



PISHIELD: IOT-BASED SMART SURVEILLANCE FOR THEFT PREVENTION

¹Praveen, ²Avinash K

Department Of ECE

Sree Chaitanya College of Engineering, Karimnagar

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ABSTRACT

In today's security-conscious environment, traditional surveillance systems often fall short in providing real-time alerts and intelligent monitoring. PiShield is an IoT-based smart surveillance solution designed to enhance theft prevention using low-cost, high-efficiency components. Leveraging the capabilities of the Raspberry Pi, motion sensors, and camera modules, the system continuously monitors the environment and detects unauthorized movements. Upon detecting suspicious activity, PiShield captures images or video and instantly transmits alerts to the user's smartphone or cloud server via Wi-Fi. The integration of artificial intelligence enables object recognition and anomaly detection, reducing false alarms and increasing accuracy. With remote access, real-time monitoring, and automated notifications, PiShield provides a scalable, efficient, and user-friendly solution for securing homes, offices, and small businesses against theft.

I. INTRODUCTION

The increasing rate of property-related crimes and the limitations of conventional surveillance systems have underscored the need for smarter, real-time, and automated security solutions. Traditional CCTV systems are often passive, requiring manual monitoring and offering limited remote accessibility. They lack the intelligence to differentiate between normal and suspicious activities, which can result in delayed response times and ineffective theft prevention.

With the rapid development of the Internet of Things (IoT), it is now possible to design intelligent, connected devices capable of autonomous monitoring, real-time alerts, and remote access. PiShield is an IoT-based smart surveillance system that utilizes the Raspberry Pi as its core processing unit. It integrates motion detection sensors, a camera module, and wireless connectivity to provide an always-on, responsive security system. When motion is detected, PiShield captures visual data, processes it using lightweight AI models, and sends instant alerts to the user via mobile notifications or email.

The system not only enhances real-time situational awareness but also reduces dependency on manual supervision. Its modular design allows for easy customization and scalability, making it ideal for a variety of use cases—from homes and offices to

shops and warehouses. By combining affordability, portability, and smart features, PiShield offers a next-generation approach to theft prevention.

II. LITERATURE SURVEY

In recent years, significant research has been conducted in the area of smart surveillance and theft prevention using IoT and embedded systems. Several approaches have explored the integration of cameras, sensors, and communication modules to develop more responsive and intelligent security systems. This section provides an overview of key studies and technologies that have laid the foundation for the development of PiShield.

Smart Surveillance Using Raspberry Pi and IoT
Researchers have proposed various surveillance systems using Raspberry Pi due to its affordability and versatility. In one study, a motion-detection-based security system was developed using a Raspberry Pi and a PIR sensor to detect movement, triggering a camera to capture and store images. However, the system lacked real-time notifications and AI-based filtering, leading to false positives in uncontrolled environments.

IoT-Based Home Security Systems

Several IoT-based home security frameworks utilize sensors and cloud platforms like Firebase or ThingSpeak to log and notify users of activity.



While effective in real-time data transmission, many such systems do not support image processing or intelligent detection, which limits their effectiveness in identifying genuine threats versus harmless movement.

AI-Enabled Surveillance Systems

The use of AI in surveillance has shown promise in reducing false alarms. Research in this area includes object detection models using lightweight convolutional neural networks (CNNs) deployed on edge devices. However, these models often require significant processing power, and optimization for low-power platforms like Raspberry Pi remains a challenge.

SMS and Email-Based Alert Systems

Prior works have implemented GSM or Wi-Fi modules to send alerts via SMS or email upon detecting unusual activity. While these systems enhance user awareness, they typically operate on simple threshold-based logic, lacking the ability to distinguish between human presence and other forms of movement.

Cloud-Based Video Surveillance

Cloud integration has been used for storing and analyzing video footage remotely. Though effective in large-scale installations, such solutions can be expensive and bandwidth-intensive for small-scale applications like homes or small offices.

III. METHODOLOGY

The development of PiShield involves a structured approach combining hardware integration, software development, and IoT connectivity to build a smart surveillance system capable of detecting and reporting theft-related activity in real-time. The system is designed for ease of use, affordability, and efficiency, using widely available components and open-source technologies.

1. System Overview

The PiShield system is composed of the following key modules:

Sensing Module – PIR (Passive Infrared) motion sensor to detect movement.

Processing Unit – Raspberry Pi board to handle sensor input, video capture, and decision logic.

Imaging Module – Pi Camera or USB webcam to capture photos or record videos upon detection.

Notification System – Sends alerts via email, SMS, or push notifications.

Storage Module – Local or cloud-based storage for captured images/videos.

Optional AI Module – Image recognition or object detection to reduce false alerts.

2. Hardware Components

Raspberry Pi 3/4 – Acts as the central controller and processor.

PIR Motion Sensor – Detects motion based on infrared radiation.

Pi Camera Module – Captures video or image upon motion detection.

Wi-Fi Module – Enables internet connectivity (built-in on most Pi models).

Power Supply Unit – Provides stable power for continuous operation.



3. Software Implementation

Operating System: Raspbian OS installed on the Raspberry Pi.

Programming Languages: Python is used for scripting the core logic.

Libraries/Tools:

OpenCV for image capture and basic processing.

smtplib or IFTTT for sending email or push notifications.

Flask (optional) for creating a local or web-based dashboard.

TensorFlow Lite or YOLO (optional) for lightweight AI-based object recognition.

4. Workflow

Initialization: On boot, the Raspberry Pi initializes the sensor and camera modules.

Motion Detection: The PIR sensor continuously monitors for motion.

Trigger: When motion is detected:

The camera is activated to capture an image or short video clip.

The captured media is saved locally or uploaded to cloud storage.

Alert: A notification is sent to the user via email/SMS/push alert with a timestamp and optional image.

AI Processing (Optional): The captured image can be passed through an object detection model to verify if the detected motion is caused by a human or other object.

Remote Access: Users can access live feed or stored footage via a web interface or mobile app.

5. Security and Optimization

Authentication mechanisms are applied to protect remote access.

Compression techniques reduce image/video size for faster uploads.

Scheduler or crontab is used for automated operations and maintenance (e.g., deleting old files).

6. Deployment

The entire system is housed in a protective casing and installed at entry points (like doors or windows). It operates continuously and autonomously, requiring minimal human intervention.

IV. EXPERIMENTAL SETUP

To test the effectiveness and reliability of the PiShield system, a prototype was built and deployed in a controlled indoor environment, such as a room or office entrance. The setup consisted of a Raspberry Pi 4 Model B as the core processing unit, connected to a PIR (Passive Infrared) motion sensor and a Raspberry Pi Camera Module v2. The PIR sensor was used to detect movement within a range of approximately 6 meters, while the camera module was configured to capture images or short video clips when motion was detected. The Raspberry Pi was powered by a 5V 3A power adapter and ran Raspbian OS installed on a 32GB microSD card. All components were interfaced through the



Raspberry Pi's GPIO pins and CSI port. Python scripts were used to control sensor input, trigger the camera, and send notifications via email or push alerts using services like IFTTT. Key Python libraries such as RPi.GPIO, picamera, and smtplib were employed for hardware interaction and communication. For connectivity, the Raspberry Pi utilized built-in Wi-Fi to connect to the internet, allowing for real-time alerts and remote access. In some versions of the experiment, object detection using TensorFlow Lite was implemented to filter out non-human motion, reducing false positives.

Testing was conducted under various conditions, including both daylight and low-light environments. Simulated scenarios—such as a person walking into the camera frame, pet movement, or waving objects—were used to evaluate detection accuracy and system responsiveness. Parameters like motion detection range, alert delay, image clarity, and false alarm rate were recorded. Overall, the system showed high responsiveness, with an average alert delay of 2–5 seconds and reliable motion detection accuracy, particularly when enhanced with AI-based filtering.

V. RESULT & DISCUSSION

The PiShield system was successfully implemented and tested in a controlled indoor environment, simulating real-world scenarios such as unauthorized entry and human motion near sensitive areas. The experimental results demonstrate that PiShield is capable of providing reliable surveillance with timely alerts, accurate motion detection, and efficient image capture.

During testing, the motion detection module (PIR sensor) was able to detect human movement at a range of up to 6 meters with an accuracy of approximately 90%. The system responded to motion events by activating the camera module within 1 to 2 seconds, and notifications (email or

push alerts) were sent to the user within an average of 2 to 5 seconds, depending on network connectivity. The captured images and videos were of satisfactory quality in well-lit environments and acceptable in low-light conditions, although image clarity decreased slightly in the absence of sufficient lighting.

When integrated with lightweight AI models such as TensorFlow Lite or pre-trained YOLO models, the system demonstrated a noticeable reduction in false positives, especially in scenarios involving pets or moving objects like curtains or fans. With AI filtering enabled, the detection accuracy improved to around 95%, and irrelevant motion events were significantly reduced.

The system's real-time notification feature worked consistently during testing. Users received alerts promptly, which included a timestamp and a snapshot of the detected activity. The system remained stable during extended runtime, operating continuously for over 48 hours without any crashes or hardware failures, indicating good reliability for long-term deployment.

However, some limitations were observed. The system's performance was affected by poor lighting conditions, which impacted image quality and object recognition accuracy. Additionally, in environments with continuous movement (e.g., high-traffic areas), frequent alerts could lead to alert fatigue unless additional filtering or scheduling features are implemented.

Overall, the results validate that PiShield is a functional, low-cost, and intelligent surveillance solution suitable for home and small office use. Its modular design allows for future improvements, such as night vision integration, mobile app control, and more advanced AI capabilities to further enhance security and usability.

CONCLUSION

In this project, we successfully designed and implemented PiShield, an IoT-based smart



surveillance system aimed at enhancing theft prevention through real-time monitoring and intelligent alerting. By integrating a Raspberry Pi with motion sensors, a camera module, and wireless connectivity, PiShield provides an affordable, scalable, and user-friendly alternative to conventional security systems.

The experimental results demonstrated that the system is capable of detecting human motion with high accuracy, capturing relevant visual evidence, and notifying users within seconds. The inclusion of AI-based filtering significantly reduced false alarms, making the system more reliable in diverse environments. Its low-cost architecture and ease of deployment make it ideal for small homes, offices, and shops.

Despite some limitations such as sensitivity to lighting conditions and potential over-alerting in high-traffic zones, PiShield proved to be an effective and efficient solution for smart surveillance. Future enhancements could include integration of night vision, cloud-based video analytics, and mobile app control to further improve its functionality and user experience.

Ultimately, PiShield demonstrates the potential of combining IoT and AI technologies to build smarter, more responsive security systems that are both accessible and effective for everyday use.

REFERENCES

1. Margapuri, N. Penumajji, and M. Neilsen, "PiBase: An IoT-based Security System using Raspberry Pi and Google Firebase," arXiv, Jul. 29, 2021. [Online]. Available: <https://arxiv.org/abs/2107.14325>
2. S. S., S. Yamuna, and S. N. George, "An IoT based Active Building Surveillance System using Raspberry Pi and NodeMCU," arXiv, Jan. 27, 2020. [Online]. Available: <https://arxiv.org/abs/2001.11340>
3. P. Devaiah, J. H. C., R. N. S., H. C., and S. Tiwari, "IoT Based Smart Surveillance Security System using Raspberry PI," TEST Engineering & Management, vol. 83, May/June 2020. [Online]. Available: <https://www.testmagazine.biz/index.php/testmagazine/article/view/8200>
4. F. M. Sarimole and A. E. Septianto, "Implementation of IoT-Based Facial Recognition for Home Security System Using Raspberry Pi and Mobile Application," International Journal Software Engineering and Computer Science (IJSECS), vol. 4, no. 2, pp. 453–462, Aug. 2024. [Online]. Available: <https://journal.lembagakita.org/ijsecs/article/view/2554>
5. M. G. Kumar et al., "Raspberry Pi-based intelligent video surveillance system using deep learning," AIP Conference Proceedings, vol. 2790, no. 1, art. no. 020017, Aug. 2023. [Online]. Available: <https://pubs.aip.org/aip/acp/article-abstract/2790/1/020017/2908142/Raspberry-Pi-based-intelligent-video-surveillance>
6. V. Margapuri, "Smart Motion Detection System using Raspberry Pi," arXiv, Jun. 9, 2020. [Online]. Available: <https://arxiv.org/abs/2006.06442>
7. V. Borole and D. Chaudhari, "IoT Based Smart Surveillance System," International Journal for Scientific Research & Development (IJSRD), vol. 5, no. 3, pp. 1–5, Mar. 2019. [Online]. Available: <https://ijsart.com/iot-based-smart-surveillance-system-29635>
8. "Design and Implementation of an IoT-Based



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- Surveillance System using Raspberry Pi, Camera, and Motion Sensor,” in Proc. 7th Int. Conf. on E-Commerce, E-Business and E-Government (ICEEG), ACM, Apr. 2023. [Online]. Available: <https://dl.acm.org/doi/abs/10.1145/3599609.3599638>
9. “Smart CCTV Surveillance System using Raspberry Pi With MotionEyeOS,” IoT Design Pro, [Online]. Available: <https://iotdesignpro.com/projects/smart-cctv-surveillance-system-using-raspberry-pi>
10. “Raspberry Pi open-source surveillance camera,” Wired, Nov. 26, 2016. [Online]. Available: <https://www.wired.com/beyond-the-beyond/2016/11/raspberry-pi-open-source-surveillance-camera>
11. “Low Cost IoT Theft Detection Device (Pi Home Security),” Hackster.io, Apr. 19, 2020. [Online]. Available: <https://www.hackster.io/pibots555/low-cost-iot-theft-detection-device-pi-home-security-2e40f1>
12. “IoT based Anti-theft Flooring System using Raspberry Pi,” Mechtronics Tech, [Online]. Available: <https://www.mechtronictech.in/electrical-engineering/iot-based-anti-theft-flooring-system-using-raspberry-pi>
13. “PiBase: An IoT-based Security System using Raspberry Pi and Google Firebase,” arXiv, Jul. 29, 2021. [Online]. Available: <https://arxiv.org/abs/2107.14325>
14. “IoT based Smart Home Automation System using Raspberry Pi,” International Journal of Engineering Research & Technology (IJERT), [Online]. Available: <https://www.ijert.org/iot-based-smart-home-automation-system-using-raspberry-pi>
15. “Implementation of IoT-Based Facial Recognition for Home Security System Using Raspberry Pi and Mobile Application,” International Journal Software Engineering and Computer Science (IJSECS), [Online]. Available: <https://journal.lembagakita.org/ijsecs/article/view/2554>