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# AN OVERVIEW OF VARIOUS TECHNIQUES INVOLVED IN DETECTION OF ANOMALIES FROM SURVEILLANCE CAMERAS

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***ABSTRACT***

*In recent years, the use of surveillance cameras is rapidly increasing in both public and private areas to enhance the security measures. Many companies are recruiting people to monitor the activities captured by surveillance cameras and due to human error they may failed to monitor the abnormal events. So, an automated system to detect the anomalous events acts as a significant approach in surveillance applications. Due to sparse occurrence of anomalous activities, the detection of anomalies is remaining as a challenging task. To overcome these drawbacks, many researchers have worked to develop an effective anomaly detection methods using different approaches. This study prioritized some existing approaches to detect anomalies takes place in surveillance videos. The existing researches utilized University of Central Florida (UCF) Crime video dataset to collect the data about the anomalous activities, UCF crime video dataset consist of 13 categories of anomalies which consist of 1900 surveillance videos. The key parameters such as accuracy, recall, F1 score and Area Under Curve (AUC) are evaluated to analyse the efficiency of the existing anomaly detection methods. This survey acts as a tool for future researchers to overcome the drawbacks in the existing methods and create a novel anomaly detection approach.*

***KEYWORDS***

*Abnormal Events, Anomaly Detection, Automated System, Security, Surveillance Cameras.*

## 1. INTRODUCTION

Detection of anomalous events in the surveillance videos is one of the significant task in computer vision and plays a major role in analyzing the structure of the videos and surveillance applications such as accident detection, crime investigation and so on [1]. Initially, the detection of abnormal activities by extracting the essential data under human guidance is seen as an easier task, but there are numerous limitations such as human incapability, hard to monitor the signals simultaneously, consumes more time and resources [2]. Since millions of surveillance cameras are placed in public and private places, an intelligent monitoring system is essential to detect the anomalous events. Anomalous activity detection is a specified area of research present in Video Content Analysis (VCA). Anomaly detection deals with identifying the patterns and events which differs from normal video stream. Anomalous events include abuse, fighting, accidents to snatch etc. [3]. Moreover, subject detection of anomalies, minimal number of annotated data, poor resolution quality of videos is also considered as a reason to which acts as a barricade to detect

the anomalies present in surveillance videos [4]. The general overview of process involved in anomaly detection is diagrammatically represented in figure 1 as follows:

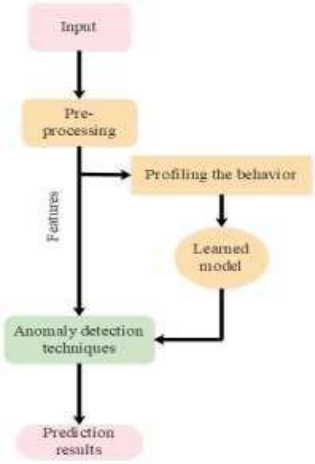


Figure 1. General process involved in the anomaly detection scheme

Detection of anomalous events have performed using probabilistic models, deep learning techniques. However, still there are many challenges occurred in the process of anomaly detection. First of all, there is always a very small chance that odd things will occur. It makes it challenging to establish relevant datasets. Additionally, it creates a situation where the focus of associated research activity is limited to the characteristics of conventional videos. The performance of classifiers in models is impacted, and it becomes challenging to offer accurate detection results when the unexpected video is close to the norm [5,6]. When determining whether a segment is normal or pathological, many existing approaches used multiple instance learning (MIL) to treat several consecutive frames as a single short-term segment [7]. Recent, effective techniques have, concentrating on just one segment but it is essential to learn the temporal links between segments by capturing all the segments of the video [8]. This survey provides a brief study about various methodologies involved in detecting the anomalous events present in the surveillance videos.

The remaining of the paper is organized as follows: Section 2 discuss the related works on different anomaly detection methods. Comparative analysis is provided in Section 3 and the taxonomy of the study is discussed in Section 4. In Section 5, the problems occurred in the existing researches are discussed and finally, the summary of this study is presented in Section 6.

UCF crime video dataset used by many researches consist of 13 categories of anomalies which consist of 1900 surveillance videos. The key parameters such as accuracy, recall, F1 score and Area Under Curve (AUC) are evaluated to analyze the efficiency of the existing anomaly detection methods. This survey acts as a tool for future researchers to overcome the drawbacks in the existing methods and create a novel anomaly detection approach.

## 2. RELATED WORKS

WaseemUllah et al. [9] have introduced an efficient light weight Convolutional Neural Network (CNN) based anomaly detection method in surveillance applications. The spatial CNN features were extracted from the frames of video and provides it to the Long-Short Term Memory (LSTM) which was utilized to recognize the anomalies present in the video. The light weight CNN utilized

in the anomaly detection process provides high level adaptability in surveillance related applications. However, the proposed light weight CNN model doesn't suit for the process of multi-objective detection.

Ramna Maqsood et al [10] have introduced an automated deep learning approach to detect and recognize the anomalous activities took place in real time applications. The deep learning approach utilized pre-trained 3D Convolutional Network (ConvNet) which has the capability to extract the spatiotemporal features from surveillance videos. Additionally, spatial augmentation was applied on 3D ConvNet to generalize the competencies and improve the effectiveness of the framework. However, the UCF crime dataset utilized in this research was incapable to perform multiclass classification.

Nasaruddin Nasaruddin et al [11] have introduced a deep anomaly detection method to detect the anomalies from Spatio temporal data. During the process of anomaly detection, the feature extraction was performed using background subtraction and indicates the utilized attention region. The output from feature extraction process was fed into 3D Convolutional Neural Network (CNN) which exploits the Spatio temporal data and categorize normal and anomalous scenarios. However, the deep anomaly detection method does not detect the anomalies which takes place in moving things.

Soheil Vosta and Kin-Choong Yow [12] have introduced a combined structure of Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN) to detect the violence which takes place in surveillance cameras. Here, ResNet50 was utilized as CNN which extracts the significant features and provide it into LSTM to detect the anomalous events present in the dataset. The combined framework categorized the data and helps to attain better capability to detect the anomalies. However, the framework was built to detect anomalies present in specified three classes such as firefighting service, about thefts and violent behavior.

S. Chandrakala et al [13] have introduced an Object-centric and Memory-guided residual spatiotemporal autoencoder (OM-RSTAE) to detect the anomalous activities in the surveillance videos. In order for the decoder to effectively reconstruct abnormal events with a low error rate, the OM-RSTAE uses a skip-connected memory-guided network to capture and preserve important normal patterns. Additionally, introducing sparsity into the memory-guided network allowed for the generation of valid latent representations from only a small subset of the patterns used for reconstruction. The LSTMs used in the skip connected memory directed network, however, it was unable to store the data in video sequences.

Maryam Qasim and Elena Verdu [14] have introduced an automated anomaly detection system using deep Convolutional Neural Network (CNN) and a Simple Recurrent Unit (SRU). The high level feature representations from the video frames are used to gather information using ResNet and the SRU was used to gather temporal features. The SRU was known for its expressive recurrence that helps in parallelized implementation and makes the anomaly detection accurate. However, the suggested approach was limited with the video sequence of 20 frames.

Ammar MansoorKamoona et al [15] have introduced a deep temporal encoding and decoding network for detection of anomalies in the applications related to video surveillance. The suggested approach was based on multi instance learning to normalize the anomaly event from the surveillance video. Moreover, the loss function of the suggested approach was minimum due to the usage of max pooling layer. However, the loss function maximizes the distance among normal instance score and the abnormal instance score.

## 3. COMPARATIVE ANALYSIS

There are numerous methodologies have developed by the researchers to detect the anomalies in video surveillance applications. Here, some distinct methodologies to detect the anomalous activities is represented in table 1.

Table 1. Comparative table

| Author | Methodology employed | Advantage | Limitation | Performance measure |
|---|---|---|---|---|
| Muhammad Zaigham Zaheer et al [16] | A weakly supervised anomaly detection method which undergoes training based on randomized training procedure and suppression mechanism to detect the abnormal activities of the video | The weakly supervised anomaly detection method separates a single video into multi sequence to detect the anomalies accurately. | The method was not able to detect the anomalous activities present in a video with short duration of time. | Area Under Curve (AUC) |
| YumnaZahid et al [17] | A bagging framework known as IBaggedFCNet was introduced which utilized the ensembles to perform an effective detection of anomalies present in the videos. | The framework effectively segment frames of the video to generate ground truth labels to provide batter accuracy | However, the bagging framework does not detect the anomalous activities in granular level videos | Precision, recall, Area Under Curve (AUC) |
| Halil Ibrahim Ozturk and Ahmet Burak Can [18] | A temporal anomaly detection network to localize the anomalous activities present in the video. AD loss function was utilized to achieve better detection performance | The temporal anomaly detection model has the capability to detect the trimmed videos with shorter time duration | The temporal AD model does not provide relation among information about the scene and the objects present in the scene | Area Under Curve (AUC), F1 score |
| Shikha Dubey et al [19] | An anomalous detection framework with Deep network and Multiple Ranking Measures (DMRM) which addresses the dependency of contexts by using joint learning method | The DMRM framework was trained to detect both the normal and abnormal events to effectively classify the anomalous activities | Howeve r, the DMRM framework does not filters the noise which leads to variation of illuminations and causes occlusion. | Accuracy, Area Under curve (AUC) |
| WangliHao et al [20] | A two stream convolutional network model to detect the anomalies takes place in surveillance videos. | A two stream convolutional network model uses complementary information from | The future extraction process must be enhanced to extract multiscale | Accuracy, Area Under curve (AUC) |

| | | | | |
|---|---|---|---|---|
| | The introduced model consist of RGB and flow stream network which detects the score of anomalous activities | two streams improve the detection accuracy of anomalous activities | information from CNN layers to improve the performance of the model. | |

## 4. TAXONOMY OF VARIOUS ANOMALY DETECTION METHODS

Detection of anomalous activities deals with detecting the abnormal events which differs from normal stream. In applications of video surveillance, the events such as road accidents, abusing and snatchingetc are considered as anomalous detection. The anomalous activities take place in a short period of time, so it is still remaining as a challenge to detect and recognize the anomalous activities. Moreover, the recognition of anomalous events from unconfined environment is a challenging task due to the variations which occur among the two or more classes. The inadequate data regarding the anomalous events and the low resolution videos from the surveillance cameras are also considered as common challenges in recent days. This survey prioritizes some of the significant researches involved in anomaly detection and it is represented in figure 1 as follows:

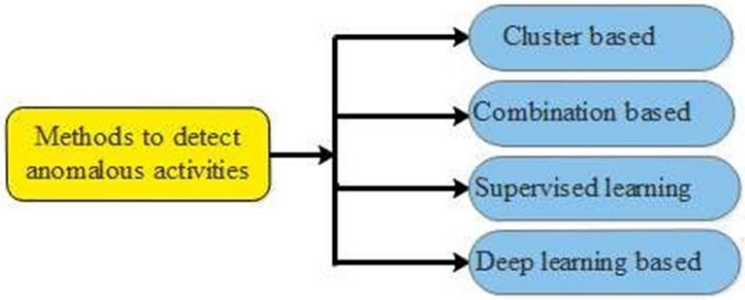


Figure 2. Taxonomy of various methods to detect anomalous events

### 4.1.Clustering based Method

In the subject of data mining, clustering algorithms [16] are often employed. These methods form clusters of similar data values and behavior. If data values do not fit into clusters or if their clusters are significantly smaller than other clusters, they are regarded as outliers. The idea that normal values are part of a big cluster underlies the identification of outliers. In contrast, outliers are either part of tiny clusters or are not part of any cluster. To cut down on communication costs, the clustering techniques group together comparable data values into clusters and combine certain clusters. The recent approaches based on clustering method to detect the anomalies in surveillance is presented in this section. The clustering distance is considered as a main parameter to detect the anomalies by obtained the features of the video. In a normal label all the segments look normal and the abnormal labels indicates the presence of anomalous features.

### 4.2. Combinational Methods

The importance of ensemble approaches is growing as a result of their consistent ability to outperform the results of a single model. If the member classifiers are reliable and varied, ensemble learning is more accurate than solo classifiers. One of the most common types of ensemble learning is bagging [19], in which several models are created by randomly choosing

data points from the training data. These models are trained traditionally using the same classifier and a #-layered neural network is utilized to perform bagging ensemble. In [12] author introduced combined structure of CNN and RNN to detect the anomalies in surveillance cameras. The CNN is utilized in extracting the features and LSTM detects the anomalous activities in the given data.

### 4.3.Supervised Learning Method

Supervised learning aims at optimizing a model without substantial manual labeling works. This learning paradigm generally resorts to MIL and applies in many AI tasks such as object detection, captioning and language grounding. Recently, some work has conducted a deep exploration of Spatio-temporal weakly supervised learning [2,13]. In [2,13] Spatio-temporal weakly supervised learning method is used to identify the anomalous scenes in surveillance videos. In [2] tube level gradients of different instances are involved in capturing associates between normal and abnormal events. In [13] author introduced anomaly localization method to localize the anomalous segments present in the surveillance videos.

### 4.4. Deep Learning Method

In recent times, deep learning has reached human levels of accuracy in several computer vision applications including surveillance. Similarly, many researchers have utilized deep neural networks to detect anomalous events in videos. In [10] anomaly detection is performed using 3D CNN. Initially, the spatiotemporal features are extracted and trained for UCF-crime video dataset then the extracted features are fed into 3D CNN model to detect the presence of anomalies. Similarly, in [9] Spatio temporal features are extracted using the layers of pre-trained CNN and then extracted deep features are fed in the multi-layered Bi-LSTM which can classify anomalous events.

## 5. CHALLENGES

Video anomaly detection is the process of identifying the unusual events which takes place in surveillance videos. There are some issues found in the existing researches which are discussed in this section along with some general problems in detection of anomalies.

- The result of anomaly detection using combinational model [12] is sub-optimized due to separation among the process of learning and classification.
- Anomaly detection using supervised learning method had issues in detecting the high degree of anomalies while segmenting the video sequences [13].
- The deep learning based anomaly detection model [11] lacks its capability to detect anomalous events which takes place in a movable object.
- The improper extraction of features in supervised learning method leads to occurrence of false positive rates which may affects the overall performance of the detection model.

## 6. CONCLUSION

The recognition of Anomalous activities deals with detecting the patterns which varies from the normal stream. The anomalous activities are defined as the abnormal events which are differed from the normal events. The anomalous events include road accidents, abusing and snatching etc and the detection of anomalies are still remains as a challenging task due to various issues in the

environment, poor resolution, minimal time period etc. An efficient anomaly detection model plays a vital role in identifying the anomalous activities captured from surveillance cameras. The existing approaches discussed in this study utilized UCF- crime video dataset to collect information about the anomalous activities. This study provides a detailed survey on various methodologies utilized in detecting the anomalous events. Taxonomy on different categories such as clustering based, combination based, supervised learning based and deep learning based methods involved in detection of anomalies are discussed. The advantages and drawbacks takes place in existing researches are deliberated in this study. Moreover, the problems faced by the existing researches based on anomaly detection with general issues are discussed. This study helps the future researchers to overcome the drawbacks and create a new anomaly detection model. In future, the hybridized learning approaches can be utilized to classify the anomalies which results in better classification accuracy.

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