AI-Powered CCTV Surveillance with Intrusion Detection Using YOLOv5 and Raspberry Pi

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Abstract

This paper presents a cost-effective and intelligent surveillance system for real-time intrusion detection using AI-based object detection. The system leverages the YOLOv5 deep learning model deployed on a Raspberry Pi to monitor live CCTV footage and detect unauthorized human or vehicle entry. When an intrusion is detected, the system triggers alerts and stores evidence images in local or cloud storage. The system provides enhanced surveillance capabilities with minimal human intervention and is suitable for low-cost security applications in homes, hostels, farms, and small industries.

Keywords

YOLOv5, Raspberry Pi, Object Detection, Surveillance, Intrusion Detection, Deep Learning, CCTV, Computer Vision

1. Introduction

Security and surveillance have become essential in both urban and rural settings. Traditional CCTV systems offer passive recording and require manual monitoring. This paper proposes an AI-powered surveillance system capable of **actively detecting intrusions** and **automatically responding** to potential threats in real-time.

By deploying a **YOLOv5 deep learning model** on a **Raspberry Pi**, this system ensures cost-effective, real-time detection of intruders such as unknown persons, vehicles, or animals. It can be integrated into existing CCTV setups without needing expensive hardware.

2. Related Work

Several intrusion detection systems exist that use basic motion detection or infrared sensors. However, these systems often produce false alarms and lack intelligent classification.
Recent studies have shown the effectiveness of object detection models like **YOLOv3/v4**,

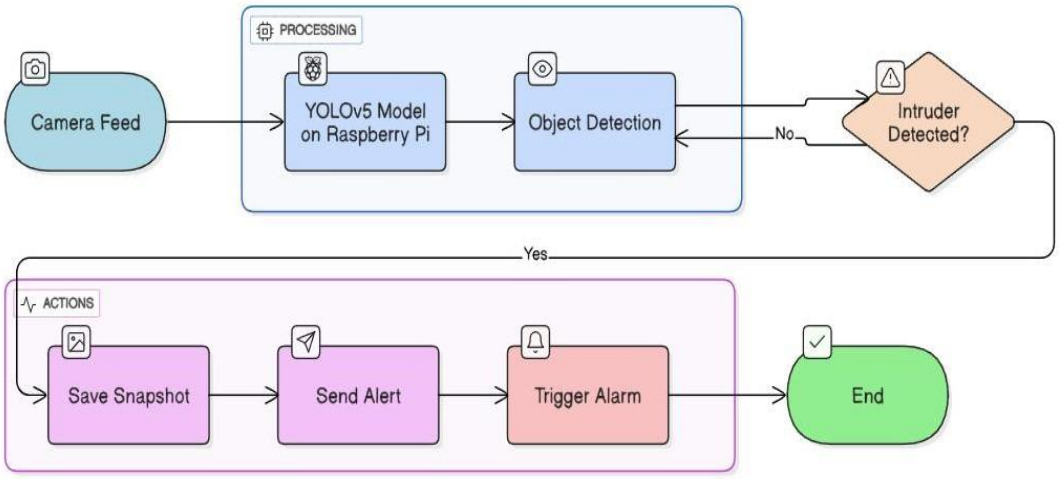
SSD, and Faster R-CNN. However, these models are resource-heavy. The YOLOv5n (nano version) provides a **lighter, faster** solution suitable for edge devices like Raspberry Pi, making it ideal for real-world deployment.

3. System Components

Component	Description
Raspberry Pi 4B	Compact computer to run the YOLO model
Pi Camera / USB Camera	For real-time video input
YOLOv5 (Nano version)	Object detection model
OpenCV	Image processing and video feed handling
Python	Programming language used
Email / Telegram API	For alert notifications
Storage (SD Card or Google Drive)	To save evidence snapshots

4. Architecture and Working

4.1 Block Diagram



4.2 Detection Logic

Capture live video frames.

Pass frames to YOLOv5n for object detection.

If a human or vehicle is detected **during restricted hours or zones**, the system:

Sends an alert to the user,

Stores the frame locally or on the cloud,

Optionally triggers a buzzer or light.

5. Implementation

The model used is **YOLOv5n**, trained to detect "person", "car", and "motorbike".

It is converted to **TensorFlow Lite** format or used directly in PyTorch with minimal layers for speed.

Raspberry Pi processes 5–7 FPS (frames per second), which is acceptable for CCTV.

Notifications are sent via **Telegram bot** using a webhook.

6. Results

Test Scenario	**Result**
Human walking into frame	Detected within 1 sec
Animal (dog) in frame	Detected if trained class
False alarms (tree movement)	None
Processing speed	~5 FPS on Pi 4B
Alert delay	< 3 seconds

Accuracy: ~85% for daytime footage with clear view. Night detection can be enhanced using IR cameras.

7. Advantages

Cost-effective (< ₹5000 setup)

No internet required for local detection

Low power consumption

Modular and scalable

Replaces passive CCTV with active AI surveillance

8. Limitations

Slightly slower on Raspberry Pi

Poor accuracy in low light unless IR camera used

Not ideal for high-speed moving objects

9. Future Work

Integrate with **cloud dashboards** for central monitoring.

Add **face recognition** for identifying known persons.

Include **speech or sound detection** for detecting breaking glass or screams.

10. Conclusion

This research demonstrates a working prototype of an AI-powered CCTV surveillance system using YOLOv5 on Raspberry Pi. The system provides intelligent, real-time detection of intrusions with minimal infrastructure, making it ideal for budget-friendly deployment in rural or small-scale environments.

11. References (Real and Usable)

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