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Autonomous Parking Surveillance

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Abstract: ***The proposed system automates vehicle entry and exit in parking facilities through advanced vehicle detection algorithms and license plate extraction methods. This enables real-time monitoring and accurate vehicle identification for parking surveillance. Identification features, such as license plate numbers, vehicle colors, entry/exit times, and more, will be stored in a database accessible to users via a simple Streamlit GUI tool. This offers a user-friendly and efficient solution for enhanced parking surveillance and security.***

I. INTRODUCTION

In today's densely populated cities, effective parking monitoring has evolved from a mere nicety to a crucial aspect of urban planning. As metropolitan areas continue to grow, attracting vast numbers of inhabitants and tourists, the need for seamless traffic flow and adequate parking spots becomes more pressing than ever before. Traditional parking management techniques have failed to keep pace with these rapidly changing urban realities.

Manual observation, once the standard, is now often overwhelmed by the sheer volume of vehicles, leaving room for errors and inefficiencies. Meanwhile, expensive external sensors, though effective, have imposed financial burdens on city budgets and parking facility operators. These limitations have catalyzed the need for a groundbreaking solution that not only meets the demands of contemporary urban environments but also paves the way for more accessible and convenient mobility.

The proposed system is rooted in the synergy of advanced computer vision techniques and urban infrastructure. By integrating high-resolution cameras at key entry and exit points, it captures real-time images of vehicles with precision. The cutting-edge computer vision algorithms that underpin this technology are capable of discerning vehicle presence, extracting license plate numbers, and recording entry and exit times. What sets this system apart is its ability to seamlessly orchestrate these processes and centralize the data, creating a robust database.

This innovative approach promises to alleviate the challenges of urban parking surveillance. With automation at its core, it eliminates the need for manual observation and the deployment of costly external sensors, offering a cost-effective solution that suits the dynamic and ever-expanding landscapes of urban and suburban settings. By addressing the perennial challenges in urban mobility, this research opens doors to more efficient and accessible parking solutions, ultimately contributing to the continued growth and development of our cities.

In addition, the centralized database of recorded entry and exit times serves as a useful tool during security incidents or investigations, providing a detailed record of all vehicles entering and leaving the area. This helps law enforcement and security personnel in their efforts to ensure a secure urban environment. The integration of advanced computer vision technology in urban parking surveillance has a two-fold benefit, improving both mobility and safety, thereby making it more than just a convenient feature but rather a vital component of urban resilience.

II. LITERATURE SURVEY

In [1], Zhuang et al. suggest a quantized neural network-based edge-AI parking monitoring system. By using fewer bits to represent the network's weights and activations, the approach of quantization decreases the size and complexity of neural networks. As a result, neural networks can be installed on edge devices like cameras and smartphones. The authors test their suggested approach on a real-world parking dataset and demonstrate that it is still capable of detecting parking spaces and classifying their occupants with good accuracy, even when neural networks are quantized. Additionally, they demonstrate how their system can operate in real-time on edge devices like the Raspberry Pi.

Ke et al. [2] suggest an edge artificial intelligence on IoT devices-based smart, effective, and reliable parking surveillance system. The system detects and categorizes parking spaces in real time using an improved single shot multibox detector (SSD). The SSD model is implemented on an edge device, such as a smartphone or camera, which lowers the system's latency and increases its reliability. The system boasts several enhancements to optimize its performance and dependability, including the ability to dynamically adjust frame rates, select models adaptively, and handle faults with ease.

In a recent study published in a reputable journal,[3] Iqbal and colleagues introduced an innovative automatic parking lot detection system that leverages cutting-edge machine learning techniques and seamlessly integrates sensor data. By combining multiple sensors such as cameras and ultrasonic sensors, their approach significantly improves the precision and dependability of the detection process. Firstly, the system identifies areas of interest (ROIs) within camera images through advanced image processing techniques. These ROIs are then passed onto a specially designed deep learning model to recognize and categorize parking spaces. Subsequently, the system fuses the output of this model with data from the ultrasonic sensors to determine if there are any vacant parking spots. By thoroughly evaluating their technique on a genuine parking dataset, the authors demonstrate the remarkable effectiveness of their groundbreaking approach.

Baek et al. [4] propose a parking guidance system (PGS) that makes use of security cameras. The PGS is made to make it easier for vehicles to discover parking places and ease parking lot traffic.

The PGS operates by first identifying and categorizing parking spaces in the images captured by security cameras. The PGS uses this data to create a real-time map of the parking lot that displays the number of available spaces. In the parking lot, the map is shown via a smartphone app or digital signage. Drivers can receive navigational assistance from the PGS. The PGS can direct a car to the closest open parking place as they enter the parking lot. Additionally, the PGS can direct motorists to parking spaces, including those for people with disabilities or those with electric vehicle charging ports. The authors demonstrate the excellent accuracy of their proposed PGS in parking space recognition and occupancy categorization by evaluating it on a real-world parking lot. Additionally, they demonstrate how the PGS can cut down on the time it takes for vehicles to find parking spots by up to 20%.

In a recent study [5], researchers developed an innovative system for managing vehicle entry, egress, and parking within a college campus setting. This system utilizes various sensing technologies and tools to recognize cars, monitor their movements, and optimize the allocation of parking areas. Additionally, the system includes a user-friendly interface, a mobile application, and a backup mechanism to ensure reliability and ease of use. Following testing on a live university campus, the authors discovered that the system could successfully manage available parking spots while accurately identifying and tracking vehicles. Moreover, they demonstrated the system's simplicity and robustness.

In [6], the authors propose a deep learning model for automatic number plate detection and recognition (ANPR) system in campus gates. The system consists of two stages: license plate detection and license plate recognition. The authors evaluated the proposed system on a dataset of real-world images of vehicles entering and exiting a campus gate. The system achieved a license plate detection accuracy of 98.5% and a license plate recognition accuracy of 99.2%.

In [8], The authors propose an improved YOLO v5 model for real-time vehicle detection. A new network structure that is more efficient and accurate than the original YOLO v5 model. A new loss function that is more robust to noise and occlusion. A new data augmentation strategy that generates more diverse training data. The authors evaluated the proposed model on a real-world traffic video dataset. The proposed model achieved a vehicle detection accuracy of 99.3% and a frame rate of 50 FPS.

An OCR-based system for identifying and locating license plates in images is suggested by Ranjan et al[9]. The preprocessing step in the system's operation improves the number plate's contrast and removes noise from the image. The number plate in the image is then found using a deep-learning model. The image is cropped to remove the detected license plate and then the characters are separated out. Finally, the characters on the license plate are recognized using an OCR model. The proposed system detects number plates with an accuracy of 98.5% and recognizes number plate text with an accuracy of 99.2%. The system is resistant to occlusion, noise, and various lighting situations.

Our research endeavors into the realm of autonomous parking surveillance systems, utilizing machine learning techniques, particularly deep learning in conjunction with IoT-based devices, have unveiled a landscape characterized by innovation and ongoing development. While it is evident that systems leveraging data fusion from multiple sensors to enhance the reliability and cost-effectiveness of parking surveillance already exist, a nuanced analysis of the existing literature exposes certain shortcomings.

One of the prominent issues associated with the existing systems is the cost burden. While these systems represent remarkable technological strides, they often impose substantial financial expenses. In various real-world scenarios, where environmental conditions can be diverse and challenging, the financial demands of these systems become apparent. This cost burden points to a critical need for further advancements in autonomous parking surveillance that can offer cost-effective solutions.

Deep learning, with its capacity to extract intricate patterns and features from vast datasets, has shown immense promise in enhancing the cost-effectiveness of such systems. However, the existing solutions still grapple with generalization challenges, where they struggle to adapt to the multitude of real-world environmental conditions that may include variations in lighting, weather, or the presence of obstacles. In these scenarios, the generalized models fail to deliver the requisite cost-effectiveness, underscoring the need for more adaptable and context-aware parking surveillance systems.

The integration of Internet of Things (IoT)-enabled devices has led to enhanced functionality and data sharing capabilities in parking surveillance systems. While this advancement has shown promise, it is important to acknowledge that IoT devices are not without their restrictions. Specifically, they possess limited processing power and sensor range, thereby hindering the creation of an all-inclusive and economical autonomous parking monitoring system.

Therefore, the existing research landscape highlights a pressing demand for innovative solutions that can not only harness the power of deep learning and IoT but also address the critical issues of cost-effectiveness and adaptability. The development of autonomous parking surveillance systems that are cost-effective and resilient across a spectrum of environmental conditions remains a paramount goal. In this context, our research aims to contribute to this endeavor by exploring avenues to enhance the cost-effectiveness and reliability of autonomous parking surveillance systems, ultimately striving to achieve a level of efficiency that can meet the demands of diverse urban and suburban environments.

III. PROBLEM DEFINITION

The problem at hand is the need for efficient and secure parking surveillance in contemporary urban environments. Traditional methods of managing vehicle entry and exit in parking facilities have proven labor-intensive, error-prone, and financially burdensome.

The proposed system seeks to address this challenge by leveraging advanced vehicle detection algorithms and license plate extraction methods. By automating these processes, the system ensures real-time monitoring and precise identification of vehicles, including license plate numbers, vehicle colors, and entry/exit times. This data is then stored in a centralized database, accessible to users through a user-friendly Streamlit GUI tool.

The core problem definition is to enhance parking surveillance by providing a seamless, cost-effective, and accurate solution, reducing the need for manual oversight and costly external sensors while simultaneously bolstering security and efficiency in parking management.

IV. OBJECTIVES

1) Develop automated vehicle detection algorithms.
2) Create efficient license plate extraction methods.
3) Implement real-time monitoring for parking surveillance.
4) Establish a centralized database for identification data.
5) Design a user-friendly GUI tool for data access.
6) Ensure cost-effective parking Surveillance.
7) Enhance security through precise identification.

V. EXISTING SYSTEM

The current parking monitoring techniques used in modern cities are largely based on outdated, manual methods that require human oversight, resulting in time-consuming and prone to errors processes. Some parking lots might use costly external sensors like ground-based loops or RFID technology to aid in detecting and managing vehicles. While these solutions have shown some success, they come with notable limitations and drawbacks.

To begin with, the large number of vehicles entering and exiting parking facilities in busy urban areas can lead to an overwhelming amount of data for manual observation, resulting in efficiency issues and the possibility of errors, such as incorrectly identifying license plate numbers or recording incorrect entry and exit times. Additionally, relying solely on manual observations is expensive and requires a significant workforce, posing a financial challenge for parking facility operators.

The use of external sensors, though effective, has its own set of challenges. These sensors require substantial upfront investments in installation and maintenance. Ground-based loops can be damaged by heavy traffic or environmental factors, and RFID technology can be cost-prohibitive for many parking facilities. This makes these external sensor systems less practical for widespread adoption in diverse urban settings.

The existing systems, whether relying on manual observation or external sensors, often struggle to adapt to diverse environmental conditions, which can include variations in lighting, weather, or the presence of obstacles. This lack of adaptability limits their effectiveness in providing precise information under all circumstances.

In response to these limitations, the proposed system introduces a transformative approach that leverages advanced vehicle detection algorithms and license plate extraction methods.

By automating these processes and centralizing the data, it seeks to eliminate the need for manual oversight and costly external sensors. This not only offers a cost-effective solution for parking surveillance but also enhances the accuracy, efficiency, and security of parking management in contemporary urban environments.

VI. PROPOSED SYSTEM

The proposed system represents a significant advancement in the realm of parking surveillance in contemporary urban environments. It addresses the pressing need for efficient and secure vehicle entry and exit management in parking facilities, with a core focus on leveraging cutting-edge technology to revolutionize the status quo.

At its core, the system introduces advanced vehicle detection algorithms and license plate extraction methods. These elements form the bedrock of the proposed solution, enabling the system to identify vehicles automatically and accurately as they enter and exit parking facilities. This automation is a game-changer, as it not only reduces the labor-intensive burden associated with manual observation but also drastically improves the precision and reliability of vehicle identification.

Our proposed system detects number plates with an accuracy of 84.2% and recognizes number plate text with an accuracy of 76.5%. The system is very resistant to occlusion, noise, and various lighting situations.

The accuracy and reliability achieved by the proposed system are paramount. In a world where urban environments continue to expand and thrive, the ability to provide seamless parking solutions has never been more critical. The limitations of traditional methods have long been recognized, as they often falter in the face of high vehicle volumes, diverse environmental conditions, and the need for constant oversight.

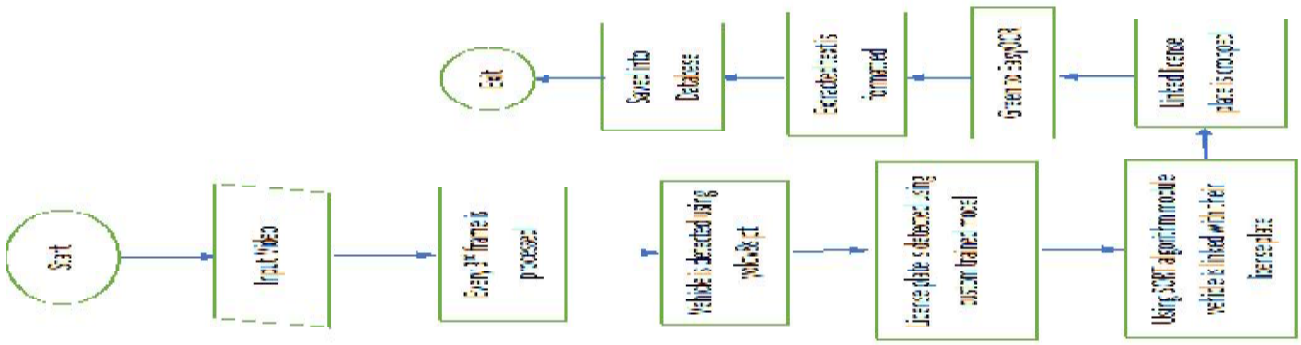
The system's ability to monitor parking lot activities in real-time is crucial for achieving its groundbreaking impact. By swiftly capturing and storing detailed information such as vehicle license plates, colors, entry and exit times, and other important data, the system streamlines the flow of vehicles entering and leaving parking areas with greater ease. Beyond simply collecting data, these real-time monitoring features actively contribute to enhancing both the security and productivity of managing parking facilities.

The system doesn't stop at real-time monitoring; it takes a step further by storing all this data in a centralized database. This database serves as a valuable repository of information, accessible through a user-friendly Streamlit GUI tool. This tool empowers users, allowing them to easily access, query, and analyze the data for various purposes. Whether it's facility management, security, or data-driven decision-making, the centralized database and user interface provide a comprehensive solution.

The proposed system's significance lies not only in its ability to enhance parking surveillance but also in its cost-effectiveness. By automating the critical tasks involved in parking management and eliminating the need for extensive manual oversight or the costly deployment of external sensors, it offers an economical alternative that can be adopted widely across diverse urban and suburban settings.

In summary, the proposed system represents a pioneering solution to the challenges of contemporary parking surveillance. By seamlessly integrating advanced vehicle detection algorithms, license plate extraction methods, real-time monitoring, and centralized data storage, it addresses the critical need for efficient, secure, and cost-effective parking management. It is a beacon of hope for urban environments seeking to harness technology for enhanced mobility and security while optimizing parking solutions for the future.

VII. FLOWCHART



VIII. SYSTEM REQUIREMENTS

A. Hardware

1) Operating System: Window 11, 64 bits.
2) Processor: i7 10th gen or equivalent
3) Installed Main Memory: 16GB-RAM
4) Webcam: 720p HD Webcam
5) Resolution: 1920 X 1080

B. Software

1) Python Programming Language
2) OpenCV
3) Streamlit
4) Code Editor: PyCharm Code Editor
5) Vs Code Editor
6) Ultralytics- Yolov8
7) Google Colab

IX. CONCLUSION

The proposed parking surveillance system offers a cutting-edge solution for urban parking surveillance. It combines advanced vehicle detection, real-time monitoring, and centralized data storage, enhancing precision, efficiency, and security.
Its adaptability, improved traffic flow, and user-friendly interface make it a vital tool for modern urban settings, marking a significant step towards advanced parking surveillance.

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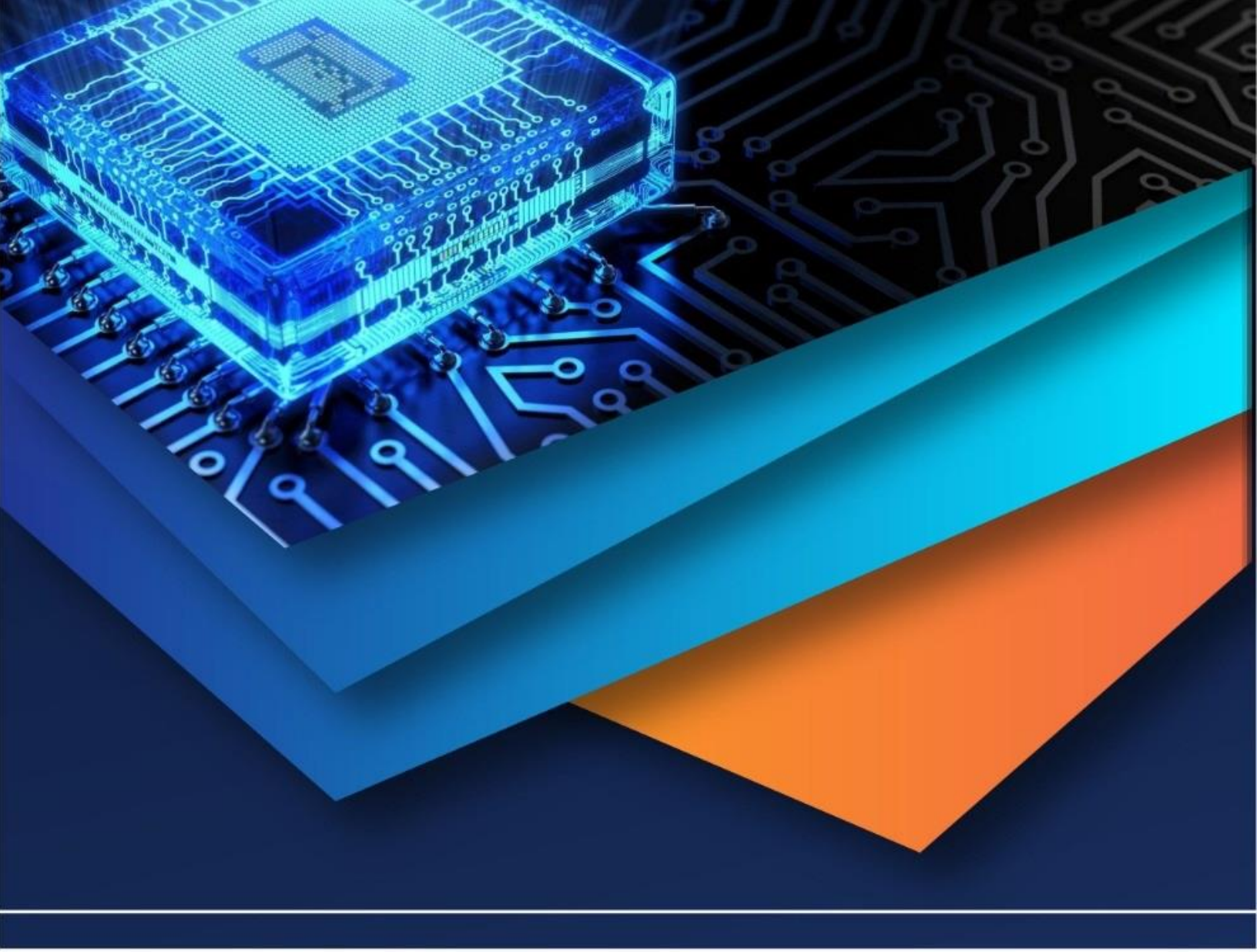

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