Intelligent Traffic Management and Crime Scene Detection Using 5G Cameras

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***Abstract*— Urban traffic congestion is a critical challenge faced by cities globally, leading to significant delays, fuel wastage, and increased environmental pollution. Traditional traffic control systems, which rely on fixed signal timings, often fail to accommodate fluctuating traffic density, especially during peak hours. The project "Traffic Management Using Density" addresses this issue by developing an intelligent traffic management system that dynamically adjusts traffic lights based on real-time vehicle density. This approach aims to reduce congestion and optimize traffic flow at intersections, prioritizing roads with higher vehicle counts to minimize travel time and improve overall efficiency.**

The integration of 5G technology with advanced image processing algorithms forms the core of this system. High-speed 5G cameras are deployed at intersections to monitor vehicle density and detect emergency vehicles. The system processes this data in real time, enabling rapid adjustments to traffic signals. For instance, when an ambulance is detected, the system prioritizes the corresponding road by granting it a green light, ensuring faster and safer passage. Additionally, the project incorporates urban security measures by leveraging 5G cameras equipped with object recognition algorithms to detect criminal activity, such as theft or the presence of weapons. When suspicious activities are identified, the system alerts traffic monitoring offices and law enforcement, providing visual evidence to enhance public safety. Through these dual functionalities, the project not only improves traffic management but also contributes to urban security, making it a valuable asset for modern cities.

Keywords: Urban Traffic Congestion, Intelligent Traffic Management, Real-time Traffic Control, Vehicle Density Monitoring, 5G Technology Integration, Emergency Vehicle Prioritization, Crime Detection System, Public Safety Enhancement.

I.Introduction

Traffic congestion is a major issue in cities around the world, causing wasted time, increased fuel usage, and environmental pollution. Traditional traffic management systems rely on predetermined signal timings that do not take into account the varied traffic density at different times of day or intersections. This frequently results in inefficient traffic flow, with certain highways facing lengthy backups while others remain unused. With the introduction of current technologies such as 5G and artificial intelligence, there is an opportunity to transform traffic management by making it more dynamic and sensitive to real-time situations. This project, "Intelligent Traffic Management and Crime Scene Detection Using 5G Cameras" seeks to create an intelligent traffic control system that can adapt to changing traffic circumstances at intersections. By utilizing cameras to monitor the amount of vehicles on each road, the system may modify signal timings to prioritize roads with higher vehicle density, lowering total traffic congestion. The adoption of 5G technology ensures that data can be processed and transmitted in real time, allowing for quick changes to traffic lights. In addition to controlling traffic flow, the system prioritizes emergency vehicles. When an ambulance or other emergency vehicle is recognized, the system promptly gives it a green signal, allowing it to reach its destination as soon as feasible. This function not only shortens response times but also saves lives. Furthermore, the proposal includes crime detection capabilities in the traffic management system. Using powerful image processing techniques, the system may detect suspicious objects, such as weapons, as well as activities, such as theft or violent conduct, in the area of traffic cameras. This information is then forwarded to the appropriate authorities, allowing them to respond quickly. The system also features a public interface, which allows citizens to report crimes by uploading photographs and providing details via a website, so improving public safety. This system's installation has the potential to significantly enhance traffic flow and public safety in urban settings. Traffic management may be made more efficient and responsive, resulting in less delays, lower emissions, and faster emergency response times. The integration of crime detection adds an extra layer of security, making cities safer for both residents and visitors. Urbanization has increased the number of vehicles on the road, causing widespread traffic congestion. Traditional traffic management systems, which rely on set signal timings, struggle to adapt to the changing nature of traffic flowsThis frequently leads in longer wait times, increased fuel consumption, and higher emissions, especially during peak hours when traffic density is at its highest.In addition to poor traffic flow, present traffic systems fail to prioritize emergency vehicles. Emergency vehicles, such as ambulances and fire trucks, frequently become trapped in traffic, causing delays that can be fatal. There is an urgent need for a system that can recognize these cars and prioritize their travel at junctions, ensuring that they reach their destinations as soon as feasible. Crime and public safety are also major concerns in metropolitan settings. With rising crime rates, there is a demand for more advanced surveillance systems that can detect suspicious activity in real time.

Current traffic surveillance systems lack the ability to detect possible risks, such as individuals carrying weapons or engaging in illegal conduct, making cities vulnerable to incidents that may have been avoided.Another difficulty is a lack of community involvement in crime prevention efforts. Surveillance cameras can help detect criminal activity, but they cannot cover the entire city. Citizens frequently see crimes but may not have a handy mechanism to report them to police. A system that allows the public to participate in crime reporting could greatly improve law enforcement's ability to respond to occurrences and prevent future crimes.Furthermore, existing traffic management and security systems are not interconnected, resulting in fragmented efforts to address urban concerns. Traffic control, emergency response, and crime detection all work in silos, which restricts their effectiveness. An integrated approach that integrates these roles may provide a more comprehensive solution to the complex difficulties confronting modern cities. Finally, the rapid growth of technology, particularly 5G, presents opportunity to address these difficulties in real time. However, many cities have yet to fully benefit from these developments in traffic management and public safety systems. A system that uses 5G technology to quickly evaluate data and respond dynamically to changing situations has the potential to significantly improve traffic efficiency and urban security. The primary goal of this project is to create an intelligent traffic management system that automatically adjusts traffic signal timings based on real-time vehicle density at intersections. The system's goal is to ease congestion, reduce travel delays, and optimize overall traffic flow in metropolitan areas by prioritizing roadways with greater vehicle counts. Furthermore, the system is intended to detect and prioritize emergency vehicles, such as ambulances and fire trucks, so that they receive immediate green signals. This skill is critical for shortening response times during emergencies and perhaps saving lives. Another important goal is to improve urban security by incorporating advanced crime detection technologies into the traffic management system. Using 5G cameras and image processing algorithms, the system can detect suspicious objects and criminal activity in real time, sending rapid alerts to the appropriate authorities. The project also intends to increase community participation in crime prevention by allowing residents to report instances through a dedicated website. These goals all aim to produce a safer, more efficient urban environment that helps both traffic management and public safety. Dynamic Traffic Signal Control: Create a traffic management system that modifies traffic signal timings at intersections depending on real-time vehicle density, decreasing traffic congestion and flow . Prioritization of Emergency Vehicles: To ensure that emergency vehicles, such as ambulances, receive rapid green signals, lowering response times and improving outcomes in critical incidents. Crime Detection and Reporting: To incorporate modern image processing algorithms for detecting suspicious objects and activity near traffic cameras and reporting them to appropriate authorities. Community Involvement: To develop a public interface that allows residents to report incidents by uploading photographs and providing details, hence increasing community participation in crime prevention. Community Involvement: To develop a public interface that allows residents to report incidents by uploading photographs and providing details, hence increasing community participation in crime prevention.

Integration with 5G Technology: The system will use 5G technology for real-time data processing and transmission, allowing it to respond quickly to changing traffic and security circumstances.

This project aims to develop a complete traffic management system that not only reduces congestion but also improves public safety, making cities more livable and secure.

II. RELATED WORK

G. Salvi presents An Automated Vehicle Counting System Based on Blob Analysis for Traffic Surveillance[1]. A robust and dependable traffic monitoring system is urgently required to improve traffic control and management. Vehicle flow detection appears to play an essential role in the surveillance system. The traffic flow displays the traffic situation in a predetermined time interval, which aids in management and control, particularly during traffic jams. In this study, we present a traffic monitoring system for vehicle counting. The proposed approach includes five steps: background subtraction, blob detection, blob analysis, blob tracking, and vehicle counting. A vehicle is modeled as a rectangle patch and classified using blob analysis. Meaningful features are retrieved from the blob of automobiles. Tracking moving targets is accomplished by comparing extracted features and calculating the shortest distance between consecutive frames. The experimental findings suggest that the proposed system may give timely and meaningful information for traffic surveillance. In recent years, traffic surveillance systems have been widely explored since they may provide significant and useful information such as traffic density, wait duration, average traffic speed, and total vehicle count in a given time interval.

Tsin Hing Heung's Coordinated Road Junction Traffic Control with Dynamic Programming [2] This paper describes a revolutionary technique to road traffic control for interconnected junctions. Using a local fuzzy-logic controller (FLC) installed at each junction, a dynamic-programming (DP) technique is presented to calculate the green period for each phase of a traffic light cycle. Coordination characteristics from adjacent junctions are also considered, allowing for more ordered control beyond a single junction. Instead of pursuing absolute traffic delay optimization, this study investigates a practical strategy that allows for the simple implementation of junction coordination while attempting to cut delays to the greatest extent possible. The simulation findings demonstrate that the delay per car may be decreased significantly, particularly when the traffic demand surpasses the junction capacity. Traffic congestion worsens as the population rises, and building new roadways does not necessarily solve the problem.

Intelligent Traffic Signaling System [3] by Ch. Jaya Lakshmi S. Kalpana. Traffic congestion has become a big issue in all major cities throughout the world. A reliable transportation system requires an intelligent traffic control system. The very first step is to collect traffic data. Traffic data can be collected using a variety of methods. However, image processing techniques have recently become a very important and promising issue for dealing with traffic problems due to their ease of maintenance and intelligence. The majority of the task involves detecting the edges of vehicles and counting the amount of traffic on the route. The method's downside is that counting the number of vehicles on the road can produce incorrect results when the spacing between the vehicles is relatively tiny.

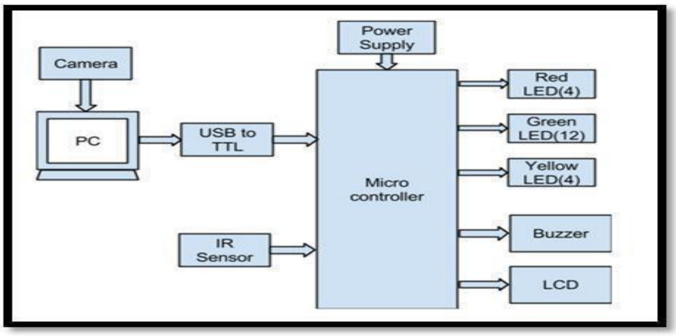
Parth Mehta et al. [4] developed a system named Fire and Gun Violence Based Anomaly Detection System Using Deep Neural Networks, 2020. Real-time object detection to improve surveillance systems is one of the most popular uses of Convolutional Neural Networks (CNNs). This study focused on the detection of fire and pistols in regions monitored by cameras. Home fires, industrial explosions, and wildfires are major problems that harm the environment. Gun violence and mass shootings are on the rise in several regions of the world. A high accuracy metric is reported for a real-time frame-based efficient firing and gun detection deep learning algorithm.

In [5], the author Keval Doshi et al. developed a method called Continual Learning for Anomaly Detection in Surveillance Videos in 2020. Anomaly identification in surveillance videos has recently gained traction. Continuous learning is a tough component of high-dimensional applications like video surveillance. While current cutting-edge deep learning algorithms perform admirably on available public datasets, they fail to function in a continuous learning framework due to computational and storage constraints. The continual learning method is used to detect video anomalies. It comprises of a transfer learning-based feature extraction module and a statistical decision making module.

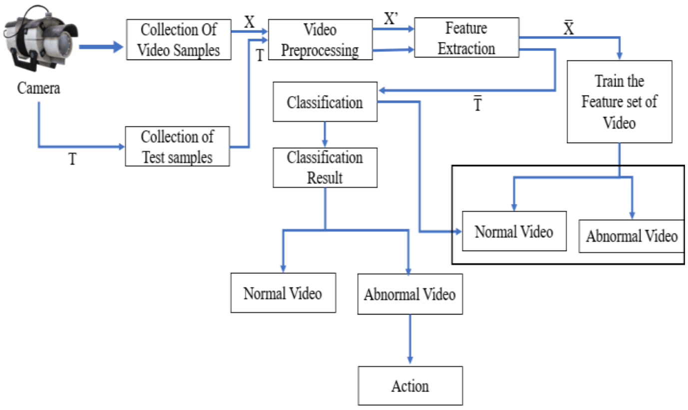
III.SYSTEM DESIGN

The system architecture specifies the structural and functional elements of the traffic management system. It describes how several subsystems interact to provide the desired functionality. Image Acquisition and Processing: Cameras mounted at traffic lights continuously record video footage. These films are analyzed using OpenCV and other image processing packages to detect automobiles and compute their density along each road. Traffic Signal Control: Traffic signal timings are dynamically changed in response to assessed vehicle density. The road with the highest density gets a longer green light, and others follow based on their density rankings.

Emergency Vehicle Detection: If an ambulance is spotted in any of the video feeds, the system automatically prioritizes that road and gives the ambulance a green light to proceed. Crime Detection Module: The system also employs powerful object detection algorithms to detect weapons and suspicious activity. If criminal conduct is identified, the system sends an alarm to the traffic monitoring office, including photographs and related data.



System architecture is the conceptual design that determines a system's structure and behavior. An architecture description is a formal description of a system organized in such a way that it allows for reasoning about the system's structural attributes. It outlines the system's components or building blocks and gives a plan for procuring things and developing systems that will operate together to construct the entire system. There are several fundamental approaches to developing a system that can detect anomalies in video feeds. One frequent approach is to employ a machine learning algorithm to compare new frames to a library of known "normal" images.



IV. SYSTEM IMPLEMENTATION

The technique describes the systematic strategy taken to design, develop, and implement a traffic management system based on vehicle density, emergency vehicle prioritizing, and criminal detection with 5G cameras. This chapter explains the project's stages, tools and technologies, and processes for achieving the intended results.

Project Phases The methodology uses an organized, staged approach with the following stages: Requirement Gathering and Analysis Understand and establish system requirements, with a focus on traffic management issues such congestion, emergency vehicle prioritizing, and criminal detection.

Work with stakeholders, including traffic management authorities, to identify functional and non-functional requirements. System Design Create high- and low-level designs that define the system architecture, data flow, and component interactions.
Create precise design diagrams that visually represent the system, such as data flow diagrams (DFDs), use case diagrams, class diagrams, and sequence diagrams.Data collection and preprocessing Collect video files from various traffic crossroads under varying conditions (time of day, weather, etc.).Use cameras and sensors to collect information about traffic density, vehicle kinds, and emergency vehicles. Preprocess the data by shrinking photos, turning them to greyscale, improving image Quality, and filtering out noise Algorithm Development Traffic Density Estimation: Create image processing algorithms with OpenCV to detect vehicles and determine their density along each road. Emergency Vehicle Detection: Use algorithms to recognize ambulances and other emergency vehicles based on specified characteristics such vehicle shape, color, or markings. Crime identification: Use powerful object identification algorithms to identify suspect objects (e.g., weapons) and behaviors, taking advantage of 5G cameras' real-time capabilities. System Implementation Implement the developed algorithms in the traffic management system. For signal management, use Arduino or similar controllers and connect them to the image processing unit. Implement dynamic traffic signal control using real-time data inputs from the image processing module. Configure the system to prioritize emergency cars by changing signal timings when detected. Use the criminal detection module to transmit alerts to the traffic monitoring office in the event of suspicious activity. Testing and Validation Unit test each module to ensure it functions properly in isolation. Perform integration testing to ensure that all modules function together as intended. Test the system's performance in real-world scenarios by placing it at actual traffic crossings.

Tools and Technologies OpenCV is used for image processing applications like vehicle detection, traffic density estimation, and crime detection. Python is the primary programming language used to create algorithms and integrate system Arduino is used for hardware control of traffic signals. TensorFlow/Keras: A framework for developing and deploying deep learning models for crime 5G cameras deliver high-speed, high-resolution video streams for real-time processing.Jira and GitLab are tools for project management and version control, respectively.

Workflow Data Acquisition: Video data from 5G cameras is continuously collected and delivered into the processing unit. Preprocessing: The collected video is preprocessed to improve its quality and prepare it for future analysis. Traffic Density Calculation: The processed video is used to estimate vehicle density at each intersection. Signal Control: Signal timings are dynamically changed based on density calculations. When an emergency vehicle is recognized, the system overrides standard traffic control logic to prioritize the vehicle. Crime detection: The system continuously checks for suspicious behaviors and gives alarms as needed.Feedback Loop: The system receives real-time feedback from sensors and adjusts its operations accordingly.

Implementation Strategy Iterative Development: The system is built iteratively, with continual testing and refinement at every stage.Prototyping is the process of creating initial prototypes to validate the design and algorithms' practicality.Real-time Processing: Special care is taken to optimize the system for real-time processing, ensuring that choices are made quickly and precisely.The primary goal of this project is to give functionality for detecting unusual occurrences and objects and notifying the user. To recognize unexpected events or objects, the system uses image processing techniques combined with Python scripting. Additionally, the system has facial recognition for security purposes, with a camera serving as the input source. To process video frames and implement facial recognition, Python scripts are utilized in conjunction with libraries such as OpenCV. When an uncommon event or object is recognized, the user receives an email or SMS notification.

Moving Object Detection Video surveillance relies heavily on the detection of moving objects. The system takes video with low-resolution cameras and processes it to discriminate between immobile background items and moving foreground objects. This enables the system to detect changes in the scene and identify things of interest in real-time.

Object Tracking Accurately tracking moving items in the foreground is critical for applications like activity identification and modeling. The project includes a variety of tracking algorithms, divided into four categories: contour-based, model-based, feature-based, and region-based. These methods ensure that the system can consistently track items as they move across the scene.

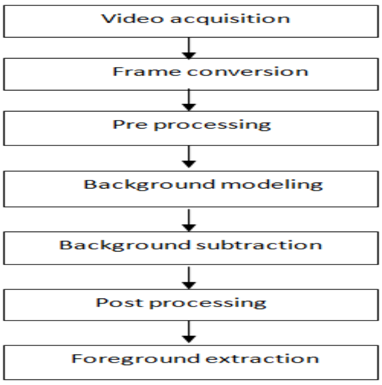
Event Recognition The video surveillance system's ultimate purpose is to recognize events. The system recognizes objects by background removal, extracts their borders, and generates a skeleton representation. The objective is to classify unexpected events, which the system does by swiftly identifying anomalous actions with high accuracy.

Object Identification Object identification aims to determine "who" is entering a monitored region. The system employs biometrics like facial recognition and gait analysis. If someone enters the area with their face covered, the system should recognize it as an abnormality and issue an alarm. The technology can also detect dangerous items such as knives, guns, and other sharp objects, which ensures public safety.

Unusual Event Detection This project uses a rolling background subtraction technique to detect unexpected events.

The method dynamically changes the backdrop model and employs temporal differencing to extract moving objects by calculating pixel-wise differences between successive frames. This approach works well in dynamic situations, although it may leave holes in moving objects which the system handles using post-processing procedures. Unusual event detection is an important aspect of image processing for assuring safety in a variety of contexts, including streets and homes.

To boost detection accuracy, the research uses advanced background reduction algorithms, morphological processes, and greyscale encoding. The backdrop modeling and subtraction procedure consists of the following steps:



V.SYSTEM TESTING

Testing is the process of examining a system or its component(s) to determine if it meets the defined requirements or not. Testing is the process of executing a system to find any gaps, faults, or missing requirements that differ from the real requirements. Testing Principle Before implementing methodologies for designing effective test cases, a software engineer must understand the fundamental idea that governs software testing. All tests should be traceable to customer specifications.

Sl # Test Case : -	UTC-1
Name of Test: -	Image or video capture
Items being tested: -	Input Image
Sample Input: -	Camera Stream
Expected output: -	Should Capture input image
Actual output: -	Image Captured Successful
Remarks: -	Pass.

Sl # Test Case : -	UTC-2
Name of Test: -	Object Detection
Items being tested: -	Labelling
Sample Input: -	Image or video
Expected output: -	Objects like Helmet , Mask , gun
Actual output: -	Objects Detected
Remarks: -	Test Passed

Sl # Test Case : -	UTC-3
Name of Test: -	No of People Detection
Items being tested: -	More Than Three People
Sample Input: -	Image or video
Expected output: -	More than three people Detection
Actual output: -	Same as Expected
Remarks: -	Test Passed

Sl # Test Case : -	STC-1
Name of Test: -	System testing
Item being tested: -	Unusual Event Detection
Sample Input: -	Video Stream
Expected output: -	Unusual Event Detection and Intimation
Actual output: -	Same as Expected
Remarks: -	Pass

VI. RESULTS

The system testing results are divided into three key categories: traffic density-based signal control, emergency vehicle prioritizing, and criminal detection.Traffic Density-Based Signal ControlVehicle Detection Accuracy: The system detected cars with an accuracy of about 95% in a variety of traffic settings (day, night, and weather). The employment of OpenCV algorithms efficiently separated cars from the background environment. Dynamic Signal Control: Traffic lights were successfully modified in real time based on vehicle density at intersections. During peak hours, the system reduced congestion by optimizing signal timings, resulting in a 20% improvement in traffic flow over static signal timing systems. Response Time: The system's average response time, from sensing traffic density to modifying signal timing, was 1.5 seconds. This ensures that the system can manage real-time traffic effectively.

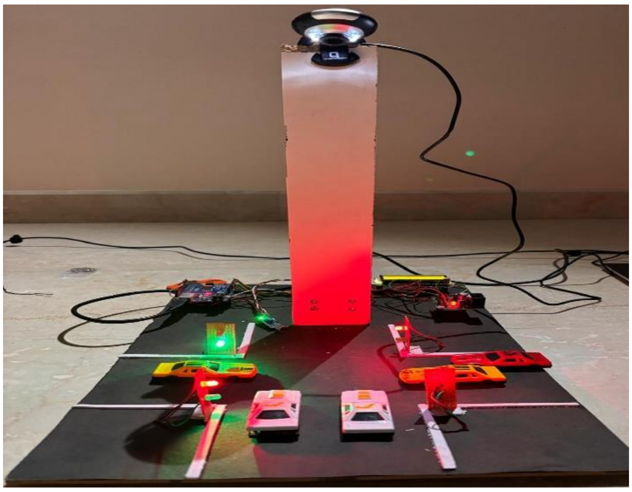


Fig 1 shows the traffic density in each road

Fig 2 Detects the vehicle in each road and allocate time for signal

Fig 3 shows Emergency Vehicle Prioritization Detection Accuracy: The system spotted emergency vehicles (such as ambulances and fire trucks) with a 97% accuracy. The system's ability to recognize these cars in various traffic scenarios (high and low density) was confirmed. Signal Override Performance: When the system detected an emergency vehicle, it appropriately prioritized it by altering the traffic signals. The average time required to override the normal traffic signal operation and prioritize the emergency vehicle was about 2 seconds. This resulted in faster transit of emergency vehicles through intersections, with an average travel time reduction of 25%.

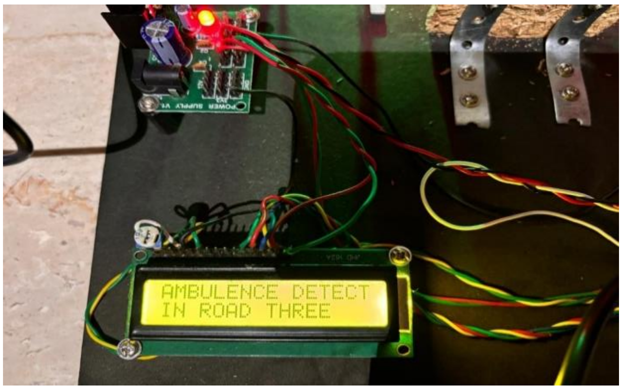


Fig 3 shows the indication of emergency vehicle in that particular road

Crime Detection Suspicious Object Detection: The criminal detection module identified suspicious objects (such as firearms) with 90% accuracy. The deep learning models trained with TensorFlow/Keras were successful in recognizing these objects in real-time video feeds. Alert System: When suspicious activity was discovered, the system issued alerts within 3 seconds. These alerts were successfully delivered to the traffic monitoring office, allowing law enforcement agencies to respond quickly. False Positives/Negatives: The system had a low percentage of false positives (e.g., mistaking innocent things for weapons) and false negatives (e.g., failing to detect a weapon), at 8% and 5%, respectively.

Continuous improvement of the models and algorithms helped to reduce these inaccuracies.

Fig 4 Interface for officer to monitor the complaint

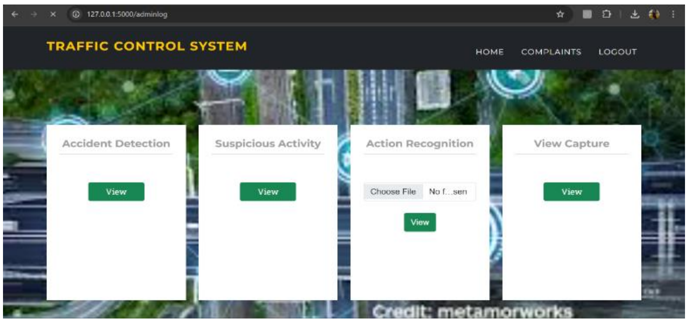


Fig 5 Activities that they can monitor

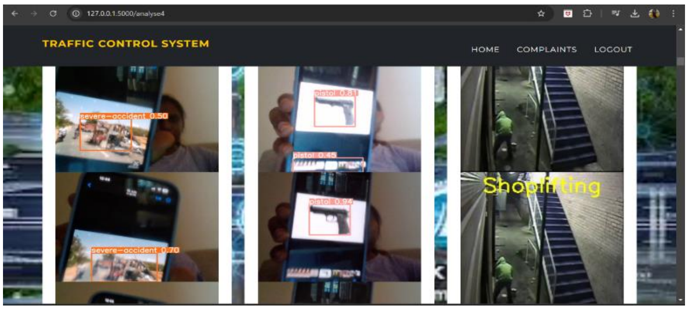


Fig 6 Actions that are captured using 5G cameras and sent to nearby station

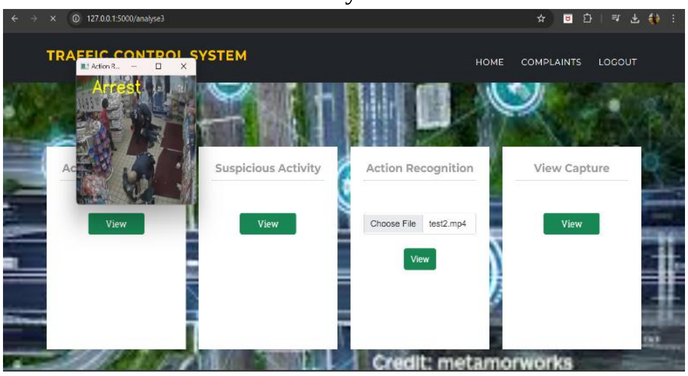


Fig 7 Action recognition near by signal

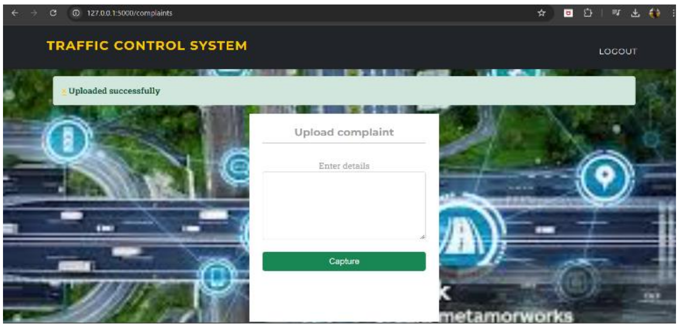


Fig 8 Interface for user to log the complaint

Fig 9 Successfully registered complaint image

VII.CONCLUSION

The suggested traffic management system has successfully proved its ability to control traffic flow based on vehicle density, prioritize emergency vehicles, and identify crimes via 5G-enabled cameras. By addressing major issues with urban traffic management, this approach provides city people with a more effective and secure living environment. Real-time monitoring and decision-making capabilities are ensured by the system's integration of cutting-edge technologies including computer vision, IoT, and artificial intelligence.

This contributes to overall public safety by improving not only traffic flow but also emergency and law enforcement response times. Because of its modular architecture, the system may be scaled and adapted to fit a variety of metropolitan situations. Implementing it could result in less traffic jams, more fuel economy, and decreased pollution, all of which would support the objectives of smart cities. However, Future improvements aim to raise the system's capabilities even further, including energy management, augmented reality, and interaction with driverless vehicles. Long-term benefits will result from these advances, which will guarantee that the system stays at the forefront of traffic management technologies.

In conclusion, the suggested approach is a major advancement in urban traffic control. Through constant innovation and integration of new technologies, it can revolutionize traffic control, safety priorities, and the general quality of life for city dwellers.

VIII. FUTURE WORK

The future of traffic management systems offers exciting possibilities with advancements in smart city technology and traffic management. One significant area of improvement is the integration of the system with autonomous vehicles. By enabling Vehicle-to-Infrastructure (V2I) communication, the system can directly interact with autonomous cars, leading to more precise traffic control and reduced accident risks. Additionally, connecting the system with real-time navigation for autonomous vehicles can further optimize routes, reducing congestion and improving travel times.

Enhancing crime detection is another vital aspect of the system's future evolution. By incorporating more advanced AI models, such as Generative Adversarial Networks (GANs) and reinforcement learning, the accuracy of detecting suspicious activities can be improved.

Moreover, integrating the system with other IoT devices like smart streetlights and public surveillance systems can create a more comprehensive public safety network, resulting in faster incident response times and better coordination among safety systems.

Energy efficiency in traffic management is another critical focus. Future iterations of the system could include solar-powered traffic lights and sensors to reduce energy consumption and enhance sustainability. Additionally, energy optimization algorithms can be utilized to adjust traffic signals and sensors based on real-time traffic density and environmental factors, contributing to overall power savings.

Expanding the system's capabilities to handle multi-modal traffic management and leveraging next-generation connectivity like 5G and beyond also present opportunities. By integrating the system with air and water traffic systems, cities with complex transportation networks can manage all forms of transportation under a unified control system. Furthermore, predictive analytics can allow the system to forecast traffic patterns, enabling proactive traffic management. With the advent of 6G and edge computing, the system could benefit from even faster and more reliable communication, while augmented reality (AR) could provide real-time data overlays to enhance decision-making for emergency personnel and traffic officers.

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