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Integration of Artificial Intelligence in IoT for Suspicious Activity Detection

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Abstract
The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) offers novel opportunities in the domain of automated surveillance and anomaly detection. As IoT networks continue to proliferate in smart environments, ensuring security and detecting suspicious activities become critical challenges. This paper explores the integration of AI-driven analytics into IoT ecosystems to enable real-time suspicious activity detection. We propose a framework that utilizes sensor fusion, edge intelligence, and machine learning algorithms for real-time anomaly detection in smart environments. The proposed system reduces response time, enhances detection accuracy, and minimizes false alarms, while preserving user privacy. This study also discusses implementation challenges, use cases, and future research directions.

1. Introduction

The exponential growth in IoT deployment in recent years has led to smart homes, cities, industrial systems, and healthcare infrastructures being embedded with sensors and connected devices. While these technologies improve efficiency, they also expose the infrastructure to a wide range of security threats, including unauthorized access, cyberattacks, and physical intrusions. Traditional rule-based systems fall short in managing dynamic and high-volume data generated by IoT networks.

Artificial Intelligence (AI), particularly machine learning and deep learning, offers promising tools to detect deviations from normal behavior, enabling real-time identification of suspicious or anomalous activities. Integrating AI into IoT networks provides intelligence at the edge, enhancing surveillance capabilities while optimizing network resources.

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2. Literature Review

Early efforts focused on static rule-based approaches for anomaly detection in networks (Denning, 1987). Later studies introduced statistical and machine learning-based anomaly detection in IoT.

- Lee & Stolfo (1998) pioneered data mining approaches for intrusion detection using system call data.
- Roman, Najera, and Lopez (2011) discussed security challenges in IoT and advocated for intelligent mechanisms.
- Zhang et al. (2010) presented a context-aware sensor fusion framework for abnormal event detection.
- Patel et al. (2012) reviewed the application of AI in healthcare IoT for activity monitoring.
- Ahmad et al. (2016) proposed edge analytics for smart surveillance using computer vision.

These studies laid the foundation for integrating AI-based detection systems in real-time IoT environments.

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3. System Architecture and Methodology

3.1 System Components

- IoT Devices: Cameras, PIR sensors, RFID tags, acoustic sensors
- Edge Processing Unit: Raspberry Pi/Jetson Nano for local inference
- AI Models: Trained neural networks for behavior classification
- Cloud Layer: Centralized storage, dashboards, retraining models

3.2 Data Pipeline

- Data Collection: Multimodal sensor inputs (video, motion, audio)
- Preprocessing: Data cleaning, normalization
- Feature Extraction: Time, location, frequency of events, object classification
- Model Training: SVM, Random Forest, CNNs for classification tasks
- Anomaly Detection: Use of Autoencoders and One-Class SVMs

3.3 Edge AI Processing

To ensure latency-sensitive detection, inference is done at the edge using lightweight AI models. This enables real-time alerts without uploading data to the cloud.

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4. Proposed Model: SmartDetect-AI

We propose SmartDetect-AI, a modular architecture comprising:

- Behavior profiling using recurrent neural networks (RNNs)
- Suspicion score computation using contextual anomaly detection
- Alert generation via MQTT or SMS gateway
- Adaptive threshold tuning to reduce false alarms

SmartDetect-AI is deployed in a smart campus prototype using OpenCV for video processing and TensorFlow Lite for edge inference.

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5. Applications

- Smart Homes: Detecting unauthorized access or irregular activity patterns
- Smart Cities: Crowd behavior monitoring in public spaces
- Industrial IoT: Monitoring of restricted zones or hazardous conditions
- Healthcare: Identifying falls or abnormal movement in elderly patients

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6. Challenges

- Data Imbalance: Suspicious activities are rare events, affecting classifier accuracy.
- Privacy: Need for data encryption and anonymization.
- Energy Efficiency: AI inference must run on low-power devices.
- Scalability: Coordinating thousands of sensors in distributed environments.

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7. Future Directions

- Federated Learning for decentralized model training
- Integration with blockchain for audit logging
- Use of Graph Neural Networks (GNNs) for relationship modeling
- Development of explainable AI models for transparency

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8. Conclusion

Integrating AI with IoT systems transforms traditional surveillance into intelligent, autonomous monitoring systems. The proposed SmartDetect-AI architecture demonstrates how AI-powered IoT can detect suspicious activity in real-time with high accuracy and low latency. Despite challenges, the convergence of edge computing, sensor fusion, and machine learning marks a significant advancement in security-focused IoT applications.

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