AN OVERVIEW OF MULTIMODAL BIOMETRICS

P. S. Sanjekar [1] and J. B. Patil [2]

[1]Department of Computer Engineering, RCPIT, Shirpur
priti_san2003@yahoo.com
[2]Department of Computer Engineering, RCPIT, Shirpur
jbpatil@hotmail.com

ABSTRACT

Unimodal biometrics has several problems such as noisy data, intra class variation, inter class similarities, non universality and spoofing which cause this system less accurate and secure. To overcome these problems and to increase level of security multimodal biometrics is used. Multimodal biometrics makes the use of multiple source of information for personal authentication. Multimodal biometrics has becoming very popular now days since it is at the frontier of unimodal biometrics. This paper presents an overview of multimodal biometrics. This includes the block diagram of general multimodal biometrics, modules of multimodal biometric system, different levels of fusion in multimodal biometrics and related work is also covered in this paper.

KEYWORDS

Biometrics, multimodal biometrics, fusion level

1. INTRODUCTION

An accurate automatic personal authentication is becoming more and more important for the operation of our electronically interconnected information society [1]. Several systems require authenticating a person's identity before giving an access to resources. Biometrics has long been known as a robust approach for person authentication [2]. With new advances in technologies, biometrics has becoming emerging technology for authentication of individuals. Biometric system identifies or verifies a person based on his or her physiological characteristics such as fingerprint, face, palm print, iris etc or behavioral characteristics such as voice, writing style, and gait. Theoretically, any human physiological or behavioral characteristic can be used to make a personal identification as long as it satisfies features like universality, uniqueness, permanence and finally collectability.

Unlike the possession based and knowledge based personal identification schemes, the biometric identifiers can not be misplaced, forgotten, guessed or easily forged [3], some examples of biometric system are fingerprint recognition, face recognition, palm print recognition, voice recognition etc. Traditional personal identification systems are based on "Something that you have" e.g. Key or "Something that you know" e.g. Personal Identification Number [PIN], but biometrics relies on "Something that you are". Biometric systems used in real world applications are unimodal [4]. These unimodal biometric systems rely on the evidence of a single source of information for authentication of person. Though these unimodal biometric systems have many advantages, it has to face with variety problems like:

- Noisy data: - Susceptibility of biometric sensors to noise leads to inaccurate matching, as noisy data may lead to false rejection.

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- Intra class variation: - The biometric data acquired during verification will not be identical to the data used for generating template during enrollment for an individual. This is known as intra-class variation. Large intra-class variations increase the False Rejection Rate (FRR) of a biometric system.

- Interclass similarities: - Inter-class similarity refers to the overlap of feature spaces corresponding to multiple individuals. Large Inter-class similarities increase the False Acceptance Rate (FAR) of a biometric system.

- Non universality: -Some persons cannot provide the required standalone biometric, owing to illness or disabilities [5].

- Spoofing: - Unimodal biometrics is vulnerable to spoofing where the data can be imitated or forged.

Best solution to overcome these problems with unimodal biometric system is to use multimodal biometric system which is based on multiple source of information for personal authentication.

2. MULTIMODAL BIOMETRICS

Noisy data, Intraclass Variation, Interclass Similarities, Non universality, Spoofing etc problems are imposed by unimodal biometric systems which tend to increase False Acceptance Rate [FAR] and False Rejection Rate [FRR], ultimately reflecting towards poor performance of the system. Some of the limitations imposed by unimodal biometrics can be overcome by including multiple source of information for establishing identity of person [6]. Multimodal biometrics refers to the use of a combination of two or more biometric modalities in a Verification or Identification system. They address the problem of non- universality, since multiple traits ensure sufficient population coverage [7]. Multimodal biometrics also address the problem of spoofing as it concern with multiple traits or modalities, it would be very difficult for an imposter to spoof or attack multiple traits of genuine user simultaneously.

Multimodal biometric system has the potential to be widely adopted in a very broad range of civilian applications: banking security such as ATM security, check cashing and credit card transactions, information system security like access to databases via login privileges. A decision made by a multimodal biometric system is either a “genuine individual" type of decision or an “imposter" type of decision. In principle, Genuine Acceptance Rate [GAR], False Rejection Rate [FRR], False Acceptance Rate [FAR] and Equal Error Rate [ERR] is used to measure the accuracy of system. Generally multimodal biometrics operates in two phases i.e. Enrollment phase and authentication phase which are described as follows:

- Enrollment phase: - In enrollment phase, biometric traits of a user are captured and these are stored in the system database as a template for that user and which is further used for authentication phase.

- Authentication phase: - In authentication phase, once again traits of a user captured and system uses this to either identify or verify a person. Identification is one to many matching which involves comparing captured data with templates corresponding to all users in database while verification is one to one matching which involves comparing captured data with template of claimed identity only [6].

3. MODULES OF MULTIMODAL BIOMETRICS

Multimodal biometric system has four modules - sensor module, feature extraction module, matching module and decision making module respectively.

- Sensor module: - At sensor module biometric modalities are captured and these modalities are given as inputs for feature extraction module.

- Feature extraction module: - At feature extraction module features are extracted from different modalities after preprocessing. These features yields a compact representation of these traits or modalities and these extracted features are then further given to the matching module for comparison.

- Matching module: - In matching module extracted features are compared against the template(s) which is (are) stored in database.

- Decision making module: - In this module user is either accepted or rejected based on the matching in the matching module.

Multimodal biometric system can operate in serial mode or parallel mode. In serial mode of operation, the output of one modality is used to narrow down the number of possible identities before the next modality is used [6]. This can reduce the overall recognition time. In parallel mode of operation, information from different modalities is used simultaneously. In case of multimodal biometric system decision can be made at various levels of fusion like Feature level fusion, Matching score level fusion and Decision level fusion. The block diagram for general multimodal biometric system is as shown in Figure 1.

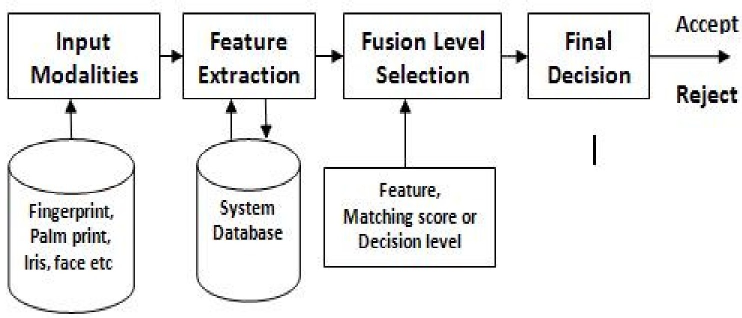

Figure 1. Block diagram of general multimodal biometrics

4. FUSION LEVELS IN MULTIMODAL BIOMETRICS

According to Jain and Ross [6], there are three fusion levels in multimodal biometrics: feature level fusion, matching score level fusion and decision level fusion respectively. It is generally believed that a combination scheme applied as early as possible in the recognition system is more effective [8, 9]. These three levels of fusion are described as follows:

4.1. Feature Level Fusion

In the feature level fusion, signals coming from different biometric traits are first processed and feature vectors are extracted separately from the each biometric trait. After that these feature vectors are combined to form a composite feature vector which is further used for classification. In case of feature level fusion some reduction technique must be used in order to select only useful features. Some of the researchers have applied fusion at feature level. Since features contain richer information of biometric trait than matching score or decision of matcher, fusion at feature level is expected to provide better recognition results but it has also observed that when features of different modalities are compatible with each other then fusion at feature level achieves more accuracy Figure 2. Shows feature level fusion.

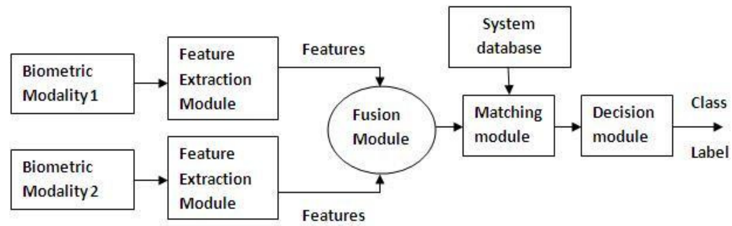

Figure 2. Fusion at feature level

4.2. Matching Score Level Fusion

In this level, rather than combining feature vectors, they are processed separately and individual matching score is found and finally these matching scores are combined to make classification. Various techniques such as logistic regression, highest rank, borda count and weighted sum, weighted product, bayes rule, mean fusion, Linear Discriminent Analysis [LDA] fusion, k-nearest neighbour [KNN] fusion, and hidden Markov model [HMM] etc may be used to combine match scores. One important aspect has to be addressed in the matching score level is the normalization of scores obtained from multiple modalities [6]. Min-max, z-score, median-MAD, double-sigmoid, tan-h, and piecewise linear these various normalization techniques can be used for normalization of the match scores. Matching score level is the most widely used fusion level due its less complexity. Many of the researchers have applied fusion at Matching score level [10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 22, 23, 24, 25, 26, 27]. Figure 3. Shows matching score level fusion.

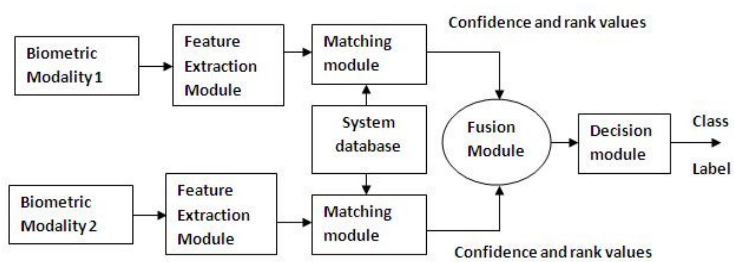

Figure 3. Fusion at matching score level

4.3. Decision Level Fusion

In decision level fusion each modality is first pre classified independently i.e. each biometric trait is captured then features are extracted from that captured trait, based on that extracted features these traits are classified like accept or reject. The final classification is based on fusion of the outputs of different modalities. Figure 4. Shows decision level fusion. In 2010, A. Cheraghian et al. have applied fusion at decision level [20].

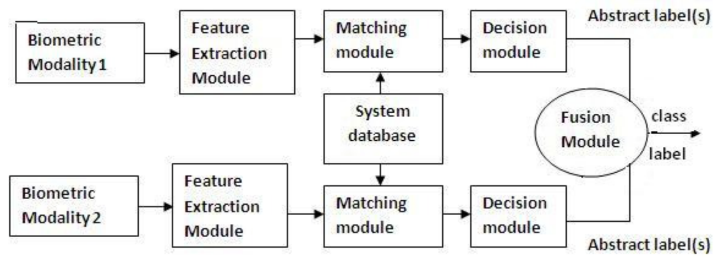

Figure 4. Fusion at decision level

5. RELATED WORK

Till date many multimodal systems have been implemented and deployed for commercial use, these systems are implemented according to different fusion levels and different algorithms, some of them are wavelet based algorithm [9, 10, 11, 18, 24]. Hariprasath. S et al. has given an approach of multimodal system with iris and palmprint using Wavelet Packet Transform [WPT] and score level fusion. It has found that WTP gives high accuracy [10]. A. Kumar et al. proposed a multimodal framework based on face and ear modalities, using Haar wavelet and Scale Invariant Feature Transform [SIFT] features are extracted. Finally integration of their ranks has been done with modified Borda count and Logistic regression method. According to A. Kumar et al. logistic regression is better than borda count method [11]. S. Jahanbin et al. proposed a novel multimodal framework for (2D+ 3D) face recognition using Gabor Wavelet. Gabor coefficients are first computed and finally decision has made with fusion at matching score level [12].

T. Murakami et al. proposed multimodal biometric system based on face, fingerprint and iris modalities with Bayes decision rule- score level fusion technique and Permutation based indexing technique for identification of these modalities [13]. Y. Zheng et al. have proposed system using multispectral face images with four different fusion methods i.e. mean fusion, Linear Discriminent Analysis [LDA] fusion, k-nearest neighbor [KNN] fusion, and hidden Markov model [HMM] and according to Y. Zheng et al. HMM fusion is the most reliable score fusion method [14]. N. Gargouri Ben Ayed et al. have developed system using fingerprint and face using Gabor wavelet and Local Binary patterns [LBP]. Finally fusion has done at match- score level with weighted sum method and found to be excellent method giving higher performance [15]. Mahesh P.K. et al. proposed the multimodal biometrics system using two traits speech and palm print, Wavelet-Based Kernel PCA and Mel Frequency Cepstral Coefficients (MFCC) is used to extract features of signal. Finally decision has made by fusion at matching score level with weighted sum [16].

A. Kumar et al. have proposed an adaptive multimodal biometrics using various modalities. Particle swarm optimization at matching score level fusion is used. According to A. Kumar system outperforms at matching score level than decision level [17]. A. P. Yazdanpanah et al. has proposed system using face, ear and gait with the use of gabor wavelet and fusion at matching score level with weighted sum and weighted product approaches [18]. F. A. Fernandez et al. proposed quality-based conditional processing in multi biometrics with fusion at rank level using linear logistic regression approach [19]. A. Cheraghian et al. has proposed system based on 2D and 3D face image by applying gabor wavelet transformation with fusion at decision level fusion [20]. A. Bhattacharjee et al. have proposed multimodal approach with iris and speech modalities with Daubechies wavelet for feature extraction and decision has made by fusion at feature level [21]. D. R. Kisku et al. has addressed multimodal biometric system using face and palm print modalities. According to D. R. Kisku et al. fusion of biometric images at low level makes the system more robust [9].

Md. M. Monwar et al.has given new approach for multimodal biometric system using face, ear and signature modalities, Principle Component Analysis [PCA] has been used with fusion at rank level- using highest rank, borda count and logistic regression approaches and logistic regression [22]. P. Kartik et al. have proposed system using face, speech and signature features. Principal Component Analysis [PCA], Linear Discriminant Analysis [LDA] and Mel Frequency Cepstral Coefficients [MFCC] used for feature extraction. Finally decision has made at matching score level with sum rule [23]. F. Yang et al. have proposed ultimodal biometric systems based on fingerprint, palmprint and hand geometry modalities using Support Vector machine [SVM] and wavelet transform with fusion at matching score itself [24]. Xiao-Na Xu et al**.** have presented a novel method of feature-level fusion based on Kernel Fisher Discriminant Analysis (KFDA) with Average rule, Product rule and Weighted-sum rule respectively and applied it to multimodal biometrics based on fusion of ear and profile face biometrics [25].

S. Ribaric et al. evaluated different techniques of matching score fusion level like Bayes-based normalization, min-max, zscore, median-MAD, double-sigmoid, tanh, and piecewiselinear on different multimodal biometric systems with fingerprint, face and palmprint modalities [26]. A. Jain et al. have developed multimodal biometrics using face, fingerprint and hand geometry modalities with matching score level fusion. As in case of matching score level fusion normalization of match score is important aspect, A. Jain et al. have done normalization of match scores of these modalities with different such as min-max, z-score and tanh technique [27].

6. CONCLUSIONS

We have observed that multimodal biometrics is frontier to the unimodal biometrics as it overcomes the problems related with unimodal biometrics like noisy data, interclass similarities, intra class variation, non universality and spoofing. There are many multimodal biometric systems in existence for authentication of a person but still selection of appropriate modals, choice of optimal fusion level and redundancy in the extracted features are some challenges in designing multimodal biometric system that needs to be solved.

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REFERENCES

[1] R. Clark, “Human Identification in Information Systems: Management Challenges and Public Policy Issues,” *Journal of Information Technology and People*, vol. 7, no. 4, pp. 6-37, 1994.

[2] M. Deriche, “Trends and Challenges in Mono and Multi Biometrics,” in *Proc. of Image Processing Theory, Tools and Application (IPTA), Sousse*, pp.1-9, 23-26 Nov 2008.

[3] A. Mishra, “Multimodal Biometrics it is: Need for Future System,” *International Journal of Computer Application,* vol. 3, no. 4, pp. 28-33, June 2010.

[4] M. S. Ahuja and S. Chabbra, “A Survey of Multimodal Biometrics**”,** *International Journal of Computer Science and its Applications*, pp. 157-160.

[5] M. Golfarelli, D. Maio and D. Maltoni, “On the Error-reject Tradeoff in Biometric Verification Systems,” *IEEE Trans. on Pattern Analysis and Machine Intelligence*, vol. 19, no. 7, pp.786-796, July 1997.

[6] A. Ross and A. Jain, “Information Fusion in Biometrics,” *Journal of Pattern Recognition Letters,* vol. 24, pp. 2115-2125, 2003.

[7] V. Mane and D. Jadhav, “Review of Multimodal Biometrics: Applications, Challenges and Research Areas,” *International Journal of Biometrics and Bioinformatics (IJBB),* vol. 3, no. 5, pp. 90-95, 2009.

[8] K. Delac and M. Grgic, “A Survey of Biometric Recognition Methods,” in *Proc. of 46th International Symposium on Electronics in Marine (ELMAR), Zadar,* pp. 184-193, 16-18June 2004.

[9] D. Kisku, A. Rattani, P. Gupta and J. Sing, “Biometric Sensor Image Fusion for Identity Verification: A Case Study with Wavelet-Based Fusion Rules Graph Matching,” in *Proc. of IEEE Conference on Technologies for Homeland Security, HST '09, Boston,* pp. 433-439, 11-12 May 2009.

[10] S. Hariprasath and T. Prabakar, “Multimodal Biometric Recognition using Iris Feature Extraction and Palmprint Features,” in Proc. of International Conference on Advances in Engineering, Science and Management (ICAESM), Nagapattinam, pp. 174-179, 30-31 March 2012.

[11] A. Kumar, M. Hanmandlu and S. Vasikarla, “Rank Level Integration of Face Based Biometrics,” in Proc. of Ninth International Conference on Information Technology: New Generations (ITNG), Las Vegas, pp. 36-41, 16-18 April 2012.

[12] S. Jahanbin, Hyohoon Choi and A. Bovik, “Passive Multimodal 2D+3D Face Recognition using Gabor Features and Landmark Distances,” *IEEE Trans. on Information Forensics and Security,* vol. 6, no. 4, pp. 1287-1304, Dec. 2011.

[13] T. Murakami and K. Takahashi, “Fast and Accurate Biometric Identification Using Score Level Indexing and Fusion,” in *Proc. Of International Joint Conference on Biometrics (IJCB), USA,* ,pp. 978-985, 2011.

[14] Y. Zheng and A. Elmaghraby, “A Brief Survey on Multispectral Face Recognition and Multimodal Score Fusion,” *in Proc. of IEEE International Symposium on Signal Processing and Information Technology (ISSPIT),* Bilbao, pp. 543-550, 14-17 Dec 2011.

[15] N. Gargouri Ben Ayed, A. D. Masmoudi and D. S. Masmoudi, “A New Human Identification based on Fusion Fingerprints and Faces Biometrics using LBP and GWN Descriptors,” in *Proc. of 8th International Multi-Conference on Systems, Signals and Devices (SSD), Sousse,* pp. 1-7, 22-25 March 2011.

[16] P. K. Mahesh and M. N. S. Swamy, “A Biometric Identification System based on the Fusion of Palmprint and Speech Signal,” in *Proc. of International Conference on Signal and Image Processing (ICSIP), Chennai*, pp. 186-190, 15-17 Dec. 2010.

[17] M. Hanmandlu, A. Kumar and V. K. Madasu, " Fusion of Hand Based Biometrics using Particle Swarm optimization, " *in Proc. Fifth International Conference on Information Technology: New Generations (ITNG)*, pp. 783-788, 2010.

[18] A. Yazdanpanah, K. Faez and R. Amirfattahi, “Multimodal Biometric System using Face, Ear and Gait Biometrics,” in *Proc. of 10th International Conference on Information Sciences Signal Processing and their Applications (ISSPA), Kuala Lumpur,* pp. 251-254, 10-13 May 2010.

[19] F. A. Fernandez, J. Fierrez and D. Ramos, “Quality-Based Conditional Processing in Multi-Biometrics: Application to Sensor Interoperability,” *IEEE Trans. On Systems, Man, And Cybernetics—Part A: Systems and Humans*, vol. 40, no. 6, pp.1168-1179, Nov. 2010.

[20] A. Cheraghian, K. Faez, H. Dastmalchi and F. Oskuie, “An Efficient Multimodal Face Recognition Method Robust to Pose Variation,” in *Proc. of IEEE Symposium on Computers & Informatics (ISCI), Kuala Lumpur,* pp. 431-435, 20-23 March 2010.

[21] A. Bhattacharjee, M. Saggi, R. Balasubramaniam, A. Tayal and Dr. A. Kumar, “A Decison Theory Based Multimodal Biometric Authentication System Using Wavelet Transform,” in *Proc. of the 8th International Conference on Machine Learning and Cybernetics , Baoding*, pp. 2336-2342, 12-15 July 2009.

[22] M. Monwar and M. Gavrilova, “Multimodal Biometric System using Rank-Level Fusion Approach,” *IEEE Trans. On Systems, Man, and Cybernetics-Part B: Cybernetics,* vol. 39, no. 4, pp. 867-878, August 2009.

[23] P. Kartik, R. V. S. S. Vara Prasad and S. R. Mahadeva Prasanna, "Noise Robust Multimodal Biometric Person Authentication System using Face, Speech and Signature Features," in *Proc. of Annual IEEE India Conference (INDICON), Kanpur,* vol. 1, pp. 23-27, 11-13 Dec. 2008.

[24] F. Yang and Baofeng M. A, "Two Models Multimodal Biometric Fusion Based on Fingerprint, Palm-Print and Hand-Geometry," in *Proc. of 1st International Conference on Bioinformatics and Biomedical Engineering (ICBBE)*, *Wuhan*, pp. 498-501, 6-8 July 2007.

[25] Xiao-Na Xu, Zhi-Chun Mu and Li Yuan, "Feature-Level Fusion Method based on KFDA for Multimodal Recognition Fusing Ear and Profile Face," in *Proc. of International Conference on Wavelet Analysis and Pattern Recognition*, *Beijing*, vol. 3, pp. 1306-1310, 2007.

[26] S. Ribaric and I. Fratric, "Experimental Evaluation of Matching-Score Normalization Techniques on Different Multimodal Biometric Systems," in *Proc. of IEEE Mediterranean Electrotechnical Conference,* Malaga, pp. 498-501, 16-19 May, 2006.

[27] A. Jain, N. Karthik and A. Ross, "Score Normalization in Multimodal Biometric Systems," *Journal of Pattern Recognition*, vol. 38, no.12, pp. 2270-2285, 2005.