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Review IJSCT

Intelligence Video Surveillance Using Deep Learning

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Abstract

Intelligent video surveillance powered by deep learning represents a transformative paradigm in security and surveillance. This new approach uses the power of complex neural networks to revolutionize the analysis and management of video data. Through the seamless incorporation of deep learning technologies like convolutional neural networks (CNN) and recurrent neural networks (RNN) into observation systems, automated identification, tracking, and classification of objects can be accomplished, alleviating storage constraints on the inspection notebook. Technology is good at detecting anomalies, identifying unusual behavior or events, and even identifying people based on facial recognition. The result is a good method for security because it can alert authorities or security personnel to threats or crimes. Additionally, optimization provides rich data-driven insights that aid decision-making beyond security, such as improving customer sales or improving business processes. Currently, big data holds much of its importance and place in business and science. Video analysis is important for smoothing large data files. The main purpose of this article is to provide a brief overview of technology analysis activities. Our main goal is to use deep learning techniques to recognize regular activities in large groups of people, participants, and all kinds of needs. This video analysis can help us ensure security. Security, theft detection, brute force detection, etc. It can mean many things like. Human activity research is simply the process of investigating unusual (unusual) human activities. To do this, we must convert the video into frames; Making these frames helps us identify people and their activities. The system comprises two modules: one for product search and another for operation search. The object detection module detects whether an object is present or not. Once an object is detected, the next module checks if the activity is unexpected.

Keywords: Intelligent video surveillance, deep learning, convolutional neural networks (CNN), recurrent neural networks (RNN), automatic identification, tracking, classification of objects, anomalies detection, video analysis, regular activities recognition, theft detection

INTRODUCTION

Intelligent video surveillance using deep learning and alarm is a technology that uses deep learning techniques to improve video monitoring ability. The system can detect possible security or medical situations and notify authorities such as police and hospitals. Transforming traditional surveillance by providing effective and intelligent surveillance that improves public safety and reduces response time.

Relevance

Intelligent video surveillance using deep learning and alerts is relevant in today's world of safety and security. Meets many important requirements:

- *Improved security:* Deep learning can detect suspicious activity, attackers, or threats, improving the overall security of public places, critical infrastructure, and private property.

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- *Rapid response:* This technology, which enables faster response to security breaches, accidents, or emergencies by immediately notifying authorities and hospitals, can save lives and reduce losses.
- *Efficiency:* Automated maintenance reduces the need for manual maintenance, allowing resources and personnel to be allocated more efficiently, while also reducing the risk of human error experience.
- *Prevention:* The nature of the system can deter criminals or offenders and have a positive impact.
- *Data analytics:* Data collected can identify patterns and trends that can help inform future public safety and policy development decisions.

Organization of Project Report

This project report aims to understand the "Intelligent Video Surveillance using Deep Learning" project. The release has several key features that provide insight into development, results, and future growth.

- *Section 1:* Literature Review In-depth examination of existing research and information on Artificial Intelligence in the field of education, positioning "smart video" in this study using deep learning for analysis.
- *Section 2:* Project Statement outlines the project's vision, goals, and principles for the AI-driven system.
- *Section 3:* Supporting Research presents experimental evidence and findings from an experiment designed to evaluate the effectiveness of "intelligent video surveillance using deep learning."
- *Section 4:* Study conducted on the success of making "Intelligence Research with Science" a reality, including technology options and challenges overcome when using the technology.
- *Section 5:* Conclusion summarizes the contributions, key findings, and future aspects of this project.
- *Section 6:* Referrals provide evidence of all sources used in the report and maintain academic standards.

LITERATURE REVIEW

Previous studies have demonstrated the efficacy of deep learning techniques in enhancing the accuracy and efficiency of video surveillance systems for intelligence gathering as shown in Table 1.

Intelligent Video Surveillance: A Review Through Deep Learning Techniques for Crowd Analysis [1]

It explores the significance of video data from CCTV cameras in the realm of big data, particularly in the context of security and surveillance. It delves into the complexities of violence detection within crowded public spaces and presents a deep-learning-based survey, focusing on methods for detecting, counting, and analyzing activities in large crowds across various weather conditions. The survey offers insights into challenges and future directions in this field.

A Systematic Review of Intelligence Video Surveillance: Trends, Techniques, Frameworks, and Datasets [2]

It presents a comprehensive review of video surveillance system research from 2010 to 2019, focusing on research trends, datasets, methods, and frameworks. It identifies 220 journal-based publications, offering insights into the state of the field, popular datasets, and network infrastructure advancements. The paper concludes by highlighting opportunities and challenges in video surveillance system research.

Intelligent Video Surveillance System Using Deep Learning [3]

This paper reviews the emerging field of abnormal activity recognition, especially in contexts like eldercare and healthcare. It explores motivations, existing approaches, and automatic learning modes (supervised, unsupervised, semi-supervised). The study identifies limitations and proposes improvements to enhance abnormal activity recognition systems, offering valuable insights for researchers.

Improving Video Surveillance Systems in Banks Using Deep Learning Techniques [4]

Advancements in automated surveillance, driven by technological progress and intelligent video processing, aim to enhance safety in the face of rising crime rates involving handguns. Video surveillance systems, often coupled with AI, enable precise recognition of faces, object analysis, and automated alerts. Deep learning, particularly convolutional neural networks (CNN), is instrumental in object detection for security control. By integrating AI into surveillance, timely action can be taken against criminal activities involving handguns.

Design and Evaluation of a Real-time Character Recognition System [5]

This paper introduces a real-time character recognition system using Histogram of Gradient (HOG) features and a Support Vector Machine (SVM) classifier. It optimizes HOG cell size and image scaling for improved accuracy. The system achieves recognition accuracies between 91.11% and 100.0%, depending on the dataset and classifier used, with a detailed analysis of computation times.

Deep Learning Based Detection and Localization of Road Accidents from Traffic Surveillance Videos [6]

This system focuses on automating the detection and localization of road accidents in smart cities using deep learning techniques. It treats road accidents as anomalies and proposes a novel approach based on spatiotemporal autoencoders and sequence-to-sequence LSTM autoencoders. The model operates in an unsupervised manner, eliminating the need for labeled anomaly data, and shows promise in improving accident response times for safer transportation.

Abnormal Event Detection Using Deep Contrastive Learning for Intelligent Video Surveillance Systems [7]

This article introduces TAC-Net, a novel approach for anomaly detection in surveillance videos. TAC-Net employs unsupervised deep contrastive self-supervised learning with multiple self-supervised tasks to capture high-level semantic features and improve anomaly detection. Experimental results outperform existing methods on three benchmark datasets, highlighting TAC-Net's effectiveness and innovation.

Deep Learning Approach for Suspicious Activity Detection from Surveillance Video [8]

Today's video surveillance systems, enhanced by artificial intelligence, machine learning, and deep learning, are vital for distinguishing suspicious behavior in live footage. This system focuses on monitoring human behavior in academic settings, employing deep learning to detect suspicious activity and alert authorities. It analyzes consecutive video frames, extracting features for classification as suspicious or normal.

General Purpose Intelligent Surveillance System for Mobile Devices Using Deep Learning [9]

This paper presents a smartphone-based intelligent surveillance system with two key components: a detection module combining background subtraction and optical flow, and a classification module using deep learning neural networks. The system achieved remarkable performance, surpassing human recognition accuracy, and can be installed on various Android-based devices and GPU-powered platforms for efficient execution. Visual examples of the system's operation on both PC and Android devices are provided.

Deep Learning Based Object Detection Combined with the Internet of Things for Remote Surveillance [10]

It proposes a deep learning and IoT-based object detection and data transmission system for remote video surveillance. The system uses a combination of YOLO-Lite and SPP to achieve fast and accurate object detection on a non-GPU platform. The detected data is transmitted to the cloud using ThingSpeak at low transmission rates. The system is evaluated on PASCAL VOC, COCO, TB-50, and TB-100 datasets and achieves high precision and recall values. Real-time results demonstrate the efficiency and suitability of the system for remote video surveillance.

Table 1. Comparative analysis of existing system (existing papers).

S.N.	Paper ID	Methodology/techniques	Performance parameters	Research gap
1.	From Reference [1]	Deep Learning for Crowd Analysis, Crowd analysis, violence detection, real-time processing	Exact Count, Involved Persons, Activity Recognition, Real-Time Processing, and Person Identification.	Complexity of deep learning models, Real-time processing challenges, Limited methods addressing multiple challenges
2.	From Reference [3]	Deep Learning for Abnormal Activity Detection	Detection Accuracy, Efficiency, and Credibility, Abnormal activity detection in video surveillance, efficiency, and credibility	Limited existing methods, Efficiency challenges
3.	From Reference [7]	Temporal-Aware Contrastive Network (TAC-Net), Deep Contrastive Learning.	Anomaly Detection Performance, Benchmark-Comparison. Advanced anomaly detection, multiple self-supervised tasks, temporal context	Data scarcity for labeled anomalous data, model complexity.
4.	From Reference [2]	Systematic Review, Machine Learning, Identify research trends, machine learning methods, datasets	Research Trends, Machine Learning Methods, infrastructure enhancements	Ongoing challenges in motion detection, illumination changes, and tracking in complex environments
5.	From Reference [10]	Object Detection with Deep Neural Networks and IoT	Object Detection Speed, mAP, Precision, and Recall. Improved recognition accuracy, automated dataset construction, practical applications	Limited existing works, efficiency challenges, Data scarcity for labeled anomalous data, model complexity

Limitations of Existing System/Research Gap

- In the current system, the video surveillance system is designed to allow personnel to monitor the protected area or record video data for further information.
- However, watching videos is a heavy task that needs to be managed.
- It is also very difficult and time-consuming work and human observers can be blinded.

Problem Statement

Performance monitoring plays an important role in monitoring applications. Video capture is necessary to capture negative activity [11]. Our intelligent video analysis uses deep learning technology to detect anomalies in videos. Events can be detected instantly, and these snapshots are saved as system images for the user to view. Cognitive processing uses models that involve complex processes that create problems in getting rapid responses to unfamiliar tasks. The system will use efficient spatial autoencoders to detect human activities in the monitoring stream.

Objectives

The main purpose of this study focuses on the following:

- To identify inappropriate behavior or behaviors in the environment.
- This process involves identifying areas of interest and identifying specific cameras or groups of cameras that can image those areas.
- Viewing surveillance videos side by side with live surveillance provides additional information about the situation, allowing users to make better decisions about the use of modes and resources.
- Depending on the number of security cameras and their locations, viewing both live and archived footage can confirm fraud or crime in personal care, to customers or those expected to reach them. Security forces.

DESIGN AND PLANNING

Survey of Technologies

Neural Networks

Neural networks (NN) are multi-layer fully connected neural nets that look like the figure below. They consist of an input layer, multiple hidden layers, and an output layer. Every node in one layer is connected to every other node in the next layer. We make the network deeper by increasing the number of hidden layers as shown in Figure 1.

Convolutional Neural Networks

Convolutional neural networks (CNN) represent a class of deep learning models pivotal in computer vision applications, particularly in video surveillance. Here's a detailed exploration of their essential components and functionalities as shown in Figures 2 and 3:

1. *Feature extraction:* CNN are engineered to autonomously extract pertinent features from images or video frames. They employ convolutional layers, applying convolution operations to input data. These convolutions discern various features like edges, textures, shapes, and patterns within the visual content.
2. *Hierarchical representation:* CNNs embrace a hierarchical approach, with early layers learning elementary features such as edges, while deeper layers grasp more intricate features like object parts or textures. This hierarchical representation enables CNN to comprehend the visual environment across varying levels of abstraction.
3. *Pooling layers:* Alongside convolutional layers, CNN architectures frequently incorporate pooling layers (e.g., max pooling). These layers down sample feature maps, reducing computational complexity while preserving crucial information.

In the realm of video surveillance, CNN plays pivotal roles across several domains:

- *Object detection:* CNN undergoes training to detect specific objects like vehicles, individuals, or weapons within video frames. This capability aids in identifying potential threats or anomalies.
- *Face recognition:* CNN is integral to face detection and recognition tasks, facilitating systems in identifying individuals depicted in surveillance footage. This functionality finds application in law enforcement and access control scenarios.
- *Event detection:* CNN can be fine-tuned to recognize events or activities, such as a person falling or a vehicle speeding. This capability is crucial for real-time monitoring and alert generation.
- *Tracking:* CNN, when integrated with tracking algorithms, aids in tracking objects or individuals across different frames, ensuring continuous surveillance coverage.
- *Adaptability:* CNN possesses the flexibility to be fine-tuned on extensive datasets, enabling them to recognize specific objects or behaviors pertinent to the surveillance context. This adaptability renders CNNs suitable for a broad spectrum of surveillance scenarios.

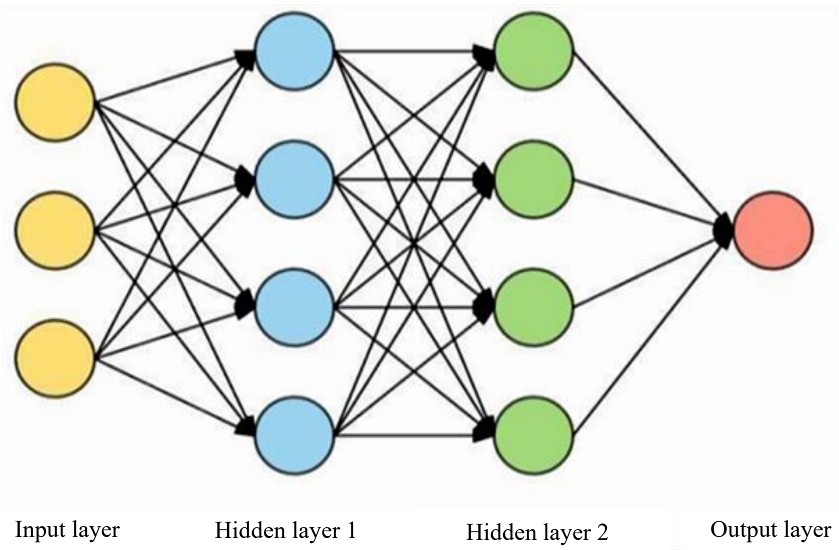

Figure 1. Neural network.

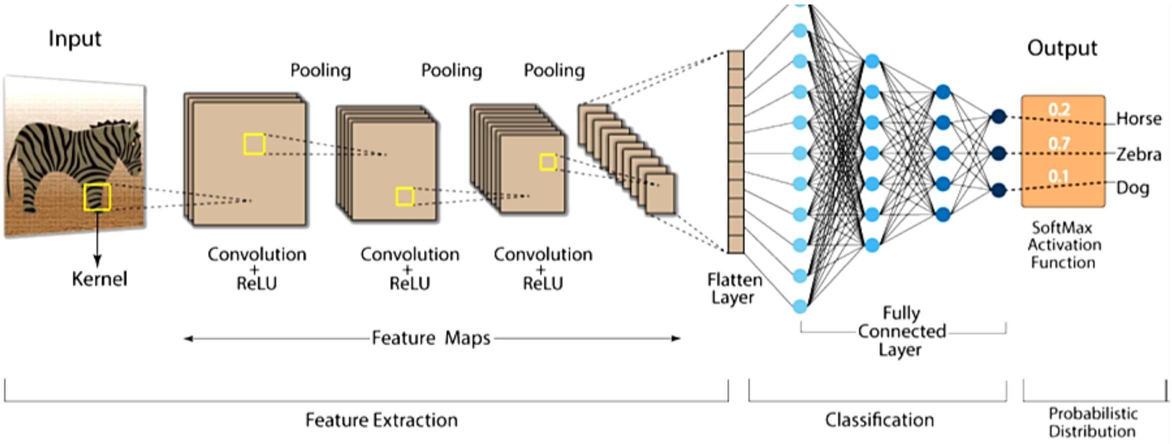

Figure 2. A general model of convolution neural network.

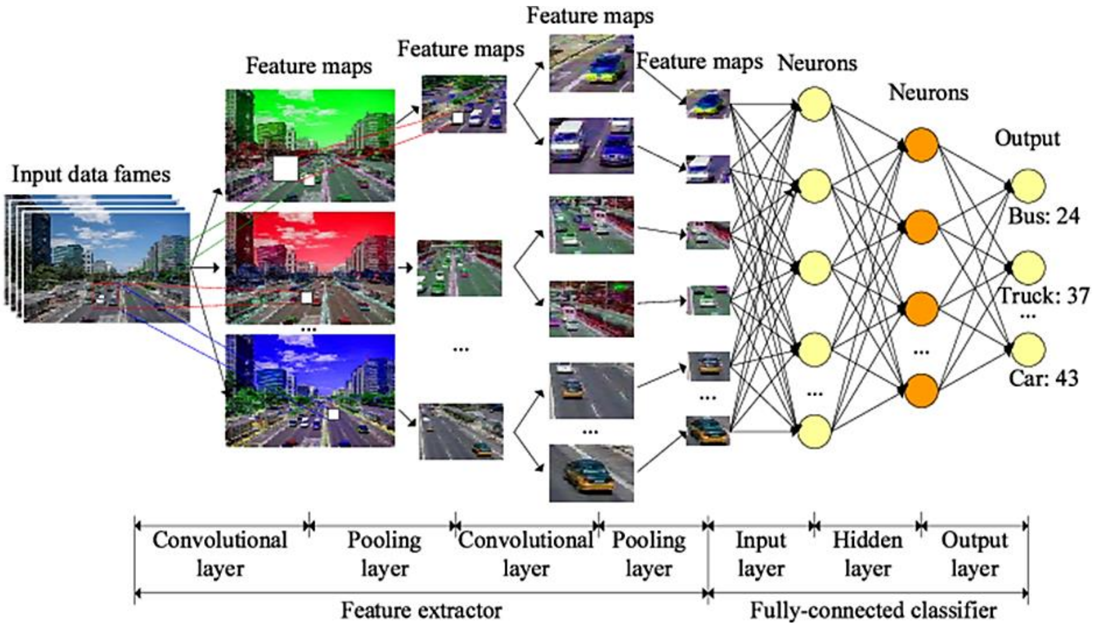

Figure 3. Convolutional neural networks model for vehicle classification.

TensorFlow

- TensorFlow is an open-source software library for dataflow and differentiable programming.
- Across a range of tasks. It was developed by the Google Brain team and used for machine learning and deep learning research.
- The library is built around a graph-based computation model, where nodes represent Mathematical operations and edges represent the data that flows between them. This enables efficient execution on both CPUs and GPUs, as well as distributed systems.

METHODOLOGY

The methodology for developing an intelligence video surveillance system using deep learning involves a structured approach encompassing various stages, from data collection to model deployment as shown in Figure 4. Here is a detailed breakdown of the methodology:

1. *Problem Definition and Requirement Analysis*
   i. Define specific objectives of the video surveillance system, such as object detection, activity recognition, or anomaly detection.
   ii. Identify environmental and operational requirements, including camera types, desired video quality, and real-time processing capabilities.

iii. Determine alerting and reporting mechanisms needed for the system.

2. *Data Collection*
   i. Gather video data from surveillance cameras, ensuring the inclusion of normal and anomaly scenarios for model training and testing.
   ii. Annotate the data to label objects, regions of interest, and events within video frames, crucial for model training.
3. Data Preprocessing:
   i. Clean and preprocess video data to remove noise, standardize formats, and enhance quality.
   ii. Extract frames from video streams and synchronize them with timestamps for analysis.
4. *Model Selection*
   i. Choose appropriate deep learning models for tasks, such as convolutional neural networks (CNNs) for object detection and recurrent neural networks (RNNs) for activity recognition.
   ii. Consider pre-trained models for transfer learning to expedite model training.
5. *Model Training*
   i. Split annotated data into training and validation sets.
   ii. Train selected deep learning models on training data, fine-tuning them for specific tasks.
   iii. Monitor model performance on the validation set, adjusting hyperparameters as necessary.
6. *Object Detection and Tracking*
   i. Implement object detection algorithms to identify and localize objects or people in video frames.
   ii. Integrate tracking algorithms (e.g., DeepSORT) for continuity when objects move across frames.
7. *Activity Recognition*
   i. Develop models for recognizing activities or events in the video, like detecting unauthorized access or unusual behavior.
   ii. Combine CNNs and RNNs for temporal analysis.

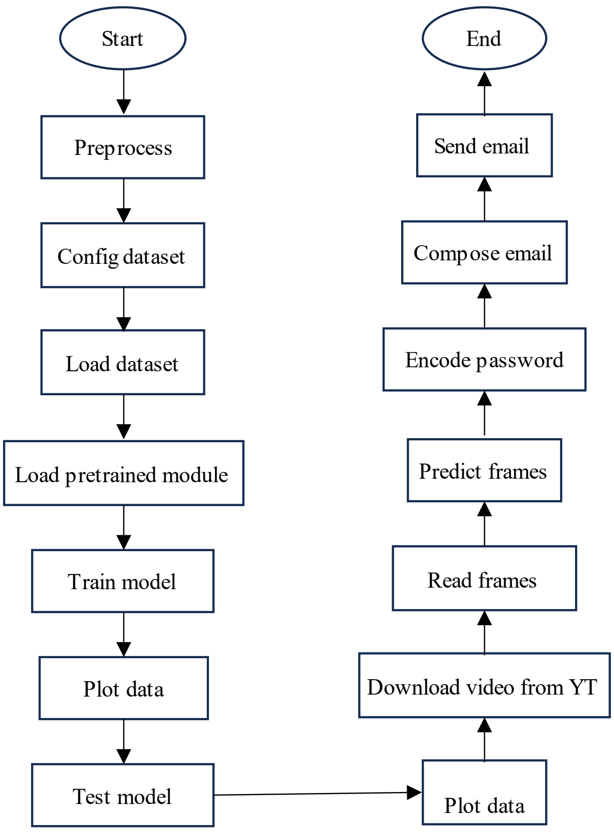

Figure 4. Flowchart of intelligence video surveillance system.

8. *Anomaly Detection*
    i. Implement anomaly detection algorithms (e.g., autoencoders, one-class SVMs) to identify unusual events or deviations from normal behavior.
9. *Real-time Processing*
    i. Establish real-time processing pipelines to analyze incoming video streams, utilizing multi-threading and GPU acceleration for performance.
10. *Alert Generation and Notification*
    i. Generate alerts with relevant information when anomalies or security breaches are detected.
    ii. Notify appropriate personnel or systems in real-time.

EXPERIMENTAL SETUP

Details of Database

The database and input data for the Intelligence Video Surveillance System are critical components to ensure the accuracy and efficiency of the mapping process. Here are some details about these components:

Database

The Avenue Dataset stands as a prominent and extensively utilized resource for abnormal event detection within video surveillance. Crafted to support research endeavors in computer vision and video analysis, this dataset specifically targets the identification of abnormal events or activities in surveillance footage.

Dataset Content

1. *Video clips:* The Avenue Dataset encompasses video clips captured from a stationary surveillance camera. These clips portray a spectrum of normal and abnormal events unfolding in a pedestrian-dense urban setting, featuring pedestrian movement, vehicular traffic, and various other activities.
2. *Anomalies:* Within the dataset, video clips deliberately introduce specific abnormal events. These anomalies span actions such as jaywalking, loitering, and sudden crowd dispersal, representing deviations from typical behavioral patterns.
3. *Training and testing splits:* Typically, the dataset undergoes partitioning into training and testing subsets. The training set incorporates video clips exhibiting normal activities, allowing machine learning models to discern standard behavior. Conversely, the testing set comprises clips showcasing both normal and abnormal events, challenging models to detect anomalies effectively.

Use Cases and Research

The Avenue Dataset serves as a cornerstone for research endeavors within the realm of abnormal event detection. Researchers and data scientists extensively utilize this dataset to pioneer the development and assessment of machine learning models, particularly deep learning models, aimed at autonomously detecting and flagging anomalies present in video streams [12].

Key Challenges and Goals

The utilization of the Avenue Dataset revolves around achieving several primary objectives:
1. *Abnormal event detection:* The overarching goal is to cultivate algorithms capable of autonomously identifying and categorizing abnormal events or activities within video footage. This task encompasses scenarios set in complex urban environments characterized by a multitude of background activities.
2. *Real-world applications:* A key aspiration is to translate research findings into practical applications within real-world contexts. This entails leveraging the insights gained from the dataset to enhance the capabilities of video surveillance systems, thereby bolstering public safety, security, and crowd management measures.

Video Description

The training videos capture normal situations. Testing videos include both normal and abnormal events. Three abnormal samples are shown in Figure 5.

Figure 5. Testing videos include both normal and abnormal events.

In summary, the avenue dataset is a valuable resource for developing and testing algorithms for abnormal event detection in video surveillance. It provides researchers with a diverse and challenging set of video clips to improve the accuracy and reliability of video surveillance.

Software and Hardware Setup

Launch the Software

1. *Deep learning framework:* Choose a deep learning framework to develop and train the model. Popular options include TensorFlow, PyTorch, and Keras. These frameworks provide tools for building, training, and deploying deep learning models.
2. *Computer vision libraries:* Use computer vision libraries such as OpenCV for tasks such as image and video preprocessing, object detection, and tracking.
3. *Anomaly detection algorithms:* Implement anomaly detection algorithms such as autoencoders, one-class SVMs, and separation forests to detect abnormal events in video data.
4. *Object recognition model:* R-CNN to recognize and localize objects in video frames.
5. *Alert and notification systems:* Set up alert and notification mechanisms such as email, SMS, and push notifications to notify security personnel or relevant authorities when anomalies are detected.
6. *User interface development:* Create user-friendly interfaces for system access, monitoring, alarm management, and historical video playback. Web-based interfaces or mobile apps are popular options.
7. *Database management system:* Use a database system (MySQL database, PostgreSQL, NoSQL, etc.) to store video data, metadata, and analysis results.
8. *Security and access control:* Implement security measures such as user authentication, role-based access controls, and data encryption to protect sensitive surveillance data.

Hardware Setup

- *Processor:* at least 1 GHz, used; RYZEN 5 (4000 series)
  Ethernet connection (LAN) or wireless adapter (Wi-Fi)
- *Hard disk:* at least 32 GB, used; 512 GB.
- *Memory (RAM):* 1 GB minimum, using 8 GB basic computer system.
  1. *GPU acceleration:* Deep learning tasks, especially real-time video analysis, take advantage of powerful GPUs (graphics processing units) to accelerate model training and inference. NVIDIA GPUs are often used for deep learning applications.
  2. *CPU:* A high-performance CPU is essential for tasks such as video pre-processing, server management, and real-time decision-making. A multi-core CPU is recommended.
  3. *Memory (RAM):* Make sure you have enough RAM to handle your data processing needs, including deep learning models and video frames.

IMPLEMENTATION WORK

Implementation Details

For implementation, the project will deploy deep learning models trained on vast datasets to analyze video streams in real time, identifying and categorizing objects, behaviors, and anomalies with high accuracy. Additionally, it will integrate advanced computer vision techniques to enhance surveillance capabilities, enabling proactive threat detection and efficient monitoring across diverse environments as shown in Figures 6–9.

Result/Output of Project

Enhanced sustainability and productivity through the implementation of modern agricultural practices (Figures 7–9).

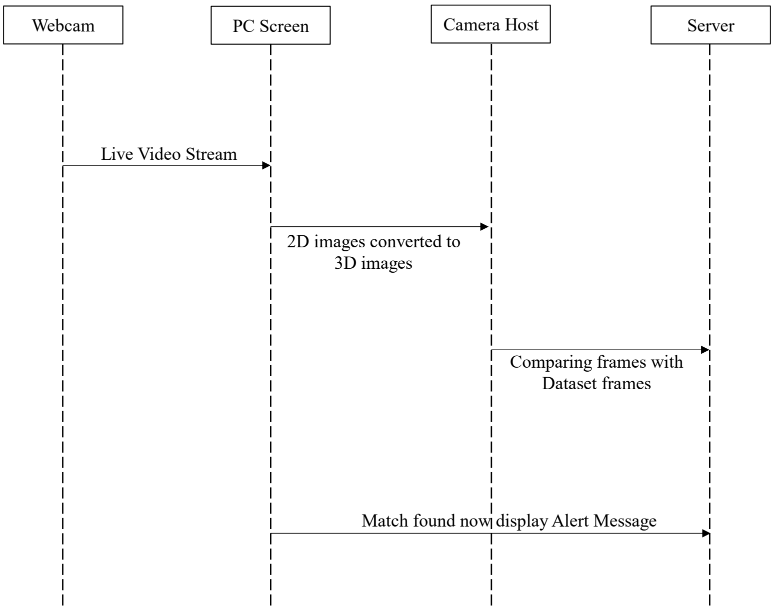

Figure 6. Sequence diagram for intelligence video surveillance system.

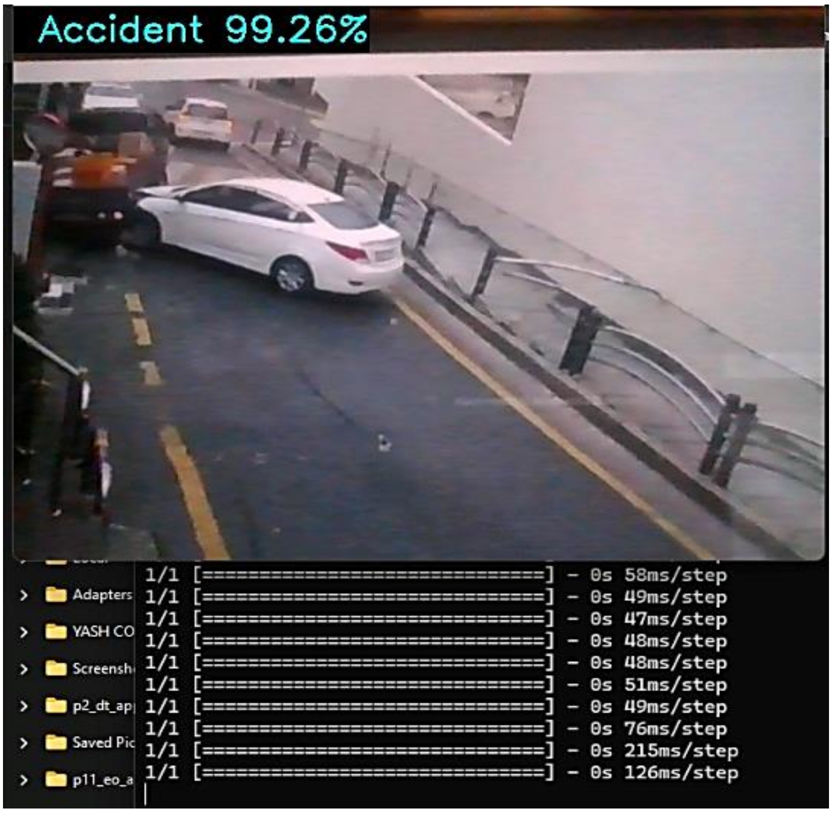

Figure 7. Accident 99.26%.

Figure 8. Accident 81.01%.

Figure 9. No accident was detected.

CONCLUSION

In conclusion, intelligence video surveillance using deep learning represents a transformative paradigm in the field of security and surveillance. This advanced technology uses the power of deep learning algorithms to not only capture and record video footage but intelligently interpret and analyze it in real time.

Deep learning models, such as convolutional neural networks and recurrent neural networks, have demonstrated their ability to recognize and track objects, identify anomalies, and interpret complex visual data. This capability is used to proactively detect security threats, unusual activities, or potential breaches, reduce response times, and improve overall situational awareness.

By combining deep learning with surveillance technology, we enable systems to understand the context of observed events, distinguishing between routine activities and real security concerns. The system's ability to generate real-time alerts and notifications for both law enforcement agencies and emergency responders significantly enhances our ability to mitigate risks and effectively manage emergencies.

Moreover, intelligence using deep learning is not limited to just providing a watchful eye for video surveillance. It also empowers us to predict and prevent incidents, creating a safer and more efficient environment. In urban settings, in transportation hubs, critical infrastructure, or commercial spaces, this technology offers a high level of protection and, subsequently, peace of mind.

As we continue to refine and expand these systems, our ability to protect our communities and assets will also evolve, marking a profound shift in the way we approach security and surveillance in the modern age. With its promising future and potential for change, intelligence video surveillance using deep learning is a beacon of innovation and progress in the field of public safety and security.

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