Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 06 , June - 2026

A Survey on AI-Based Smart Surveillance Systems Using Computer Vision and Virtual Reality

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***Abstract*—Smart surveillance systems are now a key part of modern security and monitoring. Traditional CCTV-based systems need constant human oversight and are often slow to spot suspicious activities as they happen. Recent developments in Artificial Intelligence (AI), Deep Learning, Computer Vision, and Virtual Reality (VR) have turned surveillance systems into smarter automated solutions. This survey paper offers a review of AI and VR-based smart surveillance systems, focusing on YOLOv8 object detection techniques. It examines various research papers related to real-time object detection, anomaly detection, crowd monitoring, AIoT integration, and immersive VR visualization. The survey points out the advantages and limitations of existing systems, their methodologies, and what to expect for the future. The study concludes that combining AI with VR and YOLOv8 can greatly improve surveillance accuracy, situational awareness, and decision-making in real time.**

***Index Terms*—Artificial Intelligence, YOLOv8, Virtual Reality, Smart Surveillance, Computer Vision, Deep Learning**

I. INTRODUCTION

Traditional surveillance systems mainly depend on CCTV cameras and human operators for monitoring activities. Continuous manual observation is time-consuming, inefficient, and prone to human error. In crowded environments, security personnel may miss suspicious activities due to fatigue or limited attention span.

Artificial Intelligence (AI) and Deep Learning technologies have significantly improved the capabilities of modern surveillance systems. AI-based surveillance systems can automatically detect objects, recognize abnormal activities, and generate alerts in real-time. Among various object detection algorithms, YOLO (You Only Look Once) has become one of the most widely used techniques because of its high speed and accuracy.

The latest version, YOLOv8, provides improved object detection performance with lower computational complexity and better real-time processing. In addition, Virtual Reality (VR) technologies enhance surveillance visualization by enabling immersive monitoring experiences. Operators can observe surveillance environments using 360-degree visualization and interact with the system remotely.

This survey paper reviews recent research works related to AI and VR-based smart surveillance systems using YOLOv8. The paper focuses on object detection, anomaly detection, crowd monitoring, AIoT integration, and immersive visualization techniques.

II. NEED FOR SMART SURVEILLANCE SYSTEMS

Modern surveillance systems are required in smart cities, industries, airports, public transportation, educational institutions, and commercial buildings. The major limitations of traditional surveillance systems include:

- Continuous manual monitoring requirement
- Delayed response to suspicious activities
- Difficulty in monitoring crowded environments
- High chances of human error
- Lack of intelligent analysis

AI-powered surveillance systems overcome these limitations by providing:

- Automated object detection
- Real-time anomaly detection
- Intelligent activity analysis
- Remote monitoring
- Faster security response

III. LITERATURE SURVEY

Several researchers have proposed intelligent surveillance systems using AI, Deep Learning, and YOLO-based models. The following table summarises important research contributions.

International Journal of Engineering Research & Technology (IJERT)
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TABLE I
COMPARISON OF EXISTING SURVEILLANCE SYSTEMS

Sr No	Author	Paper Title	Year	Description	Advantages	Disadvantages
1	Siva et al.	Smart Surveillance Systems Using YOLOv8	2025	YOLOv8-based real-time surveillance for crowd and threat detection	High detection accuracy and scalability	Lacks immersive visualisation techniques
2	Nimma et al.	Transformer-YOLOv8 Model	2025	Hybrid transformer and YOLOv8-based object detection system	Improved detection performance	High computational complexity
3	Ihsan et al.	Intelligent Surveillance System using Deep Learning	2025	Deep learning-based suspicious activity detection system	Reduces human effort and improves security	Requires high computational resources
4	Nasir et al.	YOLOv8-based Crowd Anomaly Detection Framework	2025	Crowd behavior and anomaly detection Soft-NMS	Better accuracy in dense crowds	Occlusion handling is difficult
5	Zhang et al.	Anomaly Detection in Video Surveillance using YOLOv8	2025	Hybrid YOLOv8 and motion analysis system	High precision and real-time processing	Requires large training dataset
6	Cheng et al.	SGST-YOLOv8	2024	Lightweight OLOv8 surveillance model	Low computational cost	Limited detection range
7	Wang et al.	Lightweight YOLOv8 Detection	2025	Optimized person detection system	Efficient for edge devices	Performance reduces in low light

IV. YOLOV8 FOR SMART SURVEILLANCE

YOLOv8 is one of the latest object detection algorithms developed for real-time computer vision applications. It processes the entire image in a single pass, making it highly efficient for surveillance systems.

A. Features of YOLOv8

- High detection accuracy
- Fast real-time processing
- Lightweight architecture
- Better object localization
- Multi-object detection capability

B. Applications in Surveillance

YOLOv8 is widely used in:

- Intruder detection
- Crowd monitoring
- Weapon detection
- Vehicle detection
- Human activity analysis

V. AI-BASED ANOMALY DETECTION

Anomaly detection is one of the most important components of intelligent surveillance systems. It identifies abnormal activities such as:

- Unauthorized access
- Suspicious movement
- Crowd violence
- Unattended objects
- Restricted area intrusion

Deep learning models analyze movement patterns, object behavior, and activity duration to identify anomalies in real-time.

VI. VIRTUAL REALITY IN SURVEILLANCE

Virtual Reality (VR) improves user interaction with surveillance systems by providing immersive monitoring environments.

A. Advantages of VR-Based Surveillance

- 360-degree visualization
- Remote monitoring capability
- Better situational awareness
- Faster decision-making
- Interactive surveillance environment

VR technology allows operators to monitor surveillance feeds as if they are physically present in the monitored environment.

VII. AIOT AND CLOUD INTEGRATION

Artificial Intelligence of Things (AIoT) combines AI with IoT devices for intelligent automation.

A. Benefits of AIoT Integration

- Real-time data processing
- Cloud-based storage
- Remote accessibility
- Scalability
- Smart analytics

Cloud computing enables storage of large surveillance datasets and supports remote monitoring systems.

VIII. CHALLENGES IN SMART SURVEILLANCE SYSTEMS

Despite advancements, intelligent surveillance systems face several challenges:

- High computational requirements

International Journal of Engineering Research & Technology (IJERT)
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- Privacy concerns
- Occlusion problems in crowded scenes
- Large dataset requirements
- Real-time processing limitations
- Network latency issues

Researchers are continuously developing lightweight and optimized models to address these limitations.

IX. Research Gap

From the literature review, it is observed that most existing systems mainly focus on object detection and activity monitoring. However, there are still several limitations:

- Lack of immersive VR visualization
- Limited anomaly prediction capabilities
- High hardware requirements
- Reduced performance in dense crowds
- Limited integration of AIoT and VR

Therefore, future surveillance systems should focus on combining YOLOv8, AIoT, cloud computing, and VR technologies for intelligent and scalable monitoring solutions.

X. Future Scope

Future intelligent surveillance systems can be enhanced using:

- Face recognition systems
- Drone-based surveillance
- Predictive AI analytics
- Edge AI processing
- 5G-enabled surveillance networks
- Advanced VR interaction systems

These technologies can improve surveillance accuracy, reduce latency, and provide better security solutions.

XI. Conclusion

AI and VR-based smart surveillance systems represent the future of intelligent security monitoring. YOLOv8-based object detection models provide fast and accurate real-time surveillance capabilities. Integration of AI, VR, AIoT, and cloud computing significantly improves monitoring efficiency, anomaly detection, and situational awareness.

This survey paper reviewed several recent research works related to smart surveillance systems and analyzed their methodologies, advantages, and limitations. The study concludes that integrating immersive VR visualization with AI-powered surveillance can provide highly efficient and scalable security systems for smart cities and modern industrial environments.

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