



# Crowd Abnormal Behaviour Detection Using YOLO V9

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**Abstract:** This paper presents a Crowd Abnormal Behavior Detection system using advanced deep learning techniques for real-time surveillance and safety monitoring. The system utilizes the YOLO (You Only Look Once) object detection algorithm to identify human activities in crowded environments and classify them as normal or abnormal. Abnormal behaviors such as fighting, running, panic situations, and sudden crowd movements are detected with high accuracy. The proposed system processes video streams in real-time and provides quick alerts, helping authorities take immediate action. The integration of computer vision and artificial intelligence enhances public safety in areas such as railway stations, shopping malls, and public gatherings.

**Keywords:** Crowd Analysis, Abnormal Behavior Detection, YOLO, Deep Learning, Computer Vision

## I. INTRODUCTION

With the rapid increase in population and urbanization, monitoring crowded environments has become a major challenge. Public places such as railway stations, stadiums, and shopping malls are highly prone to abnormal activities like violence, panic, and stampedes. Manual surveillance systems are not efficient enough to monitor such large crowds continuously.

### A. Background and Context

In recent years, the rapid expansion of urban environments has led to an increase in crowd density in public places. Locations such as transportation hubs, entertainment venues, and commercial complexes often experience large gatherings of people, making surveillance and security management a complex task. Ensuring the safety of individuals in such environments is a critical concern. Traditional surveillance systems rely on CCTV cameras and human operators, which introduces limitations such as fatigue, inattention, and delayed response. In emergency situations like fights, stampedes, or panic, delayed detection can cause severe consequences.

### B. Problem Statement

Existing surveillance systems face multiple challenges. Manual monitoring is inefficient and prone to human error. Traditional systems are reactive, detecting incidents only after they occur. They also struggle with complex scenarios such as dense crowds, lighting variations, and dynamic environments. Machine learning approaches require manual feature extraction and often fail in real-time applications.

### C. Significance of the Study

The proposed system improves surveillance efficiency by automating abnormal behaviour detection. It reduces human effort and ensures continuous monitoring. The use of YOLOv9 enhances detection accuracy and speed. The system can be applied in smart cities, transportation hubs, and public areas, improving safety and response time.

## II. LITERATURE REVIEW

The study of crowd behaviour detection has gained significant attention due to the increasing need for intelligent surveillance systems in public areas. Traditional surveillance systems mainly rely on CCTV cameras and human operators to monitor activities, which often leads to inefficiencies due to human fatigue, limited attention span, and delayed response to critical events. To overcome these limitations, machine learning techniques such as Support Vector Machines (SVM), K-Nearest Neighbors (KNN), and decision trees have been introduced for anomaly detection. These methods



analyze patterns in data and identify deviations from normal behaviour; however, they require manual feature extraction and are not suitable for real-time applications in complex environments. With the advancement of deep learning, Convolutional Neural Networks (CNNs) have significantly improved the performance of image and video analysis tasks by automatically extracting features from raw data. Among various deep learning approaches, the YOLO (You Only Look Once) family of models has emerged as a powerful solution for real-time object detection due to its high speed and accuracy. Different versions of YOLO have been developed over time, with YOLOv9 providing enhanced performance in detecting objects in dynamic and dense crowd scenarios. Recent research focuses on combining object detection with behavioural analysis to identify abnormal activities such as fighting, sudden running, panic situations, and unusual crowd movements.

### III. DATASET AND PREPROCESSING TECHNIQUES

The dataset used in the proposed system consists of surveillance video data containing both normal and abnormal crowd activities. These activities include walking, standing, gathering, as well as abnormal behaviours such as fighting, sudden running, panic situations, and irregular crowd movement. The dataset is designed to represent real-world scenarios with variations in crowd density, lighting conditions, camera angles, and background complexity to improve the robustness of the model. The data is collected from multiple sources including publicly available datasets, real-time CCTV footage, and simulated video recordings to ensure diversity and reliability. Once collected, the video data is converted into individual frames at a consistent frame rate, and each frame is stored along with relevant metadata such as timestamps and activity labels. Before feeding the data into the YOLOv9 model, several preprocessing steps are performed to enhance data quality and consistency. These steps include resizing frames to a fixed resolution, normalization of pixel values, and noise reduction to improve image clarity. In addition, data augmentation techniques such as rotation, flipping, scaling, cropping, and brightness adjustment are applied to increase dataset diversity and improve model generalization. These preprocessing techniques ensure that the model performs efficiently and accurately in detecting abnormal behaviour under various real-world conditions.

### IV. METHODOLOGY

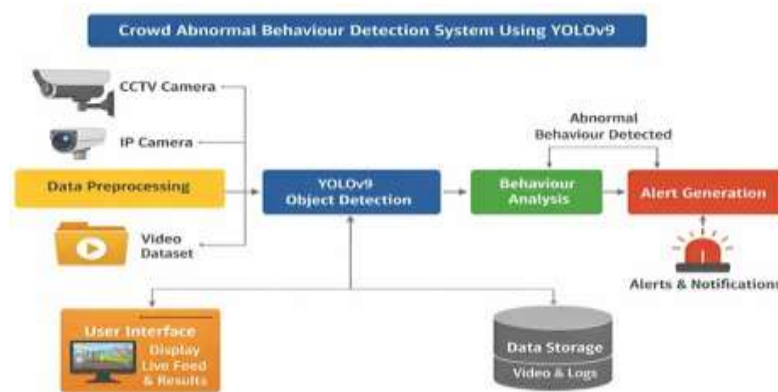


Fig. 1 System Architecture of Crowd Abnormal Behaviour Detection Using YOLOv9

The proposed system is designed to detect abnormal crowd behaviour using the YOLOv9 deep learning model. It processes video input in real time and identifies unusual activities such as fighting, sudden running, and panic movements. The system follows a structured pipeline that includes video acquisition, preprocessing, object detection, behaviour analysis, and alert generation. Each stage works together to ensure accurate and fast detection in crowded environments.

#### A. System Architecture Design

The system follows a modular architecture consisting of multiple interconnected components. The video input is captured from CCTV cameras or recorded sources and is processed frame by frame. These frames are passed through preprocessing techniques before being analyzed by the YOLOv9 model. The detected objects are then evaluated to identify abnormal behaviour, and alerts are generated accordingly.

#### B. Video Input and Processing

The system captures continuous video streams from surveillance cameras. The video is divided into frames at regular intervals to maintain temporal continuity. These frames are enhanced using preprocessing techniques such as resizing, normalization, and noise reduction to ensure consistent input quality.



### C. YOLOv9-Based Detection

The YOLOv9 model is used for real-time object detection. It identifies individuals in each frame by drawing bounding boxes and classifying objects. The model processes the entire image in a single pass, making it faster and more efficient compared to traditional methods.

### D. Behaviour Analysis

After detecting individuals, the system analyzes their movement patterns. Parameters such as speed, direction, and interaction between individuals are monitored. Sudden changes in movement or aggressive interactions are identified as abnormal behaviour.

### E. Alert Generation

When abnormal behaviour is detected, the system generates real-time alerts. The detected region is highlighted using bounding boxes, and notifications are sent to the monitoring system. This enables quick response and helps prevent critical situations.

## V. SYSTEM ARCHITECTURE

The system architecture of the proposed crowd abnormal behaviour detection system is designed to ensure efficient and real-time monitoring of crowded environments. It consists of multiple modules that work together to process video data, detect human activities, analyze behaviour, and generate alerts. Each module performs a specific function and contributes to the overall system performance.

### A. Video Input Module

The Video Input Module is responsible for capturing video data from surveillance sources such as CCTV cameras or recorded video files. It continuously collects real-time video streams and converts them into frames for further processing. This module ensures that high-quality input data is available for accurate detection.

### B. Data Collection Module

The Data Collection Module gathers video data from various sources including public datasets, real-time surveillance systems, and simulated environments. It organizes and stores the data efficiently for training and testing purposes. This module helps in maintaining a diverse dataset for better model performance.

### C. YOLOv9 Detection Module

The YOLOv9 Detection Module is the core component of the system. It detects human presence in video frames by identifying objects and drawing bounding boxes around them. The model processes frames in real time and provides high accuracy in detecting multiple individuals in crowded scenes.

### D. Behaviour Analysis Module

The Behaviour Analysis Module evaluates the detected objects and analyzes their movement patterns. It monitors parameters such as speed, direction, and interaction between individuals. Based on these factors, the system identifies whether the behaviour is normal or abnormal.

### E. Alert Generation Module

The Alert Generation Module is responsible for generating notifications when abnormal behaviour is detected. It highlights the suspicious activity in the video and sends alerts to the monitoring system. This ensures immediate response from authorities.

### F. Monitoring and Storage Module

The Monitoring and Storage Module provides a user interface for viewing detection results and system status. It stores video recordings, detected events, and alert logs for future analysis. This module ensures proper data management and system reliability.

## VI. RESULTS

The proposed system was tested using various crowd surveillance videos to evaluate its performance in detecting abnormal behaviour. The YOLOv9 model demonstrated high efficiency in identifying human presence and analyzing activities in real time. The system successfully detected abnormal events such as fighting, sudden running, panic situations, and unusual crowd movements with good accuracy. The processing speed was fast, ensuring real-time



monitoring without noticeable delay. The integration of preprocessing, detection, and behaviour analysis modules resulted in smooth system performance. Overall, the system proved to be reliable and effective for real-time abnormal behaviour detection in crowded environments.

#### A. System Performance and Accuracy

The system achieved high accuracy in detecting abnormal activities under different conditions. It performed well in scenarios with moderate crowd density and varying lighting conditions. The YOLOv9 model reduced detection errors and provided consistent results during testing.

#### B. Detection Efficiency

The system efficiently processed continuous video streams and detected multiple individuals simultaneously. It could identify abnormal patterns quickly, making it suitable for real-time surveillance applications.

#### C. User Experience and Reliability

The system provided a user-friendly interface with clear visualization of detection results using bounding boxes. The alert mechanism worked effectively, enabling quick response. The system maintained stable performance without crashes during continuous operation.

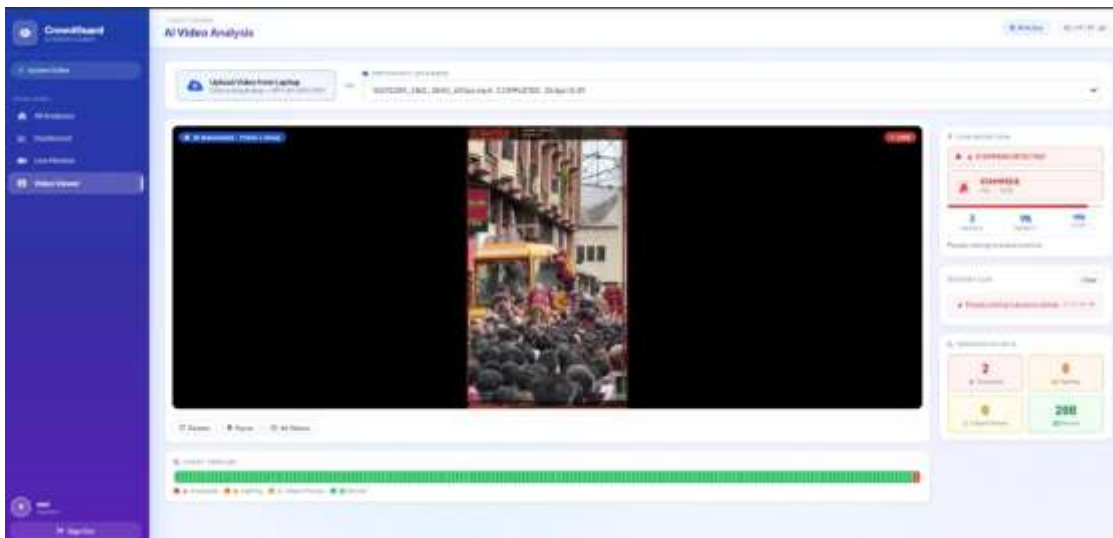


Fig. 2 Output Showing Abnormal Behaviour Detection

## VII. COMPARATIVE ANALYSIS

The comparative analysis highlights the differences between traditional surveillance systems and the proposed YOLOv9-based abnormal behaviour detection system. Traditional systems mainly rely on manual monitoring using CCTV cameras, where human operators continuously observe video feeds. This approach is inefficient and prone to errors due to fatigue, lack of attention, and delayed response. In contrast, the proposed system introduces an automated approach that performs real-time detection of abnormal activities without human intervention. It continuously analyzes video streams and identifies unusual behaviours such as fighting, sudden movement, and panic situations instantly. The system follows a proactive approach, enabling early detection and quick response to critical situations.

#### A. Existing System vs Proposed System

Traditional surveillance systems are reactive in nature, as they detect incidents only after they occur. They lack automation and require continuous human monitoring. The proposed system, on the other hand, is proactive and uses deep learning techniques to detect abnormal behaviour in real time. It reduces human effort and improves overall efficiency.

#### B. Security Features Comparison

Existing systems provide basic video recording functionality without intelligent analysis. They do not include automated alert mechanisms or behaviour analysis. In contrast, the proposed system integrates YOLOv9-based object detection, behaviour analysis, and real-time alert generation. This improves situational awareness and enhances security in crowded environments.



## VIII. CONCLUSION AND FUTURE SCOPE

The proposed Crowd Abnormal Behaviour Detection system using YOLOv9 provides an efficient and intelligent solution for real-time surveillance in crowded environments. The system successfully detects abnormal activities such as fighting, sudden running, panic situations, and unusual crowd movements with high accuracy. By integrating deep learning techniques with real-time video processing, the system overcomes the limitations of traditional surveillance methods. It reduces human effort, minimizes errors, and enables quick response through automated alert generation. The modular architecture ensures smooth data flow between different components, making the system reliable and scalable for real-world applications. Overall, the system enhances public safety by transforming surveillance from a passive monitoring approach into a proactive detection system.

## A. Future Scope

Although the system performs effectively, there is scope for further improvement. Future enhancements can include the integration of advanced deep learning models to improve detection accuracy in dense crowds. The system can be extended with facial recognition and biometric identification for better tracking of individuals. Cloud-based deployment can be implemented for large-scale monitoring and data storage. Additionally, mobile application integration can enable remote access and real-time notifications. Further improvements in behaviour analysis and predictive modeling can help in identifying potential threats before they occur.

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