Image Processing Based Detecting and Tracking for Security System

Atiq Ur Rehman *atiqkhantareen@gmail.com*
Department of Electronic Engineering
BUITEMS,
Quetta, 87300 Pakistan

Naqeeb Ullah *naqeeb.ullah@buitms.edu.pk*
Department of Electronic Engineering
BUITEMS,
Quetta, 87300 Pakistan

Naeem Shehzad *naeemshehzad@ciitlahore.edu.com*
Department of Electrical Engineering,
COMSATS (Lahore) Campus,
Lahore 53400, Pakistan

Syed Agha Hassnain Mohsan *hassnainagha@zju.edu.cn*
Optical Communications Laboratory
Zhejiang University,
Zhoushan, 316000, China

Abstract

Security systems are getting more attention and importance. Numeral security arrangements based on sensors and wireless communication are available in the form of mechanical and electronic applications. These systems are used widely in banks and government offices. However, these traditional systems lack qualities like they cannot examine, track the suspect and generate the alarm simultaneously. Thus, it is difficult to expand these systems with the help of the sensors because of the complexity of the algorithms used. Hence, viewing these points, this paper provides a security system based on Image Processing, which does not only inform the host side at the runtime through alarm but also detects and tracks the present situation by locating the target. The Optical Flow technique of image processing is used to detect using motion analysis of two consecutive frames from the imaging source. The block analysis determines the tracking capabilities of the system by the property of Good Features to track. The wireless link between the imaging sources is established through XAMPP. While the functionality of the alarm is performed at the commencement of the detection process. The results relating to the process of detecting, tracking and generating alarm simultaneously are encouraging and will help to increase the efficiency of the security systems.

Keywords: Detection, Embedded Systems, Image Processing, Optical Flow Technique, Tracking.

1. INTRODUCTION

The security of public gathering spaces, banks, and large events are crucial for the smooth functioning of public and government activities at all level. People have a profound trust in any provided areas of well-being just by keeping the core of security in their minds. Henceforth, keeping the former points into assessment, the security arrangements are done accordingly in order to ensure the safety and order of that specific section. Thus, these schemes of security vary from section to section in order of priority and threat. Moreover, these systems are divided into monitored security systems: connected with a security agency and non-monitored security

systems: without any connection with the security agency. Similarly, these, schemes of security can be in the form of machinery, human force, or electronic applications.

Many governmental and non-governmental agencies and institutions are working to find the ultimate solution for this cause. Moreover, these agencies and institutions have succeeded by far most. But still, there are areas, which are breached and damaged despite their high alert security systems. Because of this, the higher profile regions and departments have concerns about their security, which needs to be protected and secured from any type of intruder or loss such as the hospitals, plant protection, schools, governmental and non-governmental places, department store, residential areas and parking. Henceforward, these traditional security systems rely on motion sensors, IR sensors, and CCTV cameras to observe a suspect, individual and ongoing activity and require the human workforce to track continuously the images [1] . The technologies used in these security systems are of diverse behaviors intended for different jobs according to their credibility and nature [2]. Generally, the failure of the security systems can be attributed to my reasons such as human error, system glitch, criminal attack, system overload, and the shortage of the power supply.

Usually, the CCTV cameras for crime preventions in the factories' warehouses, and banks merely record the situation and do not notify the host side at runtime [3][4]. This paper provides a security system based on Image Processing helping in removing the human error, informing the host side at the runtime through an alarm, detecting and tracking the present situation by locating the target. Moreover, it also provides the advantage of wireless communication between the imaging sources in cases of a wide area coverages. The working procedure of the system is as that any intruder activity within the restricted place will be captured by the imaging source, based on which the alarm will be generated and further commands of detecting and tracking will be initiated. Likewise, large area coverage is possible in this said project as a second imaging source is wirelessly connected to the main imaging source. Apart from this, a sequence of a password is issued to the authorities helping them to roam in the restricted place without recognizing them as intruders.

2. LITERATURE REVIEW

These days the tracking of objects, for example, individuals or vehicles, coming all through specific spaces is constantly a significant issue in security and operation management. For example, in a shopping center, following the number of clients may help the market arranging, staff organization, and tracking the number of staff individuals may help in the workforce. In addition, object tracking for spots, for example, banks, buildings, and streets may improve traffic control. In general, the object tracking is possible by utilizing entryway counters, or infrared sensor to recognize objects coming all through spaces. Conventionally object tracking methods require a camera above or the entrance/exit way of a place to capture the images. However, these approaches are expensive and require human operator observers who detect any suspicious individual and therefore, challenging to obtain a prior knowledge about all objects in real-time [5][6]. Therefore, a real-time tracking and detecting system is required to detect an unauthorized person in a prohibited area and alarming the security system at the same time

A GSM based home security system includes control panel, door [7] , and windows sensors to monitor both coming in and out from the house. These systems use wireless communication to receive the SMS from a cell phone and observe the safety and ensure the security of the home by an SMS [8]. A Zigbee based parameter monitoring and controlling system using microcontrollers are used to track and secure the environment of industries [9][10]. However, these systems have no capability to analyzes the suspect and generate a real-time response. Moreover, it is very difficult to expand the security system by adding several sensors because of the complexity of the algorithm of the system. Similarly, the present bank security system focuses only on the security of lockers and has a limited level of a security system. The digital cameras are used only for monitoring and require the manual approach to inform the security [11]. Therefore, image processing-based tracking and detecting system is required for security purpose that alerts the security through a certain alarm in case of any uncertainty [12][13][14].

Likewise, the security of the border and coastal area is of huge importance and cannot be controlled and observed by the gaze of the human eye. A security system based on the combination of image processing and Support Vector machine is used to overdue this process and detect the intrusion of the unauthorized ships [15].

3. SYSTEM CONFIGURATION

The proposed system configuration makes the system cost-effective, reliable, and flexible in performance. The block diagram of the proposed research work is illustrated in Fig.1.

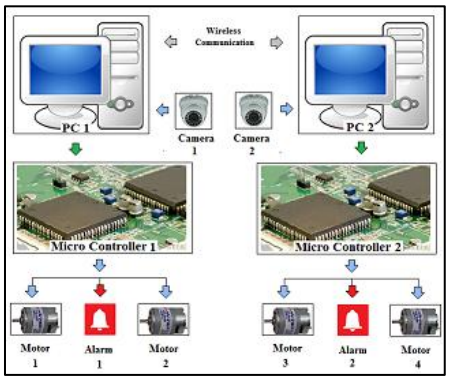

FIGURE 1: Block Diagram of the system consisting of two same modules with a wireless link as a source of communication between them.

A webcam is the main component, which detects a change in its field of view (FOV) connected with the PC for its working and display. A microcontroller is used to control the motors both in terms of pan and tilt. Further by using the technique of motion control, provides the capability to track the subject of motion along with sending of an alarm signal.

4. METHODOLOGY

The proposed detecting and tracking system makes use of image processing and its subclasses such as the Optical Flow method, Canny algorithm and Block analysis, which helps in the achievement of the results as detecting, tracking, and motion control. A flow chart of the proposed system is shown in Fig.2.

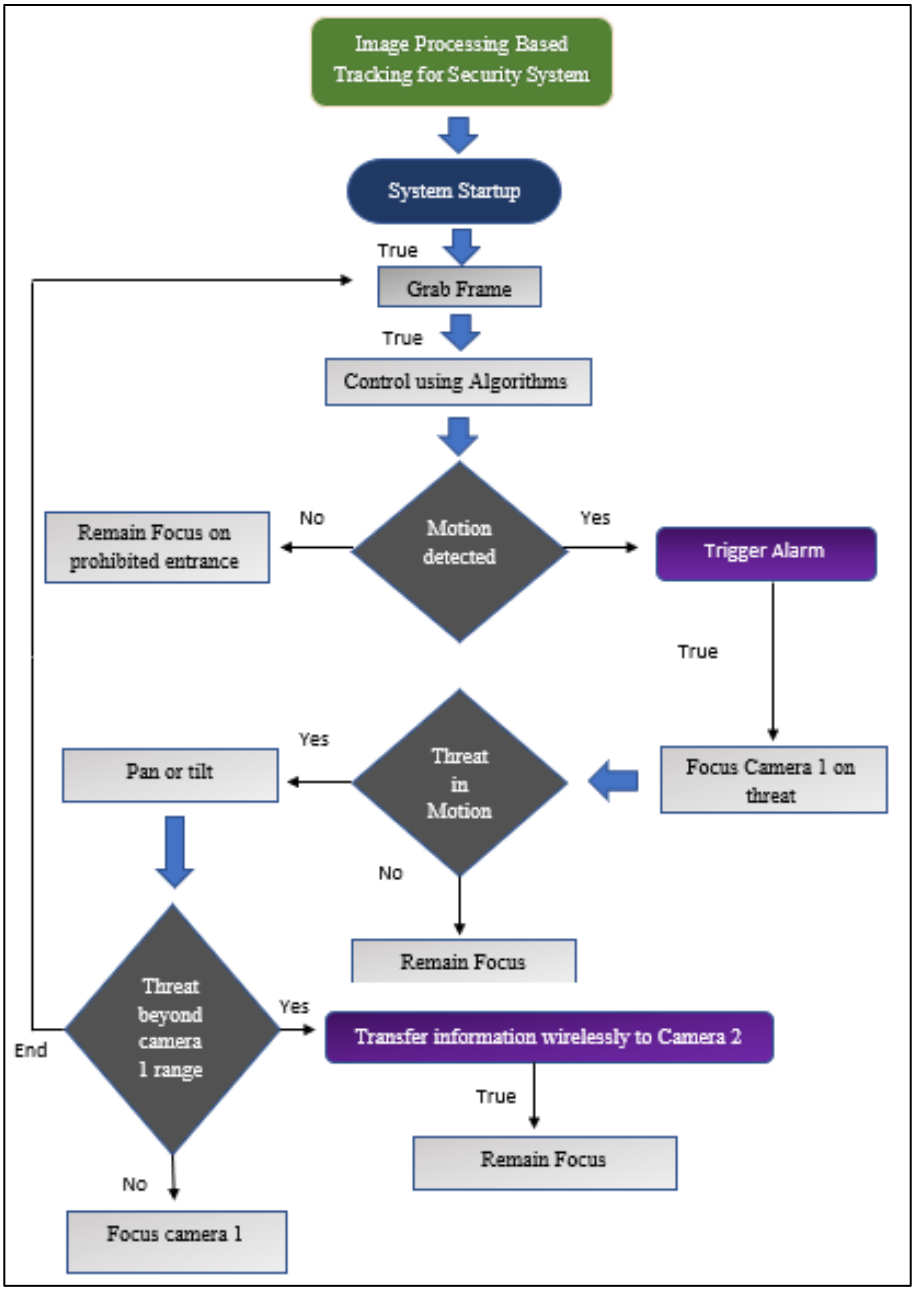

FIGURE 2: Flow chart of the proposed system.

4.1 Optical Flow

Among the parts of the segmentation, a technique to extract information and perform the action according to the requirement is the optical flow method. In this step of the segmentation two or more consecutive frames are taken. Moreover, the pixels are tracked from frame to frame in single mode or can be tracked in the cluster form as well [16]. Firstly, the images are converted into greyscale to identify the change and track the object easily. The process on both of them is performed as such that the new image is compared with the background image. However, this process is also known as the Thresholding process because of applying the values to the produced change in the background as described through Eq. (1).

$$\begin{matrix} 1 & D_i > Ti \\ 0 & D_i > T \end{matrix} \quad (1)$$

Where Di - Change between two connective frames and Ti – Threshold value.

A filter is used to make the process quick and flexible to detection of the change. Moreover, the accuracy of the detection depends upon the size of the subject, its background, connection and distance during the detecting process. A field of view (FOV) of the camera can be easily detected by comparing the two consecutive frames of video streaming to detect the change between them in terms of the change in single or cluster of pixels.

4.2 Motion Control

The computer or the processing unit capable enough to respond as fast as possible especially as the speed is a critical point. the following procedures are applied [17].

4.2.1 Block Analysis: This block analysis is the method that tracks the object based on the Good Features to track the subject extracted from the OpenCV. Thus, various blocks are being created during the tracking process. Now to select the block a condition is applied to select the block with the highest value.

4.2.2 Finding Intensity Gradient: After smoothing the Image, it is again filtered to get the derivatives of the image both in the vertical and horizontal directions most probably first derivatives. Thus, the direction, as well as the gradient of the pixel, can be easily determined by using the Eq. (2) and Eq. (3) respectively.

$$Angle = tan^{-1}\left(\frac{G_y}{G_x}\right) \quad (2)$$

$$Edge\ Gradient = ((Gx^2 + Gy^2)^{1/2} \quad (3)$$

Where G_x is the Horizontal direction and G_y is the Vertical direction. The direction of the gradient is always perpendicular to the edges and is rounded to one of four angles to represent the horizontal and vertical directions along with the two diagonal directions.

4.2.3 Threshold Values: The intensity gradient value of each edge is comparing with the maximum and minimum values of the threshold. If the value of the intensity gradient is more than the maximum threshold value, it will be considered as a sure edge. While the edges having values of intensity gradient between the minimum and maximum values of the threshold will be considered as edges only if they are connected to the sure edges. Further those edges are neglected which are not connected to the sure edge or having a value less than the maximum threshold value as determined for the process [17]. After the selection of the specific block, its center point will be determined based on which the motion will be controlled as the cameras will keep the target in their center. As illustrated in Fig. 3.

FIGURE 3: Center of the block is designed, as shown by a red spot.

The center of the block is identified by a red spot in the center. Hence based on the motion of the object, the motion of the cameras will be controlled as when to pan and tilt.

4.3 Motor Delays

However, the delay in the motion of the motors does wholly depends upon the movement of the subject, the processing speed of the microcontroller, its delays, and time associated with its responsively. The control structure of the motors is shown in Fig. 4.

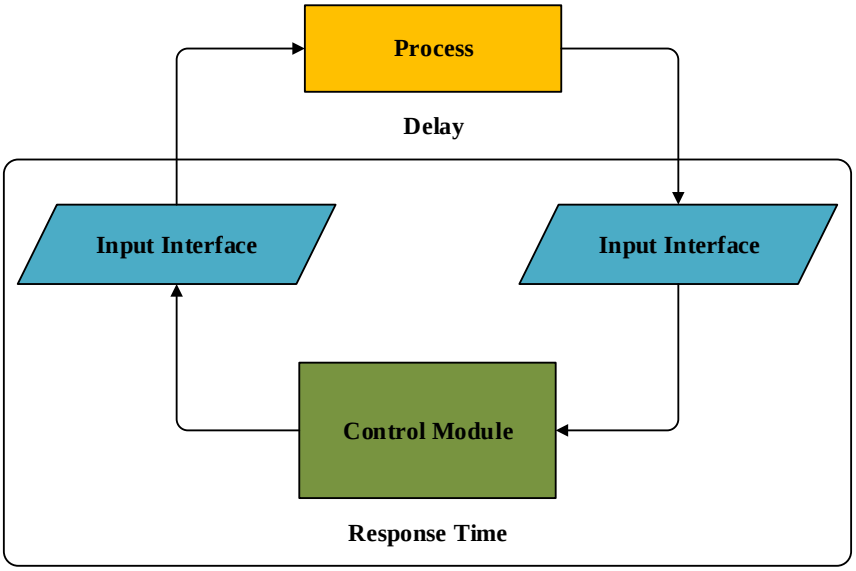

FIGURE 4: Motor delay control for the purpose of the precise motion of the motors w.r.t camera.

By motor delay control the process can be made more responsive and quicker by decreasing the size of the image, as a smaller number of pixels will be involved, with less memory transportation between the controllers and imaging source during the process of live surveillance.

4.4 Wireless Communication

In this modern era, more preference is given to the systems that are compact, reliable, and flexible. Thus, looking at the advantages of wireless communication, we decided to establish a wireless link between the two modules of the project rather than the traditional way of

communication. Hence, for this purpose, we are using Wi-Fi as a source of wireless communication between the two modules by using the same IP address on two different computers through the XAMPP software [18]. The need for wireless communication is needed, when the threat goes out of the boundary of camera 1 of module 1, the information of the threat will be transferred wirelessly to the module 2. Hence the position of the camera 2 of module 2 will track the threat onwards. Wireless communication between the camera's covering a vast area and without the need for extra wiring. Thus, benefitting the cut in the cost. Password for the authorized personals to detect and track them in the secured area without generating the alarm.

5. RESULTS

This section of the paper presents the results obtained during successful running of the system as given below.

5.1 Detection

To detect the face using the property of the Good Features to Track. The proposed system can detect any type of the object within the installed area up to 12 feet approximately by one module. While the time interval for the system to detect any unauthorized entry is about 1.5 seconds as illustrated in Fig. 5.

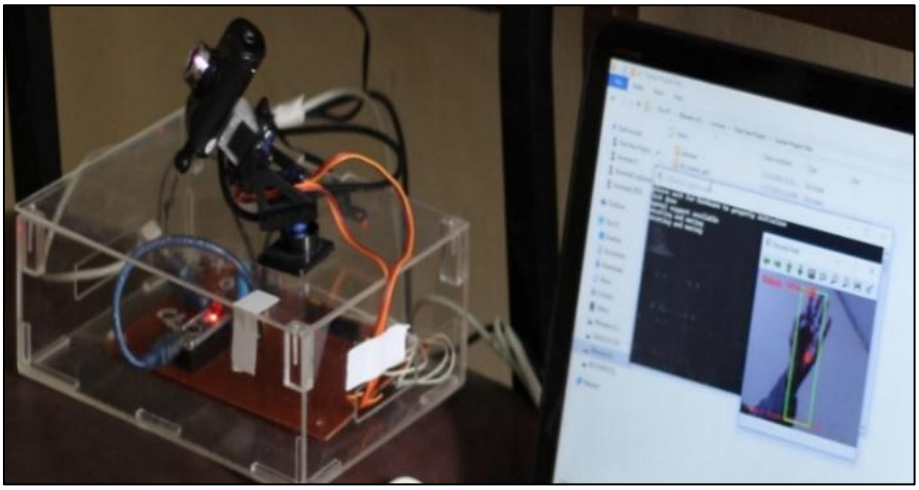

FIGURE 5: Detection property of the system.

5.2 Tracking

Motion of the subject within the prohibited region is accomplished with pan and tilt the camera with the help of servo motors. This function of the project works as whenever there is any subject of the motion, it will be tracked until the last range of distance value is achieved by the camera which is approximately 12 feet after onward the subject of motion is tracked by the camera of the second module after communicating through the established wireless link between them. The following observations were concluded which are mentioned with the help of graphs.

5.2.1 Distance: The distance from the object is inversely proportional to the detection and tracking properties of the system as shown in Fig. 6.

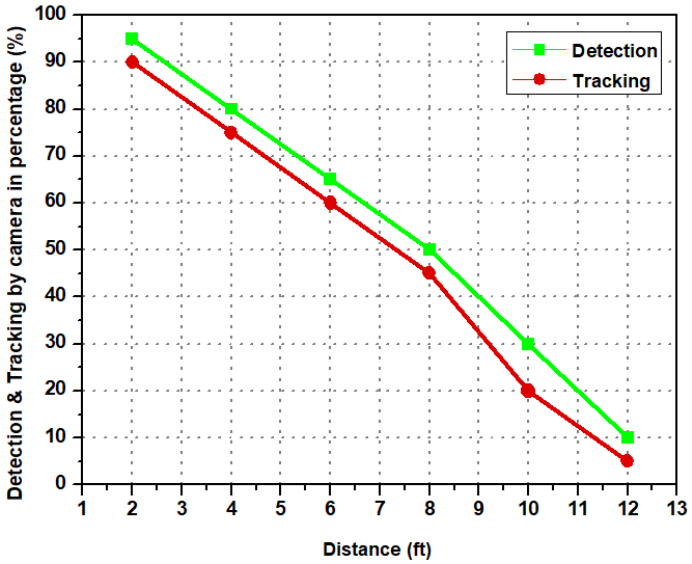

FIGURE 6: Detection and tracking by camera vs. distance.

5.2.2 Light Intensity: Light intensity is among the main factors which will greatly affect the working of the system both in terms of detection and tracking of the object through the camera. After running the project in different light intensities, the following observations are achieved shown in Fig. 7.

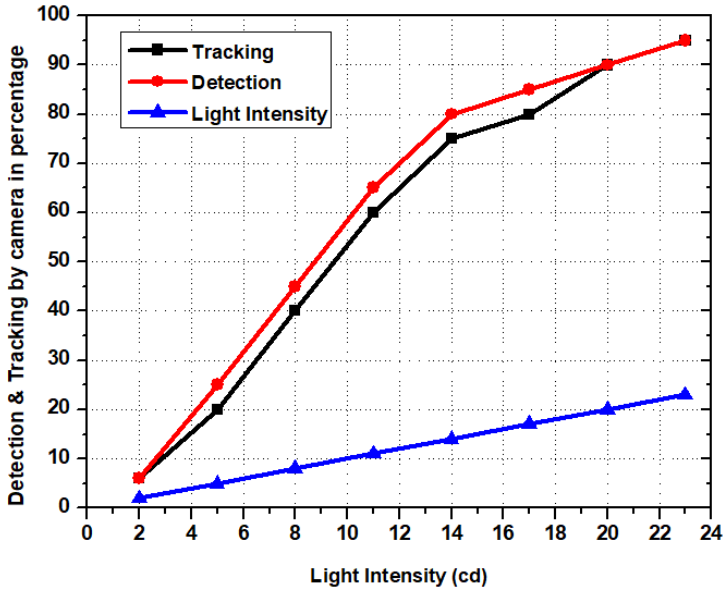

FIGURE 7: Detection and tracking vs. light intensity.

5.2.3 Speed: The results achieved as illustrated in Fig. 8. with the help of the human motion and a stopwatch representing detecting and tracking accuracy in percentage on the y-axis and speed in meters per second on the x-axis respectively.

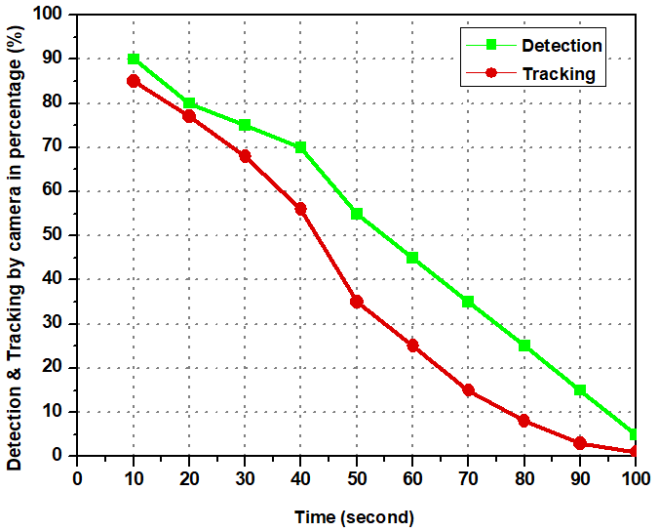

FIGURE 8: Detection and tracking by camera vs. speed,

Wireless communication between the camera's covering a vast area and without the need for extra wiring. Thus, making the system cost-effective. Password for the authorized personals to detect and track them in the secured area without generating the alarm. The proposed method is designed to track and detect a single object at a time. For multiple artifacts, however, a complicated algorithm will be required. The proposed system can be further improved using infrared lighting while utilizing the system at night time. In the case of blurry progression of the image sources, the advanced algorithms of the image processing can be used i.e. Grasshopper optimization [19].

6. CONCLUSION

In this paper, image processing-based detecting and tracking system is proposed for monitoring public gathering venues like railway stations, banks, airports, and stadiums. The proposed system uses the Optical flow method with the Canny algorithm along with the property of Good Features with pan and tilt of the camera to track and detect any type of the moving object. Moreover, an alarm will be generated automatically, whenever there is an unauthorized entry into the entrance prohibited region. Moreover, in this paper, it has observed that distance between the object and tacking system is inversely proportional to the detection and tracking properties of the system. However light intensity of the light is directly proportional to detection and tracking accuracy. Though, the speed of the moving object is also inversely proportional to the accuracy of the detecting and tracking system. Similarly, the working of the system is limited in harsh environmental conditions i.e. fog, rain and dust if used outside. Likewise, the properties of the model will be restricted at night corresponding to the property of the light as discussed.

In the future, the accuracy and performance can be enhanced by implementing artificial intelligence and advanced moving object detection methods. Apart from these, the system in the future would enable detection and tracking of multiple subjects at once, which is limited to one for the time being. Moreover, the system can be made into multiple modules consisting of several imaging sources, which will help in vast area coverage. Similarly, the accuracy of the system regarding detecting and tracking can be increased further with the installation of the white background and higher luminosity. The artificial intelligence will further help in the future in a comparison between human beings, animals, and materials based on their specific shapes, colors, and sizes. The system would therefore be a significant advancement in the field of security systems to protect areas of banks, airports, car parks, and factories. In addition, the system's password-protected property would allow the authorized staff to roam freely without creating an alarm. While in roaming, the properties such as detection and tracking will be intact of the authorized staff within the area.

7. REFERENCES

[1] K. Salunkhe, P. Rajaram, S. Raut, and S. Kurle. “Real-time Activity Detection & Recognition in Video.” *International Journal of Future Generation Communication and Networking*, Vol. 13, pp. 76- 83, May. 2020.

[2] J. Wolfendale. “Terrorism, security, and the threat of counterterrorism.” *Studies in Conflict & Terrorism*, vol. 30, pp. 75–92, Dec 2006.

[3] E. L. Piza, B. C. Welsh, D. P. Farrington, and A. L. Thomas. “CCTV surveillance for crime prevention: A 40-year systematic review with meta-analysis.” *Criminol. Public Policy*, vol. 18, no. 1, pp. 135–159, 2019.

[4] G. Alexandrie. “Surveillance cameras and crime: a review of randomized and natural experiments.”*Journal of Scandinavian Studies in Criminology and Crime Prevention*, vol. 18, no. 2, pp. 210–222, 2017.

[5] N. N. Swathi, K. Alekhya, D. Pavithra and D. Kalyan Babu. "Implementation of Vision Based Intelligent Home Security System Using ARM7."*International Research Journal of Engineering and Technology*, vol. 4, no. 02, pp. 2395-0056, 2017.

[6] M. Dinesh and K. Sudhaman. “Real time intelligent image processing system with high speed secured Internet of Things: Image processor with IOT.” *International Conference On Information Communciation And Embedded System (ICICE2016), Chennai*, 2016, pp. 1-5.

[7] A. B. Dorothy, S. B. R. Kumar, and J. J. Sharmila. “IoT Based Home Security through Digital Image Processing Algorithms.” *2017 World Congress on Computing and Communication Technologies (WCCCT)*, Tiruchirappalli, 2017, pp. 20-23.

[8] Morbale, J. S., A. Kumari, H. Mishra, K. Sachan. "GSM Based Home Automation, Safety and Security System Using Android Mobile Phone," *Internation Journal of Current Research,* vol. 8, no. 03, pp. 28239-28243, 2016.

[9] N. Ullah, M. S. Akram, H. U. Buzdar, A. U. Rehman, M. A. Khan, and S. Khan. “ZigBee-based Parameter Monitoring and Controlling Scheme for Multiple DC Motors,” *Indian Journal of Science and Technology*, vol. 13, no. 6, pp. 725–734, 2020.

[10] H. Yetis and M. Karakose. "Image processing based anomaly detection approach for synchronous movements in cyber-physical systems." *2018 23rd International Scientific-Professional Conference on Information Technology (IT)*, Zabljak, 2018, pp. 1-4

[11] M. T. Awad, S. M. Aldaw, S. M. Aldaw and B. A. r. Osman. "Video Security System for Intrusion Detection," *2019 International Conference on Computer, Control, Electrical, and Electronics Engineering (ICCCEEE),* Khartoum, Sudan, 2019, pp. 01-04.

[12] R. Socha and B. Kogut. "Urban Video Surveillance as a Tool to Improve Security in Public Spaces," *Sustainability,* vol. 12, pp. 1-12, 2020.

[13] K. N. Pentaiah and P. J. Ker. "Development of a Microcontroller-based Portable Surveillance System with User Alert Notification." *Journal of Environmental Science and Technology,* vol. 10, pp. 80-87, 2017.

[14] S. Tanwar, P. Patel, K. Patel, S. Tyagi, N. Kumar, and M. S. Obaidat. “An advanced Internet of Thing based Security Alert System for Smart Home.” *2017 International Conference on Computer, Information and Telecommunication Systems (CITS)*, Dalian, 2017, pp. 25-29.

[15] S. Dugad, V. Puliyadi, H. Palod, N. Johnson, S. Rajput and S. Johnny."Ship intrusion detection security system using image processing & SVM." *2017 International Conference on Nascent Technologies in Engineering (ICNTE),* Navi Mumbai, 2017, pp. 1-7,

[16] S. Blakeman and D. Mareschal. "A complementary learning systems approach to temporal difference Learning." *Neural Networks,* vol. 112, pp. 218-230, 2020.

[17] S. Kyle, "Human and Group Activity Recognition from Video Sequences." PhD thesis, University of York, Heslington, UK, 2016.

[18] K. V. Kai “Oswald” Seidler, “XAMPP https://www.apachefriends.org/index.html.” [Online]. Available: https://www.apachefriends.org/index.html, [Oct, 15,2020]

[19] A. Sezavar, H. Farsi and S. Mohamadzadeh. "A Modified Grasshopper Optimization Algorithm Combined with CNN for Content Based Image Retrieval," *International Journal of Engineering,* vol. 32, no. 7, pp. 924-930, 2019.