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ANPR BASED SMART PARKING SYSTEM

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Abstract

In Indian cities, where 97% of parking is unorganised, the average driver spends 20 minutes daily searching for a spot, contributing to congestion and economic losses. Our smart parking system addresses this challenge. Leveraging Automatic Number Plate Recognition (ANPR) technology, it streamlines operations. Using an ESP32Cam and Infrared (IR) sensors, approaching vehicles trigger image capture, transmitted to a web server via an Arduino WiFi module. The server, equipped with ANPR, cross references the number plate against a database, relaying a prompt response to the Arduino. This determines authorization and slot availability, facilitating efficient parking management.When conditions are satisfied, the gate opens for greater security and convenience. Using this approach will optimise parking facilities. Its real time decision making capability is a sophisticated step forwards in the solution of parking problems. It provides an adjustable model to be copied in smart cities across the world. The system's integrability is not limited to use as a parking management tool, bringing together the various elements of an advanced and complete urban infrastructure. In the future facing faster urbanisation, with all manner of difficulties confronting us in terms of mobility and space management, our smart parking solution becomes a key piece among those rewriting what an urban environment looks like.

Keywords: Smart Parking, Automatic Number Plate Recognition (ANPR), ESP32 Cam, Infrared(IR) Sensors, Urban Planning Advancements

1. INTRODUCTION

The Automatic Number Plate Recognition (ANPR) based smart parking system proposed in this project represents a groundbreaking advancement in modern parking management, leveraging cutting-edge technology to enhance efficiency and security. ANPR, a technology that involves optical character recognition to extract alphanumeric information from vehicle licence plates, plays a pivotal role in automating the identification process. In this innovative solution, an Arduino Uno, ESP32CAM, IR sensors, and a servo motor collaboratively orchestrate the system's functionality. Upon a vehicle's approach, IR sensors trigger the ESP32CAM to capture a high-resolution image of the licence plate, and the ANPR algorithm, hosted on a web server, processes the image to extract and analyse the plate information against a centralised database. The significance of ANPR lies in its ability to streamline access control seamlessly, reducing human intervention and enhancing the

overall efficiency of parking facilities. Compared to traditional parking systems, the ANPR-based solution offers advantages such as rapid and accurate identification, improved security through database cross-referencing, and the ability
to automate gate operations, thus minimising congestion and optimising resource utilisation. This project addresses the growing need for intelligent parking solutions, embodying the intersection of technology and convenience for a more sophisticated urban landscape.

2. METHODOLOGY

The methodology for implementing the ANPR-based smart parking system involves a systematic approach to integrate the hardware components and software modules seamlessly. Initially, the hardware setup, including Arduino Uno, ESP32CAM, IR sensors, and the servo motor, is assembled and interconnected. The IR sensors are programmed on the Arduino Uno to detect the presence of a car, triggering the ESP32CAM to capture an image upon detection. The captured image is then sent to a web server hosting the ANPR system for processing. The ANPR system compares the number plate information extracted from the image against a predefined database. Upon successful recognition, a request is sent to the Arduino Uno through the web server, prompting the control of the servo motor to open the gate. Rigorous testing and optimization are conducted to ensure the system's reliability, accuracy in number plate recognition, and secure gate operation, meeting the project's objectives of an efficient smart parking solution. Each component in the ANPR-based smart parking system plays a crucial role in achieving the project's functionality and overall success. The Arduino Uno serves as the central controller, orchestrating the interactions between the various elements. It interfaces with the IR sensors, strategically placed at the gate, responsible for detecting the presence of approaching vehicles. Upon detection, the ESP32CAM, equipped with a camera module, captures a clear image of the vehicle's number plate. The captured image is then transmitted to the web server housing the ANPR system. The web server performs the essential function of processing the image and extracting the number plate information, comparing it against a database of registered plates. If a match is found, the server communicates with the Arduino Uno, instructing it to actuate the servo motor. The servo motor, functioning as the gate mechanism, opens the gate, allowing authorised vehicles access to the parking area. Each component, from sensors to microcontrollers, collaborates harmoniously, highlighting their indispensable roles in creating an intelligent parking solution that streamlines access while maintaining security and efficiency.

2.1 Development and Implementation

The development and implementation of the ANPR-based smart parking system represents a meticulous process that seamlessly integrates hardware components and advanced software functionalities. In the initial stages, extensive planning and design considerations were made to determine the optimal placement of IR sensors and the deployment of the ESP32CAM for efficient image capture. The Arduino Uno emerged as the central nervous system of the project, providing the necessary interfaces for communication between components. The project's standout feature lies in its ANPR system, a critical element developed using a Convolutional Neural Network (CNN) model. This AI-driven module was trained using a dataset comprising hundreds of images showcasing diverse number plates. The CNN model, through iterative learning, became adept at discerning patterns and extracting alphanumeric information from varying plate designs, ensuring adaptability to real-world scenarios. The implementation phase

involved coding the IR sensors to trigger the ESP32CAM upon vehicle detection. The ESP32CAM, in turn, captured high-resolution images of approaching vehicles. These images, encapsulating number plates, were then transmitted to the web server hosting the ANPR module. The server, equipped with the trained CNN model, processed the images with remarkable precision, extracting and interpreting the number plate data. The integration of a comprehensive database allowed for efficient comparison and verification, enabling the system to distinguish between authorised and unauthorised vehicles. The successful identification of a registered number plate prompted the web server to communicate with the Arduino Uno, signalling the activation of the servo motor. The servo motor, acting as the gate mechanism, executed a precise 90-degree rotation, facilitating access to the parking area. Rigorous testing and fine-tuning were conducted to optimise the system's accuracy, responsiveness, and security. The collaborative effort of hardware components and an advanced ANPR system culminated in a smart parking solution that not only leverages cutting-edge technology but also underscores the synergy of artificial intelligence and physical computing in addressing real-world challenges.

2.2 Dataset

The dataset utilised for the development of the Automatic Number Plate Recognition (ANPR) module in this project is sourced from Kaggle, specifically the "Car Plate Detection" dataset, available at https://www.kaggle.com/datasets/andrewmvd/car-plate-detection. Comprising a total of 433 images, this dataset is enriched with bounding box annotations, providing precise delineations of the car licence plates within each image. The annotations adhere to the PASCAL VOC format, a widely recognized standard for object detection tasks. This comprehensive dataset not only offers a diverse array of images capturing various scenarios, lighting conditions, and plate designs but also ensures that the ANPR module is trained on a robust and representative sample. The inclusion of bounding box annotations enhances the model's ability to discern spatial relationships within the images, ultimately contributing to the accuracy and reliability of the ANPR system. Leveraging this dataset, the Convolutional Neural Network (CNN) model employed in the ANPR module underwent rigorous training, enabling it to generalise and accurately recognize licence plates in real-world conditions, making it a pivotal asset in the successful implementation of the smart parking system.

2.3 Advantages:

The ANPR-based smart parking system presents a paradigm shift in comparison to traditional parking systems reliant on security guards and manual gates or even technically assisted systems operated by humans. One of its key advantages lies in the automation of the gate access process, eliminating the need for constant human monitoring and intervention. The integration of IR sensors and an advanced ANPR module allows for swift and accurate detection and recognition of vehicle number plates, streamlining the entry process without requiring manual verification. This not only enhances the efficiency of the parking system but also minimises the potential for human errors or oversights. Furthermore, the reliance on a trained Convolutional Neural Network (CNN) for number plate recognition ensures a level of precision and consistency that surpasses human-operated systems. The ANPR-based smart parking system operates 24/7, offering continuous monitoring and access control, which can be challenging for human-operated systems to achieve consistently. Overall, the automated nature of the ANPR-based smart parking system translates to heightened security, reduced operational costs, and increased reliability compared to

traditional or human-operated parking systems.

2.4 Disadvantages:

While the ANPR-based smart parking system presents a technologically advanced solution, it is not without its disadvantages when compared to traditional parking systems manned by security guards or operated by human-controlled technical systems. One significant drawback is the potential susceptibility to technical failures or malfunctions. In the event of a power outage, system malfunction, or network connectivity issues, the automated gate operation and ANPR functionalities could be compromised, leading to disruptions in the parking access process. Moreover, the initial setup and maintenance of the ANPR system may demand a higher upfront cost and specialized technical expertise, making it less economically viable for smaller establishments or those with budget constraints. Additionally, reliance on AI-driven algorithms for number plate recognition introduces the risk of false positives or negatives, impacting the system's overall accuracy. Traditional systems, with a human presence, offer a level of adaptability and decision-making capability that automated systems may lack, allowing for more nuanced responses to unforeseen circumstances. Lastly, the dependence on complex technology may pose challenges in terms of user familiarity and acceptance, especially in environments where users may prefer the simplicity and direct communication offered by human-operated systems. Balancing the advantages of automation with these potential drawbacks is crucial for determining the system's appropriateness in specific contexts.

2.5 Future Prediction:

The future scope of this ANPR-based smart parking system holds tremendous potential for further advancements, expanding beyond its current gate-centric application. One notable avenue is the transformation of the entire parking lot into a smart infrastructure. By integrating additional sensors and cameras throughout the parking facility, the system could provide real-time data on parking

space availability, guiding drivers to vacant spots efficiently. This holistic approach not only enhances user convenience but also optimises overall parking lot management. Furthermore, envisioning a mobile-based application linked to the ANPR system opens avenues for personalised and convenient user experiences. Users could monitor their parked vehicles remotely through the app, receiving instant notifications on entry and exit events. The application could also generate digital receipts for parking durations, facilitating seamless and cashless transactions. Integrating features such as advance booking and navigation to available parking spaces can further elevate user satisfaction. These future enhancements not only refine the parking experience but also contribute to urban efficiency by reducing traffic congestion and enhancing overall mobility. The continuous integration of emerging technologies promises an exciting trajectory for the evolution of smart parking solutions.

2.6 Conclusion:

In conclusion, the ANPR-based smart parking system designed with Arduino Uno, ESP32CAM, servo motor, and IR sensors represents a technological leap in parking management. The system seamlessly integrates hardware and software components to automate the parking access process. Functioning through IR sensors, the ESP32CAM captures high-resolution images of approaching vehicles, initiating an ANPR system that employs a Convolutional Neural Network (CNN) model

trained on a diverse dataset for precise number plate recognition. While the system offers advanced functionalities, including secure gate control, and real-time number plate verification, it does come with potential drawbacks, such as technical vulnerabilities and upfront costs. However, the advantages of improved efficiency, reduced manpower, and enhanced security outweigh these limitations. Opting for this smart parking solution is compelling due to its ability to streamline parking operations, providing a hassle-free experience for users. The ANPR technology ensures quick and accurate recognition of registered vehicles, enabling automated gate access. Additionally, the future scope for expanding this system into an entire smart parking lot and integrating a mobile application for remote monitoring and digital transactions enhances its appeal. Choosing this option not only aligns with technological trends but also contributes to urban efficiency, reducing congestion and providing a user-friendly, modernised parking solution. Ultimately, the ANPR-based smart parking system offers a sophisticated, forward-thinking approach to parking management that balances technological innovation with practicality and convenience.

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