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Study of Methods Detect Anomalous Activities in Videos

Amulya R. Maitre
Computer Engineering Department
Pimpri Chinchwad College of Engineering
Pune, India

Prachi R. Khopkar
Computer Engineering Department
Pimpri Chinchwad College of Engineering
Pune, India

Pratik V. Kolaskar
Computer Engineering Department
Pimpri Chinchwad College of Engineering
Pune, India

Shreyas S. Gaikwad
Computer Engineering Department
Pimpri Chinchwad College of Engineering
Pune, India

Abstract:- These days security has become a major issue due toexponential increase in the crime rates. This lead in the adaptation of surveillance systems in various public areas like shopping centers, bus and railway stations, schools, airports etc. These systems capture daily motion of people, but keeping an eye on the ongoing in every area is difficult. Hence, there is a necessity of smart surveillance system which will detect any mishap or anomalous activities in the ongoing videos. This paper surveys the various methods proposed in earlier researches for the detection of anomalous activities in videos and concludes with the most efficient or effective system.

Keywords:- *Anomalous Activity Detection, Surveillance System, Survey.*

I. INTRODUCTION

Crimes like robbery or terrorist attacks, mostly occur in public places such as shopping centers, bus and railway stations, airports, etc. which makes it mandatory to have surveillance systems, to locate criminals. Anomalous activities are deviation of human actions from normal behavior which may include the presence of humans in restricted or unusual locations, involvement in violence, left bag, sudden movements, etc. Any event can be normal in one scenario but anomalous in another. However, it is a very tedious task for the security persons to monitor anomalous activities in the video footages obtained from the system, where most of the activities are normal. Hence, there is a need for a smart surveillance system to detect the anomalous activity then and there, while it's captured by the system. Even though a lot of research is done in real-time video analysis, there is scope for more advanced surveillance systems which will detect the anomalous activities accurately with less human intervention. Some of the related work in video anomaly detection is discussed in the following sections.

II. BASIC UNDERSTANDING

Researchers have focused on how video analytics can be used to identify potentially threatening events with less or no human intervention. Video analysis includes recognition of humans and their activities and categorizes them into usual (normal), unusual (abnormal) or suspicious activities. [2]While a specific action can be considered normal, another one will be abnormal i.e. abnormality. [6]

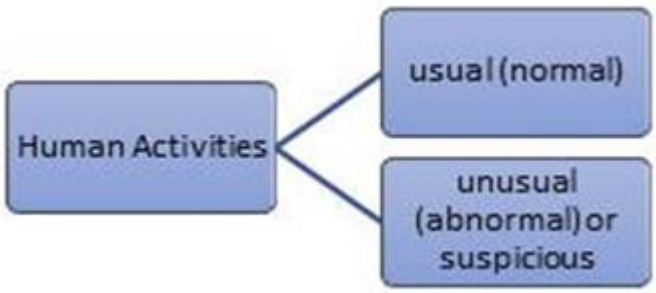

Fig. 1:- Types of Human Activities

Locating the unusual events in videos by some surveillance system can be done manually, semi-automatic or fully automatic. But it is preferred to have a semi-automatic or fully-automatic system.

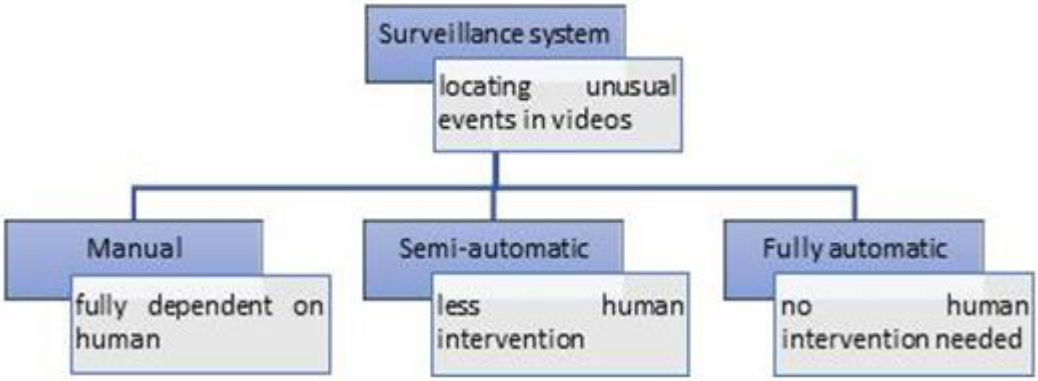

Fig. 2:- Types of Surveillance Systems

Some anomalous activities detection systems are Traffic monitoring, Medical science, highly surveillance areas like military area, airport, etc., crowd analysis, criminal activity recognition, automatic forensic video retrieval. [2]

Sarita Chaudharya et.al [2] have specified the several challenges which are faced while detecting anomalous activities. Various approaches have been proposed priory to solve those challenges. The two main assumptions that are considered while generating a method for making an anomalous event detection system are:

- Frequency of occurrence of anomalous events is less than a normal event in a video stream.
- Normal events have less similarity to the anomalous event.

To detect the anomalies in the videos captured by the surveillance system, Emmanu Varghese et.al [1] classify detection in two categories namely, supervised and unsupervised methods. Supervised methods are the ones which have a training phase and the unsupervised methods don't have such an explicit training phase.

Intensity values are used to calculate pixel density. Based on the results then determination of whether the pixel is foreground or background is done.

By using equation (1)

$$P(Y_t) = \sum_{n=1}^{k} w_{i,t} \cdot \eta(Y_t, \mu_{i,t}, \Sigma_{i,t}) \qquad (1)$$

Where
Y_t : Current pixel in frame t
k: number of k_{th} distributions in mixture
$w_{i,t}$: the weight of k_{th} distribution in frame t
$\mu_{i,t}$: the mean of k_{th} distribution in frame t
$\Sigma_{i,t}$: standard deviation of k_{th} distribution in frame t

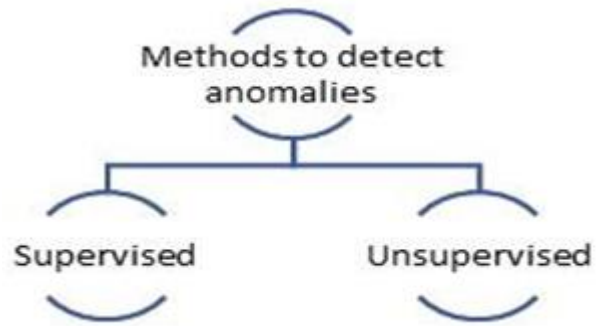

Fig. 3:- Methods to detect anomalies

III. THE SURVEY

Emmanu Varghese, Jaison Mulerikkal∗, Amitha Mathew (2017) [1] proposed a supervised algorithm for video anomalydetection in confined areas without any human intervention, and with less mathematical computations. Their algorithm learns the motion path and speed of objects from the training video by processing the video in spatio-temporal volumes and ensembles using dense sampling and detects the abnormal activities using the color pattern of the videos.

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An analysis is done by extracting multiple features like speed, direction, dimensions, and centroid. Anomalous activity is detected by using some problem domain rules that find dominant and less dominant behavior. The direction of the object is also considered in the recognition process. They considered dominant activities (higher occurrence) as normal behavior and less dominant (less occurrence) behavior as an anomalous event. This framework detects various types of anomalous activities in different scenarios like crawling (C), running (R), walking (W), (C+R), (C+W), (R+W) and (C+R+W). The framework was capable of detecting multiple anomalous activities successfully with the accuracy of up to 90% using the following equation.

$$Accuracy = \frac{correctly\ classified\ activity}{total\ occurrence\ of\ activity}$$

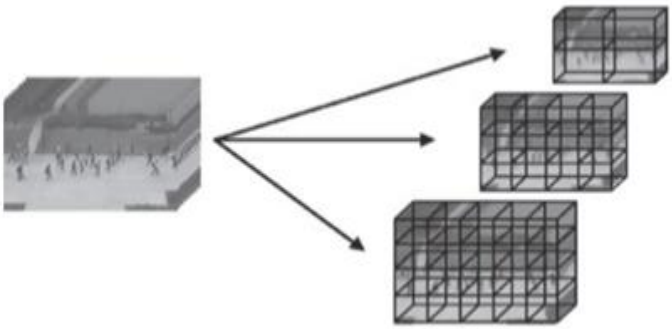

Fig. 4:- Dense Sampling

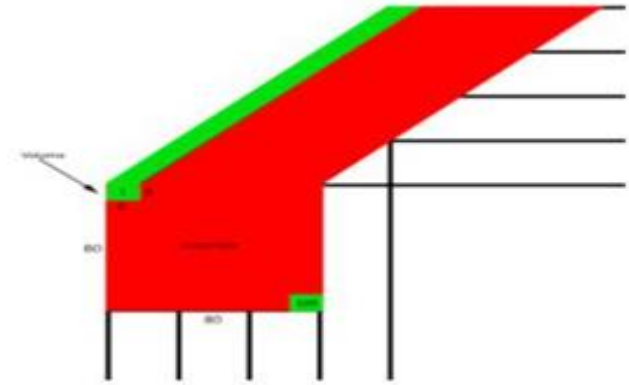

Fig. 5:- Dense Sampling if frame size is 640×480, ensembles size is 80×80 and spatio-temporal volume size is 8×8

For large variation in motion and speed during the testing phase, the algorithm alerts it as an anomaly. Motion path is learned using the pixel's grayscale value as low-feature and statistical functions minimum and maximum, to understand the object's speed. Parameters for sensitivity control are adjustable according to the situation where the algorithm is intended to work.

Sarita Chaudharya, Mohd Aamir Khana, Charul Bhatnagara (2017) [2] have proposed to automatically detectmultiple anomalous activities in videos. They used object segmentation, multiple feature extraction, and dominant behavior analysis. Usually Gaussian Mixture Model (GMM) is practised for feature extraction. Representation of parametric form of probability density function is done in GMM. In Gaussian mixture model each pixel in the frame is modelled.

Adri´an Tom´e, Luis Salgado (2017) [3]A "bottom-up"approach is used to avoid any object tracking, making the system suitable for anomaly detection in the crowds. They used optical flow method for the extraction of accurate spatio-temporal motion information, to get simple but discriminative descriptors that are employed to train a Gaussian mixture model. Evaluation of system was done using publicly available dataset, concluding that the best model is the global GMM approach which is more effective than the local GMM approach while needing the construction of only one probability distribution. Following are the equations for global GMM.

$$p(D|\Theta) = \sum_{k=1}^{K} \pi_k p(D|\mu_k, \Sigma_k) \quad (2)$$

$$p(D|\mu,\Sigma) = \frac{1}{(2\pi)^{n/2}|\Sigma|^{1/2}} \exp\left(-\frac{1}{2}(D-\mu)^T\Sigma^{-1}(D-\mu)\right) \quad (3)$$

Xianghao Zang, Ge Li, Zhihao Li, Nannan Li, Wenmin Wang (2016) [4] introduced a deep foreground segmentationand a partition-trajectory histogram algorithm for an efficient object-aware anomaly detection scheme, in certain object categories, like pedestrians. They proposed a block-based object-of-interest detection, foreground segmentation framework to confine the analysis to moving objects and avoid undesirable background redundancy.

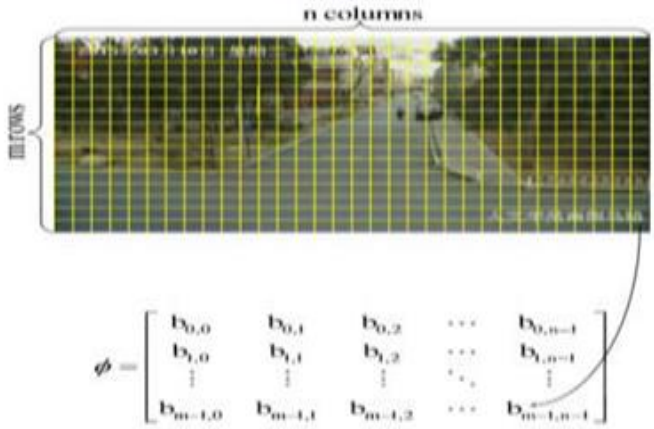

Fig. 6:- Block-based representation. We divide one frame into blocks and each block is represented by summation of pixel values. The matrix φ with smaller dimensions is obtained for anomaly detection.

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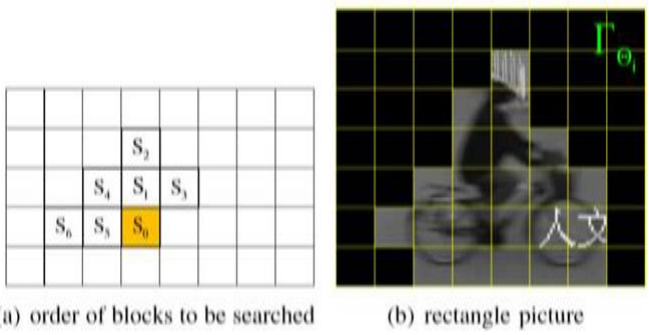

Fig. 7:- (a) the corresponding positions with S0,S1,...,S6. (b) Expanding rectangle picture with one block can improve the recognition rate.

Uninterested objects are discarded by running an object detector on connected blocks before anomaly detection. Finally, normal events are represented by extracting histograms of block-motion trajectories and clustering them. Hence, their framework gives a relatively low computation complexity and high detection accuracy. For practical consideration, they also proposed an evaluation criterion to obtain a best F-score through amounts of comparison experiments.

Mona Izadi, Zohreh Azimifar, Gholam-Hossein Jowkar* (2017)* [5] aim at exploring and proposing an unsupervisedcomputer vision algorithm in dynamic scenes for detection of abnormal events in a video. Their approach uses the dictionary (basis set) with a completely unsupervised dynamic sparse coding to be adapted to specific data for abnormal events detection which can be improved online according to changes in the context of the video. Meanwhile, their research suggests using MBH (Motion boundary Histogram) in abnormal detection, while other researches usually utilized MBH in action recognition.

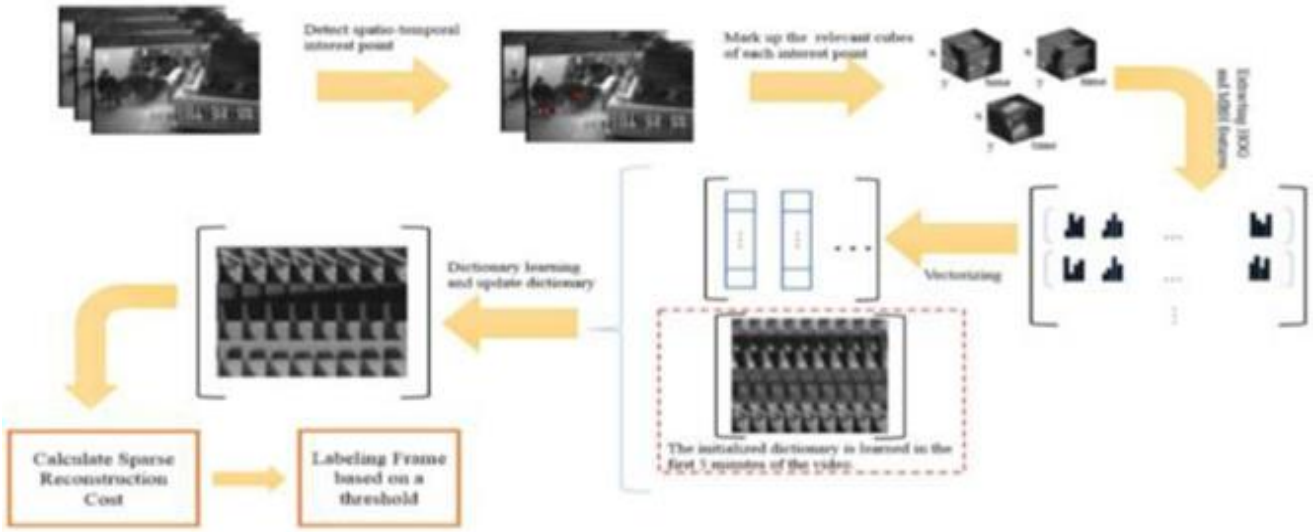

Fig. 8:- At the beginning, the interest points are detected in the video sequences. Then, the spatio-temporal cubes corresponding to each interest point is decomposed and the feature vectors are also extracted. As shown in the image initial dictionary (which is learned based on the first five minutes of the video) and the feature vectors are used to update the dictionary.

➢ *Taskeen A Mangoli, Sujatha C, Uma Mudenagudi (2018)*

An anomaly detection technique –MDMotion and Direction based is used that detects anomaly in crowded scenes. Supervised learning approach is followed by MD for which training of the model with labeled data is essential.

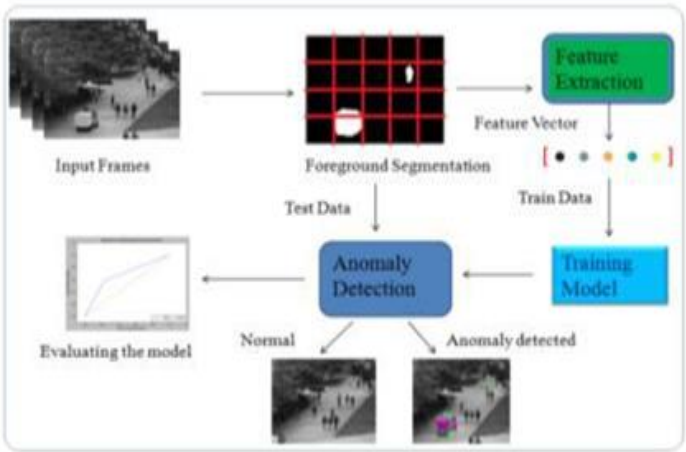

Fig. 9:- Block diagram of their proposed method

Their proposed method MD outperforms all the recent approaches like SF, MPPCA, SF-MPPCA, excluding MDT method. MDT approach performs anomaly detection at pixel level but requires more computation time whereas the proposed method detects anomaly at block level dividing the frame in to small cells which makes the computation simple. Their proposed method uses different features like motion, direction and persistence to detect anomaly in UCSD dataset.

Juan C. SanMiguel, José M. Martínez and Luis Caro-Campos [7] in this paper all the limitations related to size are taken into consideration. Ituses *background subtraction* for real-time operations in crowded environments. It models normal activity via a "background behaviour image" and detection of anomalous activities is done by takingthe threshold of the difference between observed events and normal activity. A size descriptor having window size that changes according to the size of the object is proposed. Each component has a background behavior image in the feature descriptor vector, for each direction of motion (up, down, left, right), and also for static objects.

To capture spatial and temporal changes of motion taking place at each pixel, a feature descriptor is constructed. Features like size, shape and speed of objects occurring at specific location. For an N×N pixel neighbourhoodcentredon each pixel; the size descriptor F is computed as follows:

$$F_t(\vec{x}) = \frac{1}{N} \sum_{\vec{y} \in \mathcal{N}(\vec{x})} \delta(\vec{x}, \vec{y})$$

Where, $\mathcal{N}(\vec{x})$ is the pixel neighbourhood of $\vec{x}$, and $\delta(\vec{x}, \vec{y}) = 1$ if locations $\vec{x}$ and $\vec{y}$ are moving and belong to the same connected component in the motion label image.

Limitations: Foreground estimation stage can be improved by better background models; and online learning can be included.

Shyma Zaidi, Jagadeesh B, Sudheesh K V and Audre Arlene

Humans in motion are detected and objects are tracked by background subtraction and Kalman filter technique. Objects are tracked using Kalman filter in following steps:

- Future location of the moving objects is predicted
- Removal or reduction of noise generated byincorrect detections
- Simplify the process of associating multiple objects to their track.

Kalman filtering is used for event detection and Eigen vector for feature extraction. SVM is used for classification of actions. In future different actions can be taken into consideration for detecting all types of anomalies. Better algorithms can be made for real time anomaly detection.

Manass´esRibeiro, Andr´eEug^enioLazzaretti, HeitorSilv´erio Lopes [9] from the reconstruction error of Convolutional Auto Encoder an anomaly score is generated, high-level features are aggregated with the input frames and devises a measure of spatial complexity. Regularized reconstruction error (RRE) is used to classify the events. The classification performance is measured using receiver operating characteristics (ROC) curve and area under the ROC curve (AUC). Normalized compression rate (NCR) of datasets is used to calculate the complexity coefficient and complexity is evaluated by correlating spatial complexity coefficient (SCC) and AUC. Limitations: Complexity and classification performance of CAE are negatively correlated. User should know the filters to better capture the anomalies to be detected.

Yifei Zhang, Wen Qu, Daling Wang (2013) [10] in real timevideos because of complex background, failure in single action recognition is observed. The action-scene model is explored in this paper to learn the relationship between actions and scenes in real time videos. The action-scene model is quite effective when we have to recognize the action from background behaviour. Extensive experiments were conducted on different methods of feature extraction which showed that this model is more robust for noisy features. While compared to LDA, Action-scene model is efficient in terms of recognition of background actions and movements.

Duc Vinh Ngo and Nang oan Do and Luong Anh Tuan Nguyen (2016) [11] in video surveillance a moving object is considered abnormal ifthe distance from it to trajectory is greater than the threshold. The abnormal nature of sub-trajectory leads to abnormalities in entire trajectory.

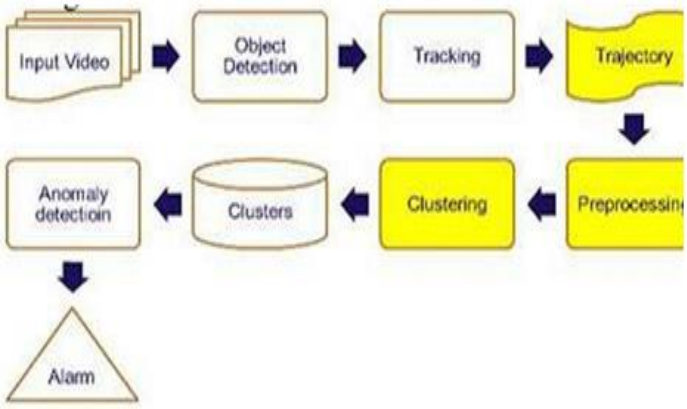

Fig. 10:- Block diagram of their anomaly detection processing method

One of the challenges for operation of monitoring system is continuous monitoring andensuring the credibility for a number of videos. This model describes the processing for anomaly detection. In this technique, based on the segmentation of medium routes and modified Hausdorff distance a sub-trajectory is calculated. Anomalies are then detected based on these sub trajectories.The results show that the proposed technique is suitable for applications in real-time video surveillance systems as the anomaly detection time is veryfast.

Quiang li, Weihai li (2016) [12] in this paper based on multiple feature extraction, anew framework is proposed for anomaly detection in video surveillance. In this technique global and local anomalies are detected separately. For detecting global anomaly we first derive kinetic energy Ek, then compute its first derivative and lastly derive a global anomaly score of each test. The method of Normality Sensitive Hashing is proposed for classification of abnormal and normal instances and is observed to be accurate after obtaining results of experiments.

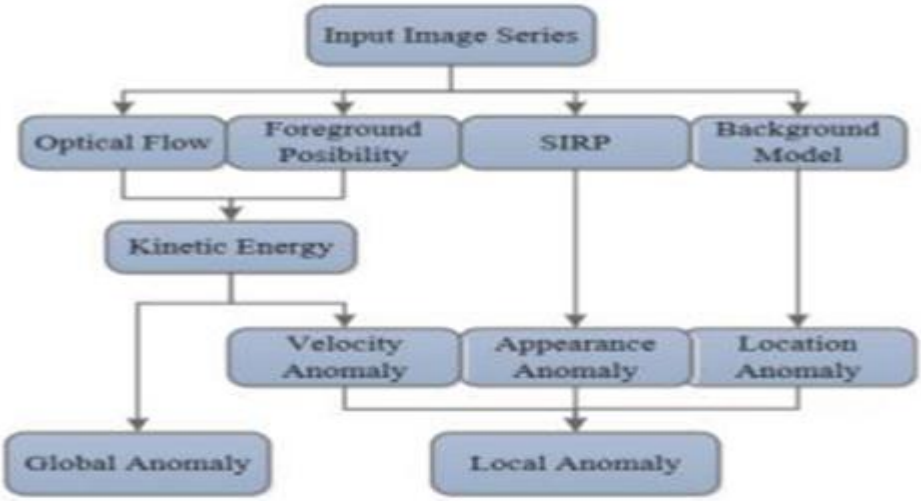

Fig. 11:- Framework for anomaly detection

Results of the experiments show that this method detects global and local anomalies with a comparatively better performance.

IV. CONCLUSION

No.	Techniques	Strength	Limitation	Remark
1.	Dense sampling. Video colour pattern observation	Fast. Adjustable sensitivity controlling parameters	Increased ensemble threshold decreases accuracy.	Other good image classification tools can be used.
2.	GMM and dominant behavior analysis	Detects activities like crawling running walking & their combination	Scenario dependent.	Anomaly Detection accuracy is up to 90%.
3.	Optical flow, GMM	Bottom-Up approach	Descriptors can be improved. Range of parameters can be increased.	The method of global GMM is better than that of the local GMM.
4.	Deep foreground segmentation, partition- trajectory histogram algorithm & K-means clustering	Low computational complexity and high detection accuracy	Scope is limited to pedestrian related activities.	Is efficient to focus only on object of interest.
5.	Completely unsupervised dynamic sparse coding algorithm	Adapts quickly to changing context & produces a smaller number of false alarms.	Presumptions like range has been defined	Uses MBH (Motion Boundary histogram) for abnormal detection.
6.	Anomaly detection is done using the Motion and Direction.	Block level detection of anomalies which makes the computation simple to SF, MPPCA, SF-PPCA.	MDT method is much better than proposed method.	It requires model to be trained with label led data which is difficult to obtain.
7.	Methods of background subtraction, feature extraction, event modelling & outlier detection are used.	Limitations related to size of the objects are taken into consideration.	Parameters such as size & dominant motion are only considered	Better background models & Online learning can be included.
8.	Kalman filter, Eigen Vector, SVM.	Tracks single person as well as multiple people. Specifications are detected as anomalies.	Direction is not considered along with different actions.	Better algorithms can be made for real time anomaly detection in video surveillance.

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9.	Convolutional Auto-Encoders. Canny Edge Detector.	Spatial complexity, motion filters, appearance are taken into consideration.	Negative correlation between complexity and classification performance. User should know the filters.	Requires training of model with labeled data which is difficult to obtain.
10.	Action Scene Model method to compute relationship between actions	Effective when we have to recognize the action from background settings.	As compared to other methods, its accuracy is less.	Only detects Human actions rather than categorising them into anomalies.
11.	Trajectory analysis. Uses Hausdorff distance to detect anomaly.	Can detect anomaly with incomplete trajectory. Detection time is reduced.	Features other than motion trajectory are not taken into consideration.	Trajectory detection sometimes takes worst case time complexity
12.	The method of Normality Sensitive Hashing is proposed for classification of abnormal and normal instances.	Detects global & local anomaly with comparative performance	Results are less accurate as compared to Video-parsing and NSH methods	Error of detection in all scenarios is less than 5 frames.

Table 1

From the above table we can conclude that the anomalous actions differ with areas. The surveillance systems thus should be designed and trained in a way to capture and alert anomalous actions applicable in that particular area. To detect the anomalous activities, following steps taken into consideration and the techniques used in them according to the above survey are:

1. **Pre-processing:** Conversion into frames, Background Subtraction.
2. **Object Detection & Tracking:** MoG2 &Kalman Filteris identified to be an ideal choice for this purpose. Hybridization of both can give better results.
3. **Feature Extraction:** Eigen vector, Action Scene Modeland Feature Descriptors are identified as some of the techniques for feature extraction.
4. **Action Detection and Classification:** Clustering
5. **Classify the action into Normal & Anomaly:** Normality Sensitive Hashing & SVM techniques hybridized together can give better results.

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