Automated Crime Detection and Alert System using Embedded Deep Learning

Mr. Chandrashekar.B.M
Assistant Professor, Department of Electronics and Communication Engineering
Jyothy Institute of Technology
Bangalore,India
chandra.shekar@jyothyit.ac.in

Aditya Gadiyar
Department of Electronics and Communication Engineering Jyothy Institute of Technology
Bangalore,India
adityagadiyar855@gmail.com

Dileep Nayaka T
Department of Electronics and Communication Engineering Jyothy Institute of Technology
Bangalore,India
dileeppalegara10@gmail.com

Harish V
Department of Electronics and Communication Engineering Jyothy Institute of Technology
Bangalore,India
hharish62690@gmail.com

I. ABSTRACT

In recent years, cc-tv cameras are used in various locations. The data captured by these cameras can be used for event prediction, real-time monitoring, and goal-oriented analysis, including anomaly and intrusion detection. With advancements in Artificial Intelligence, several methods are applied for anomaly detection, in which convolutional neural networks (CNNs) powered by deep-learning have
improved detection accuracy. This article aims to introduce a novel deep learning- based approach for crime detection in video surveillance footage. this method has been tested on the UCSD dataset and has demonstrated improved accuracy in detecting criminal activities. Nowadays, various Artificial Intelligence techniques have been used to detect anomalies, amongst them convolutional neural networks using deep learning techniques improved the detection accuracy significantly. The goal of this article is
to propose a new method based on deep learning techniques for Crime detection in video surveillance cameras. The proposed method has been evaluated in the UCSD dataset, and showed an increase in the accuracy of the Crime detection.

II. KEYWORDS

A. Automated crime Detection

This refers to the use of intelligent systems to automatically identify criminal or abnormal activities without continuous human monitoring. In the proposed system, crime detection is performed by analysing surveillance video streams and identifying deviations from normal behaviour patterns. Automation reduces human workload and enables faster response in critical situations.

B. Video Surveillance System

A video surveillance system consists of CCTV or camera-based monitoring infrastructure used to observe public or private spaces. In this project, surveillance footage acts as the primary data source for detecting suspicious activities. The system processes live or recorded video feeds to enhance security and situational awareness.

C. Deep Embedded Learning

Deep embedded learning combines deep learning models with embedded hardware platforms to enable intelligent processing at the edge. In this project, deep learning algorithms are deployed on an embedded system, allowing real-time crime detection with reduced latency and lower dependence on cloud resources.

D. Convolutional Neural Networks (CNNs)

CNNs are deep learning models widely used for image and video analysis. They automatically extract spatial features such as human posture, motion patterns, and object interactions from video frames. In the proposed system, CNNs improve detection accuracy by learning complex visual representations associated with criminal activities.

F. Anomaly Detection

Anomaly detection is the process of identifying patterns that deviate from normal behavior. In surveillance applications, crimes are treated as anomalies because they occur infrequently compared to regular activities. The system learns normal scene behavior and flags unusual events such as violence, intrusion, or suspicious motion.

G. Embedded System

An embedded system is a dedicated computing unit designed to perform specific tasks efficiently. In this project, the embedded platform integrates sensors, processing units, and communication modules to execute crime detection algorithms in real time, making the system suitable for on-site deployment.

H. Real-time processing

All the processing happens instantly as the robot moves. Real-time processing ensures that video frames are analyzed instantly as they are captured. This capability is essential for crime detection systems where delayed responses can reduce effectiveness. The proposed model processes surveillance data continuously to generate immediate alerts when abnormal activity is detected.

I. Feature Extraction

Feature extraction involves identifying important visual patterns from raw video data. Deep learning models automatically extract high-level spatial and temporal features such as motion intensity, crowd behavior, and object interactions, which are crucial for distinguishing normal and criminal activities.

J. Alert and Notification System

The alert system is responsible for informing authorities or security personnel when a crime is detected. In the proposed

system, alerts are generated automatically and transmitted using communication modules such as GSM or network-based messaging, enabling quick intervention.

K. GSM-Based Communication

GSM communication enables the system to send alerts and location information through SMS or mobile networks. This ensures reliable notification even in areas with limited internet connectivity, making the system practical for real-world security applications.

L. Smart Surveillance

Smart surveillance refers to intelligent monitoring systems that use AI and machine learning to analyze video data automatically. Unlike traditional surveillance, smart systems reduce manual monitoring and improve detection accuracy by learning behavioral patterns.

M. Edge Computing

Edge computing processes data near the source rather than sending it to centralized servers. In this project, crime detection is performed directly on the embedded device, reducing latency, improving privacy, and lowering bandwidth usage.

III. STATEMENT OF ORIGINALITY

We hereby declare that the project titled **"Automated Crime detection and alert system using Embedded deep learning"** is our original work carried out under the guidance of our project supervisor. This project has not been submitted to any other institution for any academic award. All sources of information used have been properly acknowledged. The work presented in this project is the result of our own efforts and learning. We take full responsibility for the authenticity of this work.

IV. INTRODUCTION

The rapid growth of **Artificial Intelligence (AI)** has changed the way machines work today Crime scene detection with the use of unsupervised machine learning techniques is still an open debate in the field of machine learning. Crime means the occurrence of events or actions which are unusual, irregular, unexpected and unpredictable and thus different from existing patterns. Detecting anomalies by learning from normal data can have important and different applications. And also, a Crime detection process is completely

dependent on the environment, context and Crime scenario. In different scenarios, anomalies will accordingly be different. Existing supervised methods for Crime detection such as simple CNN based methods require labels which are, difficult to attain due to the video high dimension information. High dimension of video affects representation and creation of a model. In this paper, Crime detection is based on videos of surveillance cameras. It should be noted that detection in videos is more difficult than in other data since it involves detection methods and also requires video processing as well.

This proposed model introduces a Crime detection method based on deep learning techniques. The architecture of this method has two main phases which are called train network and detection classifier. The first phase aims for feature extraction and is consisted of five components with a deep structure. The aim of the second phase is detection. This phase is consisted of five deep neural network classifiers and reconstruction network. Each component in detection phase produces a detected class and a score. At last, by these detection classes and scores, the ensemble classifier performs the final detection and announces it. The main contribution of this proposed model is the use of deep learning techniques in all phases of Crime detection.

V. METHODOLOGY

A. Video Surveillance System

The surveillance system consists of fixed cameras installed in monitored areas to capture live video streams. These video feeds act as the primary input to the system. Frames are extracted from the video stream at regular intervals and forwarded to the processing module. The system supports both real-time and recorded footage analysis to ensure flexibility in deployment.

B. Deep Embedded Learning

Deep embedded learning is implemented by deploying trained deep learning models directly on an embedded processing unit. The deep learning model performs inference locally on the device, eliminating the need for cloud-based computation. This approach reduces latency, enhances privacy, and ensures continuous operation even with limited network connectivity.

C. Convolutional Neural Networks (CNNs)

CNNs are used as the core feature extraction model. Each video frame is passed through multiple convolutional and pooling layers to extract spatial features such as human posture, motion intensity, and object interaction. These learned features enable the system to distinguish between normal behavior and suspicious activities with high accuracy.

D. Anomaly Detection

Anomaly detection is performed by training the model primarily on normal behaviour patterns. During operation, the system compares incoming video features with learned normal patterns. Activities producing high reconstruction error or classification scores beyond a predefined threshold are identified as anomalous, indicating potential criminal activity.

E. Embedded System

The embedded system acts as the central control unit integrating video processing, deep learning inference, and alert generation. It manages data acquisition from cameras, executes detection algorithms, and coordinates communication with alert modules. The embedded setup ensures compact design, low power consumption, and real-time performance.

F. Feature Extraction

Feature extraction is automatically handled by the deep learning model. Instead of manually defining features, the CNN learns discriminative features directly from raw video frames. These features represent motion patterns, object presence, and behavioral cues essential for accurate crime detection.

G. Alert and Notification System

Once a crime or anomaly is detected, the system triggers an alert mechanism. Alerts include the type of activity detected and the time of occurrence. This information is forwarded to authorized personnel, enabling quick situational awareness and action.

H. Real-time processing

The system processes video frames sequentially with minimal delay. Each frame undergoes preprocessing, feature extraction, and classification within milliseconds. This real-time pipeline ensures immediate detection of suspicious activities, enabling rapid alert generation and timely response by authorities.

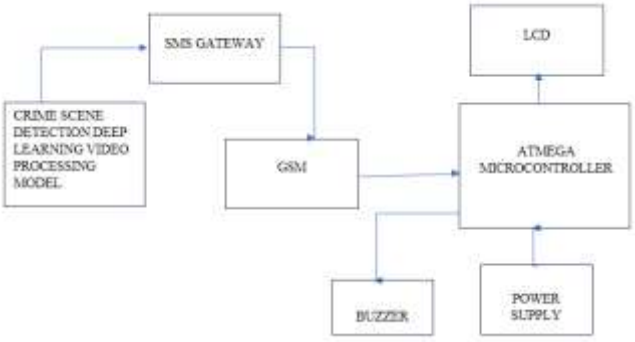
I. GSM-Based Communication

GSM communication is used to transmit alert messages to law enforcement or security personnel. The system sends SMS notifications containing alert details and location information. GSM ensures reliable communication even in areas with limited internet access.

J. Smart surveillance

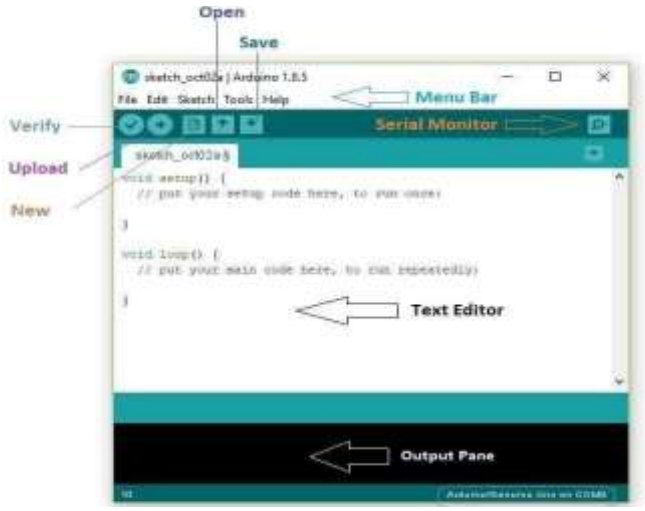
The proposed system follows a smart surveillance approach by integrating artificial intelligence with conventional CCTV infrastructure. Instead of passive monitoring, the system actively analyzes scenes, interprets behavior, and autonomously reports threats, significantly enhancing surveillance efficiency.

VI. BLOCK DIAGRAM

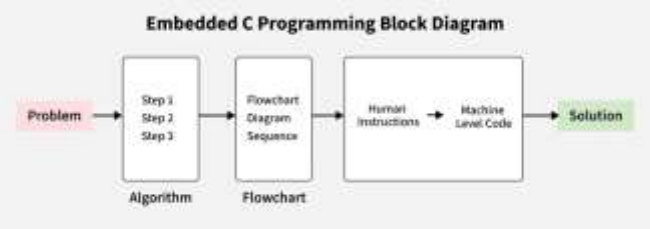


VII. SOFTWARE USED

1.Arduino IDE



2.Embedded c



3.python programming

VIII. ADVANTAGES

1.Automated and continuous Monitoring
The proposed system enables fully automated monitoring of surveillance environments without the need for continuous human supervision. By analysing video streams in real time, it ensures uninterrupted crime detection and reduces dependency on manual surveillance, which is prone to fatigue and errors.

2.Improved Detection and Accuracy
The use of deep embedded learning and convolutional neural networks significantly enhances detection accuracy. The system learns complex spatial and behavioural patterns from video data, allowing it to distinguish between normal activities and criminal behaviour more effectively than traditional rule-based surveillance systems.

3. Real-Time Crime Detection and Alerting
The system processes video frames in real time and generates instant alerts when suspicious activities are detected. This rapid response capability enables timely intervention by law enforcement agencies, thereby reducing potential damage and improving public safety.

4.ReducedFalse-AlarmRate
By training the model primarily on normal behaviour patterns and using anomaly detection techniques, the system minimizes false positives. This ensures that alerts are generated only for genuinely suspicious activities, improving the reliability and trustworthiness of the surveillance system.

5.Embedded and Edge-Based Processing
Since the detection model is deployed on an embedded platform, all processing is performed at the edge. This reduces latency, lowers bandwidth requirements, and eliminates the need to transmit large volumes of video data

to centralized servers, making the system efficient and scalable.

6.Low-OperationalCost

The proposed system utilizes commonly available hardware components and embedded platforms, making it cost-effective compared to traditional high-end surveillance solutions. Its low power consumption and minimal infrastructure requirements further reduce operational expenses.

7.Enhanced Privacy and Data Security

By processing video data locally on the embedded device, the system reduces exposure of sensitive surveillance data over networks. This edge-based approach improves data privacy and minimizes the risk of unauthorized access or data breaches.

8.Reliable Alert Communication

The integration of GSM-based communication ensures reliable alert delivery even in areas with limited or no internet connectivity. This makes the system suitable for deployment in remote and semi-urban locations where network infrastructure may be weak.

9.Scalability and Flexibility

The modular design of the system allows easy expansion by adding more cameras, upgrading the deep learning model, or integrating additional sensors. This scalability makes the system adaptable to different environments such as campuses, public spaces, and transportation hubs.

10.Support for Public Safety Applications

The proposed system contributes significantly to public safety by enabling early detection of crimes and abnormal activities. Its intelligent monitoring capability assists law enforcement agencies in preventive policing and faster decision-making.

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IX. APPLICATIONS

1.Industrial Applications

The self-driving bot can be used in **factories and warehouses** to transport materials and goods from one location to another without human effort. It can assist in **automated material handling**, reducing manual labor and increasing efficiency. With further upgrades, it can also be used in **assembly lines and inventory movement systems**.

2. Healthcare Applications

In hospitals, this type of autonomous bot can be used for **medicine delivery, file transport, and food distribution** to patients. It helps reduce the workload on hospital staff and limits human contact, which is especially useful in **infectious or risky environments**.

3. Surveillance and Security Applications

The bot can be used for **smart surveillance and security patrolling** in areas like offices, colleges, malls, and restricted zones. With a camera and object detection system, it can detect unusual movement and help monitor sensitive locations without continuous human supervision.

4. Educational and Research Applications

This project serves as an excellent **learning platform for students and researchers** in the fields of robotics, AI, and embedded systems. It can be used in **robotics labs, workshops, and research projects** to understand autonomous navigation, object detection, and real-time control systems.

5. Agricultural Applications

The bot can be used in **smart farming** for crop monitoring, pest detection, and field inspection. With future upgrades, it can help in **soil inspection, irrigation monitoring, and greenhouse automation**, reducing human effort in agricultural tasks.

6. Domestic and Service Applications

With improvements, the bot can be used as a **service robot** in homes or offices for tasks like item delivery, room monitoring, and basic assistance. It can also be used in **hotels, libraries, and shopping malls** for guidance and delivery services.

7. Defence and Rescue Applications

In dangerous environments such as **fire zones, disaster areas, and military regions**, the bot can be used for **search and inspection purposes**. It helps reduce human risk by entering areas that are unsafe for humans.

8. Smart City Applications

The self-driving bot can support **smart city development** through traffic monitoring, road inspection, public area surveillance, and automated service delivery, making urban systems more intelligent and efficient.

X. SUMMARY

The rapid growth of urbanization and public infrastructure has significantly increased the demand for intelligent surveillance systems capable of ensuring public safety. Traditional video surveillance systems rely heavily on manual monitoring, which is inefficient, error-prone, and unable to respond promptly to critical situations. To address these limitations, this project presents an **Automated Crime Detection and Alert System using Deep Embedded Learning**, designed to identify abnormal and criminal activities in real time from surveillance video streams.

The proposed system integrates deep learning techniques with embedded hardware to enable intelligent video analysis at the edge. Surveillance video feeds are continuously captured and processed using convolutional neural networks to extract meaningful spatial and behavioural features. By learning normal activity patterns, the system effectively detects anomalies that may correspond to criminal behaviour such as intrusion, violence, or suspicious motion. This approach reduces reliance on labelled datasets and minimizes false alarms compared to conventional rule-based systems.

A key contribution of the project is the deployment of the deep learning model on an embedded platform, enabling real-time processing with low latency and reduced bandwidth requirements. The edge-based architecture enhances system efficiency, improves data privacy, and ensures reliable operation even in environments with limited network connectivity. Upon detection of suspicious activity, the system automatically generates alerts and communicates them to authorized personnel using GSM-based messaging, allowing rapid response and timely intervention.

Experimental evaluation demonstrates that the proposed system achieves improved detection accuracy and robustness in comparison with traditional surveillance approaches. The system is cost-effective, scalable, and suitable for deployment,

In addition to technical knowledge, the project helped develop important skills such as **problem-solving, teamwork, and project planning**. Challenges related to image processing, motor response, and real-time decision-making were addressed through continuous testing and improvements. This project not only strengthens the understanding of autonomous systems but also prepares students for future work in fields like **robotics, AI, automation, and embedded system design**. Overall, the project serves as a strong stepping stone toward advanced research and real-world robotic applications.

XI. FUTHER WORKS

Although the proposed automated crime detection and alert system demonstrate's effective performance in identifying abnormal activities from surveillance video, there are several directions in which the system can be further enhanced to improve accuracy, scalability, and real-world applicability.

In future work, the detection model can be strengthened by integrating advanced deep learning architectures such as transformer-based networks or hybrid CNN–LSTM models. These models can better capture long-term temporal dependencies in video sequences, thereby improving the recognition of complex and evolving criminal behaviors.

The object detection system can be enhanced using **advanced deep learning algorithms** such as YOLO, SSD, or Mobile Net. With these models, the robot will be able to recognize and classify objects like humans, vehicles, and furniture instead of only detecting obstacles. This will make the robot smarter and useful for applications such as smart surveillance and service robots.

The system can also be extended to support multi-camera environments. By enabling camera-to-camera coordination and multi-view analysis, the system can track suspicious activities across larger areas and reduce blind spots commonly present in single-camera surveillance setups.

Another important enhancement involves incorporating additional sensors such as infrared, thermal, or acoustic sensors. Multi-modal data fusion can improve detection reliability in challenging conditions such as low lighting, fog, or crowded environments where visual information alone may be insufficient

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