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INTELLIGENT VIDEO SURVEILLANCE MECHANISMS FOR ABNORMAL ACTIVITY RECOGNITION IN REAL-TIME: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Video surveillance plays a crucial role in securing indoor and outdoor locations in today's unreliable world, particularly in real-time applications for behaviour detection, comprehension, and labelling activities as normal or suspicious. For example, in the development of automated video surveillance systems, smart video reconnaissance systems based on picture recognition and activity recognition that detect violent behaviours is basic to forestalling wrongdoings and giving public security. According to the literature, Artificial Intelligent, Machine Learning, and deep portrayal-based approaches have been effectively utilized in image recognition and human activity observation tasks. In this literature review, a 3D convolution neural network based on deep learning is used as the proposed methodology. Thus, this article completed a Systematic Literature Review (SLR) in light of intelligent video surveillance to real-time identify abnormal activities from 2016 to 2021. In this current study, 50 research papers were considered and based on the screen filtering, the most suitable 16 papers were filtered based on intelligent video surveillance and real-time abnormal activities. Furthermore, this study identifies potential areas for improvement in intelligent video surveillance systems that can enhance public safety and security, underscoring the importance of ongoing research in this field.

KEYWORDS: *Abnormal, Activities, Machine Learning, Real-Time, Video Surveillance*

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1. INTRODUCTION

A form which differs from a bunch of typical forms is referred to as an abnormality. When it comes to abnormal activity detection, nowadays it is a significant issue in video surveillance. Abnormal event detection can be defined as the recognition of sporadic, unexpected, uncertain or uncommon occasions or things that are not deemed to be routinely happening occasions or consistent things in a form or things contained in a dataset that deviate from current forms (Franklin, Mohana and Dabbagol, 2020).

In the utilization of wellbeing or protection and defence for the administration of individual life and the general population, video surveillance performs effectively. When considering surveillance videos, the most common behaviour is to mark it as a regular activity that does not cause concern (Mansour *et al.*, 2021). Because of these requirements, in the modern world, different types of cameras have been installed at each side and video observation systems can comprehend the moment as well as anomalous actions with immediate detection. As well, it creates an automated observation system instead of human noticed focused services (Franklin, Mohana and Dabbagol, 2020).

Nowadays, video observation has been displayed as a desirable answer to address explicit requirements for safety and public peace. As a result, CCTV (Closed Circuit Television) camera modules enable the human administrator responsible for viewing the displays to manage as well to check what is happening at all of the monitored locations in real-time. Furthermore, the exploration and categorization of events in the compressed domain allow for improved data restoration and conservation for storage (Diop, 2020).

In the modern world, an AI (Artificial Intelligence) system has made it easier for people to deal much effectively by making easy on their tasks and providing much exact and precise outcomes. When considering AI for video surveillance, that has been useful for analyzing sound and pictures from video observation cameras to identify people, items, vehicles, attributes, and occasions perfectly.

Surveillance procedures based on Artificial Intelligence and intelligent video analytics compute and give safety efforts which consist a major influence on avoiding abnormalities; especially, to identify unusual occasions different creative thoughts in video analytics and AI-related observation has been utilized in regions, for example, temporal object tracking, human identification, traffic checking, and host identification (Balasundaram and Chellappan, 2020). Compared with normal surveillance cameras, the AI systems eliminate the total reliance on human checking and, on behalf of providing notices to the security group well in advance before the happening of an abnormal activity (Balasundaram and Chellappan, 2020).

Modelling of environments, motion detection, categorization of movement of things, tracking, reaction interpretation, expression, and combination of contribution from numerous cameras are all steps of computer vision technologies. As an initial step, to extract characteristics from distinct video sequences, this approach requires a lot of pre-processing. Two types of classification techniques are available in the literature namely supervised and unsupervised. Unsupervised classification can be considered as a computer-based system that does not need any human participation, while supervised classification utilizes manually labelled training data (Amrutha, Jyotsna and Amudha, 2020).

Furthermore, GMM (Gaussian Mixture Model) method, SVM (Support Vector Machine), Neural Networks, which are all Machine Learning techniques, have been used to identify abnormal activities (Luo *et al.*, 2017; Tariq *et al.*, 2020).

AI algorithms are rapidly improving in numerous areas. In pattern recognition and object detection, Machine Learning algorithms are the most frequently used algorithm (Liu *et al.*, 2019). Stacking provides a mix of Machine Learning models into a one large model. The stacked classifiers support to acquire huge outcomes from various Machine Learning models. Stacking is used in consolidating different Machine Learning trained models (Shahad *et al.*, 2016).

Machine Learning techniques are useful in video compression for a variety of tasks, including improving the codec, reducing complexity, and

recreating characteristics lost during compression. Post-processing is another area where Machine Learning can be applied to improve the quality of compressed video. Applying quantization to an auto-encoder bottleneck is another method for learning useful latent representations and obtaining compressed images. Networks with Deep Learning capabilities may learn unsupervised from unstructured data. Deep Learning is a subset of Machine Learning in AI. (Shankar *et al.*, 2020) Machine Learning techniques can be used to enhance object tracking and anomaly detection. Machine Learning has been used in the field of crowd surveillance for tasks such abnormal event detection, item tracking, and person tagging (Mohan, Choksi and Zaveri, 2019).

Background

According to the literature, some significant issues can be seen with conventional video surveillance approaches; particularly, standard video surveillance methods need a lot of time and do not offer real-time video processing. Additionally, human mistake resulted in false alarms, maintenance issues, and storage problems (Mohan, Choksi and Zaveri, 2019).

Deep Learning implementations as well as more conventional or hand-engineered features are being employed by a variety of researchers to identify the early efforts of violent behaviours (Ishikawa and Zin, 2019; Amrutha, Jyotsna and Amudha, 2020; Koppikar *et al.*, 2020; Janakiramaiah, Kalyani and Jayalakshmi, 2021; Pawar and Attar, 2021; Rezaee *et al.*, 2021). However, most of these works have only paid attention to accuracy, paying little attention to real-time operations. Therefore, those researches will highlight a gap related to real-time detection of abnormal activity using intelligent video surveillance.

Additionally, a competent video surveillance quickly identifies any suspicious activities. However, most of the surveillance systems in use today are operated by people. They need constant human attention as a result to detect any unusual activities. When humans are involved, the system's effectiveness gradually declines over time due to the human stress factor. Additionally, errors can result from manual intervention. However, video surveillance automation offers a solution to this issue. This is because the automated system's function is to alert when a predetermined abnormal activity is taking place in the form of an alarm or in any other way. The information needed for efficient and quick decision-making can be extracted and analyzed by an intelligent surveillance system (Mathur and Bundele, 2016; Bouindour, Hu and Snoussi, 2019; Amrutha, Jyotsna and Amudha, 2020). So, this research would fill that gap which involves human attention to detect abnormal activities.

Moving targets that are too close together and incredibly small objects were not validated by the vision-based cellular model method. In addition, no viable method has been found to compress all the information from various viewpoints of a single pedestrian into a single high-dimensional point for the purpose of detecting loiterers. (Mathur and Bundele, 2016) This proposed method can identify areas for improvement or gaps in research work that have already been completed.

Rezaee *et al.* (2021) have investigated various crowd anomaly detection techniques, and they have looked at numerous factors including single monitoring, classification based on manually collected features, categorization that uses Deep Learning, and hybrid models. Automated surveillance video analytics has emerged as a new technical trend in the security industry. An automated method of detecting any anomalous activity is human behaviour recognition in a video monitoring system. (Amrutha, Jyotsna and Amudha, 2020) In order to provide safety and security, video surveillance system is commonly used in all public spaces to keep track on what is happening nearby.

And also, it has widely been utilized for a variety of tasks (Ishikawa and Zin, 2019; Tariq *et al.*, 2020) such as monitoring military-reserved areas, illegally parked vehicles, smoke, fire, crime, vehicle, person tracking, unattended object surveillance, road monitoring, security surveillance, post-disaster management and so on (Kalaivani, Roomi and Jaishree, 2017; Mohan, Choksi and Zaveri, 2019; Pawar and Attar, 2021). Therefore, this research also would support this alarming situation.

When the typical Support Vector Machines method

for unusual events is used alone, it works poorly. However, it works well when used with classification once features that used a Deep Learning algorithm have been converted. Additionally, utilizing Machine Learning applications for video surveillance such as anomalous event detection produces improved outcomes. Even the three-dimensional video input data can be handled by standard techniques like CNN (Convolutional Neural Network). CNN may be used to identify an image's features, categorize photos, and more. Additionally, CNN can extract video characteristics and patterns more quickly than conventional image processing methods (Mohan, Choksi and Zaveri, 2019; Mansour *et al.*, 2021).

Anomaly patterns are those that emerge during testing because of several restoration faults. The greatest results for image classification came from Deep Learning. As a result, it is determined to be appropriate for video activity categorization. However, when tracing is done for recording, it is difficult and frustrating to find annotations. Encoders built on Deep Learning have been used to autonomously train the model for typical behaviour while utilizing restoration loss to identify anomalies (Singh, Singh and Gupta, 2020).

Nandyal and Angadi (2021) introduced an automatic and innovative algorithm for object detection for video monitoring and tracking in real-time security systems. An enhanced version of the Kanade-Locus-Thomsai extraction algorithm for object tracking functions is given by the system. However, this paper suggests a simplified algorithm that detects and monitors a small number of features, both continuous and discontinuous, instead of constantly detecting and tracking many feature points of an object. So, this research would fill that gap.

Most publications have used computer vision, using different algorithms or Neural Networks, to analyze human activity from videos. To determine trajectories or motion patterns, computer vision algorithms need a lot of pre-processing (Greco *et al.*, 2016).

In addition, background removal has been predicated on a static backgrounds premise that was usually inaccurate in real life scenarios. The methods described above are ineffective when dealing with crowds. Consequently, a deep architecture for the prediction of suspicious activity might be built using 2D CNN (two-dimensional Convolutional Neural Network) and LSTM (Long Short-Term Memory). As a result of that, the precision of the system can be improved. Most Deep Learning papers only identify suspect behaviour. As a consequence, a reliable way is required to alert security when there is any suspicious activity (Amrutha, Jyotsna and Amudha, 2020).

Therefore, to fill those gaps, this research would be a great support.

Table 1 below shows the motivation obtained through research questions and literature review. These research questions are a great help to complete this review and a systematic literature review can provide answers to these questions.

Table 1: Research Question and Literature Review

ID	Research Question	Motivation
RQ1	When and where were the studies published?	Identify the most significant publication in the video surveillance system field
RQ2	What types of research have been done?	Identify the most active and influential researchers that gave the most contribution to a research area of video surveillance system field
RQ3	What are the gaps identified related to intelligent video surveillance to real-time identify abnormal activities?	Identify gaps for application video surveillance
RQ4	What kind of topic is popular among the researchers in the intelligent video surveillance field?	Identify research topics and trends in video surveillance system field
RQ5	What kind of datasets are the most utilized for intelligent surveillance videos?	Identify datasets commonly used in intelligent video surveillance
RQ6	What are the technologies that used in intelligent video surveillance to real- time identify abnormal activities?	Identify the common Machine Learning methods for visual surveillance and object analysis on the video surveillance system

2. METHODOLOGY

In conducting our research, we adhered to the standards outlined by Kitchenham and Charters (Kitchenham, B, 2007).

A. Planning the review

By putting up research questions related to our study's goals, we designed this review. We established the inclusion/exclusion criteria, search strategy, and search string. Below, we go into greater detail about these.

B. Review objectives and research questions

Nowadays, in order to fight crime and avert undesired events that have a significant impact on society, security management professionals heavily rely on video surveillance. The use of surveillance cameras to monitor public actions has increased rapidly in both the private and public sectors. One of the most efficient strategies for ensuring security is video monitoring. The collected footage is readily transferred to the security staff after installing a surveillance camera. However, anomaly activity can only be identified by using an intelligence system to evaluate the video (Balasundaram and Chellappan, 2020).

RQ1: When and where were the studies published?

RQ2: What types of research have been done?

RQ3: What are the gaps identified related to intelligent video surveillance to identify abnormal activities real-time?

RQ4: What kind of topics is popular among the researchers in the intelligent video surveillance field?

RQ5: What kind of datasets are the most utilized for intelligent surveillance videos?

RQ6: What are the technologies that are used in intelligent video surveillance to identify abnormal activities real-time?

C. Search strategy

The investigation was conducted using the work of Kitchenham and Charters (Pawar and Attar, 2021). After defining our objectives and questions, we developed a systematic search approach to evaluate all relevant empirical resources that were readily available for the review's purpose.

The search space, that includes printed proceedings and electronic resources, was established as shown in Table 2. The papers were initially obtained from online databases, and after that they were examined using reference searches to discover further pertinent research (snowballing). Additionally, we searched the related publications in the DBLP (Digital Bibliographic Library Browser) database to find the authors of the papers. This additional method aimed to cover any potential work which had been missed.

Table 2: Search Sources

Areas	Search Source
Electronic databases	IEEE Explorer Science Direct Springer ACM Digital Library
Searched items	Papers from journals and conferences
Search applied on	Full text—to ensure that none of the papers that have our search terms in the titles or abstracts but are nonetheless related to the review object are missed
Language	English
Publication period	From January 2016 to June 2021

Then, as described in section E, the criteria for inclusion and exclusion were applied to the recovered studies in two separate rounds, each including a varied number of researchers.

D Search criteria

The search strategy specifies the search terms and search strings that will be utilized to find materials. By evaluating previous research papers, all of the studies relevant to "video surveillance to identify

abnormal activities real-time " were identified and classified. For this, key terms such as "Surveillance", "Abnormal", "Video", and "Real-Time" were utilized to search for research papers on the above topic. Tables 3, 4, 5, and 6 demonstrate how search strings are used in databases such as IEEE Xplore, Springer, ScienceDirect, and ACM Digital Library. Many papers, reports, and articles published in various journals and conferences were investigated.

Based on each database's search capabilities, we manually created the search term in each one. Each database search was regarded as a learning and testing session.

Table 3: Search Terms of the Study on Intelligent Video Surveillance Real-Time

Areas	Search Terms
Intelligent	intelligent
Video	video, moving picture
Surveillance	surveillance, monitoring, observation, supervision
Real-Time	real-time
Search string	"intelligent" AND ("video" OR "moving picture") AND ("surveillance" OR "monitoring" OR "observation" OR "supervision") AND "real-time"

Table 4: Search Terms of the Study on Video Surveillance Abnormal Activities

Areas	Search Terms
Video	video, moving picture
Surveillance	surveillance, monitoring, observation, supervision
Abnormal	abnormal, unusual, anomalous, violence, suspicious
Activities	activities, event, behaviour
Search string	("video" OR "moving picture ") AND ("surveillance" OR "monitoring" OR "observation" OR "supervision") AND ("abnormal" OR "unusual" OR "anomalous" OR "violence" OR "suspicious") AND ("activities" OR "event" OR "behaviour")

Table 5: Search Terms of the Study on Real-Time Identify Abnormal Activities

Areas	Search Terms
Real-Time	real-time
Identify	identify, detect, recognize, identification
Abnormal	abnormal, unusual, anomalous, violence, suspicious
Areas	**Search Terms**
Activities	activities, event, behaviour
Search string	"real-time" AND ("identify" OR "detect" OR "recognize" OR "identification") AND ("abnormal" OR "unusual" OR "anomalous" OR "violence" OR "suspicious") AND ("activities" OR "event" OR "behaviour")

Table 6: Search Terms of the Study on Video Surveillance Real-Time Identify Abnormal Activities

Areas	Search Terms
Video	video, moving picture
Surveillance	surveillance, monitoring, observation, supervision
Real-Time	real-time
Identify	identify, detect, recognize, identification
Abnormal	abnormal, unusual, anomalous, violence, suspicious
Activities	activities, event, behaviour
Search string	("video" OR "moving picture") AND ("surveillance" OR "monitoring" OR "observation" OR "supervision") AND "real-time" AND ("identify" OR "detect" OR "recognize" OR "identification") AND ("abnormal" OR "unusual" OR "anomalous" OR "violence" OR "suspicious") AND ("activities" OR "event" OR "behaviour")

E Inclusion and exclusion criteria

The following inclusion and exclusion criteria were used to evaluate if a study should be included:

Inclusion Criteria

IC1: The study includes information about intelligent video surveillance and real-time

identification of abnormal activities.

IC2: The studies are only from conferences and journals.

IC3: The studies that have been published from 2016 to 2021.

Exclusion Criteria

EC1: The studies do not have an abstract.

EC2: Selected studies do not contain any keywords.

EC3: The studies that are published before 2016.

EC4: Selected studies do not contain any keywords.

F Conducting the review

This part presents the findings of our information extraction and search from related sources and databases.

G Study search and selection

Utilizing the search technique, the studies were found utilizing the given electronic databases (already mentioned in section C), and only databases that disseminate peer-reviewed publications were incorporated (16). The inclusion criteria were used to conduct a thorough review of the study titles and abstracts (1st stage). Most of the papers found met the inclusion criteria IC1, IC2, and IC3. A large portion of the results were discarded as a result of the search engines' restrictions in mapping the search string to the entire body of content of the document. We ended up with 50 potential studies as a consequence of the first round of categorization. We also double-checked to ensure that the papers we found did not include debates, editorials, comments, tutorials, prefaces, or presentations. The pre-selected papers were then examined by titles, abstracts, and keywords in the 3rd stage in order to apply the exclusion criteria (EC1, EC2, EC3, and EC4). We read the complete paper for the publications where agreement was not obtained, and then we eliminated the research based on the established exclusion criteria. 8 papers were removed from the 48 that were pre-selected after the inclusion criteria were applied due to the fact that they did not focus on any subject directly related to the subject of our enquiry (EC1 to EC4). Consequently, 16 studies are included in our final stage (take a look at the two right-hand columns in Table 7).

H Data extraction and synthesis

A total of 50 were discovered as a consequence of the 1st stage of searching. There were 30 IEEE Explorer research papers, 12 Science Direct research papers, 5 Springer research papers and 3 ACM Digital Library research papers among them. The title, abstract, and keywords were evaluated in the first step of the selection process. The inclusion criteria (IC1, IC2, and IC3) were used to select research articles, whereas the exclusion criteria (EC1, EC2, EC3 and EC4) were used to reject research papers that met exclusion requirements. The duplicate publications were removed in the 2nd stage.

Table 7: Results from Selection Stages

Stage	Applied criteria	Analyzed content	The initial number of studies	The final number of studies	Reduction (%)
1st stage	IC1, IC2	Title, abstract, keywords	50	50	0%
2nd stage	Duplication removal	Title, abstract, keywords	50	48	4%
3rd stage (a)	EC1, EC2, EC3, EC4	Title, abstract, keywords	48	40	16.6%
3rd stage (b)	IC2, IC3	Title, abstract, keywords	40	32	20%
4th stage	IC1	Full text	32	16	50%
Final stage			50 (sources)	16 (sources)	68%

The 3rd stage included applying inclusion and exclusion selection criteria to the title, abstract and keywords, and eliminating papers. In the 4th stage, the selection process (inclusion and exclusion) was used for the entire stage. From a total of 50 papers,

16 are chosen at the conclusion of the procedure. Table 8 shows the results of the various stages of selection.

In the first step, the research title, abstract, and keywords were used as selection criteria. The first round of the selection process included 50 papers. The purpose of this research is to categorize the studies and select the most important ones by rejecting those that are irrelevant to the topic. As a consequence of this selection procedure, we have chosen 16 publications from different databases. 34 documents were discarded, while 16 were saved from a total of 50. There were 10 IEEE publications, 3 Science Direct publications, 2 Springer publication, and 1 ACM publications among the 16 articles chosen. Exclusion criteria EC1, EC2, EC3, and EC4 were used to eliminate publications. We chose key publications based on the IC1, IC2, and IC3 inclusion criteria. At the end of the process, we selected 16 publications that we believe are best acceptable for conducting a comprehensive literature review on intelligent video surveillance to real-time identify abnormal activities.

I Quality Assessment criteria and screening procedures

This criterion was used to ensure that the article is a relevant study for the chosen topic by evaluating the quality of the chosen work. The chosen articles were evaluated based on the following criteria which are research goal, contextualization, literature review, related work, methodology, result, and conclusion based on aims, and suggestion of future studies.

The following are the quality evaluation criteria that were utilized to evaluate the chosen papers.

- The number of citations used in existing research.
- At the conference that paper was published.
- Papers which have ethical standard likes reference format.
- Check answers are suitable for the research questions.
- The research question that they are focused.
- Latest research publications from 2016-2021.
- Papers that clearly clarify the results and discussion.

Figure 1 shows the proposed research method to continue this research. The final result is achieved through data collection, data pre-processing, frame extraction and separation, spatial autoencoder architecture and abnormal event prediction steps. That is to identify fighting abnormal behaviours in real-time. If an abnormal event occurs, it will be notified through an alert message.

J Proposed methodology

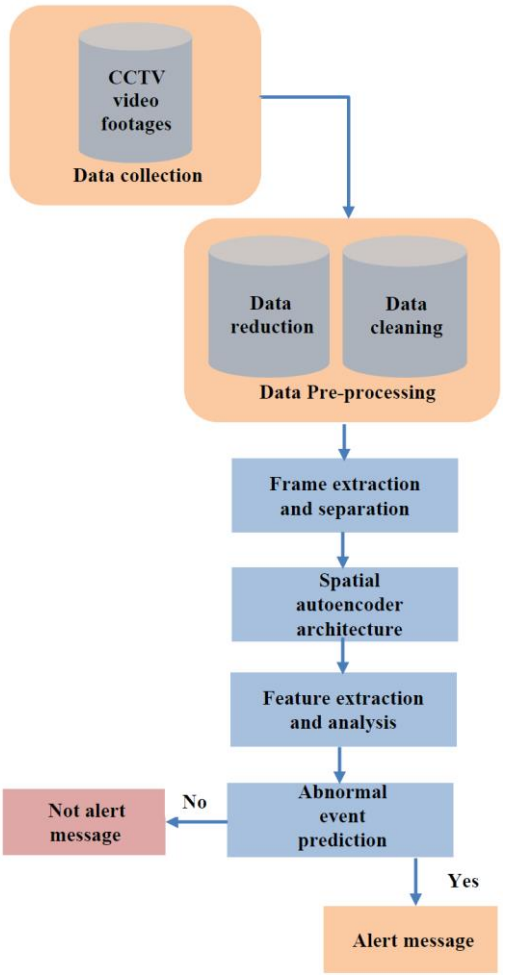

Figure 1: Proposed method for the research

3. RESULTS

We discuss the review's findings in this section in the context of the research problems.

A. Overview of studies

The chosen papers of this mapping study are shown in Figure 2. The table shows the publication year, title and other details of these publications. The research papers selected here will be carried out between 2016 and 2021.

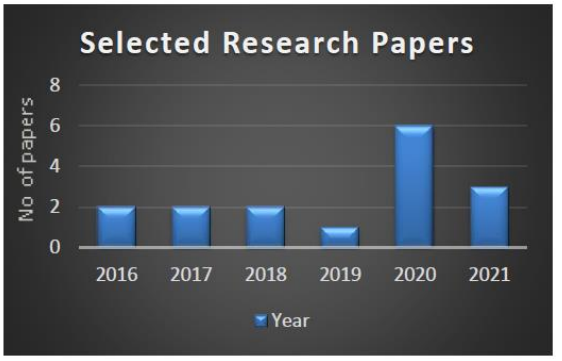

Figure 2: Selected research papers by year

B (RQ1) When and where have the studies been published?

For our research study, publications from 2016 to 2021 were gathered from a variety of reliable sources. A total of 50 research publications have been discovered. For this systematic literature review, 16 research publications were chosen from among them.

C (RQ2) What types of research have been done?

Many studies have been conducted to better understand the approaches for detecting suspicious activity, with a particular emphasis on violence detection for public settings, abnormal behaviour recognition, and anomalous event detection. Utilizing a super frame segmentation algorithm for tracking abandoned objects, identifying anomalous human behaviour, and unattended baggage, among other things, allowed for a thorough comparison of the many suggested solutions. Intelligent methods like Neural Systems, Fuzzy Logic, Support Vector Machines, Genetic Algorithms, etc. are the foundation of many technologies (Mathur and Bundele, 2016). (Diop, 2020) The suggested method for categorizing events in the compact domain in CCTV systems is related to the LDA model.

Table 8: Selected Studies

ID	Bibliographic Reference	Type	Year
#1	(Mathur & Bundele, 2016)	Conference	2016
#2	(Coming Lopez & Lien, 2020)	Conference	2020
#3	(Kamthe & Patil, 2018)	Conference	2018
#4	(Pramanik et al., 2021)	Journal	2021
#5	(Amrutha et al., 2020)	Conference	2020
#6	(Diop, 2020)	Conference	2020
#7	(Balasundaram & Chellappan, 2020)	Journal	2020
#8	(Rouhani, Mirhoseini and Koushanfar, 2017)	Journal	2017
#9	(Mohan et al., 2019)	Conference	2019
#10	(Franklin et al., 2020)	Conference	2020
ID	**Bibliographic Reference**	**Type**	**Year**
#11	(Li et al., 2020)	Journal	2020
#12	(Rasmi & Vinothini, 2015)	Conference	2016
#13	(Mansour et al., 2021)	Journal	2021
#14	(Phule & Sawant, 2017)	Conference	2017
#15	(Dong et al., 2020)	Conference	2020
#16	(Rezaee et al., 2021)	Journal	2021

D (RQ3) What are the gaps identified related to intelligent video surveillance to identify abnormal activities real-time?

This evaluation method can identify areas for

improvement or gaps in research work that have already been completed, as indicated below: Motion objects which are too close together and tiny objects are invalidated by the vision-based cellular model method. Sunlight causes the bounding box that represents a moving target to become too small in some frames, leading to inaccurate detection.

In addition to being outdoors, this also failed to recognize two moving things. Also, when many objects with the same color profile engage in an occlusion event, classification and tracking based on colour features may fail. In addition, no viable method of reducing all the information from several pedestrian perspectives to a single high-dimensional point in the event of loitering person detection has been found. Additionally, there is currently an inadequacy of demanding and professional high-quality data sets available for testing (Mathur and Bundele, 2016).

E (RQ4) What kind of topics is popular among the researchers in the intelligent video surveillance field?

The results of a few key studies indicate that the following subjects have received the most attention in recent research on video surveillance systems: the integration of various computer vision and image processing algorithms that analyze object, activity, and behaviour recognition. Aware of any unplanned event for a drone surveillance system, and visual monitoring that explains image processing or computer vision techniques which are recently being used for video surveillance. That describe how infrastructure, network design, and operational protocols are combined into a massive system to reflect the practical requirements for CCTV installations in the future.

F (RQ5) What kind of datasets are the most utilized for intelligent surveillance videos?

A dataset is a collection of data used in a particular quantity for applications of Machine Learning. It is difficult to gather a surveillance video dataset for a certain activity, like crowds, pedestrians, or cars. Newer versions of video datasets from a number of researchers and organizations enable other researchers to evaluate their approaches and make additional contributions to the field of video surveillance. Crowd, traffic, facial, pedestrian, and other forms of monitoring activities are some of the video results. Most of the videos can be used for motion segmentation, behaviour analysis, abnormal event detection, tracking objects, tracking moving objects, and density estimations. Public datasets include those from UMN, UCSD, ViSOR, UCF, AVSS, XJTU, and CAVIAR, to name a few.

G (RQ6) What are the technologies that used in intelligent video surveillance to real-time identify abnormal activities?

It has been attempted to conceptually explain the various solution methods employed by the various researchers. The TensorFlow Deep Learning framework, that is placed on a GPU system, and MATLAB R2014a are the tools (Mohan, Choksi and Zaveri, 2019) that have been utilized for the investigation. The approach has been assessed in terms of F1 score and correctness using three datasets. Additionally, they used three datasets - (i) the UMN, (ii) Avenue, and (iii) UCSD datasets - to assess anomaly detection and to compare them in respect of F1 score and accuracy. Subsets of the UCF-101 action recognition dataset make up the data set for activity recognition. (Phule and Sawant, 2017) has designed, when a crowd is identified, a message signal is instantly transmitted to the higher authority person via the GSM (Global System for Mobile Communication). In terms of computing complexity and threshold values, this strategy is safe and efficient (Wan *et al.*, 2021). The remaining lengthy video is split into many SOIs that include the video events that use a super frame segmentation technique based on feature fusion.

4. DISCUSSION

The root cause of the most common anti-corruption acts in the world today is the failure to prevent the root cause of those acts. Abnormal behaviours occur through a number of incidents such as robbery, fraud, corruption, murder, and threats. Proper solutions to these are implemented only after the occurrence of

the incidents. That person only gets justice in law. It does not re-correct the event. Therefore, in the world including Sri Lanka, a proper prevention practice has not been found in relation to these incidents so far.

Nowadays, there are many cameras, but they only record video. Only object detection can be done in some CCTV cameras, but nothing more than that. Also, when an abnormal event occurs, the videos recorded by the CCTV cameras should be monitored manually, and it is a tedious and time-consuming task. This is a very complex problem.

The main importance of this real time video surveillance is to prevent or minimize the impact of abnormal events happening to the person. That is, if a person is assaulted, it is identified by CCTV cameras to immediately identify what this event is and inform the respective authorized user. This will be notified to the respective user as an alert. Then, a quick action can be taken to prevent the incident.

In the past research findings, most of the researches are based only on the detection of abnormal activities related to abnormal behaviours such as Violence, Suspicious, Anomaly detection and Road Monitoring (Ha *et al.*, 2018; Koppikar *et al.*, 2020; Tariq *et al.*, 2020; Nandyal and Angadi, 2021). Relative to these abnormal behaviour detections, only a small amount of research has been done on real-time abnormal behaviour detection. They can be taken as traffic pre-events detection, crowd anomaly detection, Anomaly Detection in Elderly Behaviour, Anomaly Recognition, Human Violent Activity Recognition etc. (Luo *et al.*, 2017; Parvin *et al.*, 2018; Coming Lopez and Lien, 2020; Singh, Singh and Gupta, 2020; Pramanik, Sarkar and Maiti, 2021). Moreover, no proper method has been found yet to identify the fighting scene in real-time, which is taken under abnormal behaviours in places where people hang out more. And no research has been done in Sri Lanka to identify the fighting scene in real-time. For this reason, it is still traditionally used to start investigations by observing the relevant CCTV footage after an abnormal behaviour occurs. This is a time-consuming task and requires a lot of effort to catch the relevant people. However, researches have been done under various topics related to detecting this abnormal, unusual, suspicious activity around the world. (Luo *et al.*, 2017) carried out the research utilizing a real-time detection algorithm for atypical behaviour in crowds that is based on the Gaussian mixture model. In this research, they first used the GMM method to analyze the surveillance video and detected the location of the pixels that does not appear frequently. Then, they analyzed the temporal and spatial motion information of abnormal behaviour by modelling the abnormal behaviour. Eventually, they achieved real time abnormal behaviour detection. Pramanik, Sarkar, and Maiti (2021) have conducted research to develop a real-time video surveillance system capable of identifying traffic-related incidents before they occur. Here they have created a plan for a traffic monitoring system with the aim of enhancing road safety. To achieve this, they have employed spatio-temporal granules based on colour images for detecting moving objects. Singh, Singh and Gupta, 2020) proposed a real-time anomaly recognition through CCTV using Neural Networks. In this study, the anomaly recognition system consisted of a design that is composed of convolutional and recurrent Neural Networks. In this way, this research showed that real time abnormal behaviours are identified using Machine Learning and data mining techniques in many parts of the world. But this kind of research has not yet been done in Sri Lanka. Therefore, for filling those gaps in the literature, this research will be a great support.

The space-time-related properties are used to identify the observed items as normal or abnormal since the objects are moving. We have found various papers that are related to the intelligent video surveillance for real-time identification of abnormal activities. In this study, similar and related research papers were selected according to our research domain from 2016 to 2021. According to the literature, many models and studies are available for intelligent video surveillance. In this situation, we discovered some research pertaining to the design and implementation of a new intelligence video analytical solution as a human object recognition approach for surveillance footage (Balasundaram

and Chellappan, 2020). The results show that the IVA model works better than most existing approaches in terms of object recognition and classification with reduced error (Balasundaram and Chellappan, 2020). We might discover that their future work will involve using this technique to experiment with and validate the results with more benchmarked and bespoke datasets, as well as combining this and the model with a sophisticated framework that might be utilized for smart surveillance.

On the basis of complex activity recognition and deductive reasoning, Coming Lopez and Lien, (2020) also proposed a new approach for end-to-end adaptable real-time abnormal recognition with reaction localization. We discovered CSVD, a particular complex action dataset, which was developed for spotting violence in stationary security cameras. As demonstrated by their testing findings, their system has competing accuracy and speed, demonstrating its suitability for real-time applications. Additionally, they provided several recommendations for upcoming work, including the use of techniques like dynamic programming to better optimize feature extraction algorithms.

A novel IVADC-FDRL model has also been developed by Mansour *et al.*, 2021 for the recognition and categorization of anomalous in surveillance footage. The IVADC-FDRL model's categorization and anomaly detection phases are its two main components. The Faster R-CNN model is used to find anomalies in each frame once the input surveillance videos are first broken down into a collection of frames. A number of simulations were run using the benchmark UCSD anomaly dataset as their experimental results for the IVADC-FDRL model. They also indicated that in the future, the provided IVADC-FDRL model might be utilized to detect falls, find anomalies in pedestrian walkways, and other things.

When looking at Dong, Zhang and Du, 2020, they suggested an automatic object detection and tracking method that uses a cooperative working mechanism between a detector and a tracker. This approach initialized the position of the object automatically in the first frame and improves the detection accuracy. The method composed of three modules: detection, tracking, and decision-making. The detection module was designed to quickly extract specified categories of objects. The tracking module, the kernel correlation filters tracker (KCF) was used to perform data association and processing. To extract moving objects quickly and accurately, the detector employed a mixed Gaussian background modeling technique combined with HOG and SVM detection models. The suggested technique's detection and tracking modules collaborate with one another. As a result, the tracking and detection module is able to decide definitively on every frame and generate findings that are more reliable. It succeeds in improving detection precision and achieving the objective of autonomously implementing the object's placement in the first frame.

5. CONCLUSION

Based on the literature review of intelligent video surveillance for real-time abnormal activity detection, research has been done on many aspects such as road traffic, smart city using 3d road monitor and suspicious person detection, and all of them have proposed solutions to prevent abnormal behaviours. Here, 16 articles selected from 50 research papers were reviewed and several future research directions were identified. The studies conducted so far can be classified into real-time video surveillance, real-time abnormal activity detection, and intelligent video surveillance. For this review, research papers have been obtained from IEEE Explore, Science Direct, Springer and ACM digital libraries. The main research gap identified in this study is that CCTV video cameras still do not have a proper solution for identifying the location of fights in public suburbs. Therefore, a new method was proposed here. The research method proposed here is mainly expected to provide a real-time prediction to prevent fight scenes which is an abnormal activity and to present a warning to prevent the occurrence. And to achieve these goals there are many technologies like CNN architecture, Advance Motion Detection (AMD) algorithm and Support Vector Machine. Also, from

the limitations identified through this review, a new method is proposed. Therefore, this systematic literature review will be an excellent work for real-time identification of the locations of fighting scenes under real-time detection of abnormal behaviours, as well as for future research to identify the areas where these abnormal fighting behaviours are reported most and to develop a new model by focussing more attention on those locations. Also, new researchers will be able to get the basic foundation needed to start their research through this study.

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