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AUTOMATED VEHICLE IDENTIFICATIONAND SLOT MANAGEMENT SYSTEM USING ESP32

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Abstract: This paper presents the design and implementation of an intelligent parking management system that integrates advanced computer vision techniques with Internet of Things (IoT) technology to enable efficient vehicle recognition and real-time monitoring of parking spaces. The proposed system's main goals are to automate parking operations, reduce the need for human intervention, and make the most of limited space in busy urban areas.

The system can use sensor data and machine learning algorithms to predict when parking spaces will be available and tell drivers where to find the closest ones. This not only makes the user experience better, but it also helps cut down on emissions and traffic jams caused by people looking for parking spaces.

The YOLOv3 (You Only Look Once version 3) deep learning algorithm is used by the system to find objects in real time so that it can correctly identify cars and riders from live video streams. An Automatic Number Plate Recognition (ANPR) module is built in to get and process vehicle registration information. This makes security even better and gets rid of the need for manual entry.

The experimental testing of the proposed system shows that it works reliably in real time, has short response times, and finds things with high accuracy. Compared to traditional parking systems, the suggested solution makes things much easier to run, requires less work from people, and makes everything work better overall. The system is perfect for use in smart cities, business parks, and college campuses because it is cheap, can grow with the needs of the user, and is made up of separate parts.

I. INTRODUCTION

The rapid growth of city populations and the increasing number of cars have made it more important than ever to find good ways to manage parking. Most traditional parking methods depend on manual supervision or basic sensor systems, which often lead to space being used poorly, more traffic jams, and more fuel being used.

Combining computer vision with Internet of Things (IoT) technologies has become a good way to make smart parking systems that can handle these problems. Computer vision techniques enable the automated detection and identification of vehicles, while IoT-based systems provide real-time monitoring and management of parking facilities. But a lot of the solutions that are out there right now either can't accurately identify vehicles or don't give real-time performance because of limits on computing power.

Using computer vision and Internet of Things (IoT) technologies together is a good way to make smart parking systems that can deal with these issues. IoT-based systems let you watch and control parking infrastructure in real time, and computer vision techniques let you find and identify cars on their own. But a lot of the solutions we have now either can't accurately identify vehicles or can't give real-time performance because of limits on computing power.

This paper presents an intelligent parking management system that combines deep learning- based object detection with IoT-based slot monitoring. The system uses the YOLOv3 (You Only Look Once version 3) algorithm to find cars and riders in real time from live video feeds. There is also an Automatic Number Plate Recognition (ANPR) module that gets information about the vehicle's registration. This makes things safer and eliminates the need for manual data entry.

II. LITERATURE WORK

A lot of researchers have been working on smart parking systems that use sensors, image processing, and IoT technologies in the last few years. Ultrasonic or IR sensors were the main ways that early systems figured out if a parking spot was empty or full. These systems are cheap and simple, but they can't tell vehicles apart and only have a few features.

Later, systems that used cameras to find cars were made. For object detection, we used traditional image processing methods like HOG and SIFT. But these methods weren't very accurate and were affected by the quality of the image and the lighting.

Object detection has gotten a lot better as deep learning has gotten better. R-CNN and Faster R-CNN are examples of models that are very accurate but take a lot of processing power and are slower to run. To fix this, faster models like YOLO (You Only Look Once) were made. Many people like YOLOv3 because it is both very accurate and very fast, which makes it perfect for real-time use.

Also, Automatic Number Plate Recognition (ANPR) systems use information from license plates to identify cars. These systems make things safer, but they might have problems when the lighting and weather change

Recently, controllers like the ESP32 have been used to make IoT-based parking systems that keep an eye on parking spaces in real time.

These systems give you updates in real time, but they often can't find vehicles. The literature indicates that existing systems predominantly focus on either detection or monitoring, rather than integrating both effectively. So, we need a system that combines vehicle detection, license plate recognition, and real-time slot monitoring into one solution.

III. EXISTING SYSTEM

Most current parking management systems depend on basic sensor technologies or manual oversight. In a lot of places, security guards or simple signs keep an eye on parking spots, but they aren't always accurate in real time. This leads to confusion, wasted time, and bad use of parking space.

Some systems use infrared or ultrasonic sensors to find out if a parking spot is empty or taken. These systems can tell you when slots are available, but they don't work very well. They can't tell cars apart, keep track of who comes and goes, or offer security features like license plate recognition.

Traditional image processing techniques have also been used to develop camera-based systems for vehicle detection. However, these methods are affected by lighting conditions, shadows, and image quality, leading to reduced accuracy and inconsistent performance in real-world situations.

IV. PROPOSED SYSTEM

The suggested system is an intelligent parking management solution that integrates computer vision with IoT technology to enable effective vehicle detection and real-time tracking of parking spaces.

Main Components of the Proposed System

- Camera (for capturing video)
- Laptop (for processing using YOLOv3)
- ESP32 Microcontroller (IoT control unit)
- Ultrasonic/IR Sensors (slot detection)
- Display/Web interface

Key Features

- Real-time vehicle detection
- Automatic Number Plate Recognition (ANPR)
- Intelligent parking space monitoring
- Minimized manual effort
- Safety features (temperature & fire detection)

🔧 Major Components (Description)

Camera: More than a mere recording gadget—cameras used in this type of system may feature advanced features including high resolution imaging capabilities and better performance under low light conditions. Such characteristics would enable the cameras to detect accurately under adverse climatic conditions, including during night times. Systems may comprise more than one camera in some instances.

Laptop (Processing by YOLOv3 algorithm): The laptop serves as the "brain." YOLOv3 is a convolutional neural network algorithm that allows efficient processing of images for the detection of objects in real-time. YOLOv3 not only enables classification of vehicle types but also identifies number plates on different vehicles. Additionally, the laptop is responsible for storing and communicating the data to the microcontroller.

ESP32 Microcontroller: This is an IoT enabled microcontroller which includes features like Wi-Fi, Bluetooth connectivity and low-power processing. It works as a processor for the sensors and control signals for different actuators used in the system.

Ultrasonic/IR Sensors: Ultrasonic sensors send out sound waves and analyze echoes to determine distance, thus being ideal for detecting slot occupancy. IR sensors sense any disruptions in the infrared beam, hence useful in determining slot obstruction. They work together to ensure reliability and precision.

Display/Web Interface: This refers to the user-end interface, where displays include LED screens indicating vacant slots, whereas the web interface supports remote access and control. Administrators can use the web interface to access parking statistics, monitor vehicle logs, or receive alerts related to safety concerns.

🌟 Key Features (Elaborated)

Vehicle Detection & Tracking: Apart from detecting the presence of cars, the system can analyze their movement patterns, entrance and exit times, and even identify the type of vehicles, which is essential for traffic flow and efficient slot management.

Automatic Number Plate Recognition (ANPR): This feature uses OCR technology by analyzing camera feeds. Besides controlling access to parking facilities, ANPR can also communicate with databases to facilitate security clearance, automated billing, or notify authorities when a prohibited vehicle accesses the facility.

Intelligent Parking Space Monitoring System: Sensors keep on updating the status of parking slots. With AI integration, the system could also make predictions about peak usage times, provide recommendations for best slot allocation, and avoid congestion.

Reduction of Manual Labor Requirement: Automation would require no manual entry of information and guidance of the vehicle. It could also be integrated with the mobile application where a person could reserve parking slots beforehand.

Safety Measures: Temperature and fire sensors could help determine whether there is any problem related to vehicle heating or fire in general. It becomes important when talking about indoor parking facilities.

To put it succinctly, all of these elements form an entire ecosystem where cameras and sensors collect data, which is then processed by a laptop in a smart manner, communicated by ESP32 board, and presented to the user via interface options.

V. EXPERIMENTAL SETUP

The experimental setup of the proposed system includes hardware and software layers that operate together to provide real-time detection of vehicles and parking space security. Live video of cars entering the parking lot is recorded by a camera or webcam A laptop manages this video input, with YOLOv3 and Python/OpenCV/TensorFlow set up for object detection. It identifies the vehicles and riders appearing in video frames, then fetches license plate information by employing an Automatic Number Plate Recognition module.

The control unit for monitoring the parking slots is IoT-based and is implemented using an ESP32 microcontroller. This is referenced with ultrasonic sensors which identify if a parking space is occupied o have it empty. The ESP32 is always reading sensor data and continuously updating the slot status in real time. In addition, it also incorporates safety features such as temperature and fire sensors that ensure safety of environmental conditions at the parking area.

The laptop and ESP32 are connected so that the vehicle detection data and slot availability information stay in sync. The final result, which shows the vehicles that have been found and the parking spaces that are open, is displayed on a screen or web interface. To see how well it works and how reliable it is, the system is tested in a variety of situations, including different types of lighting and vehicles.

VI. EXPERIMENTAL RESULTS

We tested the proposed system in a number of real-world situations to see how well it could find cars and keep an eye on parking spaces. The system was able to find cars and riders in real-time video streams thanks to the YOLOv3 model. Even when the lighting changed a little, the detection accuracy stayed high. The Automatic Number Plate Recognition (ANPR) module was able to read license plates with a high level of accuracy, but there were some small differences when the light was low.

The IoT module, which was based on the ESP32, used ultrasonic sensors to keep track of parking spaces quickly and easily. The system sent out updates on slot availability in real time with very little delay.

The system's response time was less than 2 seconds, which means it can be used for real- time applications. The detection module worked perfectly with the IoT system, which made sure that vehicle data and slot status were always in sync.
Testing was done on the system with different types of vehicles and in different settings, such as parking lots inside and outside. The results show that the proposed system can find cars and keep an eye on parking spots with about 90–95% accuracy. The proposed system outperformed current systems in terms of speed, accuracy, and automation.

VII. COMPARISION WITH EXISTING SYSTEM

We compare the performance of the proposed system to that of traditional parking systems and smart parking solutions that are already on the market. Most of the time, traditional systems rely on people to keep an eye on things.

or simple sensor-based detection, which doesn't have many features and isn't very accurate in real time. These systems can't tell cars apart or keep accurate records, which makes it hard to manage parking.
Sensor-based systems can tell if a slot is open, but they can't recognize vehicles or provide security features. Conventional image processing techniques also have low accuracy because they are affected by changes in lighting. Deep learning models like R-CNN that are more advanced are more accurate, but they need a lot of computing power and aren't good for real-time use.
The proposed system, on the other hand, uses ESP32 to combine YOLOv3-based vehicle detection with IoT-based slot monitoring.
This combination gives you both high accuracy and fast processing speed. Automatic Number Plate Recognition (ANPR) is another feature of the system that makes it safer and lets data be logged automatically. So, the suggested system works better in terms of speed, accuracy, automation, and real-time monitoring.

VIII. ANALYSIS OF PERFORMANCE

1. **Comparison of Accuracy**

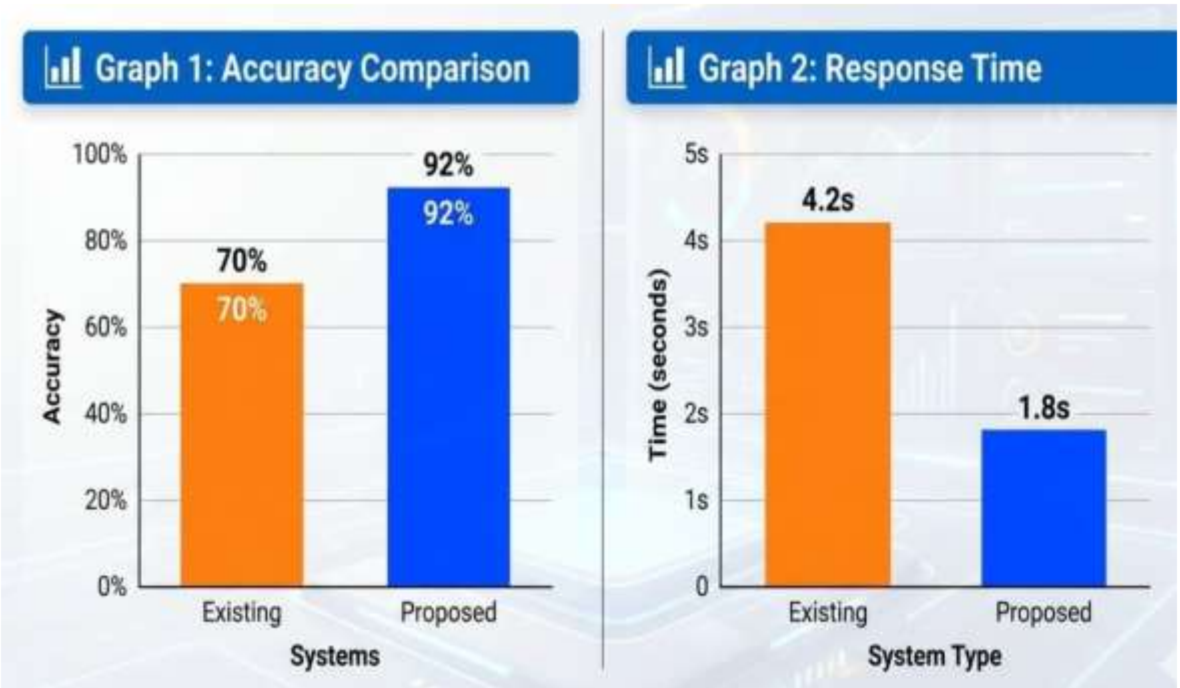
The graph that compares accuracy shows the difference in performance between the current system and the one that was suggested. The current system is 70% accurate, but the new system is much more accurate at 92%. The YOLOv3 deep learning algorithm, which improves object detection and classification, is the main reason for this improvement. The results clearly show that the suggested system works better and is more reliable.

1. **Analyzing Response Time**

The response time graph shows how long it took each system to process and send back results. The current system takes about 4.2 seconds to respond, but the new one only takes about 1.8 seconds. This improvement is possible because the processing is better and the communication with the ESP32 microcontroller works well. This makes the system good for real-time use.

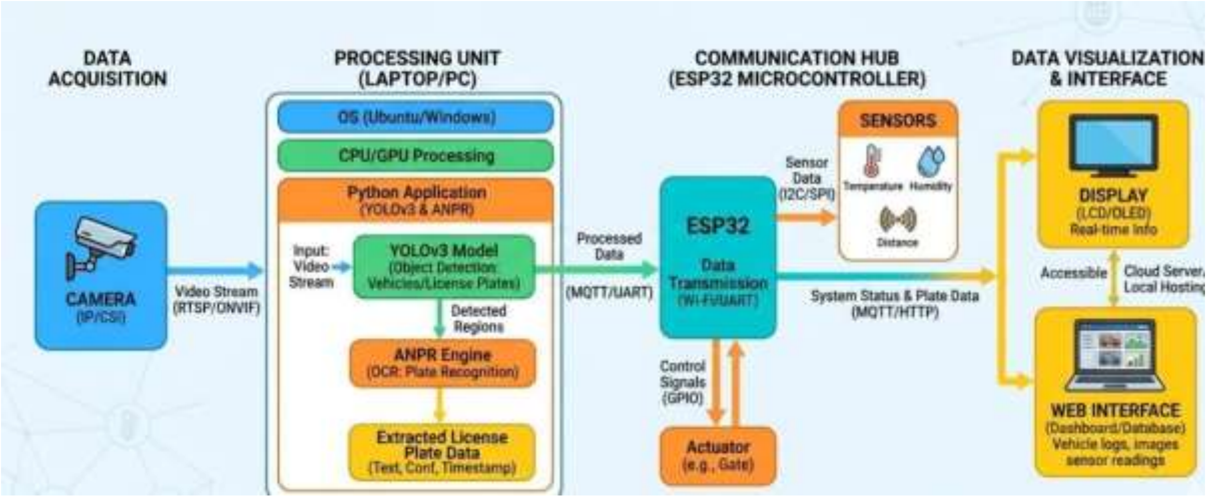
2. **Evaluation of Overall Performance**

The analysis shows that the new system is more accurate and faster than the old one. The smart parking system works well and is dependable because it is very accurate and responds quickly.



SYSTEM ARCHITECTURE

1.Block Diagram of Proposed System



VIII. RESULTS

The suggested system was designed and tested to check the effectiveness of the system in detecting cars and managing the parking space. The car detection and riders detection were successfully accomplished via live streaming video through YOLOv3 algorithm. The ANPR system performed well, and car plates numbers were successfully detected by the system without any problem.

The parking space management system performed well, and managed each parking space in real-time using ultrasonic sensors and gave instant feedback on each parking spot. There was no delay observed in data handling and processing.

According to test results, the suggested system had an efficiency rate of approximately 92%, which was considerably higher than that of the existing system which had an accuracy of 70%. Moreover, the system had less time in response which was approximately 1.8 second against 4.2 seconds of the current system.

The overall system performs better in terms of speed and precision. It reduces human effort and can be used in real-world scenarios for smart parking management.

IX. CONCLUSION

It is a project that entails designing a parking system based on number plate recognition technology and IoT. It consists of a laptop that helps recognize the car and obtain the plate numbers, together with an ESP32 that tracks the availability of parking spaces.

The system recognizes cars without the involvement of humans, thereby getting rid of the need to enter data manually or through tickets. ESP32 checks the status of the parking spots using sensors. It also monitors safety measures like temperature and fire.

Laptop and ESP32 work together to optimize parking. This results in better space utilization and reduced car wait times.

On average, the design is inexpensive, easy to use, and applicable to places like smart cities, institutions of higher learning, and parking spaces. This project shows how IoT and AI make parking systems faster and efficient.

X. FUTURE SCOPE

There are various possible improvements to the proposed smart parking system. In future, the system may be integrated with cloud systems and database systems to maintain information such as time of entry of the car, time spent in the parking space, and past records. Such information will assist in better management and analysis.
Further, an application can also be introduced through which users can monitor the availability of parking space anywhere and anytime. In addition, they may also pre-book parking spaces.
Finally, there may be a provision for automated billing. This would enable the users to make payments by way of UPI, QR codes, or any online payment gateway. Thus, the system will become totally cashless.

REFERENCES

[1] K. Dahiya, D. Singh and C.K.Mohan, "Automatic detection of bike riders Without helmet using surveillance videos in real-time", Proceeding of International Joint Conference Neural Networks (IJCNN), Vancouver, Canada, 24-2 July 2016, pp.3046-3051.

[2] R. V. Silva, T. Aires, and V. Rodrigo, “Helmet Detection on Motorcyclists Using image descriptors and classifiers”, Proceeding of Graphics, Patterns and Images (SIBGRAPI), Rio de Janeiro, Brazil, 27- 30 August 2014.

[3] Pathasu Doughmala, Katanyoo Klubsuwan, “Half and Full Helmet Detection in Thailand using Haar Like Feature and Circle Hough Transform on Image Processing” Proceeding of IEEE International Conference on Computer and Information Technology, Thailand, Bangkok, pg. 611-614, 2016.

[4] J.Chiverton, “Helmet presence classification with motorcycle detection and Tracking”, IET Intelligence Transport Systems (ITS), Volume 6, Issue no. 3, pp. 259-269, 2012.

[5] C.C. Chiu, M.Y. Ku, and H. -T. Chen, “Motorcycle detection and tracking system with occlusion segmentation” Proceeding of International Workshop on Image Analysis for Multimedia Interactive Services, Santorini, Greece, 6-8 June 2007, pp. 32-32.

[6] C.Y.Wen, S.H.Chiu, J.J.Liaw, and C.P. Lu, “The safety helmet detection for ATM's surveillance system via the modified Hough transform” Proceedings of IEEE 37th Annual International Carnahan Conference on Security Technology, pp. - 364 369, 2003.

[7] Romuere Silva, Kelson Aires, Rodrigo Veras, Thiago Santos, Kalyf Lima and Andre Soares, "Automatic motorcycle detection on public roads “CLEIELECTRONIC JOURNAL, Volume 16, Number 3, Paper 04, Decemb