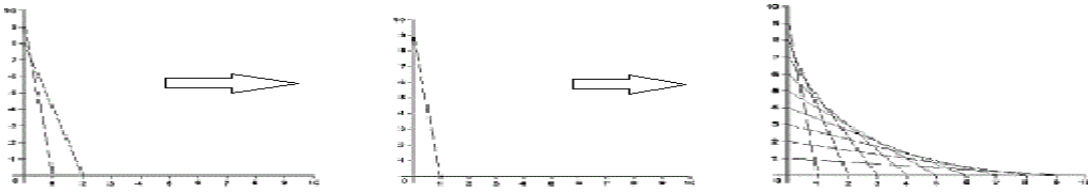


Fig1. (a) curve made up of large number of straight lines-Curve stitching

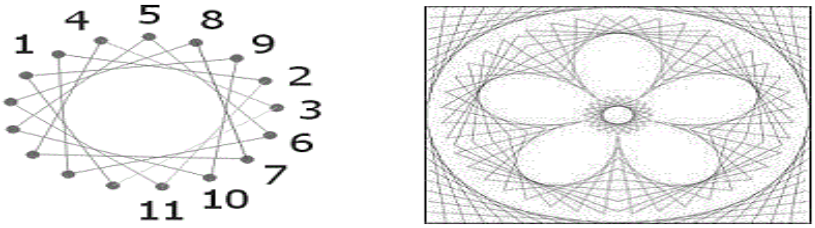


Figure 1.(b) Circle and other complex curves made up of straight line

So taking advantage of this feature, curve detection can be done. Even it can also detect curves having particular range of slopes of tangents lines. I have used Hough lines transform to detect lines which are involved in making the curve. This is done by setting parameters of Hough transform to appropriate values. There are two types of Hough transform:

1) The Standard Hough Transform and
2) The Probabilistic Hough Line Transform.

The Standard Hough Transform returns parameters of detected lines in Polar coordinate a system, which is in a vector of couples (θ, r_θ).

The Probabilistic Hough Line Transform more efficient implementation of the Hough Line Transform. It gives as output the extremes of the detected lines (x_0, y_0, x_1, y_1). It is difficult to detect straight lines which are part of a curve because they are very very small. For detecting such lines it is important to properly set all the parameters of Hough transform. Two of most important parameter are: Hough votes and minimum distance between points which are to be joined to make a line. Both of the parameter are set at very less values. Once all the lines which are tangents to the given curve are detected and stored in a vector variable, next step is to find slopes of all these lines by solving equation (1) and (2).

$$y = \left(-\frac{\cos\theta}{\sin\theta}\right)x + \left(\frac{r}{\sin\theta}\right) \tag{1}$$

$$r_\theta = x_0 \cdot \cos\theta + y_0 \cdot \sin\theta \tag{2}$$

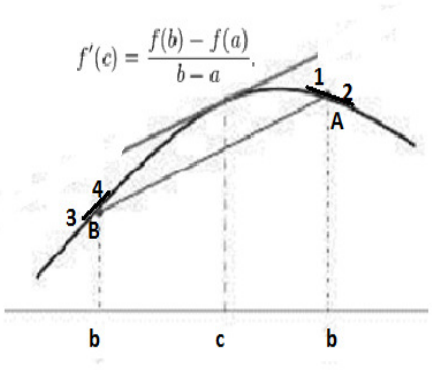
But when this algorithm was tested, it was found that curves are not detected smoothly and a lot of deviation was present. So for solving this problem, one more algorithm is applied to above algorithm.

This algorithm is based on MEAN VALUE THEOREM.

Statement of MEAN VALUE THEOREM: For f: [a, b] → R be a continuous function on the closed interval [a, b], and differentiable on the open interval (a, b), where a < b. Then there exists some c in (a, b) such that

$$f'(c) - \frac{f(b) - f(a)}{b - a}. \tag{3}$$

$$\lim_{h \to 0} \frac{f(x+h) - f(x)}{h} \tag{4}$$



- Points 1, 2 , 3, 4 lies on the curve.
- Distance between points 1, 2, 3, 4 is very less.
- 'A' represents Hough line made by joining points '1' and '2'.
- 'B' represents Hough line made by joining points '3' and '4'
- Point 'a' represents centroid of line segment 'A'
- Point 'b' represents centroid of line segment 'B'
- 'c' is point obtained after applying Mean Value Theorem on points 'a' and 'b' which are centroids of line segment A and B.
- Point 'c 'will give a line which is tangent to the curve. Therefore from two Hough lines (which are part of the curve) are used to find one tangent of the curve

figure 3. Implementation of mean value theorem on curve using centroids of Hough lines (very small line segments on curve)

In this algorithm, two very small Hough lines are taken on the curve as shown in the figure 3, then weighted centroids of these Hough lines are calculated. These centroids are input to the formula of Mean Value Theorem which returns the slope of tangent at point 'c'. In this way,

iterative implementation of above mentioned steps will give many tangents of the curve which provides very efficient tracking of curve in real time as shown in the figure 4(a) and 4(b). The biggest advantage of this algorithm is that it is not dependent on color thresholding techniques because applying color thresholding methods are not robust and may fail in adverse conditions.

Even in the case where there are many curves of similar slope characteristics in the same frame, this algorithm can be used to filter out the single desired curve (discussed in the section4). In the section 3, implementation of the above algorithm is shown and explained.

figure 4(a). Birdeye view of detected curvy lanes using mean value theorem on centroids of Hough lines on curve without color thresholding. Noise filter and shadow/illumination correction is also applied here.

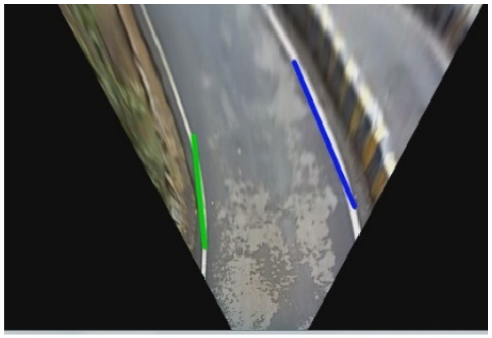


figure 4(b). Birdeye view of detected curvy lanes using mean value theorem on weighted centroids of Hough lines on curve without color thresholding. Noise filter and shadow/illumination correction is also applied here.

3. DIFFERENTIATING VARIOUS CURVES USING SLOPES OF HOUGH LINES

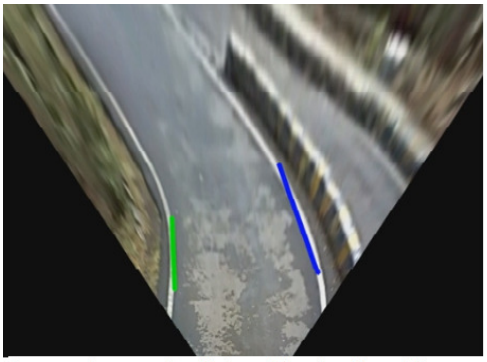


figure 5. Bird eye view of result obtained from algorithm to differentiate various curves using slopes of tangents (from mean value theorem)

- The figure 5 shows Result of the algorithm for differentiating two lanes by using slopes of the tangents(Obtained by implementing Mean Value Theorem on small Hough lines present on the curves).
- Blue colored line represents lane which have angle in range: 90 degrees to 120 degrees.
- Green color represents lane which have angle between 60 degrees to 90 degrees.
- The slopes of tangents are calculated using algorithm mentioned in section 1. For finding out slope accurately, distance between the points of a hough line is reduced to very small value, that is limit tending to zero.

$$f'(c) = \frac{f(b) - f(a)}{b - a}. \quad \Rightarrow \quad \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$$

- This algorithm also works well in case of multiple lanes or curves covering 0 to 180 degrees of slopes.

For detecting curves of desired slopes, the slopes of the tangents (randomly selected Hough lines on desired curve) of the desired curve are stored in a vector 'A'. During run time detection, the vectors of slopes of tangents of all the curves present in the view are compared with the initially saved vector 'A' (containing slopes of tangents of desired curve). If matching process is 90% successful then desired curve is recognized. The storing and matching of vector takes place in one particular direction (left to right) which means that vector will store slopes of the tangents staring from leftmost point of the curve and similarly matching process starts from the leftmost point of the other curves. So for detecting multiple curves in one frame, more than one vectors can be initialized for matching process and more than one curves can be detected in one frame.

Figures 5(a) given below shows how one particular curve is extracted out from many curves present in single frame by using above method. The slopes of the tangents of the first curve are

stored in the vector which is then compared one by one from all the curves and resultant output window will only contain the curve whose slope vector matches with the original vector.

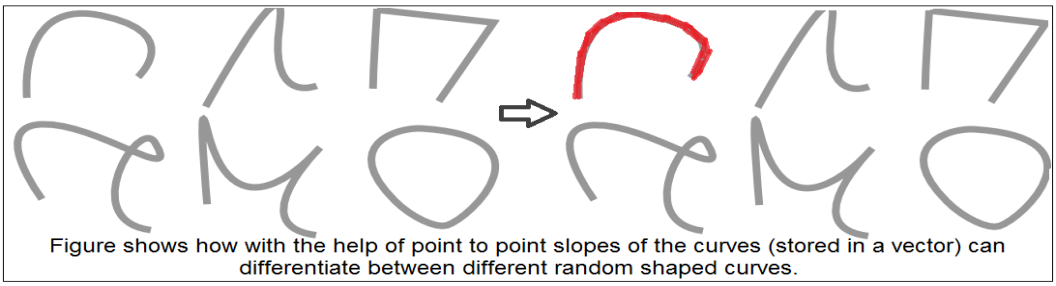


Figure 5(a)

Figure 5(b) shows how some standard curves like parabola, ellipse, circle and hyperbola can be separately detected by implementing above algorithm.

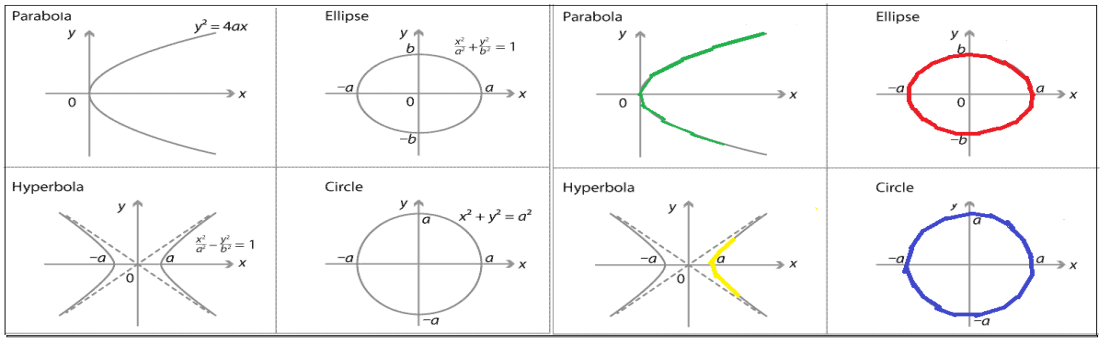


Figure shows how with the help of slope pattern recognition, different standard curves can be seperated out.

Figure 5(b)

So by implementing this algorithm, any type of curve can be detected by storing its slopes (tangents angle) in a vector and then matching it with the subjected curves.

Above given algorithm may also face some problems which may result in incorrect results. Noise and other similar smaller curves are the main reason for wrong results. For example if desired curve to be detected is ellipse, and there are many ellipse present in one frame. In such situation, when algorithm for extracting is applied then the original slope vector of the desired curve may get successfully matched with many ellipse and therefore many such ellipses may be present in the output window. But we want only one ellipse out of so many ellipses. Therefore it is very important to remove these problems to get accurate results. For solving these problems, we used important concepts called clustering of Hough lines, weighted centroid and slope filtering. These concepts and their implementation is described below in section 4. The next section explains the concept of CLUSTERING OF HOUGH LINES USING WEIGHTED CENTROIDS AND ANGLE FILTERING TECHNIQUE.

4. CLUSTERING OF HOUGH LINES USING WEIGHTED CENTROIDS AND ANGLE FILTERING TECHNIQUE

Apart from desired curves, there may be some other curves with insignificant dimensions and noise present in the region of interest. These small curves and noise may cause serious problem in curve detection and may result in wrong results. To avoid this problem, we used concept of clustering of Hough lines. Clustering of Hough lines means grouping the significant Hough lines together to get more accurate results. This is done by using concept of weighted centroid and angle filtering.

The concept of ‘weighted centroid’ is different concept then ‘centroid’ (see in figure 7(a)). 'Weighted Centroid' uses the pixel intensities in the image region as weights in the centroid calculation. With 'Centroid', all pixels in the region get equal weight (see in figure 7(b)).

$$Centroid = \frac{\sum_{n=0}^{N-1} f(n)\, x(n)}{\sum_{n=0}^{N-1} x(n)}$$

figure 7(a): Weighted centroid, here f(n) is pixel intensity and x(n) is position of corresponding pixel

$$\mathbf{C} = \frac{\mathbf{x}_1 + \mathbf{x}_2 + \cdots + \mathbf{x}_k}{k}$$

figure 7(b): Centroid, here x(k) is position of pixel and its intensity is not taken into account.

So if two Hough lines(on curve) are having there weighted centroids very near and there angles are approximately(within certain range) equal then these lines can be replaced by the single line having its weighted centroid at center of individual weighted centroids and its angle equals to average of individual angles. So for detecting desirable curve and remove small curves/noise, a parameter ‘vote’ is used.

The parameter ‘vote’ is an integer number representing total number of lines which are having their weighted centroids close enough and their slopes approximately equal. If this parameter ‘vote’ is above certain threshold value, then the corresponding Hough lines are considered as part of the desirable curve, else all these lines are rejected. The threshold value for the parameter ‘vote’ can be set according to the condition. It can be seen in figure 8(a) that there are large number of Hough lines on curve (lane) as well as outside the curve (lane). On applying above algorithm, result can be seen in figure 8(b), where only single lines are there corresponding to each curve (lane), which means that all the lines due to noise and small curves were removed.

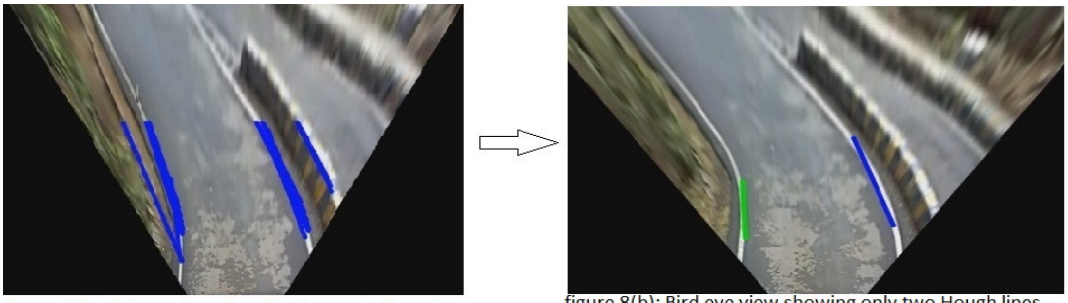


figure 8(a): Bird eye view showing large number of Hough lines on curves (lanes) as well as outside the curve (lane) due to the noise and small curves

figure 8(b): Bird eye view showing only two Hough lines corresponding to each curve (lane). Problems due to noise and small curves were removed by using weighted centroid and slope filtering algorithms

In the figure given below, there are many ellipses which have same slope (tangent) vectors and thus if algorithm mentioned in section 2 and 3 are applied then all the ellipses may be visible in the output window. Therefore, along with the algorithms mentioned in section 2 and 3, the algorithm mention in section 4 is applied simultaneously. After applying all these algorithm together, only one ellipse is extracted out which have thickest boundaries and all the other small or bigger ellipses are rejected from the output window.

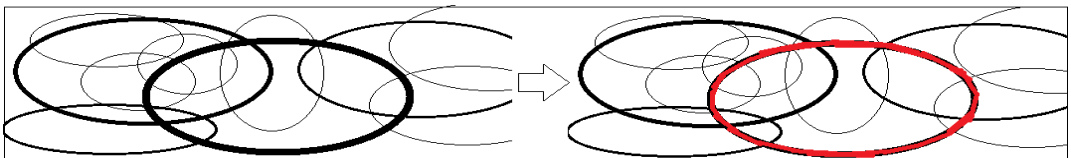


Figure shows implementation of "CLUSTERING OF HOUGH LINES USING WEIGHTED CENTROIDS AND ANGLE FILTERING TECHNIQUE" to detect the desired (thickest) curve and filter out other curves.

5. CONTINUOUS FRAME FEEDBACK ALGORITHM FOR DETECTING DISCONTINUOUS CURVES (LANES) AND SHADOW / ILLUMINATION CORRECTION

In case of discontinuous curve, it is difficult to continue tracking of a curve after even a small discontinuity. For solving this problem, we develop a feedback algorithm which compares the various parameters of previous video frame with current image frame. These are some important parameter which helps to localize the vehicle in between the lanes even in case of discontinuous lanes or absent boundaries. This feedback system is based on three parameter texture analysis, distance analysis and shadow/illumination correction. So the Frame feedback means continuous comparison of current image parameters like texture, distance (perspective vision) with the previous frame of the video feed and fill the discontinuities.

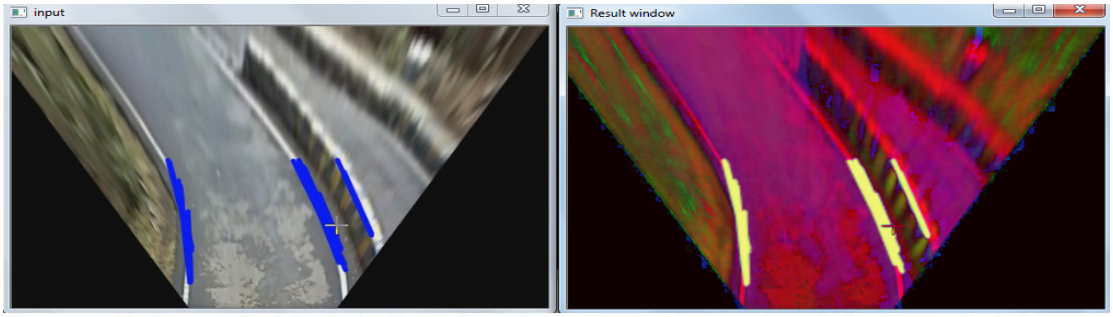


figure 9: In this figure, Result window is showing HSV image frame with noise, shadow and illumination filters. It also includes texture analysis and perspective vision (Bird eye view) .

Analysis of each algorithm: "Shadow/illumination, distance analysis and texture analysis" is discussed one by one below:

DISTANCE ANALYSIS: This is done by using perspective vision, that is by converting normal image frame to bird eye view. This is done for finding out the relation between size of a pixel in a image and real world distance (for example: 10 pixel = 1cm). This helps in localizing the vehicle in between the lanes.If some discontinuity occurs in the lanes, then system automatically maintain the distance according to the parameters obtained from previous image frame. For example in case of curvy lanes, slope of lane can be used by the vehicle to move in particular direction and follow the lanes approximately. But this method is only valid for small discontinuity and if some big discontinuity is present in the lanes then this algorithm may fail. The implementation of this algorithm is shown in the figure 10.

TEXTURE ANALYSIS AND SHADOW/ILLUMINATION CORRECTION: Texture analysis might be applied to various stages of the process. At the preprocessing stage, images was segmented into contiguous regions based on texture properties of each region; At the feature extraction and the classification stages, texture features could provide cues for classifying patterns or identifying objects. As a fundamental basis for all other texture-related applications, texture analysis seeks to derive a general, efficient and compact quantitative description of textures so that various mathematical operations can be used to alter, compare and transform textures. Most available texture analysis algorithms involve extracting texture features and deriving an image coding scheme for presenting selected features.

Figure 10(a) shows the desired curve which is required to be extracted from the live input frame. Figure 10(b) shows the same curve but with many discontinuities. Now the algorithms discussed in previous section will not work properly because of so many discontinuities. Therefore the continuous frame feedback is used to join the discontinuities. So the Frame feedback will

continuous compare current image parameters with the previous frame of the video feed and fill the discontinuities.

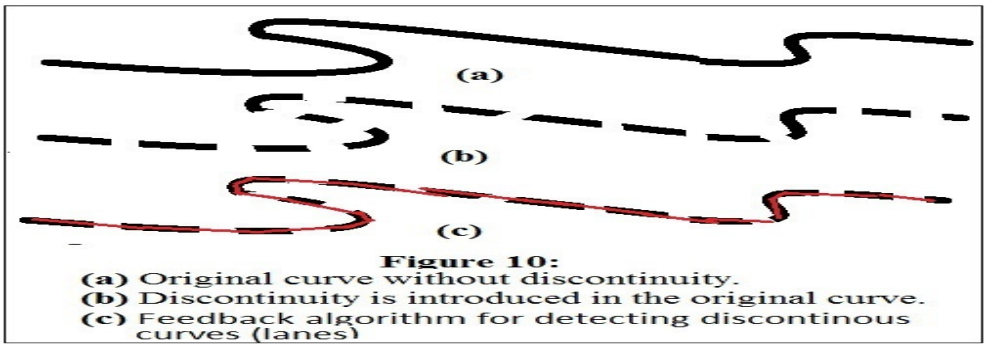
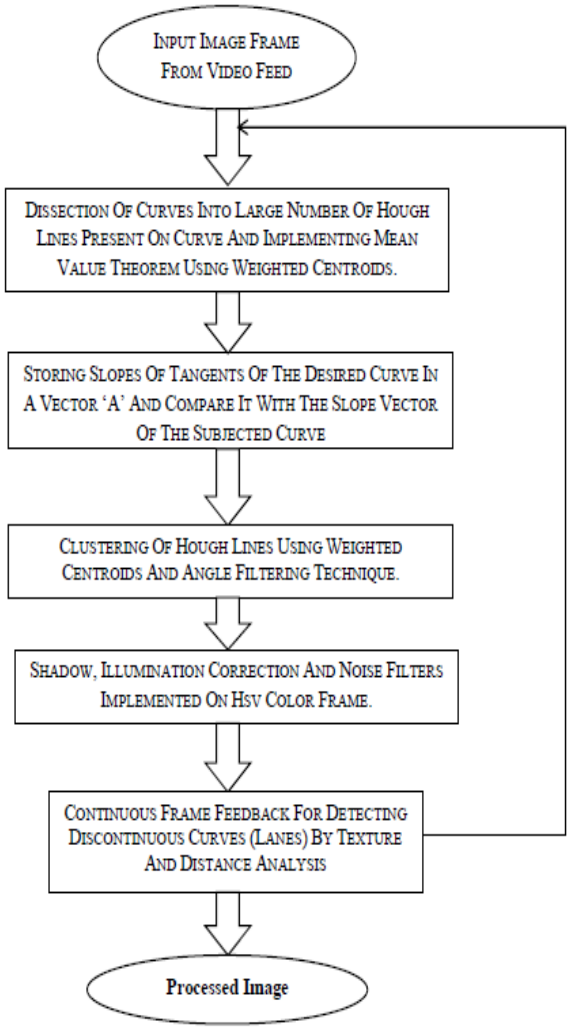


Figure 10:
(a) Original curve without discontinuity.
(b) Discontinuity is introduced in the original curve.
(c) Feedback algorithm for detecting discontinous curves (lanes)

6. FLOWCHART



Flowchart showing combinations of the entire algorithms explained above.

7. CONCLUSION

In this paper we have presented new, unique and robust algorithm for detecting any type of curve (curvy lanes) with the help of tangents of the curve. This algorithm is applicable even in adverse conditions. This algorithm provides a general method to detect any curve with desired slopes. First we dissect the curves into infinite Hough lines (called Curve stitching) and then by applying various algorithm on these Hough lines , we developed a robust algorithm to detect any curvy lanes (or in general: any curves). The implementation of concepts like mean value theorem, clustering of Hough lines, weighted centroids, bird eye view (perspective vision), slope filtering, shadow and illumination correction provides very accurate and efficient algorithm for curvy lane detection or curve detection with desired slopes. I again like to mention that famous libraries like OpenCV, Matlab are only providing functions which are able to detect some standard curves, but this algorithm provides unique feature of detecting any curve having desired range of slopes. Also, this algorithm reduces effect of noise, other small curves, shadow/illumination to great extent. These algorithms can be implemented on autonomous vehicle for robust lane detection and it can also be used in normal vehicle for speed control feedback system to avoid fatal curves on roads. This algorithm can also be used for general purpose curve detection in various image processing applications.

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AUTHOR

Amartansh Dubey

It is evident form past that most of the innovations due to electronics and computer science were never dreamt by common men. I mean no one ever imagine that mobiles, TV, 3G, nanomites, sixth sense technology, brain to brain communication, VLSI (few vaccum tubes to millions of transistors on single chip) could ever come to reality and such innovations inspire and motivate me alot, as a result when most of my friends are dreaming about good jobs and salary, i dream about publishing great research papers, becoming part of TED, MS from places like USA, EUROPE, etc. When i developed autonomous turret (autonomous weapon on wheels), smart wheelchair for paralyzed people, smart sevo motor, FM signal field strength detector, Image processing algorithms for autonomous vehicles, i realised that i with electronics could contribute to my society and may be one day i will become part of some great innovation. Visit my blog for more details : htttp://electronportal.blogspot.in/

I want to be part of some great research and innovation. Sadly, here in indian society education is primarily job and salary driven, research always comes second which leaves india far behind in electronics. For motivating my juniors in research, i have started making some very useful tutorials which can be seen on my blog http://electronportal.blogspot.in/. Apart from all these reasons, most important reason for my interest in electronics is level of satisfaction i get in this field. I simply just love electronics and very much passionate about it. Ultimate aim of my life is to become part of some great innovations and research

MEDICAL IMAGE SEGMENTATION BY TRANSFERRING GROUND TRUTH SEGMENTATION BASED UPON TOP DOWN AND BOTTOM UP APPROACH

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ABSTRACT

In this paper, we present a novel method for image segmentation of the hip joint structure. The key idea is to transfer the ground truth segmentation from the database to the test image. The ground truth segmentation of MR images is done by medical experts. The process includes the top down approach which register the shape of the test image globally and locally with the database of train images. The goal of top down approach is to find the best train image for each of the local test image parts. The bottom up approach replaces the local test parts by best train image parts, and inverse transform the best train image parts to represent a test image by the mosaic of best train image parts. The ground truth segmentation is transferred from best train image parts to their corresponding location in the test image.

KEYWORDS

Shape matching, Hausdorff distance, affine transformation, Medical image segmentation, simulated annealing optimization

1. INTRODUCTION

Image segmentation is an essential topic in the field of the image processing. The segmentation is to highlight the object of interest in the image. The image segmentation provides the meaningful information about an object in an image which can be further used in the different application like face recognition, motion tracking and many more. As in the medical field, image segmentation plays an important role. The medical image segmentation is still a difficult problem due to poor contrast, noise and imaging artifacts. In the medical images, sometimes the boundaries of anatomical parts are not clearly visible. To obtain good segmentation of anatomical parts, various properties of images should be considered like intensity distribution, prior knowledge of shape.
In this paper, we solve the problem of segmentation of the hip joint structure in the MR images of the pelvic region of human. The abnormality of shape in the hip joint structure is called fermoacetublar impingement (FAI). The hip joint structure is the ball and socket joint. The ball is femur and socket is acetabulum. The abnormal shape of femur and acetabulum causes the lot of friction. Thus, the result is the damage of cartilage of femur or acetabulum in the hip joint [1] [2]. The FAI can be cured by medical surgery. For the treatment of FAI, medical practitioner

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performs the extraction of the hip joint manually. The boundaries of hip joint give the proper understanding of abnormality of structure.

Several techniques have been developed for medical image segmentation. The results are not accurate enough, so medical experts correct the results for medical surgery. In this paper, we propose the novel method to transfer the ground truth segmentation from the database to the MR image of another patient. The ground truth segmentation is manual segmentation done by the medical experts. The algorithm is based on the top down approach to match the test image globally and locally over the database images in order to find the best train image for each of the local part of test image. The bottom up approach assembles all the best train parts that are obtained from top down approach to represent the test image by the collection of train image parts. The ground truth segmentation is transferred from train image parts to test image at the respective location.

2. RELATED WORK

The different techniques have been developed for medical image segmentation over the years. The medical image segmentation has been difficult task due to poor contrast, noise, intensity variation and not clear understanding of boundaries of the parts in the image. The popular techniques for image segmentation are based on the intensity of the pixels. The pixel with similar gray scale values are considered as a region based upon the constraints. The region growing, merging and splitting methods are region based image segmentation [4]. The region growing method needs the initial seed point to start segmentation process. The method compares the initial seed point with other neighbouring pixels to merge into one region. This is an iterative process [4] [7]. The other techniques, the region merging and splitting are divided into two stages. First, the region splitting involves the decomposition of the image into a number of regions based on some criteria. Second part of the process involves the merging of decomposed parts. The merging of regions is the searching and aggregation process into similar regions [7]. As both methods have their advantages and disadvantages. As in [14], the region growing and region merging is combined for the ultrasound medical image segmentation. The combination of different approach like genetic algorithm, gradient based methods, wavelet processing, morphological methods with region growing and merging used for better initial condition to start the segmentation of medical image segmentation [13] [10].

The model based approach uses the prior knowledge for the segmentation of the object. The approach makes benefit of prior model to get the approximation of the object to be expected in the image. The top down strategy deform the model to fit with the data in the image. The model deformation is done by different methods. The active contour techniques so called snake uses energy minimization technique to deform the model [12]. The method is based on two energy function, internal and external energy. The internal energy keeps the closer to the prior model and gives smoothness to the curve. The external energy moves model towards salient features of image. The total energy is the summation of internal and external energy. The minimization of total energy results the segmentation of image. There is different version of snakes like gradient field snake [16], level set approach based on Mumford shah model [17]. The statistical model based on training set of shape that we want detect in the image. The training set consists of images of changing shapes that we want to detect in the image. The deformation of the model is obtained by the statistical properties of large number of shapes in the training set. The methods use only the shape constraint is called active shape model based segmentation [8] [9] [11] and the method uses the shape and image information like texture, salient feature is called active appearance model. The small training set of shapes causes the segmentation problems like holes in the final segment, over segmentation and many more.

In the field of medical image analysis, the object recognition and boundary detection of the organ in a medical image is very important to delineate their shape. For a proper segmentation, it is important to segment the local and global parts of the object. The top down approach gives a global detection and bottom up approach start from a low level and the results the object shape. Both the approach has their own importance, without the global detection, it is difficult to get proper local structural information. The prior model is used for searching the object in the image. The model is transformed to find similarity with objects in the image [3] [15]. After the global detection, the local structure matching is important to get acceptable segmentation. As in [6], the local part based template matching is used for human detection and segmentation.

The medical image segmentation is obtained from existing algorithms still corrected by the expert people. We develop the novel method to transfer the expert people segmentation by the shape matching algorithm based on the hausdorff distance to extract the boundaries of hip joint structure in the MR image of the pelvic region.

3. METHODOLOGY

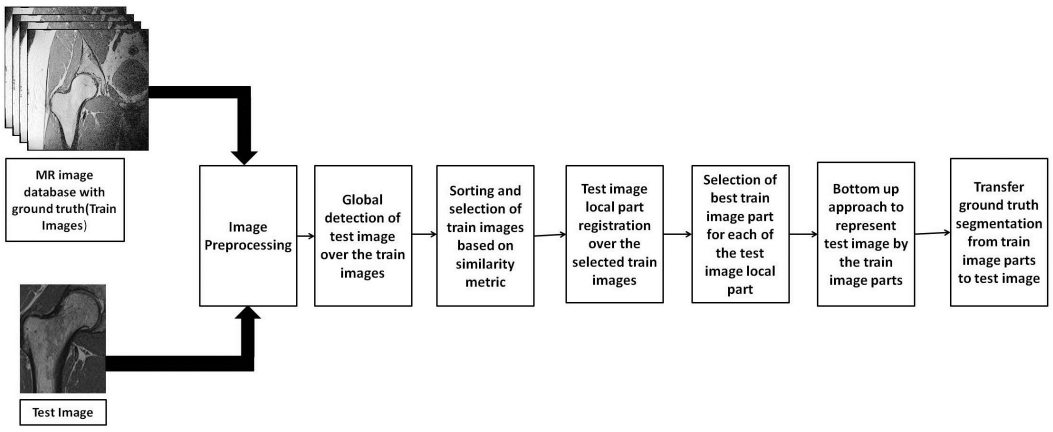


Figure 1: Workflow of the system

The method is the top down approach for shape matching based on the hausdorff distance of test image with train images and bottom up strategy to represent the test image from the collection of best train image parts. So, the ground truth segmentation can be transferred to test image.

3.1. Hausdorff distance

The hausdorff distance is the metric to measure the degree of mismatch between two shapes of images. The hausdorff distance is max-min distance between the two sets of points. To calculate the distance between two images, the boundaries are extracted from both test and train image. The edge image represents the set of points for test and train image. Given a test image *A* and train image *B*, the hausdorff distance is defined as

$$H(A,B) = \max(h(A,B), h(B,A)),$$

Where

$$h(A,B) = max_{a \in A} \min_{b \in B} \|a - b\| ,$$

The *h (A,B)* is the directed Hausdorff distance. It is defined as by considering every point of *A*, calculating the distance from that point to the closest point of *B* and evaluate the maximum

among them [3]. The hausdorff distance is sensitive to the noise and outliers. The hausdorff distance is modified to fix this problem. The parts of shapes are compared. The directed partial hausdorff distance is defined as

$$h_k = K^{th}_{a \in A} \min_{b \in B} \|a - b\|$$

,

Where $K^{th}_{a \in A}$ denotes the *K*th ranked value among the measured distances. The every point of A, calculate the distance from that point to the closest point of B and then points of B are sorted according to their distances and the *K*th value will indicate the *K* of the model point of A is within the distance of d with some points of A.

The partial hausdorff distance gives bad results with corrupted data; we need more a robust measure to solve the problem with corrupted data. The least trimmed square (LTS-HD) hausdorff distance is robust measure. It is defined by the linear combination of order statistics. LTS hausdorff distance is defined as

$$h_{LTS}(A, B) = \frac{1}{k} \sum_{i=0}^{k} min \|a - b\| (i)$$

Where *k* is *K=f.N*, the N is the number of points in the chunk of A. We used LTS-HD as a similarity metric to detect test image model in the database of train images [5].

3.2. Simulated annealing optimization

The simulated annealing is the search algorithm which finds the optimal solution in the search space. It is based on the probabilistic method to find the global optimum solution of the function in the given search space. The algorithm is influenced by the annealing process of the metal in the thermodynamics. The annealing process heats up the metal at high temperature to excite the molecules of the metal. At high temperature, it is possible to change the structure of the metal. The metal undergoes through the cooling process to obtain new physical structure. The temperature is reduced gradually to obtain the desired structure of the metal. The temperature is kept as a variable to simulate the heating and cooling process. The initial temperature and random solution are important parameters to start the algorithm [3]. When the algorithm is at high temperature, it will accept the more solution. This step will avoid the local optimum solution as it comes along the path of finding a global optimum solution. The temperature of the system is reduced gradually to work on the limited solution. The system can accept a worse solution, so algorithm concentrate on the search area where we can find the global optimum solution. The major advantage of the simulated annealing is not stuck in the local optima but search for the global optimum solution.

In our system, we have used the simulated annealing optimization to minimize the LTS hausdorff distance to detect the test image model in the train image dataset. The initial and final temperature is very important parameter to obtain desired solution.

3.3. Database of MR images

The segmentation of MR images is divided into three categories.1) Automatic 2) semi automatic 3) manual segmentation. The automatic segmentation is based on the intensity of the pixels in the image. The semi automatic segmentation needs human intervention to select the region of interest for segmentation. The human can recognize the boundaries and shape of the object of interest

more accurately than the computer algorithm [1]. The manual segmentation is most accurate segmentation among all of them. We created a knowledge base of ground truth segmentation of MR images of hip joint structure. The MR images are segmented manually by the medical experts. The MR images are collected with their ground truth segmentation and then stored in the database. We used the database images knowledge to segment the MR image of other patients. The database images are named as train images. The knowledge $_1$base consists of 20 images.

4. TOP DOWN AND BOTTOM UP APPROACH

4.1. Global detection of test image

The main objective of top down approach is to detect global and local structure of the test image in the train images. In the hausdorff distance based shape matching is used for detection of the test image in a train image. The canny edge detection algorithm is used for the extraction of boundaries of both test and train images. Given a test image M and train image I_1 , I_2 .....I_n, the objective of shape matching is to obtain a transformation T to find similarity by the minimization of hausdorff distance as the similarity metric. The affine transformation maps the point in one plane to the other. The affine transformation parameter is scaling, rotation and translation. Let p= (x, y) represents the point of test image, then the transformation is defined as

$$\begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \end{bmatrix}, \quad \begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = \begin{bmatrix} x_1 \\ y_1 \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

$$\begin{bmatrix} x_2 \\ y_2 \end{bmatrix} = \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \end{bmatrix}$$

Where S_x and S_y are the scaling parameters in x and y direction. The translation parameters are t_x and t_y in x and y direction and the rotation parameter either in a clockwise or anticlockwise direction. The transformed point (x_2, y_2) is close to the train image points. The simulated annealing search for best possible transformation in the given search space to minimize hausdorff distance to make test image more similar to the train image. The test image is registered with all the train images in the database. Then each of the registration gives the hausdorff distance and affine transformation parameters. The train images are sorted in the ascending order according to the hausdorff distance, half of the train images are selected from database for further processing. So, out of the 20 images only 10 images are selected.

4.2. Hierarchical tree based local part registration

As in the previous section, the train images are selected with their respective transformation parameters. The scaling and rotation is used for the transformation of the test image. Thus, the total number of transformed images is ten. Each of the transformed test images is decomposed into four parts as shown in figure 2. The hierarchical tree is constructed by placing decomposed parts into tree as shown in figure 2. The tree has three levels denoted by L_i, i= 0, 1, 2. Each level has transformed test image and decomposed for the next level like level 0 (L_0) which has only transformed test image. At each level, the local parts are registered with the selected train images. The train image is again sorted in ascending order according to the hausdorff distance obtain in registration process of local parts. The transformed test parts at the level 1 (L1) are denoted as Part 1, Part 2, Part 3, Part 4. Each of the tree nodes consists of 10 local parts. For example, Part_1 has 10 images and each of the Part_1 is registered with selected train image. The train images are sorted according to the hausdorff distance and first half of the train images are selected for their respective test image parts. For Part_1, the I_{10}, I_{13}, I_{14}, I_{15}, I_{16} is selected for next level registration. The transformation obtained in L_1 is used for next level registration.

The level 2 has 80 local parts. Each of the parts of level 1 is transformed and decomposed into four parts for the next level. The level 2 parts are represented as Part j_k. The j represents parts of level 1 and k represent the decomposition of level 1 part into level 2.So, Part 1_2 means Part1 of level1 is decomposed into four parts and it is the second decomposition of Part 1 of level 1.At level 2 (L_2) , the decomposed parts are registered with selected train images. For L_2, rotation and translation is used as transformation parameter for local part registration based on hausdorff distance. The train images for L_2 are sorted in ascending order according their respective hausdorff distance. The train image with lowest hausdorff distance is selected with their transformation as a best train image for its corresponding test image local part at level 2. Finally, each of the local part of level 2 are transformed and matched with their best train image. So, there are 16 local parts with their 16 best train images. We stop the decomposition of test image parts at level 2.

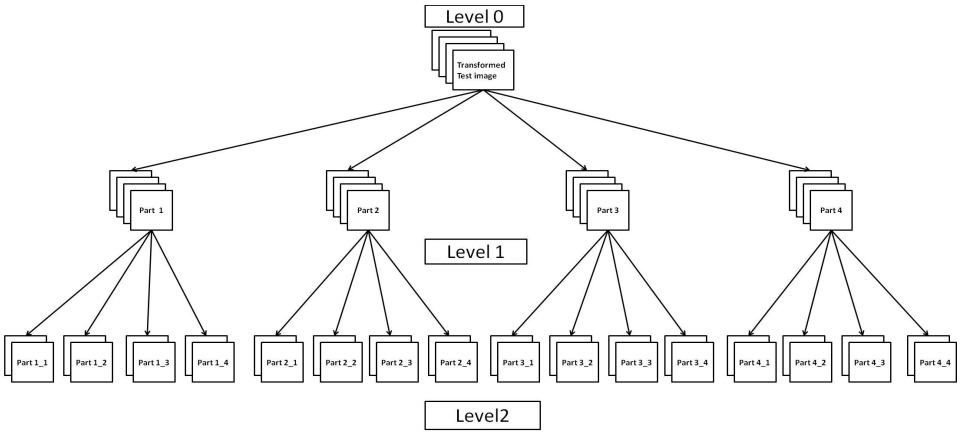


Figure 2: Top down approach of shape matching

4.3. Bottom up approach

The bottom up approach aggregates all best train image parts, and represent the test image from the collection of best train image parts. As in the previous section, each of the local part has their corresponding best train image. For each of the local part of test images, train image part is cropped to the same size of test image local parts at L_2. The local test image parts of L_2 are replaced by the corresponding train image part. The transformation obtained after the level 2 local part registrations is inversed and applied to the best train image part. The level 2 consists of best train image parts which are transformed inversely. The inverse scaling parameters are $1/S_x$ and $1/S_y$ in x and y direction. The inverse rotation is negative of angle of rotation; if the top down parameter is clock wise then inverse rotation is anti-clockwise. The $-t_x$ and t_y is the inverse translation in x and y direction. As we climb up the tree, at every level, we merge the best train parts into one region and as we can see in the figure 3, the final image is the mosaic of best train image parts.

The test image is symbolized by the collection of best train image parts. The database consists of ground truth of these train images. The ground truth segmentation from the train image parts of the test image to their corresponding location. Finally, the segmentation of test image is the collection of the ground truth segmentation of train images.

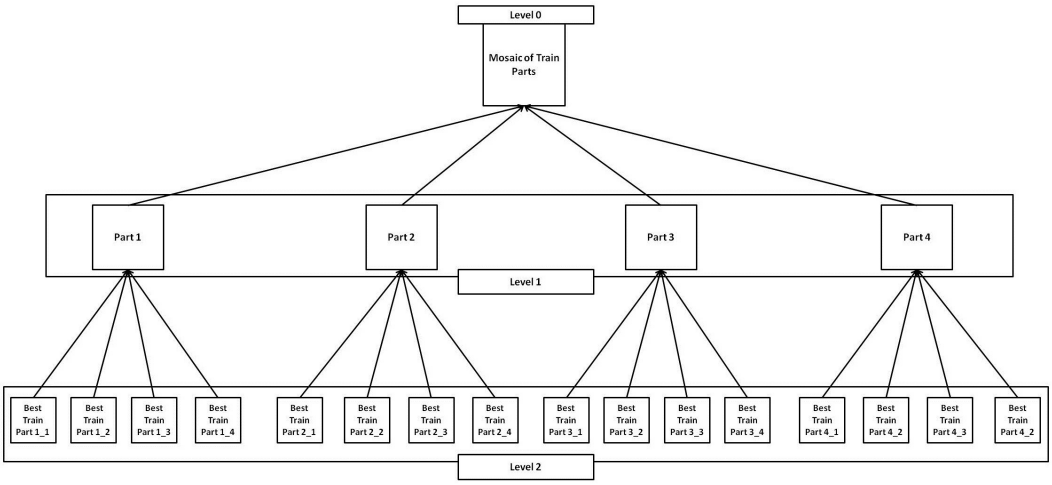
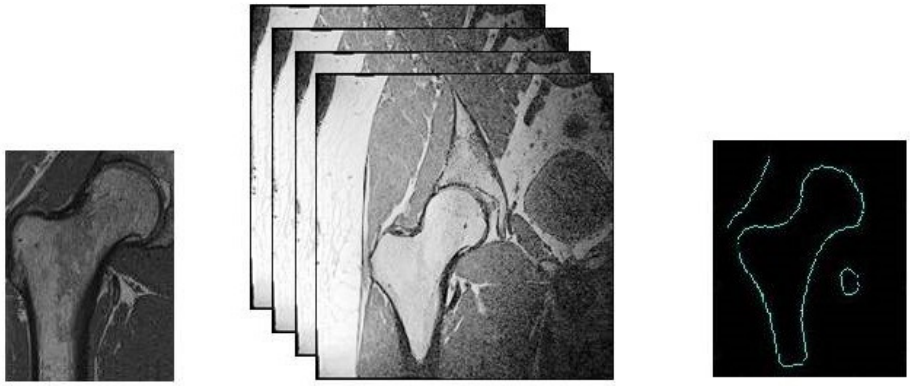


Figure 3: Bottom a test image to represent test image by the train image parts

5. EXPERIMENTAL RESULTS

The database consists of 20 MR images of size 256 x 256 of hip joint structure with their ground truth segmentation. The size of test image is 155 x 123. The canny edge detector is used for extraction of boundaries of test and train images. The threshold and sigma are 0.545 and 4 for the canny edge detector. The simulated annealing initial temperature parameter is 100. The affine transformation parameter for global detection is $0.863 \leq S_x \leq 0.982$ and $0.79 \leq S_y \leq 0.97$ as a scaling parameter in x and y direction. The rotation parameter is from -10 to 10 and translation parameter is $0 \leq t_x \leq 400$ and $0 \leq t_y \leq 400$ in x and y direction.



(a) (b) (c)

Figure 4: (a) Test image (b) MR image database and (c) Transformed test image.

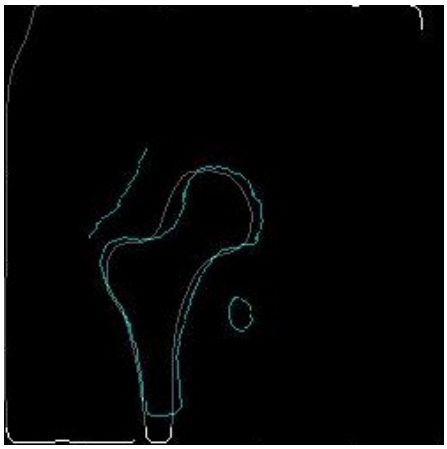
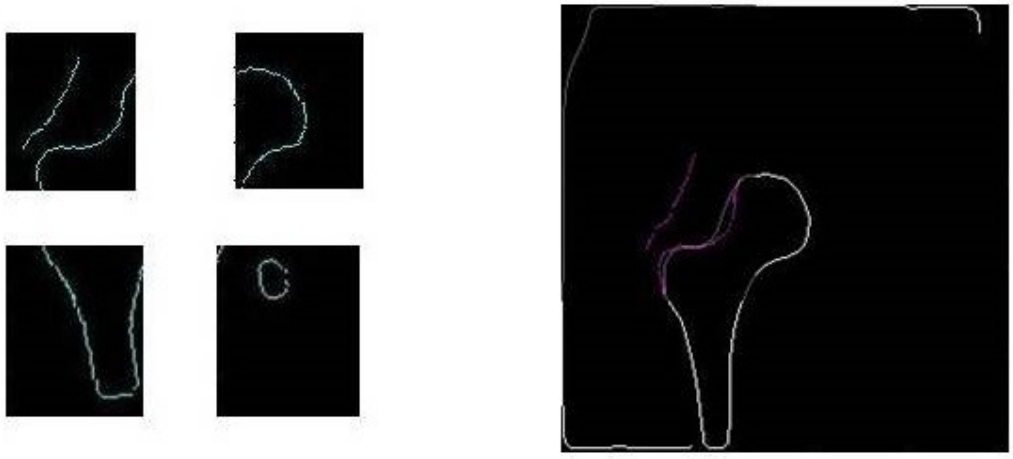
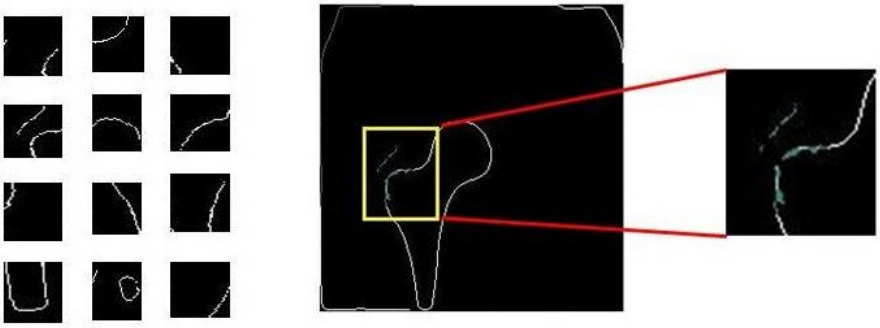


Figure 5: The global registration of test image over train image.



(a) (b)

Figure 6: (a) Decomposed test parts at level one and (b) Local part registration.



(a) (b)

Figure 7: (a) shows local parts at level two and (b) shows its registration with train images.

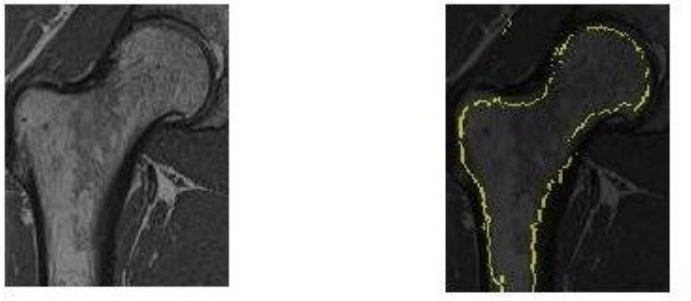


Figure 8: The segmentation of test image from ground truth data

6. CONCLUSIONS

We have proposed the novel method of image segmentation of hip joint structure in MR image. The method is to transfer ground truth segmentation from the train image database to the test image. The train image database consists of MR images of hip joint structure with their ground truth segmentation. The ground truth segmentation is done by medical experts. The method based on the top down approach to register test image globally and locally with the train images. The top down approach uses the hausdorff distance based shape registration algorithm. The objective of the top down approach is to find the best train image for each of the local test image parts. The bottom up approach uses the inverse transformation to match best train image parts with the original test image and the test image is represented by the mosaic of best train image parts. The ground truth segmentation from train image parts to their respective location of test image.

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FEATURE SELECTION: A NOVEL APPROACH FOR THE PREDICTION OF LEARNING DISABILITIES IN SCHOOL-AGED CHILDREN

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ABSTRACT

Feature selection is a problem closely related to dimensionality reduction. A commonly used approach in feature selection is ranking the individual features according to some criteria and then search for an optimal feature subset based on an evaluation criterion to test the optimality. The objective of this work is to predict more accurately the presence of Learning Disability (LD) in school-aged children with reduced number of symptoms. For this purpose, a novel hybrid feature selection approach is proposed by integrating a popular Rough Set based feature ranking process with a modified backward feature elimination algorithm. The approach follows a ranking of the symptoms of LD according to their importance in the data domain. Each symptoms significance or priority values reflect its relative importance to predict LD among the various cases. Then by eliminating least significant features one by one and evaluating the feature subset at each stage of the process, an optimal feature subset is generated. The experimental results shows the success of the proposed method in removing redundant attributes efficiently from the LD dataset without sacrificing the classification performance.

KEYWORDS

Rough Set Theory, Data Mining, Feature Selection, Learning Disability, Reduct.

1. INTRODUCTION

Learning Disability (LD) is a neurological disorder that affects a child's brain. It causes trouble in learning and using certain skills such as reading, writing, listening and speaking. A possible approach to build computer assisted systems to handle LD is: collect a large repository of data consisting of the signs and symptoms of LD, design data mining algorithms to identify the significant symptoms of LD and build classification models based on the collected data to classify new unseen cases. Feature selection is an important data mining task which can be effectively utilized to develop knowledge based tools in LD prediction. Feature selection process not only reduces the dimensionality of the dataset by preserving the significant features but also improves the generalization ability of the learning algorithms.

Data mining, especially feature selection is an exemplary field of application where Rough Set Theory (RST) has demonstrated its usefulness. RST can be utilized in this area as a tool to discover data dependencies and reduce the number of attributes of a dataset without considering

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any prior knowledge and using only the information contained within the dataset alone [2]. In this work, RST is employed as a feature selection tool to select most significant features which will improve the diagnostic accuracy by SVM. For this purpose, a popular Rough Set based feature ranking algorithm called PRS relevance approach is implemented to rank various symptoms of the LD dataset. Then by integrating this feature ranking technique with backward feature elimination [15], a new hybrid feature selection technique is proposed. A combination of four relevant symptoms is identified from the LD dataset through this approach which gives the same classification accuracy compared to the whole sixteen features. It implies that these four features were worthwhile to be taken close attention by the physicians or teachers handling LD when they conduct the diagnosis.

The rest of the paper is organized as follows. A review of Rough Set based feature ranking process is given in section 2. In section 3, conventional feature selection procedures are described. A brief description on Learning Disability dataset is presented in Section 4. Section 5 presents the proposed approach of feature selection process. Experimental results are reported in Section 6. A discussion of the experimental results is given in Section 7. The last section concludes this research work.

2. ROUGH SET BASED ATTRIBUTE RANKING

Rough Set Theory (RST) proposed by Z. Pawlak is a mathematical approach to intelligent data analysis and data mining. RST is concerned with the classificatory analysis of imprecise, uncertain or incomplete information expressed in terms of data acquired from experience. In RST all computations are done directly on collected data and performed by making use of the granularity structure of the data. The set of all indiscernible (similar) objects is called an elementary set or a category and forms a basic granule (atom) of the knowledge about the data contained in the dataset. The indiscernibility relation generated in this way is the mathematical basis of RST [18].

The entire knowledge available in a high dimensional dataset is not always necessary to define various categories represented in the dataset. Though the machine learning and data mining techniques are suitable for handling data mining problems, they may not be effective for handling high dimensional data. This motivates the need for efficient automated feature selection processes in the area of data mining. In RST, a dataset is always termed as a decision table. A decision table presents some basic facts about the Universe along with the decisions (actions) taken by the experts based on the given facts. An important issue in data analysis is whether the complete set of attributes given in the decision table are necessary to define the knowledge involved in the equivalence class structure induced by the set of all attributes. This problem arises in many practical applications and will be referred to as knowledge reduction. With the help of RST, we can eliminate all superfluous attributes from the dataset preserving only the indispensable attributes [18]. In reduction of knowledge, the basic roles played by two fundamental concepts in RST are *reduct* and *core*. A reduct is a subset of the set of attributes which by itself can fully characterize the knowledge in the given decision table. A reduct keeps essential information of the original decision table. In a decision table there may exist more than one reduct. The set of attributes which is common to all reducts is called the core [18]. The core may be thought of as the set of indispensable attributes which cannot be eliminated while reducing the knowledge involved in the information system. Elimination of a core attribute from the dataset causes collapse of the category structure given by the original decision table. To determine the core attributes, we take the intersection of all the reducts of the information system. In the following section, a popular and more effective reduct based feature ranking approach known as PRS relevance method [19] is presented. In this method, the ranking is done with the

help of relevance of each attribute/feature calculated by considering its frequency of occurrence in various reducts generated from the dataset.

2.1. Proportional Rough Set (PRS) Relevance Method

This is an effective Rough Set based method for attribute ranking proposed by Maria Salamó and López-Sánchez [19]. The concept of reducts is used as the basic idea for the implementation of this approach. The same idea is also used by Li and Cercone to rank the decision rules generated from a rule mining algorithm [20, 21, 22, 23]. There exist multiple reduct for a dataset. Each reduct is a representative of the original data. Most data mining operations require only a single reduct for decision making purposes. But selecting any one reduct leads to the elimination of representative information contained in all other reducts. The main idea behind this reduct based feature ranking approach is the following: the more frequent a conditional attribute appears in the reducts and the more relevant will be the attribute. Hence the number of times an attribute appears in all reducts and the total number of reducts determines the significance (priority) of each attribute in representing the knowledge contained in the dataset. This idea is used for measuring the significance of various features in PRS relevance feature ranking approach [19]. With the help of these priority values the features available in the dataset can be arranged in the decreasing order of their priority.

3. FEATURE SELECTION

The Feature selection is a search process that selects a subset of significant features from a data domain for building efficient learning models. Feature selection is closely related to dimensionality reduction. Most of the dataset contain relevant as well as irrelevant and redundant features. Irrelevant and redundant features do not contribute anything to determine the target class and at the same time deteriorates the quality of the results of the intended data mining task. The process of eliminating these types of features from a dataset is referred to as feature selection. In a decision table, if a particular feature is highly correlated with decision feature, then it is relevant and if it is highly correlated with others, it is redundant. Hence the search for a good feature subset involves finding those features that are highly correlated with the decision feature but uncorrelated with each other [1]. Feature selection process reduces the dimensionality of the dataset and the goal of dimensionality reduction is to map a set of observations from a high dimensional space M into a low dimensional space m ($m<<M$) by preserving the semantics of the original high dimensional dataset. Let $I = (U, A)$ be an information system (dataset), where $U = \{x_1, x_2, \ldots, x_n\}$ be the set of objects and $A = \{a_1, a_2, \ldots, a_M\}$ be the set of attributes used to characterize each object in I. Hence each object x_i in the information system can be represented as an M dimension vector $[a_1(x_i), a_2(x_i), \ldots, a_M(x_i)]$, where $a_j(x_i)$ yields the j^{th} ($j = 1, 2, 3, \ldots, M$) attribute value of the i^{th} ($i = 1, 2, 3, \ldots., n$) data object. Dimensionality reduction techniques transform the given dataset I of size $n \times M$ into a new low dimensional dataset Y of size $n \times m$.

While constructing a feature selection method, two different factors namely search strategies and evaluating measures [2] are to be considered. Commonly used search strategies are complete or exhaustive [3], heuristic [4] and random [5][6]. In general feature selection methods are based on some exhaustive approaches which are quite impractical in many cases, especially for high dimensional datasets, due to the high computational cost involved in the searching process [25]. To reduce this complexity, as an alternate solution strategy, heuristic or random search methods are employed in modern feature selection algorithms.

Based on the procedures used for evaluating the scalability of the generated subset, heuristic or random search methods are further classified into three – classifier specific or wrapper methods [7][8][9][10][11], classifier independent or filter methods [12][13][14] and hybrid models [15]

which combines both filter and wrapper approach to achieve better classification performance. In a classifier specific feature selection method, the quality of the selected features is evaluated with the help of a learning algorithm and the corresponding classification accuracy is determined. If it satisfies the desired accuracy, the selected feature subset is considered as optimal; otherwise it is modified and the process is repeated for a better one. The process of feature selection using wrapper (classifier specific) approach is depicted in Figure 1. Even though the wrapper method may produce better results, it is computationally expensive and can encounter problems while dealing with huge dataset.

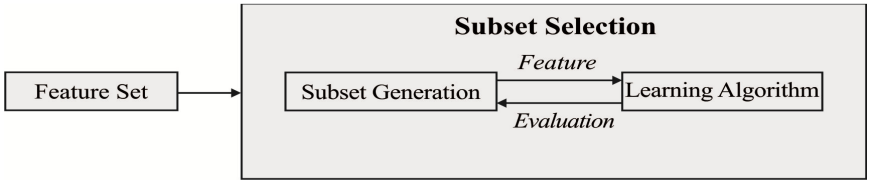

Figure 1: Wrapper approach to feature selection

In the case of classifier independent method, to evaluate the significance of selected features one or more of classifier independent measures such as inter class distance [12], mutual information [16][17] and dependence measure [13][18] are employed. In this approach, the process of feature selection is treated as a completely independent pre-processing operation. As an outcome of this pre-processing, irrelevant/noisy attributes are filtered. All filter based methods use heuristics based on general characteristics of the data rather than a learning algorithm to evaluate the optimality of feature subsets. As a result, filter methods are generally much faster than wrapper methods. Since this method does not depend on any particular learning algorithm, it is more suitable in managing high dimensionality of the data.

In the case of hybrid model, as a first step, features are ranked using some distance criterion or similarity measure and then with the help of a wrapper model an optimal feature subset is generated. The method usually starts with an initial subset of features heuristically selected beforehand. Then features are added (forward selection) or removed (backward elimination) iteratively until an optimal feature subset is obtained.

4. LEARNING DISABILITY DATASET

Learning disability (LD) is a neurological condition that affects the child's brain resulting in difficulty in learning and using certain skills such as reading, writing, listening, speaking and reasoning. Learning disabilities affect children both academically and socially and about 10% of children enrolled in schools are affected with this problem. With the right help at the right time, children with learning disabilities can learn successfully. Identifying students with LD and assessing the nature and depth of LD is essential for helping them to get around LD. As nature and symptoms of LD may vary from child to child, it is difficult to access LD. A variety of tests are available for evaluating LD. Also there are many approaches for managing LD by teachers as well as parents.

To apply the proposed methodology on a real world dataset, a dataset consisting of the signs and symptoms of the learning disabilities in school age children is selected. It is collected from various sources which include a child care clinic providing assistance for handling learning disability in children and three different schools conducting such LD assessment studies. This dataset is helpful to determine the existence of LD in a suspected child. It is selected with a view to provide tools for researchers and physicians handling learning disabilities to analyze the data and to facilitate the decision making process.

The dataset contains 500 student records with 16 conditional attributes as signs and symptoms of LD and the existence of LD in a child as decision attribute. Various signs and symptoms collected includes the information regarding whether the child has any difficulty in reading (DR), any difficulty with spelling (DS), any difficulty with handwriting (DH) and so on. There are no missing values or inconsistency exists in the dataset. Table 1 gives a portion of the dataset used for the experiment. In this table *t* represents the attribute value true and *f* represents the attribute value false. Table 2 gives key used for representing the symptoms and its abbreviations.

Table 1**:** Learning Disability (LD) dataset

DR	DS	DH	DWE	DBA	DHA	DA	ED	DM	LM	DSS	DNS	DLL	DLS	STL	RG	LD
t	t	f	f	f	f	f	f	f	f	f	f	f	f	f	f	t
t	t	f	t	f	t	f	t	t	t	t	f	t	f	t	f	t
t	t	f	t	f	t	f	t	t	t	t	f	t	f	t	f	t
t	t	f	f	f	f	t	t	t	t	f	f	f	f	f	f	t
f	f	f	t	t	f	f	f	f	f	f	f	f	f	f	f	f
f	f	f	f	f	f	t	t	t	f	f	f	f	f	f	f	f
t	t	t	t	t	f	t	t	t	t	f	f	f	f	t	f	t
f	f	f	f	f	f	f	f	f	t	f	f	t	f	t	f	f
t	t	f	t	f	f	f	f	f	f	f	f	t	f	f	f	t
t	t	f	t	f	t	t	t	t	t	t	f	t	t	t	f	t
t	t	f	t	f	t	t	t	t	t	t	f	f	f	t	f	t
f	f	f	t	f	f	t	f	f	f	f	f	f	f	f	f	f
t	t	f	t	f	t	f	t	f	t	t	f	t	f	t	f	t
f	f	f	f	f	t	f	t	f	f	f	f	f	f	f	f	f
t	t	f	t	f	f	f	t	f	f	t	t	t	f	t	f	t

Table 2**:** Key used for representing the symptoms of LD

Key/ Abbreviations	Symptoms	Key/ Abbreviations	Symptoms
DR	Difficulty with Reading	LM	Lack of Motivation
DS	Difficulty with Spelling	DSS	Difficulty with Study Skills
DH	Difficulty with Handwriting	DNS	Does Not like School
DWE	Difficulty with Written Expression	DLL	Difficulty in Learning a Language
DBA	Difficulty with Basic Arithmetic	DLS	Difficulty in Learning a Subject
DHA	Difficulty with Higher Arithmetic skills	STL	Is Slow To Learn
DA	Difficulty with Attention	RG	Repeated a Grade
ED	Easily Distracted	LD	Learning Disability
DM	Difficulty with Memory		

5. PROPOSED APPROACH

The proposed method of feature selection follows a hybrid approach which utilizes the complementary strength of wrapper and filter approaches. Before feature selection begins, each feature is evaluated independently with respect to the class to identify its significance in the data domain. Features are then ranked in the decreasing order of their significance[26]. To calculate the significance and to rank various features of the LD dataset, in this work, PRS relevance approach is used. To explain the feature ranking process, consider a decision table $T = \{U, A, d\}$, where U is the non-empty finite set of objects called the Universe, $A = \{a_1, a_2, ..., a_n\}$ be the non-empty finite set of conditional attributes/features and d is the decision attribute. Let $\{r_1, r_2, ..., r_p\}$ be the set of reducts generated from T. Then, for each conditional attribute $a_i \in A$, reduct based attribute priority/significance $\beta(a_i)$ is defined as [19, 20, 21]:

$$\beta(a_i) = \frac{\left|\{r_j | a_i \in r_j, j = 1,2,3,..., p\}\right|}{p}, i = 1,2,3,...,n \qquad 1$$

where the numerator of the Eq. 1 gives the occurrence frequency of the attribute a_i in various reducts.

From Eq. 1 it is clear that an attribute a not appearing in any of the reducts has priority value $\beta(a) = 0$. For an attribute a, which is a member of core of the decision table has a priority value $\beta(a) = 1$. For the remaining attributes the priority values are proportional to the number of reducts in which the attribute appear as a member. These reduct based priority values will provide a ranking for the considered features.

After ranking the features, search process start with all available features and successfully remove least significant features one by one (backward elimination) after evaluating the influence of this feature in the classification accuracy until the selected feature subset gives a better classification performance. When a certain feature is eliminated, if there is no change in the current best classification accuracy the considered feature is redundant. If the classification accuracy is increased as a result of elimination, the removed feature is considered as a feature with negative influence on the classification accuracy. In these two cases, the selected feature is permanently removed from the feature subset; otherwise it is retained. Feature evaluation starts by considering the classification accuracy obtained from all available features as the current best accuracy. The search terminates when no single attribute deletion contributes any improvement in the current best classification accuracy. At this stage, the remaining feature subset is considered as optimal. For classification, Sequential Minimal Optimization (SMO) algorithm using the polynomial kernel is used in this work. It is implemented through Weka data mining tool kit [24]. This algorithm is used for the prediction of LD because it is simple, easy to implement and generally faster. The proposed feature selection algorithm *FeaSel* is presented below. The algorithm accepts the ranked set of features obtained from the PRS relevance approach as input and generates an optimal feature subset consisting of the significant features as output. The overall feature selection process is represented in figure 2.

Algorithm *FeaSel*($\mathcal{F}_n$, $\mathcal{Y}$, n, $\mathcal{X}_n$)
//$\mathcal{F}_n = \{f_1, f_2, ..., f_n\}$– Set of features obtained from PRS relevance approach ranked in descending order of their significance.
//$\mathcal{Y}$ – class; n – total number of features.
// $\mathcal{X}_n$ – The optimal feature subset.
{

```
    X_n=F_n;
    max_acc=acc(F_n,Y); //acc() returns the classification accuracy given by the classifier
    for (i=n to 1 step -1) do
      {
        F_n=F_n-{f_i};
        curr_acc=acc(F_n, Y);
        if (curr_acc==max_acc)
            X_n=F_n;
        else if (curr_acc>max_acc)
            {
            X_n=F_n;
              max_acc=curr_acc;
            }
            else
                X_n=F_n∪{f_i};
        F_n=X_n;
      }
  return(X_n, max_acc);

}
```

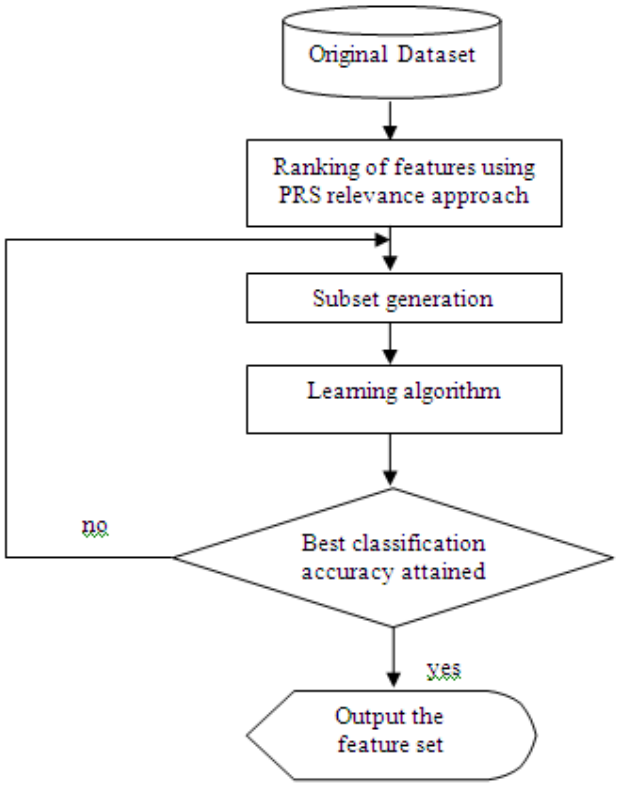

Figure 2: Block diagram of the feature selection process

6. EXPERIMENTAL ANALYSIS AND RESULTS

In order to implement the PRS relevance approach to rank the features, as a first step of the process, various reducts are generated from the LD dataset. For this purpose, the discernibility matrix approach of Rough Sets Data Explorer software package ROSE2 is used which generates 63 reducts from the original LD dataset. Then frequencies of various features occurring in these reducts are computed. These frequencies are given in Table 3. Based on these frequencies and by applying Eq. 1, the priority/significance values of various features are calculated. Ranked features as per their significance are shown in Table 4.

Table 3: Frequencies of various attributes in reducts

Feature	Frequency	Feature	Frequency
DR	63	DSS	18
DS	34	DNS	23
DWE	32	DHA	21
DBA	41	DH	16
DA	44	DLL	50
ED	63	DLS	27
DM	63	RG	36
LM	41	STL	27

Table 4: Attributes with priority values

Rank	Feature	Significance	Rank	Feature	Significance
1	DR	1	9	DS	0.5397
2	ED	1	10	DWE	0.5079
3	DM	1	11	DLS	0.4286
4	DLL	0.7937	12	STL	0.4286
5	DA	0.6984	13	DNS	0.3651
6	LM	0.6508	14	DHA	0.3333
7	DBA	0.6508	15	DSS	0.2857
8	RG	0.5714	16	DH	0.2540

For feature selection using the proposed algorithm, the classification accuracy of the whole LD dataset with all available features is determined first. In the feature selection algorithm the construction of the best feature subset is mainly based on this value. Then, the set of features ranked using PRS relevance approach is given to the proposed feature selection algorithm *FeaSel*. Since the features are ranked in decreasing order of significance, features with lower ranks gets eliminated during initial stages. The algorithm starts with all features of LD and in the first iteration the algorithm selects lowest ranked feature DH as a test feature. Since there is no change occurs in the original classification accuracy while eliminating this feature, it is

designated as redundant and hence it is permanently removed from the feature set. The same situation continues for the features DSS, DHA, DNS, STL, and DLS selected in order from right to left from the ranked feature set and hence all these features are removed from the feature set. But when selecting the next feature DWE, there is a reduction in the classification accuracy which signifies the influence of this feature in determining the classification accuracy and hence this feature is retained in the feature set. The process is continued until all features are evaluated. The performance of various symptoms of LD during the feature selection process is depicted in figure 3.

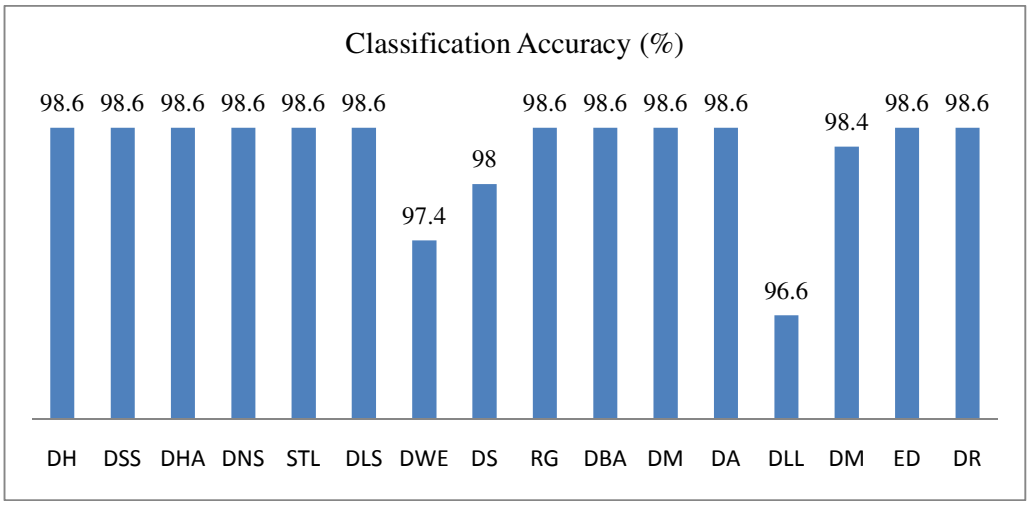

Figure 3. Influence of various symptoms in classification

After evaluating all features of the LD dataset, the algorithm retains the set of features {DWE, DS, DLL, DM}. These four features are significant because all other features can be removed from the LD dataset without affecting the classification performance. Table 5 shows the results obtained from the classifier before and after the feature selection process. To determine the accuracy 10 fold cross validation is used.

Table 5: Classification results given by SMO

Various cases	Dataset prior to perform feature selection	Dataset reduced using the proposed approach
No. of features	16	4
Classification accuracy (%)	98.6	98.6
Time taken to build the model (Sec.)	0.11	0.01

7. DISCUSSION

From the experimental results presented in Table 5 it is clear that, in the case of the proposed approach a 75% reduction in the dataset does not affect the classification accuracy. It follows that the original dataset contains about 75% redundant attributes and the feature selection approach presented is efficient in removing these redundant attributes without affecting the

classification accuracy. From the comparison of results, it can be seen that when using the selected significant features for classification, the time taken to build the learning model is also greatly improved. This shows that in an information system there are some non-relevant features and identifying and removing these features will enable learning algorithms to operate faster. In other words, increasing the number of features in a dataset may not be always helpful to increase the classification performance of the data. Increasing the number of features progressively may result in reduction of classification rate after a peak. This is known as peaking phenomenon.

8. CONCLUSION

In this paper, a novel hybrid feature selection approach is proposed to predict the Learning Disability in a cost effective way. The approach follows a method of assigning priorities to various symptoms of the LD dataset based on the general characteristics of the data alone. Each symptoms priority values reflect its relative importance to predict LD among the various cases. By ranking these symptoms in the decreasing order of their significance, least significant features are eliminated one by one by considering its involvement in predicting the learning disability. The experimental result reveals the need of feature selection in classification to improve the performance such as speed of learning and predictive accuracy. With the help of the proposed method, redundant attributes can be removed efficiently from the LD dataset without sacrificing the classification performance.

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MULTICLASS RECOGNITION WITH MULTIPLE FEATURE TREES

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ABSTRACT

This paper proposes a multiclass recognition scheme which uses multiple feature trees with an extended scoring method evolved from TF-IDF. Feature trees consisting of different feature descriptors such as SIFT and SURF are built by the hierarchical k-means algorithm. The experimental results show that the proposed scoring method combing with the proposed multiple feature trees yields high accuracy for multiclass recognition and achieves significant improvement compared to methods using a single feature tree with original TF-IDF.

KEYWORDS

SIFT, SURF, K-means, TF-IDF

1. INTRODUCTION

For machine intelligent applications, one of the critical issues is to achieve high accuracy in multi-object recognition. This paper, motivated by Nister's previous work[3], proposes an algorithm comprising multiple hierarchical k-means feature trees with an improved TF-IDF[4] scheme. The TF-IDF scheme takes account of not only the occurrence frequency of an item / feature but also the inverse of the frequency of documents containing the item/features to the total document. Such an item/feature is apparently good for distinguishing objects from multiple classes. In our study, the proposed method with improved TF-IDF scheme and multiple feature trees significantly improves the accuracy of recognizing multiple objects.

2. RELATED RESEARCH

For decades, feature descriptors are widely used in image matching and object recognition applications. One of the classical descriptors is the state-of-the-art SIFT[2] scheme. In the SIFT scheme, local features are detected and extracted by looking for optima in the pyramid of scale spaces generated by the difference of Gaussian (DoG) method. Each SIFT feature consists of orientations computed based on the local image gradient directions around a detected optimum. As the SIFT descriptor is proved efficient and effective for image matching, object recognition, motion tracking, and related fields in machine intelligence, various adaptations are proposed Similar to SIFT, the SURF scheme proposed by Bay[5] generates the pyramid of scale spaces by discrete wavelet transform and approximates the determinant of Hessian blob detector by an

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integer evaluation to save computing cost. The two feature descriptors are adopted in the paper for object representation. The vocabulary tree proposed by Nister[3] is to categorize all training features into hierarchical clusters by k-means. In the progress of tree construction, the training set is divided into a certain number of clusters in each level. The aim of hierarchical clustering by k-means is not only to enhance the distinctiveness among cluster of features, but also save the searching cost in classification time with TF-IDF scoring for testing data.

3. THE PROPOSED METHOD

3.1. Build the Feature Tree

The feature tree adopted in the proposed method is constructed by hierarchical k-means. The basic operation of k-means, illustrated by Figure 1, is started by choosing k (in this case k=3) feature points randomly as initial cluster centroids. Each feature point is assigned to the cluster whose centroid is closest to it. Then, each centroid is recomputed. The process iterates until, the difference of consecutive positions for each centroid converges or a termination condition is reached. After finishing k-means clustering in the first layer of the hierarchical tree, it continues to apply k-means clustering with the identical degree in successive layers to construct the hierarchical feature tree, as illustrated in the Figure 2 and Figure 3. Apparently each cluster, represented by its centroid, is a node in the feature tree. A node stop growing if the number of its members is less than a specific value or its level reaches a default upper bound. The detail algorithm for constructing a feature tree is shown in Table 1.

Figure 1. Randomly choose three features as initial cluster centroids.

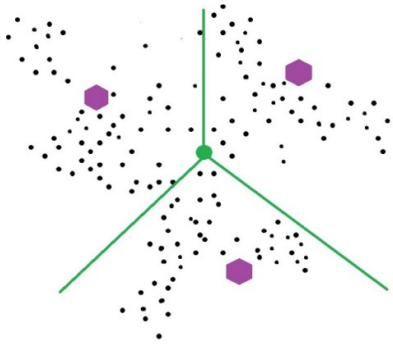

Figure 2. Layer one clustering.

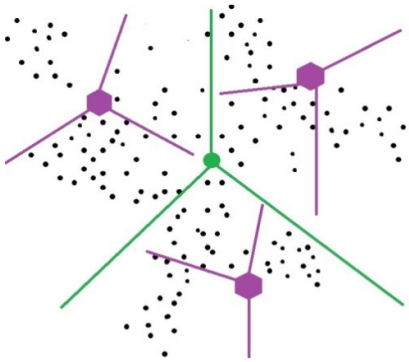

Figure 3. Layer two clustering.

Table 1. Build the Feature Tree

Input : 1. P: input feature data 2. H: number of tree layer 3. T: initial feature tree Output : 1. hktree: the output feature tree Temporal: 1. Hktree : type definition of the feature tree, owning clustering function to save center or leaf node data 2. C : the set of cluster centers 3. Kmeans(P) : k-means processing for input data and returning centers 4. A(C,P) : assigning data to the center closest to it, and returning data clusters

Hktree HKTree(P,H,T){
Hktree hktree
C = Kmeans(P)
hktree.group = A(C,P)
IF P.size > limit or T.layer < limit {
T→next = hktree
HKTree(hktree.group,H+1,T→next)
}
Else
Return hktree
}

3.2. Searching

To search an image in an image base, the image is represented by a features vector which is compared with the features of the feature tree built in the last section as the inverted-index file of the image base. Each feature is categorized to a cluster by following the path from the root to the leaf node, of which each node has the closest distance to the input feature.

3.3. Scoring

3.3.1. Weighted TF-IDF

The first attempt that we adopt for scoring is the weighted TF-IDF approach based on the original TF-IDF scheme. The scoring policy is defined as follows. Let f_i denote the total number of features that reaches the leaf node i from an input image. Let M denote the total number of image classes, d_{ij} denote the number of all features of a specific image class j clustered in the leaf node i, m_i denote the number of all features clustered in the leaf node i, N denote the total number of leaf nodes, and n_j denote the total number of leaf nodes containing the specific image class j. Then d_{ij}/m_i is the weighting value, and the natural log of N/n_j is the IDF value. Let $Score[j]$ denote the score of the image class j. The searching algorithm along with the scoring policy defined in eq. (1) is shown in Table 2. After each feature extracted from an input image reaches the leaf node that it belongs to, the total score for each candidate image class can be evaluated respectively.

Table 2 : Algorithm for searching and scoring

```
FeatureTree Tree
Queue Layer=Tree.root
Queue Feature = TheSetofTotalPoints
DO{
    Node node = Layer.dequeue()
    Point points = Feature.dequeue()
    IF node != leaf_node {
       Assign points to k childs of node
       FOR i=1 to k{
          Layer.enqueue(childs[i])
          Feature.enqueue(points[i])
       }
    }
    ELSE{
       FOR i=1 to N
          FOR j=1 to M
             Score[j]+= f_i × (d_ij/m_i) × ln(N/n_j)      (1)
    }
}WHILE node is not null
```

3.3.2. VT(vocabulary tree)

The vocabulary tree(VT)[3] uses the total number of features that reaches the leaf node i from an input image as the TF value, denoted by f_i. Let D denote the total number of all features in the dataset. Then, the second scoring policy adopted for experiment is defined as in eq. (2).

$$\boldsymbol{Score[j]} \mathrel{+}= \boldsymbol{f_i} \times \boldsymbol{d_{ij}} \times \boldsymbol{ln}\left(\frac{\boldsymbol{D}}{\boldsymbol{m_i}}\right) \quad (\mathbf{2})$$

3.3.3. Proposed Scoring Method

The proposed method for scoring adopts identical TF definition in method (a), but improves the IDF. Let D_j denote the total number of features of a specific image class j. Then the improved IDF is defined as the natural log of D/D_j to imply that classes with rare features are important. That is, the scoring policy is defined as in eq. (3). The design concern for the proposed scoring method is to generally consider the impact of rare features from the aspect of the whole dataset.

$$\boldsymbol{Score[j] += f_i \times \frac{d_{ij}}{m_i} \times ln\left(\frac{D}{D_j}\right)} \qquad (3)$$

3.4. Proposed Multiple Tree Searching

With the three scoring policies, we design two additional multiple-feature-trees schemes, SIFT⊕ SURF and SIFT→SURF, to improve the image retrieval accuracy. The scheme denoted by SIFT ⊕SURF, is to do score normalization for the SIFT and SURF trees, respectively, and sum up the normalized scores as the final score. The scheme denoted by SIFT→SURF, is designed for cascade searching. It represents that the search process on SURF tree activates only if the search result on SIFT tree is unmatched. The reason behinds this scheme is to improve the resistance to distortion of feature representation; i.e., the complementary of distinct types of feature facilitates the enhancement of distinctiveness among different classes and promotes similarity among identical ones.

4. EXPERIMENTS AND RESULTS

In this paper, the INRIA Holiday dataset[1] is used for experiment. We pick 612 images from 119 image classes. Each class contains at least 4 images. One image in each class is used as test data, and the other 493 images are used for training data. Two well-known feature extraction schemes, SIFT and SURF, are applied to the training data to build a SIFT feature tree and a SURF feature tree by hierarchical k-means, respectively. For each input image, the six highest scores images are outputted. If the test image indeed belongs to any one of the six image classes, we call it "matched". Otherwise, it is unmatched. The accuracy for this experiment is defined as the mean matching rate for all the test data. The experiment shows, as in Table 3, the performance of SIFT ⊕SURF using the proposed scoring method yields higher accuracy compared to the other two scoring methods. Although it is slightly lower than those of applying the first two scoring methods using a single SIFT feature tree, it is resulted from averaging with the low scores from SURF. This issue might be alleviated by adjust the dimension of SURF features. The performance of SIFT→SURF as shown in Table 3, Figure. 4, and Figure. 5 is superior to all other combings of feature trees and scoring methods.

Table 3. Mean accuracy of different weighted scoring method and feature trees schemes

	Weighted TF-IDF	**VT**	**Proposed Scoring Method**
SIFT	0.605042	0.613445	0.739496
SURF	0.336134	0.327731	0.436975
Proposed **SIFT⊕SURF**	0.588235	0.563025	0.739496
Proposed **SIFT→SURF**	0.638655	0.672269	0.781513

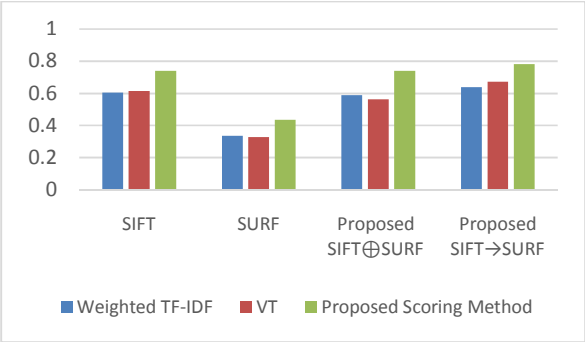

Figure 4. Mean accuracy of feature trees when selecting different scoring methods.

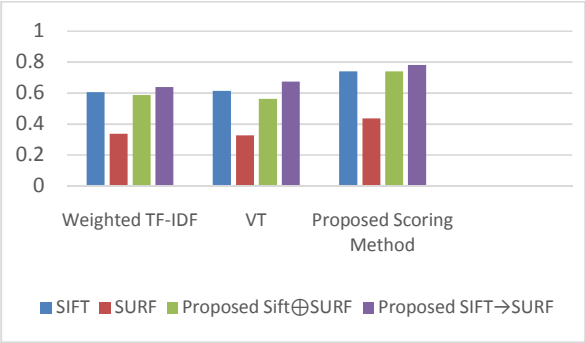

Figure 5. Mean accuracy of scoring methods when applying to various feature trees.

5. CONCLUSIONS

Inspecting Figure. 4 and Figure. 5, we can see that applying the three scoring methods on SIFT feature tree yields acceptable results. The outcomes show that although the performance of the single SURF feature tree might be insufficient, the proposed combination of SIFT and SURF trees, SIFT→SURF, with proposing scoring method outperforms the other methods in the experiment. In addition, we observed that the scoring method has the crucial impact on accuracy, and the selection of feature tree scheme also affects the improvement of accuracy. Besides, due to a certain portion of similarity of SIFT and SURF algorithms, it can be expected that there still exists rooms for improvement if more heterogeneous features descriptors, such as HOG[6], DAISY[7], and covariance[8], are applied.

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THE CHAOTIC STRUCTURE OF BACTERIAL VIRULENCE PROTEIN SEQUENCES

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ABSTRACT

Bacterial virulence proteins, which have been classified on structure of virulence, causes several diseases. For instance, Adhesins play an important role in the host cells. They are inserted DNA sequences for a variety of virulence properties. Several important methods conducted for the prediction of bacterial virulence proteins for finding new drugs or vaccines.

In this study, we propose a method for feature selection about classification of bacterial virulence protein. The features are constituted directly from the amino acid sequence of a given protein. Amino acids form proteins, which are critical to life, and have many important functions in living cells. They occurring with different physicochemical properties by a vector of 20 numerical values, and collected in AAIndex databases of known 544 indices.

For all that, this approach have two steps. Firstly, the amino acid sequence of a given protein analysed with Lyapunov Exponents that they have a chaotic structure in accordance with the chaos theory. After that, if the results show characterization over the complete distribution in the phase space from the point of deterministic system, it means related protein will show a chaotic structure.

Empirical results revealed that generated feature vectors give the best performance with chaotic structure of physicochemical features of amino acids with Adhesins and non-Adhesins data sets.

KEYWORDS

Bioinformatics, Virulence Protein Sequences, Attribute Encoding, Chaotic Structure, Classification.

1. INTRODUCTION

Proteins, which have vital importance for organisms, reacts in all biochemical reactions. Physicochemical properties of amino acids are the most important determinant to formation for three-dimensional structure of proteins and binding orders of amino acids. In addition, physicochemical properties determine functions of proteins and life cycles.

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Physicochemical properties have different 544 input data. We think that these properties shows a chaotic structure because they create a certain system and this certain system also affect themselves.

According to chaos, a deterministic system can behave in irregular. In other words a deterministic system can behave in an unexpected way. Chaos that depends on certain parameters usually appear in undetermined, complicated and nonlinear systems.

544 physicochemical properties should be analyzed in a scalar form of data in the phase space by regenerating. Equality of movements in phase space will show the results of the model to quantiles such as positioning attractor dimensions and Lyapunox exponents of system.

Bacterial virulence protein sequences have similar patterns. On these similarities are pretty difficult estimation for classification. In studies conducted to date, based on different strategies about various methods have been proposed to estimation of virulence proteins. To illustrate, the first studies and developed methods were based to search similarity such as BLAST [1] ve PSI-BLAST [2]. In more recent times, machine learning algorithm used for estimation. In the recent times, studied for estimation of bacterial virulence proteins about physicochemical properties.

Our aim in this study is that proving a chaotic structure of physicochemical properties of amino acids that constitute bacterial virulence proteins.

2. MATERIALS AND METHODS

2.1 Dataset

In this study, Adhesins dataset has been used on SPAAN. Dataset have 469 Adhesins and 703 non-Adhesins proteins. Adhesins protein sequences were downloaded from http://www.ncbi. nlm.nih.gov using the keyword 'Adhesin'. Non-adhesins, The rationale we used here was to collect sequences of enzymes and other proteins that function within the cell. They probably have remote possibility of functioning as adhesins and would differ in compositional characteristics (Nakashima and Nishikawa, 1994) [3].

Also, current version of AAIndex included in the dataset. The AAIndex contains 544 amino acid indices. For each the properties of 20 amino acids, input consists of reference information, a short description of the index, an accession number and the numerical values.

In additional to this study, algorithm of this application developed on MatLab. For all Lyapunov Exponents were calculated by Tisean Software.

2.2. Physicochemical Properties Of Amino Acids

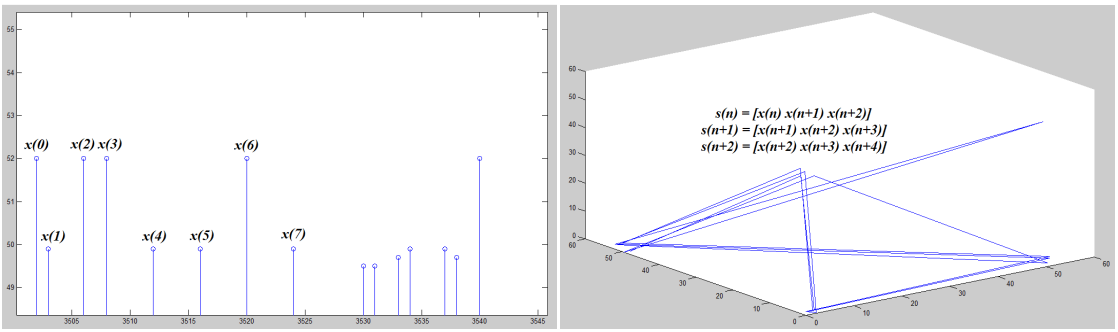
Amino acids which, determine the functions of proteins have different physicochemical properties such as hydrophobicity, polarity and molecular weight. These properties, termed the amino acid indices, can be represented with 20 numeric values of vectors.

2.3. Chaotic Type Features

In exploring the link between physicochemical properties and chaos, phase spaces of physicochemical properties are necessary. They are constructed from 1-D series, and by considering a high-dimensional vector, the dynamics of physicochemical properties production system can be unfold. The phase-space vector of physicochemical properties are reconstructed as follows;

$$\mathbf{s}(n) = [\, x(n)\; x(n+1)\; \ldots\; x(n+(D_E-1))] \qquad (1)$$

where x(n) is the nth sample of the physicochemical properties, D_E is the embedding dimension of the phase space [4].



(a) (b)

Figure 1. (a) series of the signal for physicochemical properties and (b) reconstructed phase space of the signal for $D_E = 3$.

Figure 1. (a) shows a segment of the scalar physicochemical properties with its time-delay vector trajectory. Figure 1. (b) shows phase space for D_E.

Phase spaces make signal dynamics clearly observable, which is not easy to see in a series representation. Some similar patterns come into closer proximity in phase-space representation, though they are apart in series representation. After determining the appropriate embedding dimension D_E for series, chaotic-type features, such as Lyapunov Exponent, calculated for D_E - dimensional phase space [4].

2.4. Lyapunov Exponents

The Lyapunov Exponent is a quantitative measure for the divergence of nearby trajectories, the path that a signal vector follows through the phase space. The rate of divergence can be different for different orientations of the phase space. Thus, there is a whole spectrum of Lyapunov Exponents - the number of them is equal to the number of dimension of the phase space. A positive exponent means that the trajectories, which are initially close to each other, move apart over time (divergence). The magnitude of a positive exponent determines the rate as to how rapidly they move apart. Similarly, for negative exponents, the trajectories move closer to each other (convergence) [4].

The lyapunov exponent is calculated for each dimension for the phase space as

$$\lambda = \lim_{N\to\infty} \frac{1}{N} \sum_{n=1}^{N} \ln \frac{d(\mathbf{s}(n+1), \mathbf{s}(m+1))}{d(\mathbf{s}(n), \mathbf{s}(m))}. \quad (2)$$

Here, **s**(n) is the reference point and **s**(m) is the nearest neighbor of **s**(n) on a nearby trajectory. d(**s**(n),**s**(m)) is the initial distance between the nearest neighbors. d(**s**(n + 1),**s**(m + 1)) is the distance between s(n + 1) and s(m + 1) which are the next pair of neighbors on their trajectories. It must be considered that the LE calculation algorithm finds a new nearest neighbor **s**(m) for each **s**(n), (n = 1,2,...,N). There are D_E Lyapunov exponents (i.e., {λ_1, λ_2,..., λ_{DE} }) in descending order. λ_1 is known as the largest LE and a positive largest LE is the indicator of chaos [4].

After calculating lyapunov exponents for all of the nearest neighbor pairs on different trajectories, the lyapunov exponent for the whole signal is calculated as the average of these lyapunov exponents, as the magnitude on d(s(n),s(m)) depends on the whole phase space only, and distortion does not change the global form of the phase space [4].

2.5. Tisean Software Project

In this study, developed of this project by Tisean. It is a software project for the analysis of time series with methods based on the chaos theory. Tisean Package is analysis of time series with methods based on the theory of nonlinear deterministic dynamical systems. Tisean software can be downloaded from http://www.mpipks-dresden.mpg.de/~tisean/. Also, we studied with Cygwin for Tisean software. Cygwin can be downloaded from https://www.cygwin.com/. In this problem, using Tisean Package with MATLAB by Cygwin on Windows 7 operation system.

3. EXPERIMENTAL SETUP

In this study, we advanced an algorithm that using Lyapunov exponents for the purpose of classification using physicochemical properties of residues. Through this algorithm, we will demonstrate chaotic structure of bacterial virulence protein sequences. We think that protein sequences show chaotic structure with the physicochemical properties of amino acids. Our hypothesis prove that, we developed an application which using Tisean Software Project with MatLab. Figure 3. shows a work flow diagram forming of physicochemical properties.

According to Figure 2, first step, we used the *AAIndex* for values of 20 amino acids. AAIndex has 544 physicochemical properties to each amino acids. Thus, we have created a matrix with size of [20 X 544]. Thereby, getting the length of each protein have created a matrix with size of [1 X Protein Length]. For example, show regard to protein that is hemolysin / hemagglutinin - like protein HecA (Erwinia chrysanthemi). It consists by 3848 amino acid. So, This sequence should be in size of 3848, and also should be create a matrix with size of [1 X 3848].

According to that matrix with size of [1 X 3848], can create a matrix with 544 physicochemical properties for each amino acids about that proteins. So, length of the just created a matrix should be in size of [544 X Protein Length]. Also respectively created 544 files within terms of protein length, line by line. And then, they saved and moved in one directory, called *AA2File*.

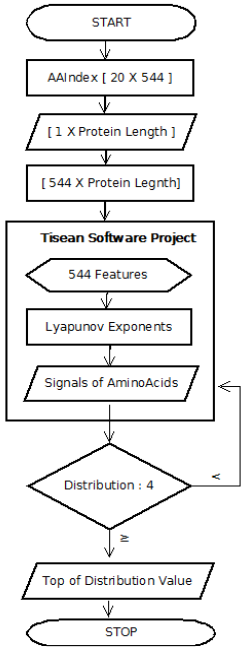


Figure 2. Work Flow Diagram forming of physicochemical properties

The AA2File folder includes each files of 544 properties, in addition to that will be calculated all of them with using Tisean Software Project by Matlab. And then, receive results of 544 properties from Tisean. The file extensions named as .LYAP. Also, they saved and moved in one directory, named as File2Lyap.

Whole of result are received by Tisean, because of that analyzed to convert at lyapunov exponent. Lyapunov Exponents have observable results at LYAP file; such as protein length, signals belong to each amino acids of a protein, average relative forecast erros, average absolute forecast errors, average neighborhood size, average number of neighbors and estimated KY-Dimension. Last of all, according to the signs of lyapunov exponents is given to the decision by Tisean.

Tabel 1. shows a lyapunov exponent results of the protein with 3848 length, as follows;

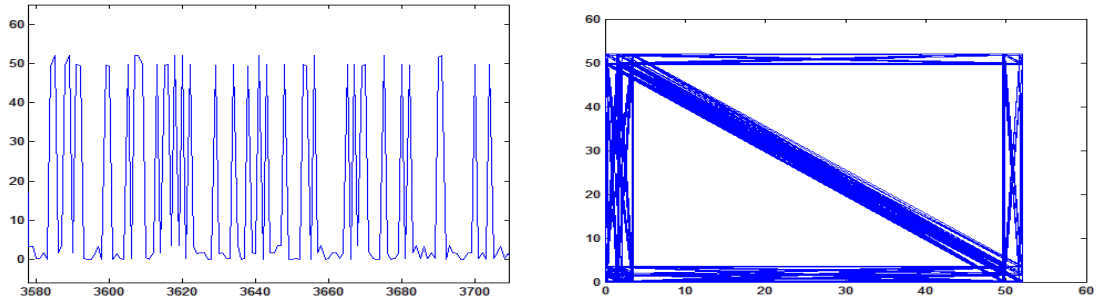
Table 1. The LEs results of the protein with 3848 length

The Lyapunov Exponents Results	
Length of Protein (Amino Acid) :	3848
Signals belong to each amino acids of a protein :	
9.044008e-001 4.018379e-001 2.226827e-001 1.310360e-001 4.904960e-002 -1.972889e-002 -1.013593e-001 -1.959663e-001 -3.338790e-001 -7.586726e-001	
Average relative forecast errors :	1.157800e+000
Average absolute forecast errors :	2.145047e+001
Average Neighborhood Size :	2.398085e+001
Average num. of neighbors :	3.000000e+001
Estimated KY-Dimension :	10.000000

Finally, LEs results show evidence of the better distribution by LYAP file, because of that the chaos theory analyzed on 2-D or 3-D in phase space. Our results demonstrate that negative lyapunov exponents and positive lyapunov exponents can be determined as quickly and easily, simply by analyzing data in Tisean as Table 1. In such a case that, the first few positive and negative exponents are enough to characterize the complete distribution. So, need to know for sure that the chaotic system should to have at least one positive lyapunov exponents. According to that this protein has five positive and five negative lyapunov exponents as Table1 shown. So, there are more protein like this sample on Adhesins and non-Adhesins Datasets.

4. EXPERIMENTAL RESULTS

In this hypothesis, will explain with an experiment that fit for purpose with our algorithm. First of all, shows physicochemical properties on phase space, after then calculate results of lyapunov exponents. At the beginning that create a *x* vector by matrix size of [1 X 3848]. Figure 3. (a) shows a line plot of the data values in *x*.



(a) (b)

Figure 3. (a) Creates a line plot of the data values in *x* and (b) shows a 2-D line plot of data.

*n*th sample of the physicochemical properties are calculated on 2-D phase space by MATLAB. Thus, Figure 3. (b) shows a 2-D line plot of data, *Y* axis values and *X* axis values. And finally, *n*th sample of the physicochemical properties are calculated on 3-D phase space by MATLAB. Thus, Figure 4. shows *X, Y* and *Z* are vectors, plots one or more lines in three-dimensional space through the points which coordinates are the elements of *X, Y* and *Z*.

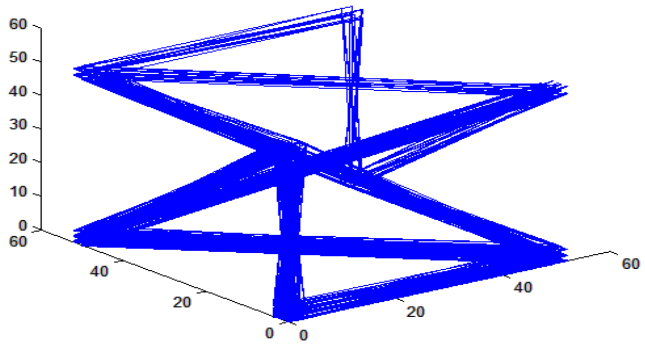


Figure 4. Creates a 3-D line plot of the data values in *X,Y and Z*.

In examined to Lyapunov Exponents signs, according to chaos has been shown an alteration on the phase space, it may be appear or not. So, Lyapunov Exponent signs were vary chaotic structure at phase space. Also, according to length of phase space that LEs show reconciliation and rapprochement at all dimensions of LEs signs as Figure 4. shown. It has a real distribution on phase space.

For this study, used Adhesins Dataset. Thus, give an example of the results, consider a protein that is hemolysin / hemagglutinin - like protein HecA. Top of distributions' values have results between greater or equal to 4. For instance, these values generally have four positive and six negative signs, five positive and five negative signs, six positive and four negative signs etc.

If analyze the Table 2., show the best results from 544 properties on AAIndex Table via Tisean - Lyapunov Exponent Calculator.

Table 2. Gives the best results for protein HecA

Featues of AAIndex	**Positive**	**Negative**
14	4	6
96	4	6
114	4	6
173	4	6
185	4	6
247	4	6
252	4	6
400	***5***	***5***
488	4	6
496	4	6
537	4	6
538	4	6
539	4	6
543	4	6

If analyze the Table 3., shown Lyapunov Exponents, that include to five postive and five negative on phase space, according to chaos theory has distribution as chaotic structure.

Table 3. Lyapunov Exponents belong to each aminoacids for protein HecA

LEs belong to each aminoacids of protein HecA	
Positive	**Negative**
9.044008e-001	*-1.972889e-002*
4.018379e-001	*-1.013593e-001*
2.226827e-001	*-1.959663e-001*
1.310360e-001	*-3.338790e-001*
4.904960e-002	*-7.586726e-001*

Consequently, we have proved this hypothesis that physicochemical properties have distribution on phase space as chaotic structure. So, there are positive and negative signs from lyapunov

exponents of phase space at this distribution, and in addition that belong to each amino acids of proteins on Adhesins dataset.

5. RESULTS

In this paper, we analyzed to Adhesins and non-Adhesins datasets at chaotic structure at phase space. Shortly after, we determined the best physicochemical features on these dataset by result of Lyapunov Exponents. Therefore, if analyzed to other datasets on phase space, in our opinion that dataset will obtain different results about physico chemical features. In the future works, we will be using our developed method, also will be improving this algorithm for classification to unfolded protein regions.

Unfolded protein regions plays an important role in determining transcriptional and translational regulation of the protein, protein-protein, protein-DNA interactions and tertiary structure. To date, studies have been shown that unfolded regions associated with cancer, cardiovascular, diabetes, autoimmune diseases and neurodegenerative disorders.

As a result, will be explained to generate feature vectors that using with chaotic structure for prediction of unfolded protein regions and also we will be making comparison with similar studies in the literature about classification and recognition.

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ANT COLONY OPTIMIZATION FOR CAPACITY PROBLEMS

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ABSTRACT

This paper deals with the optimization of the capacity of a terminal railway station using the Ant Colony Optimization algorithm. The capacity of the terminal station is defined as the number of trains that depart from the station in unit interval of time. The railway capacity optimization problem is framed as a typical symmetrical Travelling Salesman Problem (TSP), with the TSP nodes representing the train arrival /departure events and the TSP total cost representing the total time-interval of the schedule. The application problem is then optimized using the ACO algorithm. The simulation experiments validate the formulation of the railway capacity problem as a TSP and the ACO algorithm produces optimal solutions superior to those produced by the domain experts.

KEYWORDS

Travelling Salesman Problem, Ant Colony Optimization, Capacity Problems, Meta-heuristic Optimization, Soft Computing.

1. INTRODUCTION

This study focuses on the simulation optimization of rail capacity, a prominent application problem in the transportation domain. Zhu [1] defines the railway capacity as the maximum number or pair of trains with standard load passing by a fixed equipment in unit time (usually one day) on the basis of the given type of locomotives and vehicles. It usually depends on the condition of the fixed equipment as well as the organization of the train operation. According to the European Community directives [2], the provision, maintenance and marketing of the railway track capacities should be separated from the operation of trains. This would imply a separation of the management of the railway infrastructure from the management of the railway operation. With this in mind, we frame the aim of this study as: the optimization of rail capacity by managing the train operation, given a fixed railway network and equipment infrastructure. In particular, we focus on the capacity of a terminal station, i.e., the number of trains departing from the terminal station in unit time. The problem basically boils down to constructing an optimal schedule of the passenger trains so as to maximize the terminal station capacity. However, owing to the multiple decision variables, the problem becomes a typical combinatorial optimization problem which cannot be solved using the conventional optimization algorithms.

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In order to solve the combinatorial optimization problem, we first cast it in the form of a Travelling Salesman Problem and use some of the soft–computing techniques to find the optimal solution. Although the TSP has applications in practical problems like Vehicle Routing, Job Sequencing, Computer Wiring, etc. [3], it is known to be NP hard. Since brute force approach is an infeasible option, heuristics approach can be fairly relied upon to solve thesetypes of problems since heuristics approach utilizes much less computing power. Some of the conventional heuristic techniques designed to solve the TSP include branch and cut [4], dynamic programming [5], regression analysis [6], exact methods [7], etc. Recently many meta-heuristic algorithms (i.e. heuristics that do not depend on the domain knowledge of the problem) are successfully employed to search for the optimal TSP solution. The Genetic Algorithm (GA) based on the Darwinian theory of natural selection and its variants are reported to be successful in finding the optimal solutions to the benchmark TSP problems in a reasonable amount of computing time [8-11]. In some studies, the Genetic Algorithm is combined with other meta-heuristic optimization algorithms to improve the optimization results [12].

However, the most successful soft computing algorithm to obtain the optimal solution of the TSP is the Ant Colony Optimization (ACO) algorithm. The development of the ACO algorithm has been inspired by the foraging behaviour of some ant species. These ants deposit pheromone on the ground in order to mark some favourable path that should be followed by other members of the colony. The ACO algorithm exploits a similar mechanism for solving optimization problems [13-19]. From the early nineties, when the first ACO algorithm was proposed, it has attracted the attention of an increasing numbers of researchers and it has been extended to many successful applications.

In this study, the railway capacity optimization problem is cast in the form of a TSP. The arrival/departure *events* in the schedule are treated as *nodes* which need to be ordered under the given scheduling constraints so as to minimize the entire schedule time. Some of the other constraints are imposed by the track-changing hardware equipment. The time between two events is considered to be the *distance* between two TSP edges and the train operation schedule is considered to be the *tour length* of the TSP. The standard ACO application to this problem yields an optimal schedule, under the given infrastructure and operational constraints.

This paper is organized as follows: Section 2 describes the TSP and ACO. Section 3 describes the formulation of the railway capacity optimization problem (RCP) as the TSP and its solution using the standard ACO algorithm. Section 4 presents the simulation optimization results and section 5 concludes the paper.

2. TSP AND ACO

In this section, we introduce the Travelling Salesman Problem and the Ant Colony Optimization algorithm. We show how the Ant Colony Optimization algorithm is designed to solve the Travelling Salesman Problem.

2.1. Travelling Salesman Problem (TSP)

The Travelling Salesman Problem (TSP) is a classic problem in computer science which may be stated as follows: Given a list of cities and their pairwise distances, the task is to find the

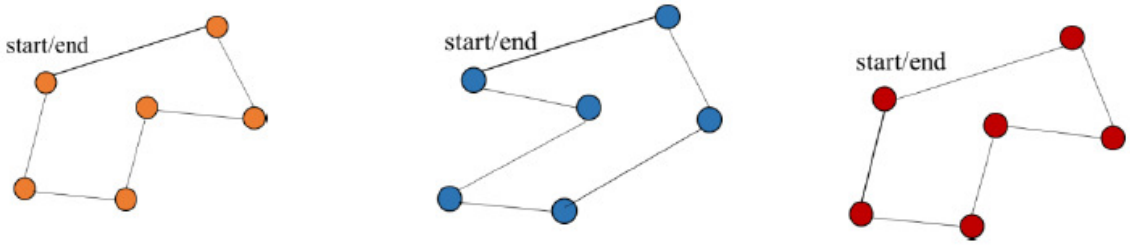


Figure 1. Three feasible routes of a 6-node TSP

shortest possible route that visits each city exactly once and then return to the original city. If n is the number of cities to be visited, the total number of possible routes covering all cities, $S_n$is given by:

$$S_n = (n-1)!/2 \quad (1)$$

A naive solution solves the problem in O(n!) time, simply by checking all possible routes, and selecting the shortest one. A more efficient dynamic programming approach yields a solution in $O(n^2 2^n)$ time [3]. The TSP is proved to be NP-hard and various Operation Research (OR) solution techniques have been proposed, yielding varying degrees of success [4-7]. The Ant Colony Optimization, described in the following sub-section is a novel soft computing algorithm developed to tackle combinatorial optimization problems.

2.2. Ant Colony Optimization CO

The Ant Colony Optimization (ACO) which is based on the foraging behaviour of ants was first proposed by Dorigo [13].

1 Initialize parameters and solutions
2 While the termination criterion is not met
3 Evaluate solutions
4 Update pheromone
5 Construct new solutions
6 End
7 Output the optimum solution

Figure 2. The ACO algorithm

A generic ACO algorithm is shown in Figure. 2. In step 1, the algorithm parameters are initialized and all the artificial ants (random solutions) are generated. The loop from lines 2 through 6 is repeated until the termination condition is met. The steps inside the loop consist of evaluating the solutions, updating the pheromones and constructing new solutions from the previous solutions. The two main steps inside the loop are further described below.

Solution construction

Ant *k* on node *i* selects node *j,* based on the probability, p_{ij}, given by:

$$p_{ij}^{k} = \begin{cases} \dfrac{[\tau_{ij}]^{\alpha}[\eta_{ij}]^{\beta}}{\sum_{j \in \mathcal{N}_i^k}[\tau_{ij}]^{\alpha}[\eta_{ij}]^{\beta}} & \text{if } j \in \mathcal{N}_i^k, \\ 0 & \text{otherwise,} \end{cases} \tag{2}$$

where $\mathcal{N}_i^k$ denotes the set of candidate sub-solutions; τ_{ij} and η_{ij} denote, respectively, the pheromone value and the heuristic value associated with e_{ij}.

Updating the pheromone

The pheromone update operator employed for updating the pheromone value of each edge e_{ij} is defined as

$$\tau_{ij} = (1-\rho)\tau_{ij} + \rho\sum_{k=1}^{m}\Delta\tau_{ij}^{k} \tag{3}$$

$$\Delta\tau_{ij}^{k} = \frac{1}{L^k} \tag{4}$$

Where L_k denotes the quality of the solution created by ant k; $\rho \in (0,1]$ denotes the evaporation rate.

3. CAPACITY PROBLEM AS TSP

This section describes in detail the railway capacity problem to be optimized. It explains the optimization constraints, the framing of the railway capacity problem as a typical TSP and finally the solution process by using the standard ACO algorithm.

3.1. Capacity Problem

When dealing with the railway capacity problem, the railway management has to consider the different types of capacities in the railway domain. Some of the relevant capacities, for instance, are: (1) the capacity of the platform to hold passengers, (2) the capacity of the carriages to hold passengers, (3) the rail network capacity to hold the number of trains at a given time, and (4) the capacity of the railway station structure to schedule the maximum number of trains per unit time. Dealing with all these types of capacities simultaneously is a complex problem. This study is dedicated to the maximization of only the type 4 railway capacity, i.e., maximization of the number of trains that can be scheduled at a railway station per unit time. The type 4 rail capacity optimization in turn leads to optimization of the royalties and alleviation of the congestion problem during rush hours.

3.2. Capacity problem as TSP

In the generalized form of the TSP, the cities are represented as *nodes* (Figure 3a). The task is then finding the shortest route, starting from a given node and visiting each node in the network exactly once before returning to the starting node. In the Railway Capacity Optimization (RCP) problem, the arrival/departure *events* (Figure 3b) in the schedule are treated as *nodes* which need to be ordered under the given scheduling constraints so as to minimize the entire schedule time.

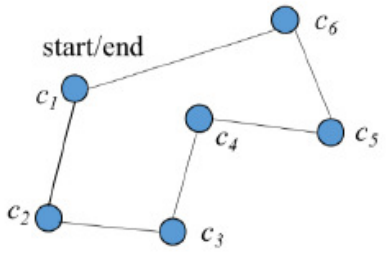
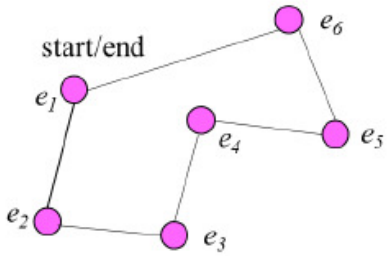


Figure 3a.The TSP nodes (cities) Figure



3b. The RCP nodes (events)

3.3. Structure constraints

In this study, we consider a railway terminal station with four railroads, each with an attached platform. The trains can arrive at the terminal and leave the terminal via any of these four railroads. There are five train services, namely, S55, S5, L7, S2 and S1 and the railroad access constraints are given in Table 1.

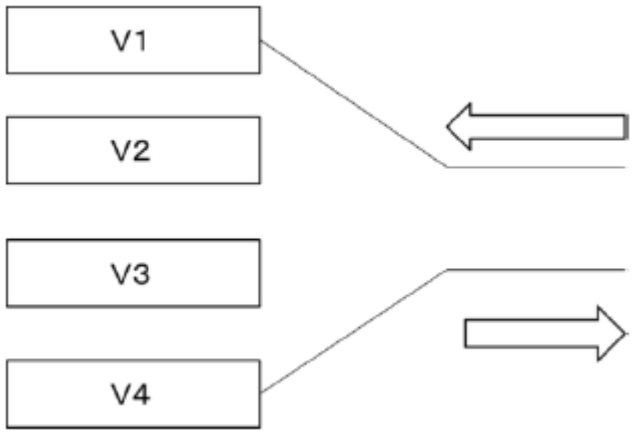


Figure 4. The platforms in the terminal station

.

Table 1. Given parameters of the train capacity problem

Trains		Offset		Time betweew arrivals		Stop Time(seconds)		platform	
Trains	N°t/h	OffsetMin	OffsetMax	Cmin	Cmax	Dmin	Dmax	arrival	departure
L7	2	0	0	0	700	110	300	v2	v2
S1	1	0	0	0	700	110	300	v4	v4
S2	1	0	0	0	700	110	300	v3	v3
S5	1	0	0	0	700	110	300	v1	v1
S55	1	0	0	0	700	110	300	v1	v1

4. OPTIMIZATION RESULTS

The aim of the simulation experiments using the ACO algorithm is to maximize the number of trains leaving the terminal station in an hour. However, to reduce the calculation load, we divide the hourly interval into 5 equal intervals, each being of 720 seconds (12 minutes) duration. The assumption here is that the train schedule is periodic. The same period can then be stretched over an hour. In Table 3, the final capacity of the terminal station is calculated by using the following formula:

$$C = \frac{3600}{T} * 6 \tag{5}$$

where, T is the total time for the entire schedule covering a period of 720 seconds.

The minimum time for the entire schedule over a period of 720 seconds is found to be 555 seconds and correspondingly the maximum capacity is 38.9 trains/hour

We conducted several experiments by varying the α, β and ρ parameters of the ACO algorithm. Some of the optimal results obtained by these tuned parameters are shown in Table 4. Another important parameter that needs an empirical tuning is the population size of the agents, N. Table 5 shows the results obtained by varying this number. As expected, the larger the population size, the better the results are, although this increases the computational overhead.

Table 2. Varying the population size of the ACO agents

N	α	β	ρ	T seconds (average)
100	1	5	0.7	558.4
200	1	5	0.7	558
300	1	5	0.7	557

5. CONCLUSIONS

The Ant Colony Optimization soft computing algorithm is apt for solving combinatorial optimization problems like the classical NP-hard Travelling Salesman Problem. Basing the search on the stigmery of the food foraging real-life ant colony, the algorithm explores the huge search space of the NP-hard problems to find the optimal solution. In this study, the authors have applied the ACO algorithm to optimize the capacity of a terminal railway station. The capacity optimization problem is cast into the form of a TSP-like problem, where the arrival and departure events of the trains are considered to be the nodes and the schedule length as the TSP total route. The standard ACO optimizes the schedule length subject to the infrastructure and operational constraints. The simulation experiments validate the formulation of the railway capacity problem as a TSP. The optimal solutions obtained by the soft-computing technique is superior to those produced by the domain experts.

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OUDG: CROSS MODEL DATUM ACCESS WITH SEMANTIC PRESERVATION FOR LEGACY DATABASES

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ABSTRACT

Conventional databases are associated with a plurality of database models. Generally database models are distinct and not interoperable. Data stored in a database under a particular database model can be termed as "siloed data". Accordingly, a DBMS associated with a database silo, is generally not interoperable with another database management system associated with another database sil. This can limit the exchange of information stored in a database where those desiring to access the information are not employing a database management system associated with the database model related to the information. The DBMS of various data models have proliferated into many companies, and become their legacy databases. There is a need to access these legacy databases using ODBC. An ODBC is for the users to transform a legacy database into another legacy database. This paper offers an end user's tool of Open Universal Database Gateway(OUDG) to supplement ODBC by transforming a source legacy database data into Flattened XML documents, and further transform Flattened XML document into a target legacy database. The Flattened XML document is a mixture of relational and XML data models, which is user friendly and is a data standard on the Internet. The result of reengineering legacy databases into each other through OUDG is information lossless by the preservation of their data semantics in terms of data dependencies.

KEYWORDS

Open universal database gateway, Legacy databases, Flattened XML Documents, Data semantics, Data dependencies, Open database connectivity

1. INTRODUCTION

The database management system (DBMS) of various data models have proliferated into many companies and, over time, have become legacy databases within the companies. However, there is a need to access these legacy databases, e.g., for mass information transmission associated with e-commerce, etc. Legacy databases, e.g., conventional databases, can be associated with a plurality of database models, e.g., database silos. These database silos can be distinct and fail to interoperate without significant costs or loss of data or data semantic information. Siloed data, e.g., data within a database model acts is typically only readily accessible or interoperable within that database model and not with data stored in another database silo, can limit the exchange of information where those desiring to access the information are not employing a related DBMS.

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Additionally, even where a database environment is relatively modern, it can be incompatible with other relatively modern database silos. The plurality of database silos in itself can be an impediment to sharing data among them. As an example, where a first company employs a first database associated with a first database model, a second company employs a second data model for their data, and a third company employs a third data model for their data, sharing of data across the three data silos can be impractical or impossible. Where the first company purchase the second company, incorporating the second company's data can be problematic, e.g., it can require rewriting the data into the first data model at the risk of losing data or semantics. Alternatively, the first company can operate the two databases separately but are then internally faced with the incongruences of the two databases, bear the costs associated with operating or maintaining two separate databases, etc. Further, the first company, even with access to the first and second databases, still can face serious challenges with sharing data with the third company.

The evolution of database technologies intend to meet different users requirements. For example, the Hierarchical and Network (Codasyl) databases(NDB) are good for business computing on the large mainframe computers. The user friendly relational databases(RDB) are good for end user computing on personal computers. The object-oriented databases(OODB) are good for multi-media computing on mini computers. The XML databases(XML DB) are good for Internet computing on the mobile devices. These are first generation Hierarchical and Network databases, second generation relational databases, and third generation Object-Oriented and XML databases.

Flattened XML documents

Flattened XML documents are generic representation of any legacy database instance in any legacy database data model. Flattened XML document is a valid XML document which contains a collection of elements of various types and each element defines its own set of properties. The structure of the flattened XML document data file is a relational table structured XML document. It has XML document syntax with relational table structure. It replaces primary key with ID, and foreign key with IDREF as follows:

```
<?xml version="1.0">
<root>
 <table1 ID="…" IDREF1="…" IDREF2="…" … IDREFN="…">
  <attribute1>…</attribute1>
    …
  <attributeN>…</attributeN>
 </table1>
 …
 <tableN ID="…" IDREF1="…" IDREF2="…" … IDREFN="…">
  <attribute1>…</attribute1>
  …
  <attributeN>…</attributeN>
 </tableN>
</root>
```

For each table, the name of the table (tableN) determines its type name and the name of property (attributeN) determines its property name. Each table defines an ID type attribute that can uniquely identify itself and there are optional multiple IDREF type attributes that can refer to the ID in other tables in the same flattened XML document instance. Each property XML element encloses a property value in a proper textual representation format. In order to ensure a flattened XML document instance to be valid, there must be either an internal or an external DTD document that defines the XML structures and attribute types, in particular for those ID and IDREF type attributes.

Open Universal Database Gateway

An open universal database gateway(OUDG) is a database middleware which provides more flexibility for the users to access legacy databases in their own chosen data model. Users can apply OUDG to transform legacy databases into flattened XML documents, and then further transform them into user's own familiar legacy database for access. Since XML is the data standard on the Internet, it becomes information highway for user to access data.

The reason we choose flattened XML document is due to its openness for DBMS independence. All other data models are DBMS dependent. For example, an Oracle database can only be accessed by Oracle DBMS, and a MS SQL Server database can only be accessed by MS SQL Server DBMS. Nevertheless, users can access flattened XML documents on the Internet by Internet Explorer without programming. Therefore, an Oracle user can access an MS SQL Server database by using OUDG transforming the MS SQL Server database into flattened XML document, and then further transform flattened XML document to Oracle database.

Similarly, the reason we choose relational table structure for the flattened XML document is that relational table structure has a strong mathematical foundation of relational algebra to implement the constraints of major data semantics such as cardinality, isa and generalization to meet users' data requirements by replacing primary keys and foreign keys into ID(s) and IDREF(s) in XML schema.

The OUDG can transform legacy databases into flattened XML document, and then further transform the flattened XML document into one of four target legacy databases: relational, object-oriented, XML and network. The result is that OUDG allows users reengineer a source legacy database into an equivalent target legacy database of user's choice with data semantics preservation.

This paper offers flattened XML documents as universal database medium for the interoperability of all legacy databases that can be accessed by the users using their own familiar legacy database language via OUDG. We consider hierarchical data model same as XML data model in this paper because they are all in tree structure. All proprietary legacy data models can be united into flattened XML document as universal database as shown in Figure 1.

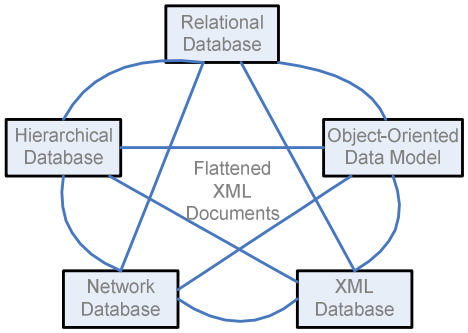


Figure 1. Legacy Databases Interoperability via Flattened XML documents

The major difference between regular tree-based XML document and flattened XML document is that the latter is more user friendly and efficient in database update since its database navigation access path is much shorter than the former. The flattened XML document database navigation access path is limited to 2 levels from root element to sibling elements while the regular XML document database access path is in several levels and much longer in general.

Problems:
(1) Most legacy database systems are proprietary. Database vendors do not facilitate tools to export their databases to other legacy databases. Thus, companies need to use ODBC to access heterogeneous databases, which requires programming and much time effort.
(2) Most users cannot access all legacy databases because they do not know all legacy database languages. They rely on ODBC, which is not easy to learn.
(3) It is difficult to convert legacy databases in different data models because the data conversion of legacy database involves data models transformation.

Solution:
Through OUDG, users can use one database language access another legacy databases of relational, object-oriented, network and XML. The operation is more reliable and speedy because same data can be concurrently processed by legacy database and their equivalent flattened XML document.

Academic merit:
The novelty is that it is feasible to replace ODBC by OUDG transforming legacy database into flattened XML document for access. ODBC needs programming, but OUDG is an end user software utility.

Industrial merit:
The application of flattened XML document is for information highway on the Internet for data warehouse, decision support systems (Fong, Li & Huang, 2003). The benefits are information sharing among users for database interoperability.

OUDG as supplement for ODBC
OUDG can supplement ODBC to access any legacy database by transforming(reengineering) them into a flattened XML document for access as universal database which is defined as a database interchangeable to all legacy databases.

At present, most database systems are proprietary. Each DBMS vendor has software tools which convert other legacy databases into databases using their own DBMS(s), but not vice versa for converting their own databases into a target legacy database. The result makes legacy databases not open to each other. However, using OUDG, any legacy database can be transformed into any other legacy database via flattened XML documents. The benefit is that data sharing and data conversion among legacy databases becomes possible. The openness of legacy database is necessary for such application such as data warehousing, data mining and big data.

Figure 2 shows the architecture of an open universal database gateway which transforms legacy databases into each other with different data models via flattened XML document as a replacement for open database connectivity.

Data Semantics preservation in legacy databases
Data semantics describe data definitions and data application for users' data requirements, which can be captured in the database conceptual schemas. The following are the data semantics which can be preserved among the legacy conceptual schemas and their equivalent flattened XML schema:

(a) Cardinality: 1:1, 1:n and m:n relationships set between two classes
A one-to-one relationship between set A and set B is defined as: For all a in A, there exists at most one b in B such that a and b are related, and vice versa. The implementation of one-to-one relationship is similar to one-to-many relationship.

A one-to-many relationship from set A to set B is defined as: for all a in A, there exists one or more b in B such that a and b are related. For all b in B, there exists at most one a in A such that a and b are related.
A many-to-many relationship between set A and set B is defined as: For all a in A, there exists one or more b in B such that a and b are related. Similarly, for all b in B, there exists one or more a in A such that a and b are related.
In relational schema, 1:n is constructed by foreign key on "many" side referring to primary key on "one" side. It can also be implemented by association attribute of a class object on "one" side points to another class objects on "many" side in object-oriented schema. It can also be implemented by owner record occurrence on "one" side and member record occurrences on "many" side in network schema. It can also be implemented by element occurrence with IDREF on "many" side links with element occurrence with ID on "one" side in XML schema. As to m:n cardinality, it can be implemented by two 1:n cardinalities with 2 "one" side classes link with 1 "many" side class.

(b) Isa relationship between a superclass and a subclass
The relationship A isa B is defined as: A is a special kind of B.
In relational schema, a subclass relation has same primary key as its superclass relation, and refers it as a foreign key in isa relationship. In object-oriented schema, isa can be implemented by a subclass inheriting its superclass's OID and attributes. In Network schema, isa can be implemented by an owner record that has same key as its member record in network schema via SET linkage. In XML schema, isa can be implemented by an element links one-to-one occurrence with its sub-element.

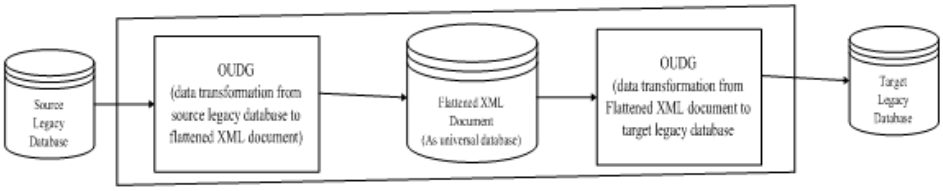


Figure 2. Architecture of OUDG with schema translation and data transformation

(c) Generalization is the relationship between a superclass and its subclasses.
Multiple isa relationships construct generalization with common superclass.
In relational schema, A is a special kind of B, and C is also a special kind of B, then A and C subclasses can be generalized as B superclass. In relational schema, multiple subclass relations and their superclass relation contain the same key, with subclass relations' keys referring to superclass key as foreign key in generalization. In object-oriented schema, multiple subclasses objects contain the same OID as their superclass object in generalization. In network schema, one owner record links with multiple member records through a SET in generalization. In XML schema, multiple subclass elements and their superclass element are in 1:1 linkage with same key attribute in generalization. Generalization can be implemented by multiple isa relationships with multiple subclasses generalized into one superclass.

Initially, OUDG maps major data semantics of cardinality, isa, and generalization into each legacy data model as shown in Table 1 which shows data semantics preservation in legacy data models and Flattened XML document

The preservation of data semantics among legacy databases can be verified by the preservation of their data dependencies as follows:

Definition of FD (functional dependency)

Given a relation R, attribute Y of R is functionally dependent on attribute X of R, i.e., FD: R.X → R.Y, iff each X-value in R has associated with it precisely one Y value in R. Attribute X and Y may be composite.

Definition of ID (inclusion dependency)
ID: Y ⊆ Z states that the set of values appearing in attribute Y must be a subset of the set of values appearing in attribute Z.

Definition of MVD (multi-valued dependency)
Let R be a relation variable, and let A, B and C be the attributes of R. Then B is multi-dependent on A if and only if in every legal value of R, the set of B values matching a given AC pair value depends on the A value, and is independent of the C value.

In general, the mapping and the preservation of the data semantics of cardinality, isa, and generalization among legacy databases schemas can be shown in Figure 3 as follows:

In one-to-many cardinality, for example, each child relation B tuple determines its parent relation A tuple in relational schema; each member record B determines its owner record A in network schema; each "many" side object B determines its associated "one" side object A in object-oriented schema, and each sub-element B occurrence determines its element A occurrence in XML schema.

In many-to-many cardinality, two one-to-many cardinality MVD(s) can construct a many-to-many cardinality. For example, many tuples in relation B determine many tuples in relation A and vice versa (many relation A tuples determine many relation B tuples); many records B determine many records A. Therefore many elements B occurrence determine many elements A occurrences, and vice versa.

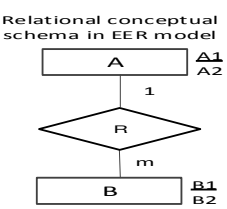
Table 1 showing information related to data semantic preservation.

Data model\ Data Semantic	Relational	Object-Oriented	Network	XML	Flattened XML
1:n cardinality	Many child relations' foreign keys referring to same parent relation's primary key.	A class's association attribute refers to another class's many objects' OID(s) as a Stored OID.	An owner record data points to many member records data via SET linkage.	An element has many sub-elements.	The IDREF(s) of a "many" side sibling element's data refer to an ID of "one" side sibling element data under root element.

m:n cardinality	A relationship relation's composite key are foreign keys referring to 2 other relations' primary keys.	A class's association attribute refers to another class's many objects' OID(s) as an Stored OID, and vice versa.	Two owner records data point to the same member record data via 2 SETs linkages .	A sub-element of an element links another element IDREF referring to the latter's ID. The 2 elements are in m:n cardinality.	An sibling element data has 2 IDREF(s) referring to 2 other sibling elements ID(s) under root element.
Is-a	Subclass relation's primary key is a foreign key referring to its superclass relation's primary key.	A subclass inherit OID(s), attributes and methods of its superclass as its OID plus its own attributes and methods.	An owner record data links to a member record data in 1:1 with same key.	An element occurrence links with a sub-element occurrence in 1:1 linkage.	The IDREF of a subclass sibling element data refers to the ID of a superclass sibling element. Both elements has same key value under root element.
Generalization	2 subclass relations' primary keys are foreign keys referring to same superclass relation's primary keys.	Two subclasses inherit OID and attributes of their identical superclass as their OID plus their own attributes.	An owner record data occurrence points to two member records data occurrence with same key.	An element data occurrence links with two sub-elements data occurrence in 1:1 linkages.	The IDREF(s) of 2 subclass sibling elements data occurrence refer to an ID of a superclass sibling element data occurrence with same key value under root element.

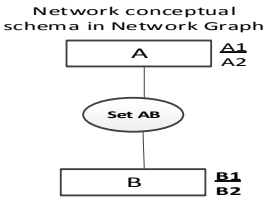
In isa relationship, for example, each B tuple is a subset of A tuple; each record B is a subset of A record; each object B is a subset of object A; and each sub-lement B occurrences is a subset of element A occurrence. In generalization, the data dependencies are similar to isa relationship, except the pair of subclass B and C is a subset of superclass A.

The above data semantics can be preserved in flattened XML documents with sibling elements only, linking with each other via IDREF and ID as shown in Figure 4.



Relational Schema

Relation A (A1, A2)
Relation B (B1, B2, *A1)



Network Schema

Record Name is A
A1 Character
A2 Character
Record Name is B
B1 Character
B2 Character
Set AB
Owner is A
Member is B

Relations

R1

A1	A2
a11	a21
a12	a22

R2

B1	B2	*A1
b11	b21	a11
b21	b22	a12

FD: B → A

(a) one-to-many cardinality

Records

A

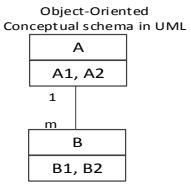
A1	A2
a11	a21
a12	a22

B

B1	B2
b11	b21
b12	b22

FD: B → A

(a) one-to-many cardinality



Object-Oriented Schema

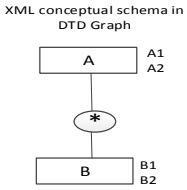
Class A
Attribute A1 Char
Attribute A2 Char
Attribute A_B set (B)
End
Class B
Attribute B1 Char
Attribute B2 Char
Attribute B_A (A)
End

Classes

OID_A	A1	A2	Stored_OID
#1	a11	a21	#3, #4
#2	a12	a22	#3, #4

OID_B	B1	B2	Stotred OID
#3	b11	b21	#1
#4	b12	b22	#2

FD: B → A



XML schema in DTD

```
<!ELEMENT A(B*)>
<!ATTLIST A1 CDATA #REQUIRED>
<!ATTLIST A2 CDATA #REQUIRED>
<!ELEMENT B EMPTY>
<!ATTLIST B1 CDATA #REQUIRED>
<!ATTLIST B2 CDATA #REQUIRED>
```

XML Docment

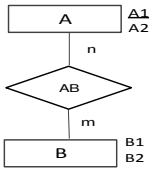
```
<A A1=" a11" A2=" a12">
      <B B1="b11"></B>
      <B B1="b12" ></B>
</A>
<A A2=" a21" A2=" a22">
      <B B1="b21"></B>
      <B B1="b22" ></B>
</A>
```

FD: B → A

Figure 3a Data semantics preservation in legacy databases (1:n Cardinality)

(b) many-to-many cardinality

Relational conceptual schema in EER model



Relational Schema

Relation A (A1, A2)
Relation B (B1, B2)
Relation AB (*A1, *B1)

Relations

A

A1	A2
a11	a21
a12	a22

B1	B2
b11	b21
b21	b22

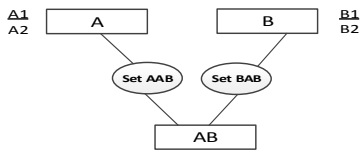
AB

*A1	*B1
a11	b11
a12	b21

MVD: B →→ A
MVD: A →→ B

(b) many-to-many cardinality

Network conceptual schema in Network Graph



Network Schema

Record Name is A
A1 Character
A2 Character
Record Name is B
B1 Character
B2 Character
Record Name is AB
Set AAB
Owner is A
Member is AB
Set BAB
Owner is B
Member is AB

Records

A

A1	A2
a11	a21
a12	a22

B

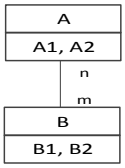
B1	B2
b11	b21
b12	b22

AB

A1	B1
a11	b11
a12	b21

MVD: A →→ B
MVD: B →→ A

Object-Oriented Conceptual schema in UML



Object-Oriented Schema

Class A
Attribute A1 Char
Attribute A2 Char
Attribute A_B set (B)
End
Class B
Attribute B1 Char
Attribute B2 Char
Attribute B_A set (A)
Member is B

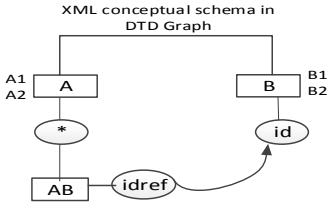
Classes

OID_A	A1	A2	Stored_OID
#1	a11	a21	#3, #4
#2	a12	a22	#3, #4

OID_B	B1	B2	Stotred OID
#3	b11	b21	#1, #2
#4	b12	b22	#1, #2

MVD: A →→ B
MVD: B →→ A

XML conceptual schema in DTD Graph



XML schema in DTD

<!ELEMENT A(AB*)>
<!ATTLIST A1 CDATA #REQUIRED>
<!ATTLIST A2 CDATA #REQUIRED>
<!ELEMENT AB EMPTY>
<!ATTLIST AB_iderf IDREF #REQUIRED>
<!ELEMENT B EMPTY>
<!ATTLIST B id ID CDATA #REQUIRED>
<!ATTLIST B1 CDATA #REQUIRED>
<!ATTLIST B2 CDATA #REQUIRED>

XML Docment

<A A1=" a11", A2=" a21">
<AB idref=" 1"></AB>
</A>
<A A1=" a12", A2=" a22">
<AB idref=" 1"></AB>
</A>
<B B1="b11" B2=" b12" id=1"></B>

MVD: A →→ B
MVD: B →→ A

Figure 3b Data semantics preservation in legacy databases (m:n Cardinality)

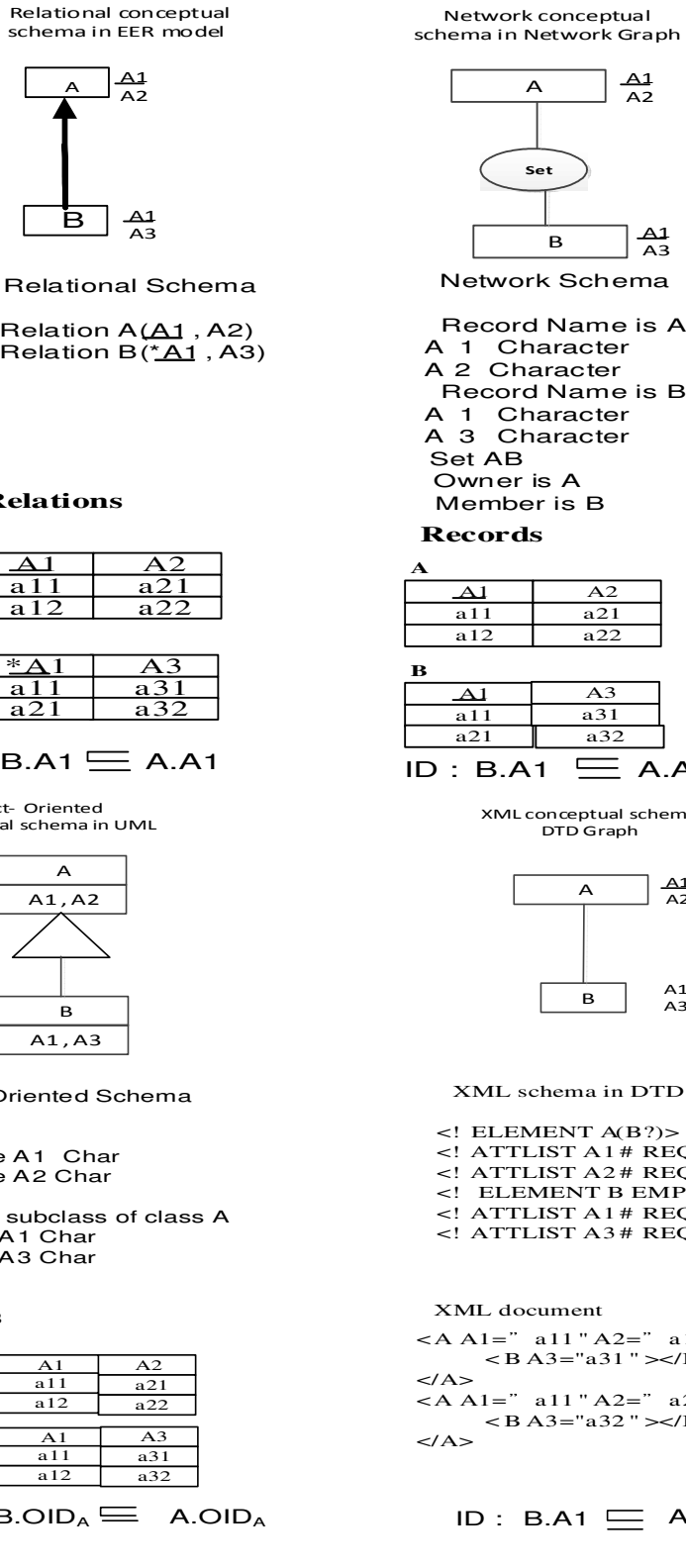
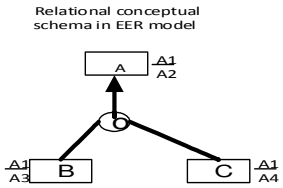


Figure 3c Data semantics preservation in legacy databases (ISA relationship)



Relational Schema

Relation A(A1 , A2)
Relation B(*A1 , A3)
Relation C(*A1 , A4)

Relations

A

A1	A2
a11	a21
a12	a22

B

*A1	A3
a11	a31
a21	a32

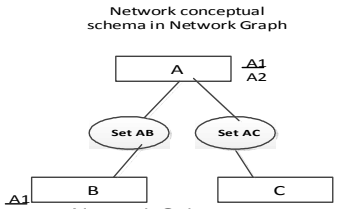
C

*A1	A4
a11	a41
a21	a42

ID : B.A1 ⊆ A.A1

ID : C.A1 ⊆ A.A1

(a) one-to- many cardinality



Network Schema
Record Name is A
A 1 Character
A 2 Character
Record Name is B
A 1 Character
A 3 Character
Record Name is C
A 1 Character
A 4 Character
Set AB
Owner is A
Member is B
Set AC
Owner is A
Member is C

Records

A

A1	A2
a11	a21
a12	a22

B

*A1	A3
a11	a31
a21	a32

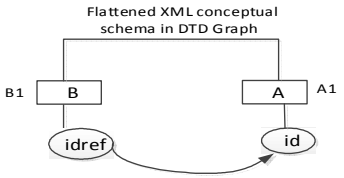
C

A1	A4
a11	a41
a12	a42

ID : B.A1 ⊆ A.A1

ID : C.A1 ⊆ A.A1

(b) many-to- many cardinality



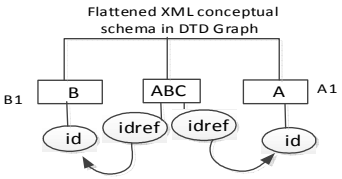
Flattened XML Document schema in DTD

```
<! ELEMENT ROOT (A , B)>
<! ELEMENT A EMPTY >
<! ATTLIST A id ID # REQUIRED >
<! ATTLIST A A 1 CDATA # REQUIRED >
<! ELEMENT B EMPTY >
<! ATTLIST B idref IDREF # REQUIRED >
<! ATTLIST B B 1 CDATA # REQUIRED >
```

Flattened XML Document Data

```
<ROOT>
    <A A1="a11 " id="1"></A>
    <B B1="b11 " idref=1"></B>
    <B B1="b12 " idref=1"></B>
</ROOT>
```

FD : B.iderf → A.id



Flattened XML Document schema in DTD

```
<! ELEMENT ROOT (A , AB , B)>
<! ELEMENT A EMPTY >
<! ATTLIST A id ID # REQUIRED >
<! ATTLIST A A 1 CDATA # REQUIRED >
<! ELEMENT B EMPTY >
<! ATTLIST B id ID # REQUIRED >
<! ATTLIST B B 1 CDATA # REQUIRED >
<! ELEMENT AB EMPTY >
<! ATTLIST AB idref 1 IDREF # REQUIRED >
<! ATTLIST AB idref 2 IDREF # REQUIRED >
<! ATTLIST AB C CDATA # REQUIRED >
```

Flattened XML Document Data

```
<ROOT>
    <A A1="a11 " id="1"></A>
    <B B1="b11 " id="2"></B>
    <A B C="c11 " idref1="1" idref2="2" ></AB>
    <A B C="c12 " idref1="2" idref2="1" ></AB>
</ROOT>
```

MVD : A.id →→ B.id

MVD : B.id →→ A.id

Figure 4a Data semantics preservation in flattened XML documents (1:n & m:n cardinalities)

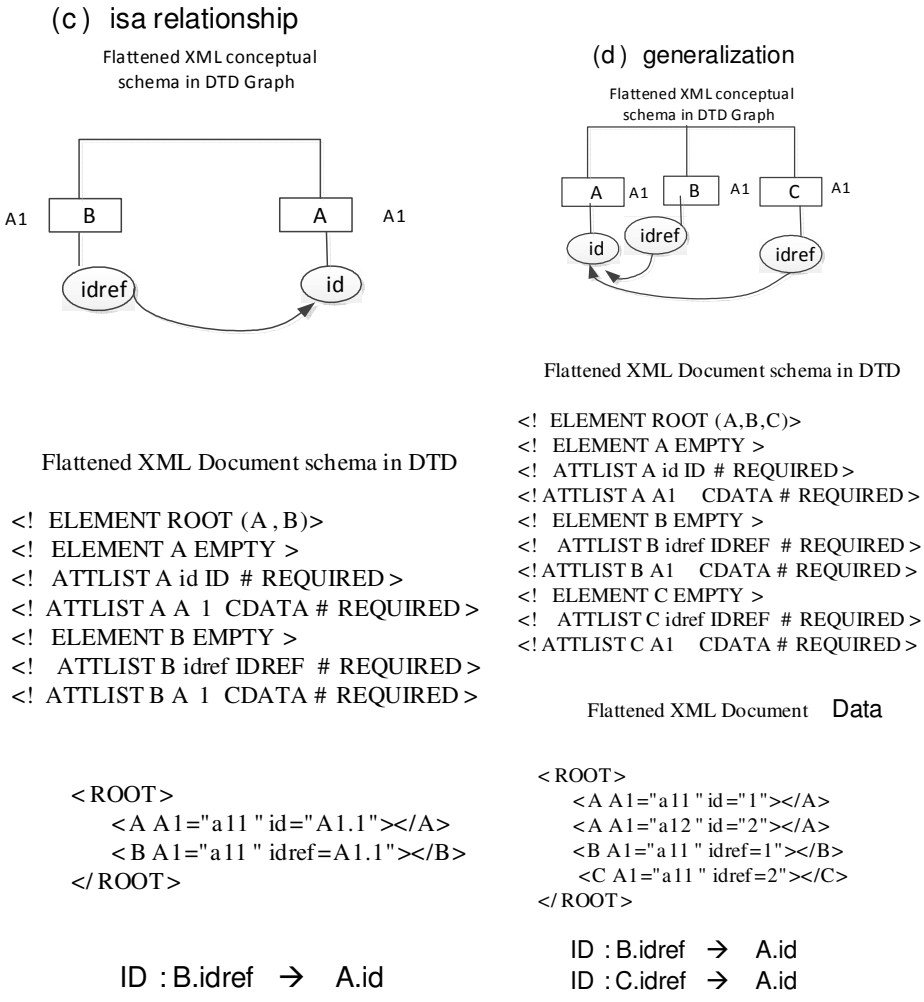


Figure 4b Data semantics preservation in flattened XML documents (ISA, generalization)

2. RELATED WORK

On data transformation

Shoshani, A.[1] defined logical level approach data conversion by using source and target schemas to perform data type conversion instead of physical data type conversion. He provided a general methodology of using logical level approach of downloading source legacy database into sequential file and uploading them into target legacy database for data transformation.

Lum et al [2] showed how to construct data conversion languages SDDL and TDL to extract and restrict data from source legacy database into target legacy database.

The above two paper differ from this paper such that they apply sequential file as medium for legacy databases exchange, but this paper applies flattened XML document as medium for legacy databases exchange.

Fong and Bloor [3] described mapping navigational semantics of the network schema into a relational schema before converting data from network database to relational database.

Fong [4] presented a methodology of transforming object-oriented database objects into Relational database by using SQL Insert statements.
Fong and Shiu [5] designed a Semantic Export Markup Language as a data conversion language to export component of relational database into XML database.
Fong et al.[6] applied logical level approach for data materialization between relational database and object-oriented database using sequential file as medium.

On Heterogeneous database
Given huge investment for a company put into heterogeneous databases, it is difficult for company convert them into homogeneous databases for new applications. Therefore, researchers have come up with a solution of universal databases that can be accessed as homogeneous databases by the user [7] . For instance, we can provide an relational interface to non-relational database such as Hierarchical, Network, Object-Oriented and XML [8] .
Hsiao & Kamel [9] offered a solution of multiple-models-and-languages-to-multiple-models-and–languages mapping to access heterogeneous databases.
Their papers propose a universal database for Hierarchical, Network and Relational databases while this paper proposes a universal database for Network, Relational, Object-Oriented and XML databases.

On Universal database
Fong et al. [10] applied universal database system to access universal data warehousing for the integration of both relational databases and object-oriented databases with star schema and OLAP functions.
Silverston & Graziano [11] used a universal data model in a diagram to design the conceptual schema of different legacy data models of any legacy database.
The above papers differ from this paper such that the above paper proposes a universal data model diagram for universal database conceptual schema while this paper proposes using DTD Graph in Figure 3 and 4 as conceptual schema for universal database.

On Homogeneous database
Sellis, Lin & Raschid [12] presented a solution to decompose and store the condition elements in the antecedents of rules such as those used in production rule-based systems in homogeneous databases environment using relational data model.
This paper differs from the above paper such that it uses flattened XML document environment for universal database.

On schema translation
Funderburk et al. [13] proposed DTD Graph as XML conceptual schema which is identical to DTD, but in a graph format.

On Cloud Database
Derrick Harris [14] defines cloud database as databases in virtual machines.
This paper plans to include cloud computing for further research in future.

On Flattened XML document
Fong et al. [15] converted an XML document into Relational database by transforming XML document into flattened XML document with relational table structure by Extensible Stylesheet Language Transformation.
Compared with the above references, this paper has 3 uniqueness:
(1) Cover more data model
All other database research paper only involve 2 or 3 data models in the universal database. This paper involves 4 data models such as Network, relational, object-oriented and XML.
(2) Use cloud platform

The reference papers do not use cloud platform to implement universal database. This paper performs prototype in cloud platform.
(3) Flattened XML document as middleware
This paper applies flattened XML document as medium to transform legacy databases among each other which is not done by other research papers.

Above all, this paper extends the work of universal database into an "open" universal database gateway such that the universal database is not limited to a particular DBMS, but can be any legacy database of user's choice. Similarly, OUDG is more user friendly than ODBC because it requires less programming effort.

3. METHODOLOGY OF OUDG AS ODBC SUPPLEMENT

This paper proposes OUDG as a database middleware to access legacy databases via flattened XML documents as an universal database as follows:
First Legacy databases → Phase 1: Second Flattened XML documents (universal database)
→ Phase 2:Third Legacy databases
The major functions of OUDG are:

Phase I: Transform first legacy databases into flattened XML documents
Any one of the four first legacy database can be transformed into the flattened XML document as follows:

Case 1: Transform first legacy relational databases into second flattened XML documents
Firstly, we perform the preprocess of mapping relational schema into flattened XML schema. Secondly, we perform their correspondent data conversion. The input is a relational database and the output is an flattened XML document. The system will read relational table according to the legacy relational schema. In one-to-many data semantic, it will post parent and child relations into 2 table structured sibling XML elements linked with id and idref. In many-to-many data semantic, it will post 2 relations and their relationship relation into 3 table structured XML sibling elements linked with idref(s) and id(s). In isa data semantic, it will post superclass and subclass relations into 2 table structured XML sibling elements linked with id and idref with the same key as shown in Figure 3 and Figure 4.

Case 2: Transform first XML databases into second flattened XML documents
Firstly, we perform the preprocess of mapping XML schema into flattened XML schema. Secondly, we perform their correspondent data conversion. The input is an XML database and the output is a flattened XML document with relational table structure. The system will read XML document according to the XML schema. In one-to-many data semantic, it will post element and sub-element into 2 XML sibling elements linked with id and idref. In many-to-many data semantic, it will post 3 elements linked with id(s) and idref(s) into 3 XML sibling elements linked with id(s) and idref(s). In isa data semantic, it will post superclass and subclass elements into 2 XML sibling elements linked with id and idref with the same key as shown in Figure 3 and Figure 4.

Case 3: Transform first legacy Object Oriented database into second flattened XML document
Firstly, we perform the preprocess of mapping object-oriented schema into flattened XML schema. Secondly, we perform their correspondent data conversion. The input is an OODB and the output is a flattened XML document. The system will read OODB according to OODB schema. In one-to-many data semantic, it will post object and set of associated objects into 2 XML sibling elements linked with id and idref. In man-to-many data semantic, it will post 2 sets of associated objects with a common object into 3 XML sibling elements such that a sibling

element with 2 IDREF(s) referring 2 sibling elements with 2 ID(s)). In isa data semantic, it will post superclass and subclass objects with same OID into 2 XML sibling elements linked with id and idref with the same key as shown in Figure 3 and Figure 4.

Case 4: Transform first legacy Network databases into second flattened XML documents
Firstly, we perform the preprocess of mapping network schema into flattened XML schema. Secondly, we perform their correspondent data conversion. The input is a Network database(NDB) and the output is a table structured flattened XML document. The system will read NDB according to NDB schema. In one-to-many data semantic, it will post owner and member records into 2 XML sibling elements linked with id and idref. In many-to-many data semantic, it will post 2 owners and 1 common member records into 3 XML sibling elements linked with id(s) and idref(s). In isa data semantic, it will post an owner and a member records into 2 XML sibling elements linked with id and idref with the same key as shown in Figure 3 and Figure 4.

Phase II: Transform second flattened XML documents into third legacy databases
In step 2, we map the flattened XML schema into another legacy database schema, followed by the data transformation of the flattened XML documents into a legacy database according to the mapped legacy database schema. In this way, each source database data type can be read by the legacy database schema. Therefore, there is no need for physical data type conversion in this approach. Therefore, we can post the flattened XML document into a legacy database of relational, object-oriented, network or XML.

Case 5: Transform second flattened XML documents into third relational databases
Firstly, we perform the preprocess of mapping flattened XML schema into relational schema. Secondly, we perform their correspondent data conversion. The input is a flattened XML document and the output is a relational database. The system will read flattened XML document according to flattened XML document schema. In one-to-many data semantic, it will post 2 XML sibling elements into parent and child relations. In many-to-many data semantic, it will post 3 XML sibling elements linked with id(s) and idref(s) into 2 parents and 1 child relations. In isa data semantic, it will post 2 XML sibling elements into superclass relation and sub-class relation as shown in Figure 3 and Figure 4.

Case 6: Transform second flattened XML documents into third object-oriented databases
Firstly, we perform the preprocess of mapping flattened XML schema into object-oriented schema. Secondly, we perform their correspondent data conversion. The input is a flattened XML document and the output is an object-oriented database. The system will read flattened XML document according to flattened XML document schema. In one-to-many data semantic, it will post 2 XML sibling elements into 2 associated objects with OID and Stored OID. In many-to-many data semantic, it will post 3 XML sibling elements linked with id(s) and idref(s) into 3 associated objects. In isa data semantic, it will post 2 XML sibling elements into 2 superclass and sub-class objects as shown in Figure 3 and Figure 4.

Case 7 Transform second flattened XML documents into third network databases:
Firstly, we perform the preprocess of mapping flattened XML schema into network schema. Secondly, we perform their correspondent data conversion.

The input is a flattened XML document and the output is a network database. The system will read flattened XML document according to flattened XML document schema. In one-to-many data semantic, it will post 2 XML sibling elements into 2 owner and member records. In many-to-many data semantic, it will post 3 XML sibling elements linked with id(s) and idref(s) into 2 owners linked with 1 member record with the same key. In isa data semantic, it will post 2 XML

sibling elements into 2 owner and member record with the same key as shown in Figure 3 and Figure 4.

Case 8: Transform second flattened XML documents into third legacy XML databases
Firstly, we perform the preprocess of mapping flattened XML schema into XML schema. Secondly, we perform their correspondent data conversion.

The input is a flattened XML document and the output is an XML document. The system will read flattened XML documents according to flattened XML documents schema. In one-to-many data semantic, it will post 2 XML sibling elements into 2 XML element and sub-elements. In many-to-many data semantic, it will post 3 XML sibling elements linked with id(s) and idref(s) into 2 pairs of XML elements linked with same sub-element. In isa data semantic, it will post 2 XML sibling elements with the same key into XML element and sub-elements with the same key as shown in Figure 3 and Figure 4.

4. CASE STUDY

A logistic system records the customer shipment information including which orders are being packed and what the packing information is. Based on the XML schema below, there are three intermediate independent entities: PL_INFORMAION recording the general information of the shipment, PL_LINE_INFORMATION storing the packing information — particularly information about the BOXES — and ORDER_INFORMATION storing the information of orders such as the product information. A many-to-many relationship between ORDER_INFORMATION and PL_LINE_DETAIL must be resolved early in the modeling process to eliminate repeating information when representing PL_INFORMATION or ORDER_INFORMATION (MySQL 2013). The strategy for resolving many-to-many relationship[s] is to replace the relationship with two one-to-many cardinality with an association entity and then relate the two original entities to the association entity. As a result, these two one-to-many relationships are between PL_LINE_INFORMATION and PL_LINE_DETAIL, and between ORDER_INFORMATION and PL_LINE_DETAIL. Similarly, the ORDER_INFOR MATION can be divided into BulkOrder and CustomerOrder in generalization as shown in Figure 6.

In Figure 6, there are six relations in relational database. Each table has its primary key and foreign key. Their data dependencies are such that each foreign key determines its referred primary key in functional dependency (FD) in one-to-many cardinality with foreign key on the "many" side, and subclass foreign key is a subset of its referred primary key in inclusion dependency (ID). For relations in many-to-many cardinality, their primary keys are in multi-valued dependencies(MVD) to each other as follows:

FD: PL_Line_Information.PL_Information_Seqno → PL_Information.PL_Information_Seqno
ID: Bulk_Order.BulkOrder.Order_Number ⊆ Order_Information.Order_Number
ID: TailorMadeOrder.Order_Number ⊆ Order_Information.Order_Number
MVD: PL_Line_Information.PL_Information_Seqno →→ Order_Information.Order_Number
MVD: Order_Information.Order_Number →→ PL_Line_Information.PL_Information_Seqno

In Figure 7, the relations are transformed into flattened XML document. The input relational conceptual schema is Extended Entity Relationship model(Chen, 1976). We map input relational schema into an flattened XML OUDG schema with relational structure in two levels tree. Notice that the second level elements (under root elements) are linked together using idref referring to id, which is similar to foreign key referring to primary key. There are seven elements. The second level elements has id(s) and/or idref(s). Their data dependencies are such that each idref

determines its referred id in FD for one-to-many cardinality, and each subclass idref is a subset of its superclass id in ID. For elements in many-to-many cardinality, their id(s) are in MVD as follows:
FD: idref1 → id1
ID: idref3 ⊆ id3
MVD: id2 →→ id3
MVD: id3 →→ id2

In Figure 8, the flattened XML document is transformed into XML document. Elements Pl_information and Pl_line_information are in element and sub-element 1:n association. Elements Pl_line_information and Order_information are in m:n association through element Pl_line_detail linked by pairs of idref referring to id. Elements Order_information and Bulk_Order are in isa association. Elements Order_information and TailorMadeOrder are also in isa association. Their data dependencies are such that each sub-element can determine its element in FD. Each sub-class key is a subset of its superclass key in ID. Two one-to-many cardinality with the same element on the "many" side is equivalent to a many-to-many cardinality of the two "one" side elements in MVD as follows:
FD: PL_Line_Information.PL_Information_Seqno → PL_Information.PL_Information_Seqno
ID: BulkOrder.TechnicalOrderNo ⊆ Order_Information.Order_Seqno
ID: TailorMadeOrder.CustomerOrderNo ⊆ Order_Information.Order_Seqno
MVD: PL_Line_Information.PL_Information_Seqno →→ Order_Information.Order_Seqno
MVD: Order_Information.Order_Seqno →→ PL_Line_Information.PL_Information_Seqno

In Figure 9, the flattened XML document is transformed into Object-Oriented database. It shows the mapping of flattened XML schema into UML as object-oriented conceptual schema. There are six classes. Each class has its OID (object identity), which is similar to primary key in relational schema, and Stored OID, which is similar to foreign key in relational schema. Their data dependencies are such that each Stored OID key determines its referred OID in FD, and each subclass OID is a subset of its superclass OID in ID. The class PL_Informationa nd class PL_Line_Information are in 1:n association in FD. Classes PL_line_Informaton and class Order_Information are in m:n association through class PL_Line_Detail. Subclass BulkOrder and subclass TailorMadeOrder are in generalization under same superclass Order_Information in ID as follows:
FD: PL_Line_Information.Stored_OID → PL_Information.OID
ID: Bulk_Order.OID ⊆ Order_Information.OID
ID: TailorMadeOrder.OID ⊆ Order_Information.OID
MVD: PL_Line_Information.OID →→ Order_Information.OID
MVD: Order_Information.OID →→ PL_Line_Information.OID

In Figure 10, flattened XML document is transformed into Network database. Record Pl_informations and record Order_information are under network DBMS as first records for database navigation access path. The path can go from record Pl_information to Pl_line_information in owner and member record in 1:n relationship in FD. Records Pl_line_information (owner), Order_information(owner) and Pl_line_detail (member) are in flex structure such that records Pl_line_information and Order_information they are in m:n relationship in MVD. Records Order_information and BulkOrder are in isa relationship since they have same key value in ID. Similarly, records Order_information and TailorMadeOrder are in isa relationship due to same key value in ID. The set records are pointers only. Their data dependencies are as follows:
FD: PL_Line_Information.PL_Information_Seqno → PL_Information.PL_Information_Seqno
ID: Bulk_Order.TechnicalOrderNo ⊆ Order_Information.OrderSeqno
ID: TailorMadeOrder.CustomerOrderNo ⊆ Order_Information.OrderSeqno
MVD: PL_Line_Information.PL_Information_Seqno →→ Order_Information.OrderSeqno

MVD: Order_Information.OrderSeqno →→ PL_Line_Information.PL_Information_Seqno

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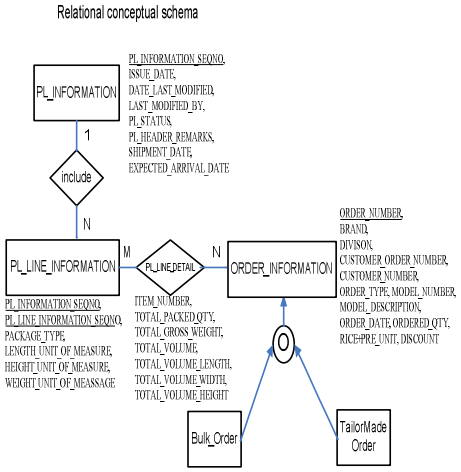

Fig. 6 First source legacy Relational database MySQL with EER model

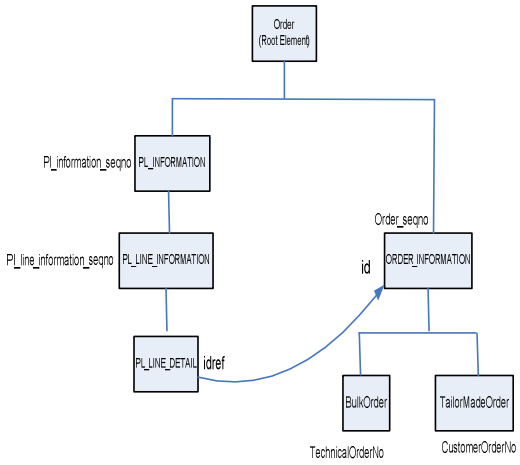

Fig. 8. Transformed second legacy XML document from flattened XML document

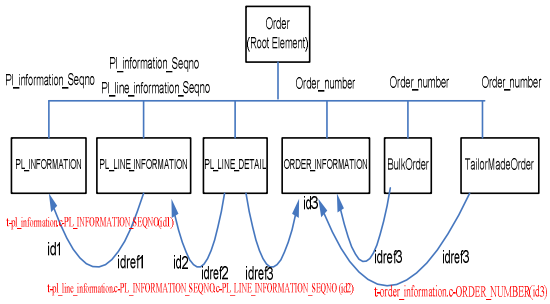

Fig. 7. Transformed flattened XML document and map from first legacy relational database

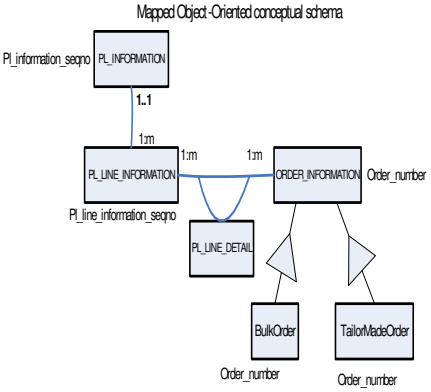

Fig. 9. Transformed second legacy Object Oriented database from flattened XML document

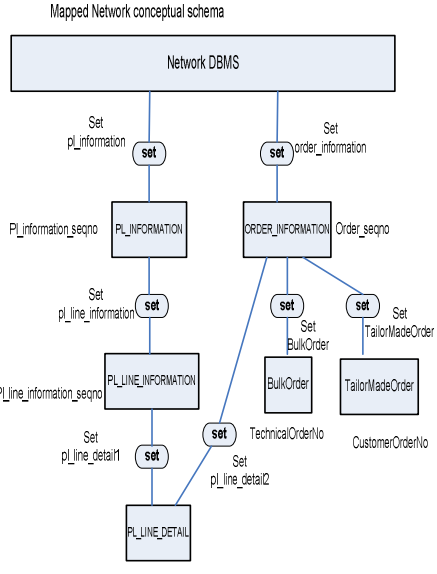

Fig. 10. Translated second Network database from flattened XML document

5. CONCLUSION

Since relational database is the most user friendly legacy database, and XML database is the most portable database for information highway on the Internet. In this project, we propose a Flattened XML database as universal database such that it is most user friendly and portable as a database middleware for all legacy databases.

The uniqueness of this paper are:

(1) Openness of an universal database: The reason we choose flattened XML document is due to its openness, and DBMS independence. All other data models are DBMS dependent.
Nevertheless, users can use OUDG to access any legacy database via flattened XML documents on the Internet by Internet Explorer without programming.

(2) Recovery of legacy database: Since flattened XML document is a replicate legacy database, it can be used to recover any legacy database whenever the production legacy database is down. As a result, replicate XML document can be parallel processing with legacy database in non-stop computing.

(3) Heterogeneous database integration for data warehousing: By transforming all in-house legacy databases into one legacy database as the data cube, companies can use OUDG to integrated their legacy databases into a data warehousing for decision support system.

(4) Portability of Flattened XML document as Universal database: The OUDG solution is not limited to using a particular DBMS, but allows users of any legacy database access other legacy database.

In summary, the proposed OUDG unites all legacy databases data models into flattened XML schema. The portability of the proposed flattened XML document can be transferred into any open platform. The data conversion methodology of this OUDG is to download the raw data of source database into flattened XML document using source database schema, and upload the flattened XML document into target database using translated target database schema, which is a logical level approach, and which can avoid physical data type conversion. Therefore, the methodology can transform any legacy database into any other legacy database. The reason of using flattened XML document as medium is to reduce the number of programs for the data conversion; otherwise, we need 4 * 4 = 16 programs, instead of the current 4 + 4 = 8 programs to do the data conversion for the four legacy database models: relational, network, object-oriented and XML. Above all, all legacy databases can be transformed into each other via flattened XML documents for data access in the same way as computers connect to each other via computer network for information retrieval.

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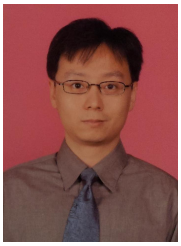

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CLUSTERED COMPRESSIVE SENSING-BASED IMAGE DENOISING USING BAYESIAN FRAMEWORK

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ABSTRACT

This paper provides a compressive sensing (CS) method of denoising images using Bayesian framework. Some images, for example like magnetic resonance images (MRI) are usually very weak due to the presence of noise and due to the weak nature of the signal itself. So denoising boosts the true signal strength. Under Bayesian framework, we have used two different priors: sparsity and clusterdness in an image data as prior information to remove noise. Therefore, it is named as clustered compressive sensing based denoising (CCSD). After developing the Bayesian framework, we applied our method on synthetic data, Shepp-logan phantom and sequences of fMRI images. The results show that applying the CCSD give better results than using only the conventional compressive sensing (CS) methods in terms of Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE). In addition, we showed that this algorithm could have some advantages over the state-of-the-art methods like Block-Matching and 3D Filtering (BM3D).

KEYWORDS

Denoising, Bayesian framework, Sparse prior, Clustered prior, posterior, Compressive sensing, LASSO, Clustered Compressive Sensing

1. INTRODUCTION

Image denoising is an integral part of image processing. There are different sources of noise for images and different noise models are assumed to remove or reduce noise (to denoise), accordingly. Mostly image noises are modelled by additive white Gaussian distribution while others like ultrasound and MRI images can be modelled by speckle and Rican distribution respectively [1]. In the past decades, removing the noises has been given ample attention and there are several ways to de-noise an image. A good image denoising technique removes the noise to a desirable level while keeping the edges. Traditionally, this has been done using spatial filtering and transform domain filtering. The former uses median filter, Weiner filter and so on while the later uses Fast Fourier Transform (FFT) and Wavelet Transform (WT) to transform the

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image data to frequency or time-frequency domain, respectively. The later transform method have been used intensively due to the fact that the Wavelet transform based methods surpasses the others in the sense of mean square error (MSE) or pick signal to noise ratio (PSNR) and other performance metrics [1], [2], [3].

Recently, another way of image denoising has been used after a new way of signal processing method called compressive sensing (CS) was revived by authors like Donoho, Candés, Romberg and Tao [4]- [7]. CS is a method to capture information at lower rate than the Nyquist- Shannon sampling rate when signals are sparse or sparse in some domain. It has already been applied in medical imaging. In [8] the authors have used the sparsity of magnetic resonance imaging (MRI) signals and showed that this can be exploited to significantly reduce scan time, or alternatively, improve the resolution of MR imagery and in [9] it is applied for Biological Microscopy image denoising to reduce exposure time along with photo- toxicity and photo-bleaching. Since CS-based denoising is done using reduced amount of data or measurement. Actually, it can remove noise better than the state-of the art methods while using few measurements and preserving the perceptual quality [10]. This paper builds up on the CS based denoising and incorporates it with the clustredness of some image data. This is done using a statistical method called Bayesian framework.

There are two schools of thoughts called the classical (also called the frequentist) and the Bayesian in the statistical world. Their basic difference arises from the basic definition of probability. Frequentists define P(x) as a long-run relative frequency with which x occurs in identical repeats of an experiment. Where as Bayesian defines P(x|y) as a real number measure of the probability of a proposition x, given the truth of the information represented by proposition y. So under Bayesian theory, probability is considered as an extension of logic. Probabilities represent the investigators degree of belief- hence it is subjective. That belief or prior information is an integral part of the inference done by the Bayesian [11] - [20]. For its flexibility and robustness this paper focuses on Bayesian approach. Specifically the prior information's like sparsity and clusterdness (or structures on the patterns of sparsity) of an image as two different priors are used and the noise is removed by using reconstructing algorithms.

Our contribution in this work is to use the Bayesian framework and incorporate two different priors in order to remove the noise in an image data and in addition we compare different algorithms. Therefore, this paper is organized as follows. In section II we discuss the problem of denosing using the CS theory under the Bayesian framework, that is using two priors on the data, the sparse and clustered priors, and define the denosing problem in this context. In section III we provide how we implemented the analysis. Section IV shows our results using synthetic and MRI data, and section V presents conclusion and future work.

2. COMPRESSED SENSING BASED DENOISING

In Wavelet based transform denosing the image data is transformed to time-frequency domain using Wavelet. Only the largest coefficients are kept and the rest are thrown away using thresholding. Then by applying the inverse Wavelet transform the image is denoised [21], however, in this paper we used CS recovery as denosing.

Considering an image which is sparse or sparse in some domain, which has sparse representation in some domain or most of the energy of the image is compressed in few coefficients, say $x \in \mathbb{R}^N$ with non zero elements k, corrupted by noise $n \in \mathbb{R}^N$. It is possible to use different models of noise distribution. By using a measurement matrix $A \in \mathbb{R}^{M \times N}$, we get a noisy and under sampled measurements $y \in \mathbb{R}^M$. Further we assume that $w = An \in \mathbb{R}^M$ is i.i.d. Gaussian random variables with zero mean and covariance matrix $\sigma^2 I$, due to the central limit theorem. This assumption can

be improved further. However, in this work we approximate it by Gaussian distribution for w. The linear model that relates these variables is given by

$$y = Ax + w \tag{2.1}$$

Here $N \gg M$ and $N \gg k$, where k is the number of nonzero entries in x. Applying CS reconstructions using different algorithms we recover the estimate of the original signal x, say $\hat{x}$. In this paper, denosing is done simultaneously with reconstructing the true image data using non-linear reconstruction schemes, which are robust, [22] and the block diagram describing the whole process is given by Figure 1.

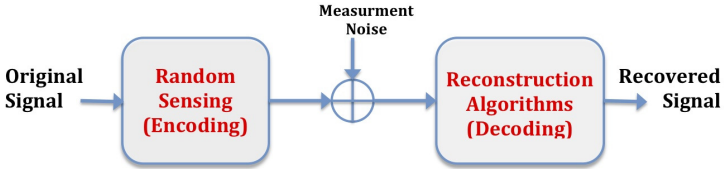

Figure 1: Block diagram for CS based denosing.

Various methods for reconstructing x may be used. We have the least square (LS) estimator in which no prior information is applied:

$$\hat{x} = (A^T A)^{-1} A^T y, \tag{2.2}$$

which performs very badly for the CS based denoising problem considered here. Another approach to reconstruct x is via the solution of the unconstrained optimization problem

$$\hat{x} = \min_{x \in \mathbb{R}^N} \frac{1}{2} \|y - Ax\|_2^2 + uf(x) \tag{2.3}$$

where $uf(x)$ is a regularizing term, for some non-negative u. If $f(x) = \|x\|_p$, emphasis is made on a solution which shall LP norm, and = norm, and $\|x\|_p$ is denoted a penalizing norm. When $p = 2$, we get

$$\hat{x} = \min_{x \in \mathbb{R}^N} \frac{1}{2} \|y - Ax\|_2^2 + u\|x\|_2. \tag{2.4}$$

This is penalizing the least square error by the L2 norm and this performs bad as well, since it does not introduce sparsity into the problem. When $p = 0$, we get the L0 norm, which is defined as

$$\|x\|_0 = k \equiv \{i \in \{1,2,\dots,N\} | x_i \neq 0\},$$

the number of the non zero entries of x, which actually is a partial norm since it does not satisfy the triangle inequality property, but can be treated as norm by defining it as in [23], and get the L0 norm regularizing estimator

$$\hat{x} = \min_{x \in \mathbb{R}^N} \frac{1}{2} \|y - Ax\|_2^2 + u\|x\|_0 \tag{2.5}$$

which gives the best solution for the problem at hand since it favour's sparsity in x. Nonetheless, it is an NP- hard combinatorial problem. Instead, it has been a practice that one reconstructs the image using L1 penalizing norm to get the estimator

$$\hat{x} = \min_{x \in \mathbb{R}^N} \frac{1}{2} \|y - Ax\|_2^2 + u\|x\|_1 \quad 2.6$$

which is a convex approximation to the L0 penalizing solution II.5. These estimators, 2.4 - 2.6, can equivalently be presented as solutions to constrained optimization problem [4] - [7], and in the CS literature there are many different types of algorithms to implement them. A very popular one is the L1 penalized L2 minimization called LASSO (Least Absolute Shrinkage and Selection Operator), which we later will present it in Bayesian framework. So first we present what a Bayesian approach is and come back to the problem at hand.

2.1. Bayesian framework

Under Bayesian inference consider two random variables x and y with probability density function (pdf) $p(x)$ and $p(y)$, respectively. Using Bayes' theorem it is possible to show that the posterior distribution, $p(x|y)$, is proportional to the product of the likelihood function, $p(y|x)$, and the prior distribution, $p(x)$,

$$p(x|y) \propto p(y|x)p(x) \quad 2.7$$

Equation (2.7) is called Updating Rule in which the data allows us to update our prior views about x. And as a result we get the posterior which combines both the data and non-data information of x [11], [12], [20].

Further, the Maximum a posterior (MAP), $\hat{x}_{MP}$, is given by

$$\hat{x}_{MP} = \arg\max_x p(y|x)p(x)$$

To proceed further, we assume two prior distributions on x.

2.2. Sparse Prior

The reconstruction of x resulting from the estimator (2.3) for the sparse problem we consider in this paper given by, (2.4) - (2.5), can be presented as a maximum a posteriori (MAP) estimator under the Bayesian framework as in [23]. We show this by defining a prior probability distribution for x on the form

$$p(x) = \frac{e^{-uf(x)}}{\int_{x \in \mathbb{R}^N} e^{-uf(x)} dx} \quad 2.8$$

where the regulirizing function $f : \chi \to R$ is some scalarvalued, non negative function with $\chi \subseteq \mathbb{R}$ which can be expanded to a vector argument by

$$f(x) = \sum_{i=1}^{N} f(x_i) \quad 2.9$$

such that for sufficiently large u, $\int_{x \in \mathbb{R}^N} e^{-uf(x)} dx$ is finite. Further, let the assumed variance of the noise be given by

$$\sigma^2 = \frac{\lambda}{u}$$

where λ is system parameter which can be taken as $\lambda = \sigma^2 u$. Note that the prior, (2.8), is defined in such a way that it can incorporate the different estimators considered above by

assuming different penalizing terms via $f(x)$ [23]. Further, the liklihood function, $p(y|x)$, can be shown to be

$$p_{y|x}(y|x) = \frac{1}{(2\pi\sigma)^{N/2}} e^{-\frac{1}{2\sigma^2}\|y-Ax\|_2^2} \quad 2.10$$

the posterior, $p(x|y)$,

$$p_{x|y}(x|y;A) = \frac{e^{-\frac{1}{2\sigma^2}\|y-Ax\|_2^2}}{(2\pi\sigma)^{N/2}\int_{x\,\epsilon\,\mathbb{R}^N} e^{-u(\frac{1}{2\lambda}\|y-Ax\|_2^2+\lambda f(x))}dx}$$

and the MAP estimator becomes

$$\hat{x}_{MP} = \arg\min_{x\,\epsilon\,\mathbb{R}^N} \frac{1}{2}\|y - Ax\|_2^2 + \lambda f(x) \quad 2.11$$

as shown in [20]. Note that (2.11) which is equivalent to (2.3). Now, as we choose different regularizing function, which enforces sparsity into the vector x, we get different estimators listed below [23]:

1) Linear Estimators: when $f(x) = \|x\|_2^2$ (2.11) reduces to

$$\hat{x}_{Linear} = A^T\left(AA^T + \lambda I\right)^{-1} y, \quad 2.12$$

which is the LMMSE estimator. But we ignore this estimator in our analysis since the following two estimators are more interesting for CS problems.

2) LASSO Estimator: when $f(x) = \|x\|_1$ we get the LASSO estimator and (II.11) becomes,

$$\hat{x}_{LASSO} = \arg\min_{x\,\epsilon\,\mathbb{R}^N} \frac{1}{2}\|y - Ax\|_2^2 + \lambda\|x\|_1, \quad 2.13$$

which is the same as (2.6).

3) Zero-Norm regularization estimator: when $f(x) = \|x\|_0$, we get the Zero-Norm regularization estimator (2.5) to reconstruct the image from the noisy data and (2.11) becomes

$$\hat{x}_{Zero-Norm} = \arg\min_{x\,\epsilon\,\mathbb{R}^N} \frac{1}{2}\|y - Ax\|_2^2 + \lambda\|x\|_0, \quad 2.14$$

which is identical to 2.5. As mentioned earlier, this is the best solution for reconstruction of the sparse vector x, but is NP-complete. The worst reconstruction for the sparse problem considered is the L2- regularization solution given by (2.12). However, the best one is given by the equation (2.13) and its equivalent forms such as L1-norm regularized least-squares (L1-LS) and others [5]-[7].

2.3. Clustering Prior

Building on the Bayesian philosophy, we can further assume another prior distributions for clustering. The entries of the sparse vector x may have some structure that can be represented using distributions. In [18] a hierarchical Bayesian generative model for sparse signals is found in

which they have applied full Bayesian analysis by assuming prior distributions to each parameter appearing in the analysis. We follow a different approach. Instead we use another penalizing parameter to represent clusterdness in the data. For that we define the clustering using the distance between the entries of the sparse vector x by

$$D(x) \equiv \sum_{i=2}^{N} |x_i - x_{i-1}|,$$

and we use a regularizing parameter . Hence, we define the clustering prior to be

$$q(x) = \frac{e^{-\gamma D(x)}}{\int_{x \in \mathbb{R}^N} e^{-\gamma D(x)} dx} \qquad 2.15$$

The new posterior involving this prior under the Bayesian framework is proportional to the product of the three pdf's:

$$p(x|y) \propto p(y|x)p(x)q(x). \qquad 2.16$$

By similar arguments as used in 2.2 we arrive at the Clustered LASSO estimator

$$\hat{x}_{Clu-LASSO} = \arg\min_{x \in \mathbb{R}^N} \frac{1}{2} \|y - Ax\|_2^2 + \lambda \|x\|_1 + \gamma \sum_{i=2}^{N} |x_i - x_{i-1}|, \qquad 2.17$$

where λ, γ are our tuning parameters for the sparsity in x and the way the entries are clustered, respectively.

3. IMPLEMENTATION OF THE ANALYSIS

The main focus of this paper is to give a practical application of compressed sensing, namely denoising. That is we interpret the reconstruction of images by CS algorithms, given relatively few measurements y and measurement matrix A, as denosing. That means the CS based denosing happens when we apply the reconstructing schemes. Actually, we have used both CS based (LMMSE, LASSO and Clustered LASSO given by equations (2.12), (2.13), (2.17) respectively) and non-CS based denoising procedures (LS (2.2); BM3D). So that we compare the merits and draw backs of CS based denoising techniques.

In the equations (2.12) , (2.13), and (2.17) we have parameters like λ and γ. As we have based our analysis in Bayesian framework we could have assumed some prior distributions on each of them, and build a hierarchical Bayesian compressive sensing. Instead we have used them as a tuning parameter for the constraint and we have tried to use them in the optimal way. Still it needs more work! However, we have found an optimal λ value for the LMMSE in (2.12), that is λ = 1e−07. In implementing (2.13), that is least square optimization with L1 regularization, we have used the Quadratic programming with constraints similar to Tibshirani [24], [25]. That is solving

$$\hat{x} = \arg\min_x \|y - Ax\|_2^2 \qquad 3.1$$
$$subject\ to\ \ \|x\|_1 \leq t,$$

instead of (2.13). We see that t and λ are related.

In addition, equation (II.17) is implemented similar to LASSO with additional term on the constraint. That is we bounded $D(x) \leq d$. This d is some how related to γ, i.e., we put constrain on the neighboring elements. Since we have vectorized the image for the sake of efficiency of the algorithm, the penalizing terms are applied column wise. Other ways of implementing

(constraining) are also possible. But we differ it for future work. In our simulations we have used optimal values of these constraints. Figure 2 and 3 show the respective optimal values for one of the simulations in the next section.

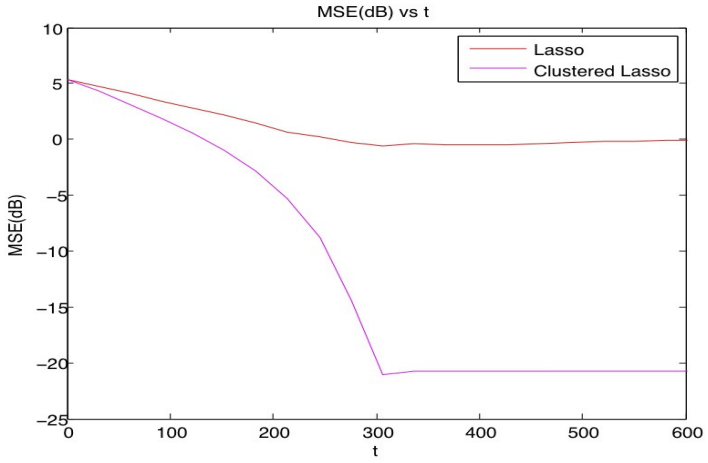

Figure 1: This figure shows the MSE of LASSO and clustered LASSO for different values of t for figure 4. It can be seen that there is only one optimal value.

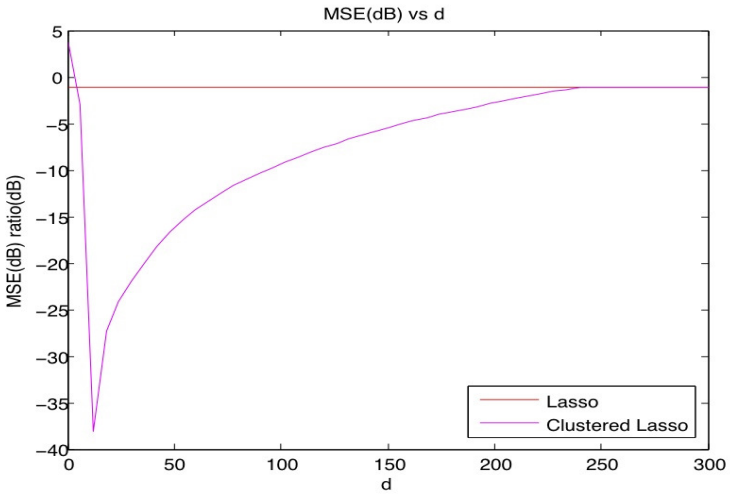

Figure 2: This figure shows the MSE of LASSO and clustered LASSO for different values of $\boldsymbol{d}$ for figure 4. It can be seen that there is only one optimal value d and by loosening the constraint clustered LASSO will converge to LASSO.

4. RESULTS

4.1 First set of Synthetic Data

In order to demonstrate the performance of reconstruction of the sparse signal (denosing) presented in the paper we have used synthetic data. The first set of data is the image with several English letters, where the image itself is sparse and clustered in the spatial domain. We have applied Gaussian noise with mean zero and variance $\sigma 2 = 0.2$ and random matrix A with Gaussian entries with variance $\sigma 2 = 1$. For LMMSE we used $\lambda = 1e - 07$ in our simulations. However, we have used equivalent constraints for λ and γ for the LASSO and clustered LASSO.

The original signal after vectorization is x is of length N = 300 and we added noise to it. By taking 244 measurements, that is y is of length M = 244, and maximum number of non-zero elements k = 122, we applied different denosing techniques. There are several CS reconstructing algorithms like LMMSE, LASSO and Clustered LASSO, which are used as denosing techniques in this paper. In addition, the state of the art denosing technique, called Block-matching and 3D filtering (BM3D) (http://www.cs.tut.fi/foi/GCF-BM3D/) [26], is used as reference. Note that BM3D uses full measurements in contrast to the CS based denoising methods. The results are shown in figure 4. The result in figure 4 shows that denosing using clustered LASSO performs better than other methods, which use fewer measurements. However, BM3D, which uses full measurements, has better performance. This is also visible in Table I, by using the performance metrics like the mean square error (MSE) and pick signal to noise ratio (PSNR). However, it is possible to improve the performance of clustered LASSO by considering other forms of clustering, which will be our future work.

TABLE I: Performance comparison in figure 4

Algorithm	MSE	PSNR in dB
LS	0.41445	7.6506
LMMSE	0.14623	16.699
LASSO	0.11356	18.8955
Clustered LASSO	0.082645	27.1302
BM3D	0.044004	21.6557

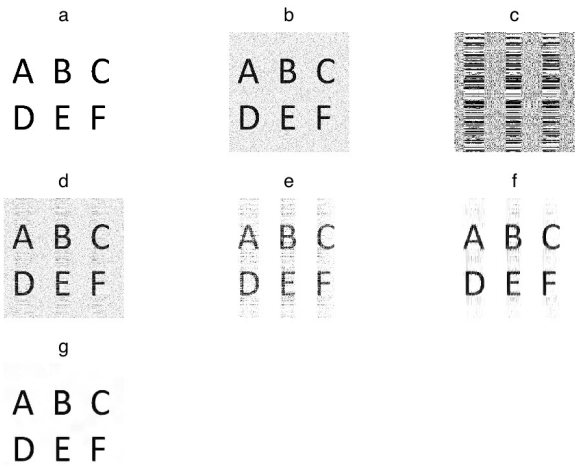

Figure 3: Comparison of denosing techniques for the synthetic image: a) Original image x b) Noisy image c) Least Square (LS) d) LMMSE e) LASSO f) Clustered Lasso g) BM3D.

4.2 Second set of Synthetic Data

On this image we added different noise models such as Gaussian with mean 0 and variance 0.01, Salt & pepper with noise density 0.03, and Speckle noise, i.e. with uniform distribution zero mean and variance 0.3. Clustered LASSO performs consistently better than LASSO. The original signal after vectorization is x is of length N = 300 and we added noise to it. By taking 185 measurements, that is y is of length M = 185, and maximum number of non-zero elements k = 84, we applied different denosing techniques. The results in figure 5 are interesting. Because clustered LASSO has higher PSNR than BM3D as shown in Table II.

TABLE II: Performance comparison in figure 5

Algorithm	Gaussian (0, 0.01)	Salt & pepper	Speckle
LS	2.3902	4.3149	8.9765
LMMSE	26.4611	24.6371	24.8943
LASSO	17.9837	22.6761	30.8123
Clustered LASSO	32.1578	40.6193	37.3392
BM3D	41.6925	32.1578	32.7813

Figure 4: Application of different denosing techniques discussed in the paper (in their vertical order: LS, LMMSE, LASSO, Clustered LASSO, BM3D) on different types of noises (in the vertical order: Gaussian with mean 0 & variance 0.01, Slat & Pepper with 0.03 and Speckle 0.3) .

4.3 Phantom image

The third image is a known medical related image, Shepp-Logan phantom, which is not sparse in spatial domain but in K-space. We add noise to it, and we took the noisy image to K-space. After that we zero out small coefficients and apply the CS denoising methods and then converted it back to spatial domain. But for BM3D we used only the noisy image in the spatial domain. The original signal after vectorization is x is of length N = 200. By taking 138 measurements, that is y is of length M = 138, and maximum number of non-zero elements k = 69, we applied different denosing techniques. The result shows clustered LASSO does well compared to the others CS algorithms and LS. But it is inferior to BM3D, which uses full measurement. This can be seen in figure 6 and Table III.

TABLE I: Performance comparison in figure 6

Algorithm	MSE	PSNR in dB
LMMSE	0.016971	35.4057
LASSO	0.0061034	44.2885
Clustered LASSO	0.006065	44.3434
BM3D	0.0020406	53.8048

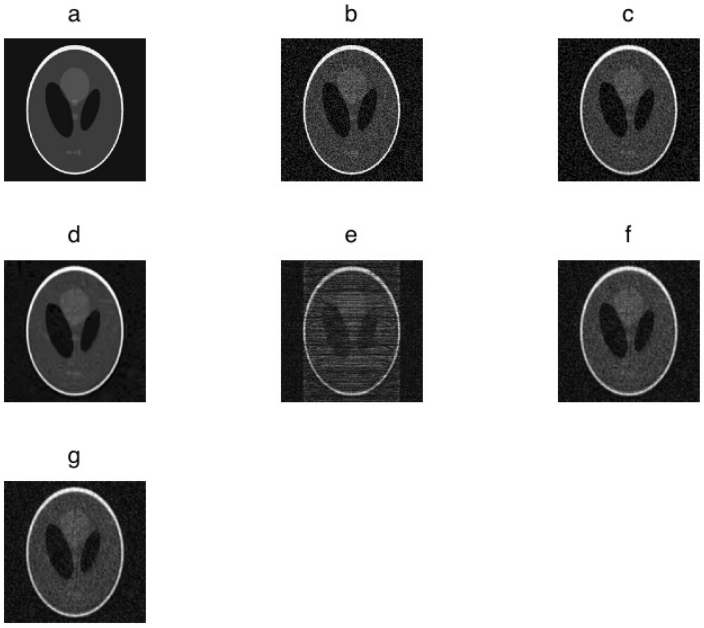

Figure 5: Comparison of denosing techniques for the phantom image: a) Original image b) Noisy image c) sparsed noisy image d) denosing using BM3D e) denosing using LMMSE f) denosing using LASSO g) denosing using Clustered LASSO.

In addition for the first set of synthetic data we have compared the different denoising techniques using PSNR versus measurement ratio (M/N) and the result is shown in figure 7. Generally, the CS based denosing performs well in relation to these metrics if we have a sparse and clustered image.

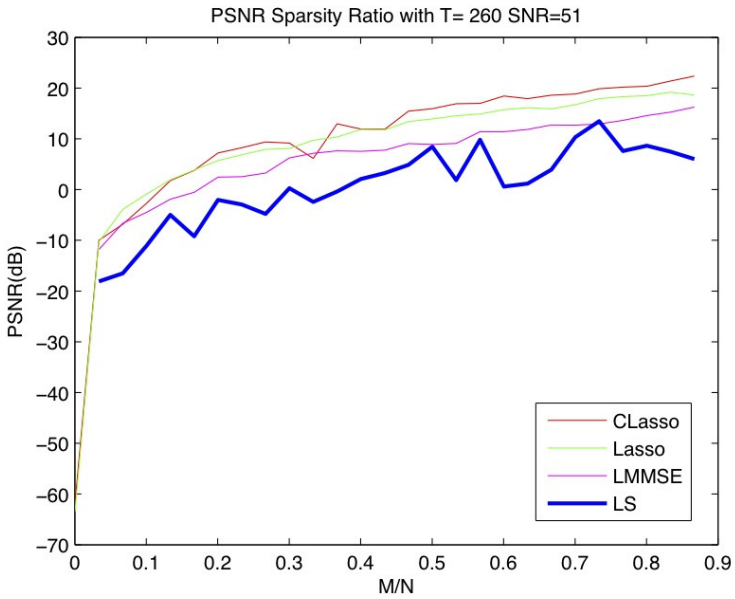

Figure 6 Comparison of denosing (reconstruction) algorithms using PSNR versus measurement ration M/N.

5. CONCLUSIONS

In this paper, denosing using compressive sensing under Bayesian framework is presented. Our emphasis in this work is to incorporate prior information's in the denosing of images with further intention to apply such techniques to medical imaging, which usually have sparse, and some clustredness characteristics. The denosing procedure in this work is done simultaneously with the reconstruction of the signal, which is an advantage from the traditional denosing procedures. Since using CS basically has already additional advantage of recovering images from under sampled data using fewer measurements! We showed also that clustered LASSO denosing does well for different noise models. In addition, in this work we have shown comparison of the different reconstruction algorithms performance for different amount of measurement versus PSNR. For future work we plan to apply different forms of clustering depending on the prior information's of images or geometry of clustredness.

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