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Crowd Detection and Notifier System

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***Abstract*—The purpose of this paper is to describe the Crowd Management system using the implementation of the Raspberry Pi technology integrated with GSM and YOLOv8, where monitoring and confrontation of violent conduct within a group of people is vital. The architecture takes advantage of the latest recognized model YOLOv8, which has a large degree of accuracy and possibly high detection speed and low level of latency. A portal which users can access and monitor crowd activities in real-time as well as configure limits is made available. All the detected violent incidents were sent as alerts via GSM. The cost-effective and quick system solutions utilize advanced communication technologies and detection mechanisms for safety.**

***Index Terms*—Crowd management, Violence prevention, Space monitoring, Raspberry Pi, YOLOv8, GSM Module, Violent incidents, Images monitoring.**

I. Introduction

The astronomical growth of technology calls for demand for new ideas capable of enhancing public safety in areas such as public places, bus stops, schools, non-prohibited zones, among others which are characterized by numerous instances of congestion and violence [14]. This specific project seeks to implement a crowd management and unrest management mechanism in real time making use of Raspberry Pi, GSM, Google Edge TPU and YOLOv8 object detection [2,3]. It works by physically placing cameras over crowd congested areas and through video analytics, crowd density and violent behavior are tracked over time. As an advanced algorithm, YOLOv8 will provide the means required for real time people counting at a particular maximum occupancy rate which has been set on a web portal [1]. In situations in which the density of the crowd demand, or violent behavior is detected, the relevant authorities contact the system with a GSM module [7]. These developing technologies provide an efficient, affordable, and practicable security tool ideal for delicate and high-risk areas. The purpose of this tool is to enhance security infrastructure by reducing the degree and number of instances that may lead to loss of property or life by responding to growing threats effectively.

II. Objective

- Building a real-time system to monitor the count of people caught by a CCTV or other video source using YOLOv8 for object detection.

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- There must be a self-alarm system that, on reaching above the threshold value of crowd density, automatically gives alarm to employees.
- Building an interactive GUI that can operate, monitor, and control the crowd detection system.
- Assess the system in terms of scalability and reliability for its practical applications.

III. Proposed Methodology

The aim of this work is to develop a real-time surveillance system using a Raspberry Pi that monitors and analyzes live video feeds coming from a CCTV camera or any other video source [9]. This system will detect and count the number of people in a particular area as well as detect violent activities. Initially, we develop a web portal using HTML and CSS, which allows the users to set a threshold value. Threshold value represents the maximum size of crowd allowed at different decision points [1]. Real-time feed coming from CCTV/video source further processed through YOLOv8 Nano, a lightweight pre-trained model fine-tuned for crowded scene detection [4]. YOLOv8 Nano is responsible for detecting, tracking, and counting individuals detected in video streams, making real-time monitoring of crowds efficient. For violence detection we are using a separate model trained on a violence database collecting information about pose patterns, changes in dynamics, etc., to identify violent activity among people [13]. After the video feed is processed by the Raspberry Pi, the detected crowd size is compared with the user's threshold. If it exceeds or information about violence is recognized, a possible immediate notification is generated. These notifications are sent to the user using a GSM module that can be configured as an SMS sender or call maker [16, 17]. The Raspberry Pi appliance with Raspbian OS enables easy control and coordination of real-time monitoring of video feed using YOLOv8 Nano for crowd detection and for transmitting data from the violence model to the GSM module [5,9]. The implemented system has a main priority task: providing on-time notification by processing sequential scenes from the monitored environment loop designed into the system [2].

A. Raspberry Pi

The main processing unit in the project is Raspberry Pi, which can perform real-time video streaming, and processing of the live video. It also executes the YOLOv8 model for crowd estimation and violent activity detection. Raspberry Pi being small and low power consumption is used here for public places to provide a portable system at very low cost [14].

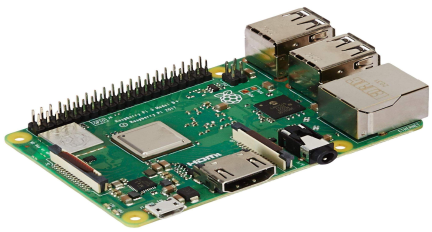

Fig 1 Raspberry Pi

B. GSM Module

The GSM module is used in the system to reach authorities immediately in any emergency situations. Overall, when the system detects a crowd, violence, or panic, it will send SMS to assigned numbers with the help of the GSM module for an immediate approach, so this feature is a very important, profound advantage to achieve public safety by delivering instant alerts for responsible bodies. [17]

Fig 3.2 Global system for mobile communication

C. Google Edge TPU

The Google Edge TPU, in general, and particularly YOLOv8 benefited from the fast processing of the object detection task that is achieved by use of the Google edge TPU. This puts Raspberry Pi application on track to meet real time video feed analysis with low power consumption, resulting in a fast and accurate detection and decision in a mobile and versatile form.

Fig 3. Google Coral edge TPU

D. Flowchart

The system initializes with a live video feed capturing the scene it is monitoring, captured by the camera and processed through the central processing unit from the Raspberry Pi. Footages are analyzed and crowd sizes computed along with determination of any scenes of violent events by the YOLOv8 model. However, for full real-time running, the edge TPU uses the Google hardware to accelerate its YOLOv8 to make quick running of objects. If the number of people reaches a set value or if violent activities are perceived, the Raspberry Pi will then activate the GSM module to automatically send SMS signals to the police, thus rapidly responding to incidents. Users will be able to follow the situation with an interactive web portal where thresholds can be reset and live data received. This integration of state-of-the-art technologies offers a cost-effective and scalable solution to improve public safety in densely populated areas. The workflow of the project is shown in Figure 3.4.

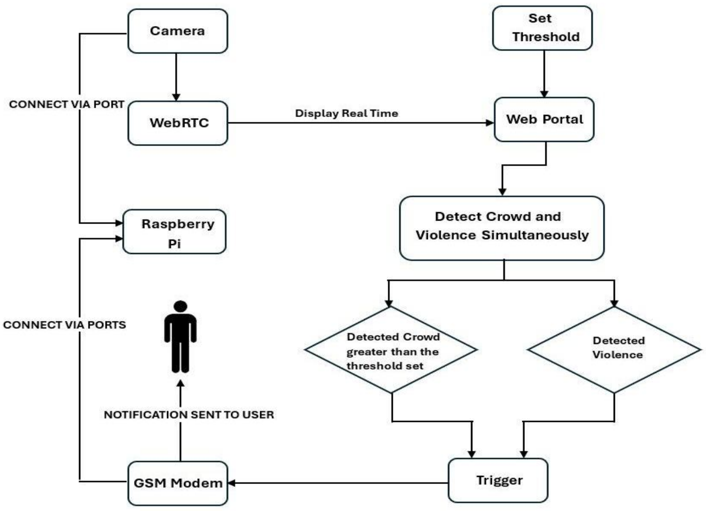

Fig. 4 Flowchart

IV. RESULTS

The experiment with the real-time violence detection and crowd monitoring system indicated promising results in the applicability of the YOLO algorithm. Applying the YOLOv8 application, the system was able to achieve real-time accuracy in detecting persons and violent activities. Fig.1: Mean average precision (map) for person detection during the testing process represents person detection and counting, and Fig. 2 presents the output for violence detection. The system's threshold-based alerts were able to trigger notifications via GSM when the crowd exceeded the defined threshold, thereby proving that the system was effective in dealing with crowded situations. This is a very useful feature in the supervision of risky locations such as schools, railway stations, and temples, where averting perilous overcrowding is crucial. Besides that, the feature function of real-time streaming performed well, offering a live feed to the user through the web portal for remote monitoring with minimum latency. Network stability problems, though, affected video quality and latency; hence, the system has areas for improvement such as changing the video resolution based on the network strength for better streaming. The system was found to have efficient detection sensitivity to violence in controlled scenarios regarding explicit pose patterns and velocities. Nevertheless, when overlapping movements are presented in the environments, sometimes there are false positives. Adjusting algorithmic parameters or implementing additional verification might be useful for further accuracy in more complex conditions. The diversity in environments exposed its robustness; hence it could be utilized for deployment within many public locations. Besides this, the fact that it is portable and cost-effective besides having optimized use of resources augurs well for widespread application. The performance characteristics of the system as presented in Table 4.1 resulted in the following: YOLO pre-trained values for precision (P) at 70.0%, recall (R) at 65.0%, mAP@0.5 at 67.2%, and mAP@0.5:0.95 at 36.0%. The violence dataset on the other hand results in a precision of 63.7%, recall of 67.2%, mAP@0.5 of 69.7%, and mAP@0.5:0.95 of 27.1%. These figures just go to outline the system's performances and indicate areas for future enhancement.

TABLE I. METRICS FOR YOLO PRETRAINED AND VIOLENCE DATASET VALUE

Metric	YOLO Pretrained Detection (COCO Dataset) Value	Violence Dataset Value
Precision (P)	0.633	0.637
Recall (R)	0.475	0.672
mAP@0.5	0.521	0.697
mAP@0.5:0.95	0.371	0.271

Figure 4. Detection of person

Figure 5. Detection of fight

V. DISCUSSION

The research results also support the ease of installation of the live crowd and violence monitoring system within a Raspberry Pi device fused with YOLOv8 and GSM technology. This initiative presents a low-cost device that is portable and easy to use for different security needs, particularly in crowded places and other high-risk areas [14] Such threats can be reasonably predicted as activities that led to the system being inoperative. An example could possibly be the use of mild hardware like embedded systems. A rapid improvement of the system may also be achieved through incorporating further detection systems such as audio or facial recognition, which, rationalizes expectations, are expected to increase operational effectiveness of the system with eye to providing a wider surveillance coverage [11].

VI. CONCLUSION

This paper aims to provide an integrated solution not only in the gauging of the crowd density in the areas of interest but also in the response to violence or overcrowding in these targeted locations. It uses advanced technologies such as YOLOv8, single board computers, GSM modules and specialized web interface. The combination of all of these provides an efficient, low-cost and realistic solution for a timely modern surveillance system that has the capability of detecting overshoot and violent acts and then sending alarm to the orders. This proactive style of security plan increases the general safety of the community in areas of concern like schools, temples, airports, as well as train stations. This prevention of violence and abuse is one step in the direction of making an area where a huge number of people are expected to gather much safer.

FUTURE SCOPE

Though the present system provides a viable framework for the efficient surveillance and monitoring of crowds, it can be stretched and enhanced as follows:

Artificial Intelligence Integrated Crowd Dynamics Prediction: Trends of crowd behavior could be integrated as part of predictive analytics to give insight into possible security threats that may occur, enabling these authorities to take necessary steps before security situations arise.

Mobile Application Developments: It would create a mobile application that would send out notifications effectively as well as keep the security personnel updated on the go and monitor the system when they are outside from the campus.

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