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Original Article

YOLO-Based Weapon Detection and Mail Alert System Using Machine Learning

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Weapon Detection, YOLOv8, Computer Vision, Deep Learning, OpenCV, Real-Time Surveillance, Email Alert System, Object Detection, Security Systems, Artificial Intelligence.

Abstract

This paper presents the design and development of a YOLO-Based Weapon Detection and Mail Alert System aimed at enhancing real-time surveillance and public safety. The system leverages deep learning techniques, specifically the YOLO (You Only Look Once) object detection algorithm, to identify weapons such as guns and knives from live video streams or uploaded images.

The proposed system integrates computer vision using OpenCV, real-time detection using YOLOv8, and automated email alert mechanisms using SMTP. Upon detecting a weapon, the system captures the frame, highlights the detected object, and sends an instant alert email with the image, timestamp, and location details to authorized personnel.

The system is implemented using Python and Streamlit, providing an interactive interface for users. Experimental results show that the system achieves high detection accuracy, fast response time, and reduced dependency on manual surveillance. This approach significantly improves security monitoring efficiency and enables proactive threat detection in real-world environments.

Introduction

With the increasing number of violent crimes and security threats, there is a growing need for intelligent surveillance systems capable of detecting potential dangers in real time. Traditional CCTV systems rely heavily on human monitoring, which is inefficient, error-prone, and unable to provide immediate response.

This research proposes a YOLO-Based Weapon Detection System that automates surveillance by detecting weapons using deep learning. The system uses YOLOv8 for real-time object detection, which processes images in a single pass, making it faster and more efficient than traditional methods.

The system also integrates an email alert mechanism that sends notifications when a weapon is detected, ensuring quick response from authorities. This improves overall security and reduces reliance on manual monitoring.

Background

Recent advancements in deep learning and computer vision have enabled real-time object detection systems. YOLO (You Only Look Once) is one of the most efficient algorithms for detecting objects in images and videos.

Earlier approaches like R-CNN and Fast R-CNN were slower due to multi-stage processing. YOLO overcomes this by treating detection as a regression problem, enabling faster performance suitable for real-time applications.

Applications of such systems include Airport security , Public surveillance ,Smart cities and Crime prevention systems

Problem Statement

In recent years, the increasing rate of violent crimes, armed attacks, and security threats has ex-posed significant limitations in traditional surveillance systems. Most existing systems rely heavily on continuous human monitoring of CCTV footage, which is time-consuming, labor-intensive, and highly prone to human error due to fatigue and lack of attention. As a result, critical events such as the presence of weapons often go unnoticed or are detected too late, leading to delayed response and increased risk to public safety. Additionally, conventional systems lack the capability to automatically identify and differentiate between harmful objects like guns and knives and non-threatening objects. The absence of real-time detection and instant alert mechanisms further reduces the effectiveness of these systems in preventing incidents. Therefore, there is a strong need for an intelligent, automated solution that can accurately detect weapons in real time and immediately notify authorities, ensuring faster response, reduced human dependency, and enhanced overall security..

Literature Survey

Redmon (2016): Introduced YOLO for real-time object detection with high speed and accuracy.

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- Thakur (2024): Applied YOLOv8 for weapon detection achieving improved performance over earlier models.
- Gupta & Sharma (2024): Compared traditional ML and deep learning methods, showing YOLO-based systems outperform others.
- Torregrosa (2024): Analyzed improvements in real-time detection using YOLO variants.
- Quyyum & Abdullah (2022): Developed a weapon detection system using deep neural net-works for surveillance videos.

Proposed System

The proposed system is a real-time intelligent surveillance system designed to detect weapons automatically and send instant alerts to authorities. It integrates deep learning, computer vision, and automated communication to improve security and reduce human dependency.

Weapon Detection using YOLOv8

The core component of the system is the YOLOv8 (You Only Look Once) algorithm, which is a state-of-the-art deep learning model used for object detection. It is trained to identify weapons such as guns and knives from images and video streams.

YOLOv8 processes the entire image in a single step, making it extremely fast and suitable for real-time applications. It divides the image into grids and predicts bounding boxes, class labels, and confidence scores for detected objects. This enables the system to accurately locate and classify weapons in real time.

Real-Time Video Processing using OpenCV

The system uses OpenCV for capturing and processing video frames from a webcam or CCTV feed. OpenCV continuously extracts frames from the video stream and converts them into a format suitable for the YOLO model.

Each frame is analyzed instantly, and if a weapon is detected, it is highlighted using bounding boxes and labels. This ensures continuous monitoring without delay and allows the system to respond immediately to potential threats.

Automated Email Alert System

When a weapon is detected, the system automatically triggers an email alert to notify authorized personnel. The system captures the frame containing the detected weapon and sends it as an attachment along with details such as timestamp and detection message.

This feature ensures quick response and helps authorities take immediate action. Additionally, a cooldown mechanism is implemented to prevent repeated alerts for the same detection, avoiding unnecessary email flooding.

User Authentication and Dashboard

To ensure secure access, the system includes a user authentication module where users must log in using valid credentials. Different roles such as admin and user can be assigned to control access and functionality.

The dashboard provides useful information such as:

- Number of weapons detected
- System status
- User activity

This helps in monitoring system performance and managing usage effectively.

Streamlit-Based User Interface

The system is built with a Streamlit-based web interface, making it user-friendly and easy to operate. Users can interact with the system through features such as:

- Starting and stopping webcam detection
- Uploading images for analysis
- Adjusting confidence threshold
- Viewing real-time detection results

The interface displays live video feed, detection outputs, and statistics in a clear and organized manner, making it accessible even to non-technical users.

Modules used

- **User Authentication Module:** This module manages user registration and login functionality. It ensures only authorized users can access the system. Passwords are securely stored using encryption techniques like hashing.

It also supports role-based access such as admin and normal user.

- I**mage/Video Input Module:** This module captures live video from a webcam or CCTV feed. It also allows users to upload images for weapon detection. The input data is converted into frames for processing.

It acts as the starting point for the detection pipeline.

- **YOLO Detection Module:** This is the core module responsible for detecting weapons. It uses the trained YOLOv8 model to identify objects in frames. The model outputs bounding boxes, labels, and confidence scores.

It ensures fast and accurate real-time detection.

- **Alert Module:** This module sends alerts when a weapon is detected. It captures the detected image and attaches it to the email. The alert includes details like timestamp and detection message. It ensures authorities are notified immediately for quick action.
- **Visualization Module:** This module displays detection results on the screen. It draws bounding boxes around detected weapons. Labels and confidence scores are also shown for clarity. It helps users easily understand detection outputs.
- **Admin Dashboard Module:** This module provides system monitoring and management features. It tracks the number of detections and user activity. Admins can view system usage and performance statistics.

It helps in analysing and controlling the overall system.

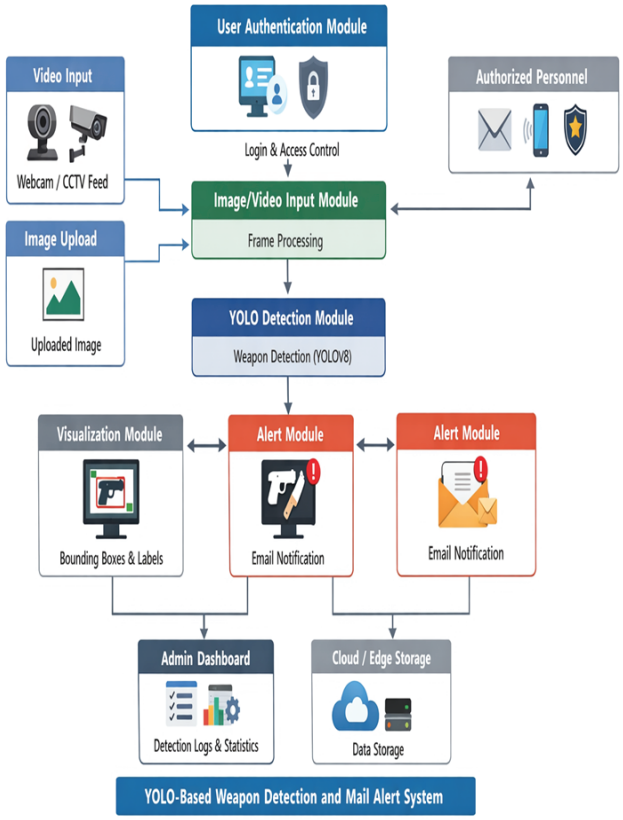
Advantages of Proposed System

- **Real-Time Weapon Detection:** Detects weapons instantly from live video streams. Ensures immediate identification of potential threats.
- **High Accuracy using Deep Learning:** Uses YOLOv8 for precise and reliable detection. Reduces false positives and improves system performance.
- **Instant Email Alerts:** Automatically sends alerts when a weapon is detected. Helps authorities take quick action without delay.
- **Reduced Human Effort:** Minimizes the need for manual monitoring of CCTV footage. Reduces errors caused by human fatigue.
- **Continuous Monitoring (24/7):** Works continuously without breaks or interruptions. Provides constant

surveillance for better security.

- **Scalable and Flexible:** Can be expanded to support multiple cameras and locations. Easily adaptable to different environments and needs.
- **Improved Public Safety:** Helps detect threats early and prevent incidents. Creates a safer environment for people.
- **Faster Response Time:** Instant detection and alert system speeds up response. Enables quick action during emergencies.

System Architecture



Results

The system demonstrates strong performance and reliability in real-time surveillance by accurately detecting weapons such as guns and knives using advanced deep learning techniques. By leveraging the YOLOv8 model, it is capable of processing video frames instantly and identifying threats with high precision. Unlike traditional manual monitoring systems, which are slow and prone to human error, this system performs detection at a much faster rate, ensuring that potential dangers are identified without delay.

In addition to fast detection, the system incorporates a reliable alert mechanism that automatically sends email notifications to authorized personnel whenever a weapon is detected. These alerts include important details such as the captured image, timestamp, and detection message, enabling quick and informed decision-making. This ensures that authorities can respond immediately to critical situations, thereby improving overall security response.

Furthermore, the system is designed to reduce false positives by using a well-trained model and appropriate confidence thresholds. This means that non-threatening objects are less likely to be misclassified as weapons, which increases the accuracy and trustworthiness of the system. As a result, the proposed solution provides a balanced combination of speed, accuracy, and reliability, making it highly effective for real-world surveillance applications.

Table 1: *Accuracy Comparision*

Model	Accuracy
Traditional CCTV Monitoring	70%
Basic ML Models	85%
Proposed YOLO System	92%

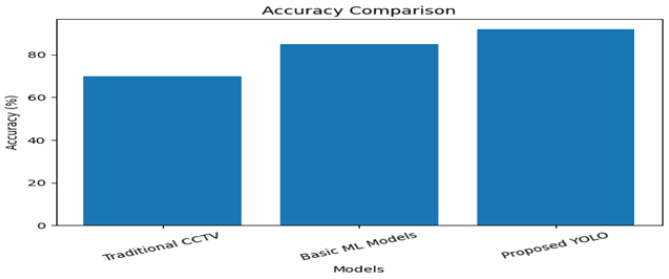


Figure 1. *Graph for Accuracy comparison*

Table 2: *Accuracy Comparision*

Model	F1 Score
Traditional CCTV Monitoring	0.68
Basic ML Models	0.83
Proposed YOLO System	0.90

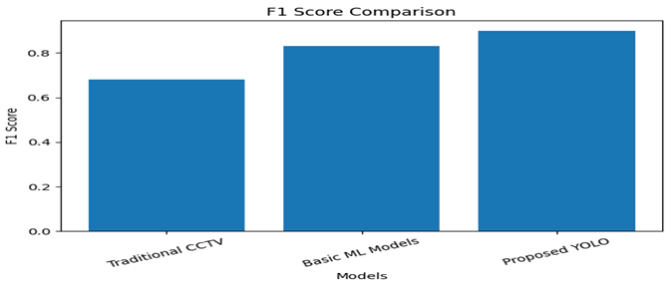


Figure 2. *Graph for F1 Score comparison*

Conclusion

The proposed YOLO-Based Weapon Detection and Mail Alert System successfully demonstrates the practical implementation of deep learning and computer vision techniques in modern surveillance systems. By integrating the YOLOv8 object detection model with real-time video processing, the system is capable of accurately identifying weapons such as guns and knives from live video feeds and images. This significantly enhances the efficiency of traditional security systems, which largely depend on manual monitoring and are prone to human error.

One of the major strengths of the system is its ability to perform real-time detection with high speed and accuracy. The YOLO algorithm processes images in a single pass, allowing the system to quickly analyse video frames and identify potential threats without delay. This ensures that dangerous situations are detected at the earliest possible moment, reducing the chances of incidents escalating. Compared to conventional methods,

the proposed system offers faster processing and more reliable results.

Another important feature is the automated email alert mechanism, which plays a crucial role in improving response time. Whenever a weapon is detected, the system immediately sends an alert to authorized personnel along with the captured image and relevant details such as timestamp. This eliminates the need for constant human supervision and ensures that security teams can take prompt action. The inclusion of such an alert system makes the solution proactive rather than reactive.

The system also contributes to reducing human effort and operational costs. Continuous manual monitoring of surveillance cameras is not only labor-intensive but also inefficient over long periods. By automating the detection process, the system allows security personnel to focus on critical decision-making instead of routine observation. Additionally, the use of a user-friendly interface developed with Streamlit ensures that the system can be easily operated even by non-technical users.

Furthermore, the system is designed to be scalable and flexible, making it suitable for deployment in a wide range of environments such as public places, educational institutions, offices, transportation hubs, and high-security zones. It can be extended to support multiple cameras and integrated with existing surveillance infrastructure. The ability to adapt to different use cases highlights its practical applicability in real-world scenarios.

In conclusion, the proposed system provides an efficient, accurate, and automated solution for weapon detection in surveillance systems. It improves security by enabling real-time threat detection, instant alert generation, and reduced dependency on manual monitoring. With its strong performance and adaptability, the system has significant potential to enhance public safety and modernize existing surveillance technologies.

Future scope

Although the proposed system performs effectively in its current form, there are several opportunities for enhancement and expansion to make it more advanced, scalable, and suitable for real-world large-scale deployment. Future improvements can focus on integrating additional technologies, improving detection capabilities, and extending system functionality.

One major area of improvement is the integration with CCTV networks. Currently, the system primarily operates using a single webcam or video input. In the future, it can be connected to multiple CCTV cameras across different locations, enabling centralized monitoring of large areas such as airports, railway stations, shopping malls, and smart cities. This would significantly increase the coverage and effectiveness of the surveillance system.

Another important enhancement is the development of mobile-based alert systems, including SMS and push notifications. Instead of relying only on email alerts, the system can be integrated with mobile applications to provide instant notifications directly to smartphones. This ensures faster communication and allows authorities to respond immediately, even when they are not actively monitoring emails.

The system can also be extended to support multi-weapon and threat detection. Currently, it focuses mainly on detecting weapons like guns and knives. In the future, it can be trained to identify a wider range of threats such as explosives, suspicious objects, or even abnormal human behavior. This would make the system more comprehensive and capable of handling diverse security challenges.

Another significant improvement is cloud-based monitoring and storage. By integrating cloud technologies, the system can store detection data, images, and logs securely on cloud platforms. This allows remote access, real-time monitoring from different locations, and better data management. Cloud integration also improves scalability and enables the system to handle large volumes of data efficiently.

The incorporation of AI-based predictive threat analysis is another promising direction. Advanced machine learning models can be used to analyze patterns and predict potential threats before they occur. For example, the system can identify suspicious behavior patterns or detect unusual activities over time. This transforms the system from a reactive tool into a proactive security solution.

Finally, the system can be optimized for edge deployment using devices like Raspberry Pi or NVIDIA Jetson. This allows the system to run directly on embedded hardware without requiring high-end computers. Edge deployment reduces latency, improves processing speed, and makes the system more cost-effective and portable. It also enables deployment in remote or resource-constrained environments.

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