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An AI-Driven Real-Time Parking Monitoring and License Plate Recognition System using CCTV

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Abstract- This paper proposes a smart car parking system that uses image processing and real-time CCTV monitoring to efficiently detect parking space availability and recognize vehicle license plates. The system is designed for both open parking areas and multi-storey parking environments. It uses Python along with the OpenCV library to analyze video input and determine whether parking slots are occupied or vacant based on pixel-level analysis and image processing techniques. In addition, the system integrates Optical Character Recognition (OCR) using the Tesseract engine to automatically extract license plate information from captured images. To improve accuracy, multiple preprocessing techniques are applied to handle variations in image quality, lighting, and noise. The proposed system enables automated parking management, reduces manual effort, and enhances monitoring efficiency, making it suitable for real-time smart parking applications.

Keywords- Smart Parking System, Image Processing, OpenCV, Optical Character Recognition (OCR), Tesseract, License Plate Recognition, Real-Time Monitoring, Computer Vision, Parking Space Detection, Cloud Storage.

I. INTRODUCTION

With the rapid growth of urbanization and globalization, metropolitan cities are becoming increasingly crowded, leading to serious traffic congestion and parking challenges. As the population continues to rise, the number of vehicles on the road has also increased significantly. This rapid growth has created a strong demand for efficient parking management systems, making parking one of the major concerns in modern cities and smart urban environments [4], [5].

In many urban areas, individuals purchase vehicles without having dedicated parking spaces. As a result, roads, sidewalks, and public areas are frequently used for parking, which reduces road capacity and contributes to heavy traffic congestion. Traditional parking systems typically consist of open spaces where drivers must manually search for an available slot. This process is time-consuming, inefficient, and often frustrating, especially in large parking areas and multi-storey structures where drivers need to move across multiple levels to find a free space [2], [6].

The lack of an efficient parking management system also leads to increased fuel consumption, environmental pollution, and driver stress due to unnecessary vehicle movement while searching for parking. Moreover, poor monitoring results in inefficient space utilization and difficulties in managing parking facilities in crowded locations such as malls, offices, and public areas. Therefore, there is a strong need for intelligent and automated systems that can optimize parking space usage and reduce search time.

To address these challenges, several technologies have been introduced, including sensor-based, IoT-based, and cloud-based parking systems. Sensor-based approaches can accurately detect vehicle presence; however, they involve complex installation, higher costs, and maintenance challenges [1], [3], [5]. Cloud-based systems offer centralized control and data management but rely heavily on stable network connectivity [6].

In comparison, image processing-based systems provide a more flexible, scalable, and cost-effective solution. By utilizing cameras and computer vision techniques, these systems can monitor parking areas in real time and identify whether a parking slot is occupied or vacant. Image processing methods such as grayscale conversion, edge detection, and contour analysis play a key role in accurately determining parking status [2], [3].

In this context, the proposed smart parking system employs image processing techniques to automatically detect parking availability and enhance parking efficiency. It also integrates Optical Character Recognition (OCR) for license plate recognition and cloud storage for managing vehicle data. The system reduces traffic congestion, minimizes search time, improves user convenience, and supports the development of smart city infrastructure [4], [5].

II. LITERATURE SURVEY

Several studies have been carried out to enhance parking management systems using different technologies. Ming-Yee Chiu et al. proposed a vehicle counting system at checkpoints to estimate available parking spaces [1]. This method utilized induction loop sensors embedded beneath the road surface. Although the system provided accurate detection and was less affected by environmental conditions, it faced challenges such as complex installation, road damage, and high maintenance requirements in case of system failure [2].

Image processing has become an important research area with applications across multiple domains, including security, engineering, healthcare, and media. Various preprocessing techniques such as RGB to grayscale conversion, blurring, thresholding, and contour detection play a crucial role in improving the accuracy of image-based systems. These methods help extract meaningful features from images and are widely used in computer vision applications [3].

In many real-world applications, large volumes of image data are processed to extract useful information. Histogram-based techniques are commonly used to obtain statistical insights from images and classify them based on quality. These methods are also useful for image normalization and equalization. Furthermore, advanced histogram approaches help remove noise and eliminate small unwanted details, thereby improving the overall performance of image processing systems [4], [5]

License plate detection is another important application of image processing, where text extraction plays a key role. Effective preprocessing is required before converting images into text. A method proposed in [6] utilizes corner detection techniques to extract text from images. This approach is efficient and fast, as it uses predefined parameters for handling different types of images such as handwritten, printed, and skewed formats.

Another approach focuses on detecting license plates under varying conditions such as different lighting levels and distances. This method applies wavelet transformation and masking techniques to identify potential license plate regions in images [7]. After preprocessing, the extracted region is passed to the Tesseract Optical Character Recognition (OCR) engine, which converts the image into readable text through a command-line interface [8].

Overall, these studies emphasize the significance of image processing and OCR techniques in developing efficient and automated smart parking systems.

III. SYSTEM ANALYSIS

A. EXISTING SYSTEM

The existing smart parking system is based on image processing techniques for detecting parking space availability and recognizing vehicle license plates. It is designed to operate in both multi-storey parking structures and open parking environments, making it adaptable to different real-world scenarios [2], [6].

The system primarily uses Python along with the OpenCV library for processing video input obtained from cameras. OpenCV is used for image acquisition, preprocessing, and analysis tasks such as grayscale conversion, edge detection, and contour extraction [2], [3]. Parking slot occupancy is determined by applying edge detection algorithms and analyzing coordinate-based pixel regions within the captured frames. Based on pixel variations, each parking space is classified as either occupied or vacant.

In addition to parking detection, the system incorporates Optical Character Recognition (OCR) using the Tesseract engine for extracting text from images. This is mainly used for license plate recognition, where images are processed and converted into readable text format [8]. To improve performance, the system applies multiple levels of image preprocessing depending on the quality and characteristics of the input images. This adaptive processing helps in enhancing text extraction results and overall system performance [3], [5]. Overall, the existing system integrates image processing and OCR techniques to provide automated parking monitoring and basic vehicle identification capabilities.

DISADVANTAGES OF THE EXISTING SYSTEM

Despite its functionality, the existing system has several limitations:

- **Dependency on Image Quality:**
  The system's performance highly depends on the quality of input images. Poor lighting conditions, low resolution, or noise in images can reduce the accuracy of parking detection and text recognition [3].
- **Sensitivity to Environmental Conditions:**
  External factors such as shadows, weather conditions, and varying illumination levels can affect the system's ability to correctly identify parking slot occupancy, leading to false detections [2], [4].
- **Processing Speed Issues:**
  Real-time image processing requires significant computational resources. In systems with limited hardware capability, this may lead to delays in processing and reduced system efficiency [5].
- **Limited Adaptability:**
  Although the system is designed for different parking environments, its performance may vary depending on layout complexity, camera angle, and structural variations in parking areas [6].
- **Text Extraction Limitations:**
  The accuracy of OCR using Tesseract can be affected by factors such as font style, orientation, blur, and noise in images. This may result in incorrect license plate recognition in certain conditions [8].

B. PROPOSED SYSTEM

When a vehicle enters the parking area, the system first checks for the availability of vacant parking spaces using real-time image processing. If empty slots are available, the system captures the vehicle's license plate using an entry camera and stores the information in the cloud database. The system then displays the available parking spaces and allows the vehicle to enter [2], [6].

If no parking slots are available, the system notifies the user accordingly. When the vehicle exits the parking area, a second camera captures the license plate again. The system compares this information with the stored entry data and calculates the total parking duration. Based on the duration of stay, the system automatically generates the parking fee, enabling a fully automated parking management process [5], [6].

ADVANTAGES OF THE PROPOSED SYSTEM

- **Real-Time Parking Availability Information:**
  The system provides real-time updates on parking space availability, enabling users to quickly identify vacant slots. This reduces search time and improves overall parking efficiency [4], [5].
- **Optimized Space Utilization:**
  By accurately detecting occupied and vacant parking spaces, the system ensures better utilization of available parking areas. This leads to improved organization and increased parking capacity [2], [4].
- **Resource Efficiency:**
  The system minimizes unnecessary vehicle movement while searching for parking, which helps in reducing fuel consumption and lowering environmental pollution [5].
- **Enhanced Security and Monitoring:**
  Continuous monitoring through cameras improves security in parking facilities. The system can help detect unusual activities and provides better surveillance for vehicles and users [6]

IV.SYSTEM DESIGN

SYSTEM ARCHITECTURE

Below diagram depicts the whole system architecture.

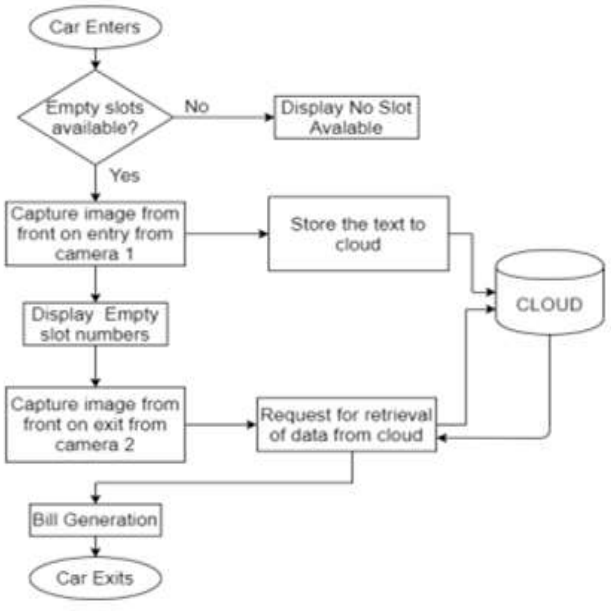

Fig 1. Methodology followed for proposed model

V. SYSTEM IMPLEMENTATION

MODULES

The Smart Parking System based on image processing is divided into multiple modules to efficiently manage different functionalities and ensure smooth operation

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1. Image Acquisition and Preprocessing:

This module is responsible for capturing images or video streams from cameras installed in the parking area. The captured data is pre-processed using techniques such as image enhancement, normalization, filtering, and grayscale conversion to improve image quality for further analysis [2], [3].

2. Parking Spot Detection:

The parking detection module uses image processing techniques such as edge detection, contour analysis, and coordinate-based pixel evaluation to determine whether a parking slot is occupied or vacant. Based on pixel variations, each parking space is classified accurately [2], [3].

3. Text Extraction and Recognition:

This module applies Optical Character Recognition (OCR) using the Tesseract engine to extract text from images. It is mainly used for recognizing vehicle license plate numbers. Proper preprocessing ensures better accuracy in text extraction under different conditions [6], [8].

4. Data Storage and Management:

This module manages the storage of processed data, including parking slot status, entry and exit timestamps, and extracted license plate information. Cloud-based systems or databases are used for efficient data storage, retrieval, and management [5], [6].

5. User Interface and Communication:

The user interface module provides real-time parking availability information to users through mobile applications, web interfaces, or display boards. It also enables communication between the system and users, supporting features such as navigation assistance and smart parking management [4], [5].

VI . RESULTS AND DISCUSSION

This experiment demonstrates the efficiency of the proposed system in reducing processing time and accurately detecting whether a parking space is occupied or vacant. The system uses coloured rectangular regions to represent the status of parking slots, where different colours indicate whether a space is free or occupied. Figures 4 and 5 illustrate the visual representation of parking slot detection in the parking structure.

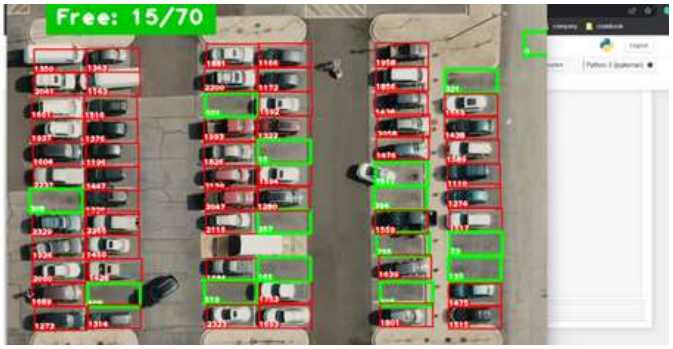

Fig 2. **Upload an image for Image Cartoonization**

Fig 3. **Number plate was recognized upon leaving, along with the bill provided.**

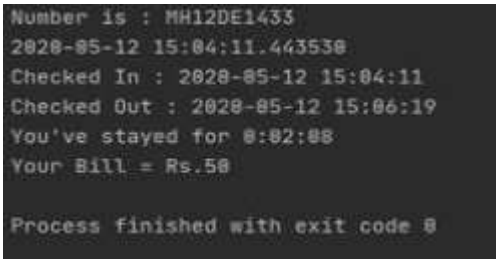

fig 4. Number plate identified upon exit, together with the bill produced

VII. CONCLUSION AD FUTURE WORK

Image processing plys a crucial role in extracting meaningful information from visual data. In this study, a smart parking system based on image processing was successfully designed and implemented using video input from indoor parking

environments. The system accurately detects parking space occupancy by indicating occupied slots in red and vacant slots in green, enabling efficient and real-time monitoring of parking areas [2], [3].

For license plate recognition, appropriate image preprocessing techniques were applied before using the Tesseract OCR engine to extract text from vehicle images. Since images may vary in terms of lighting, font style, size, and quality, different levels of preprocessing were applied to improve recognition accuracy. By selecting the most suitable processed image for OCR, the system achieved reliable and near-accurate results in text extraction [6], [8].

Overall, the proposed system enhances parking management by reducing manual effort, minimizing search time, and improving space utilization. It also contributes to reducing traffic congestion and supports the development of efficient and intelligent smart parking solutions for modern urban environments [4], [5].

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