Automated Parking management system using machine vision

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***Abstract* — As the parking industry continues to evolve for an increasing number of cities struggle with traffic congestion and inadequate parking availability. Up to 30% of traffic in congested urban areas is due to drivers looking around in search of parking spaces. Searching for a parking space becomes increasingly difficult. Leading to development of smart technologies that can help drivers find a parking spot efficiently, not only reducing traffic congestion but also the subsequent air pollution. Existing solutions require multiple sensors in every parking spot to address the automatic parking spot detection problems. However, their costs are very high, especially for large parking structures. A wide variety of other technological innovations like license plate detection, digital parking meter, and vision-based parking spot detection are included in this paper. In this paper, we propose to design naive distributed cameras, edge computing, Data analysis techniques to accomplish this task. Specifically, we deployed cameras to capture to identify which slots are occupied; cameras with wide angle fish-eye lenses will monitor the large parking lot via openCV and YOLO. We further optimize the algorithm and enable the real-time deep learning inference. Through this system a significant cost of existing systems can be saved.**

Keywords — smart cities, smart parking, Secure Payment, Microcontrollers, OpenCV, YOLO.

I. INTRODUCTION

Smart parking solutions play an important role in cities considering that drivers spend an average of 17 hours per year searching for available parking spaces. While many current solutions rely on sensors at each parking spot to detect availability, the cost and limited data provided pose challenges in older parking structures. Some systems opt for cameras to gather information yet this requires a robust network infrastructure due to high bandwidth demands.

Although autonomous vehicles present a solution, concerns arise about traffic disruptions if they struggle to find suitable parking spots. Robotic valet systems are also under exploration. Involve expensive mechanical components. Vision based techniques aim to reduce sensor deployment costs. Often lack features like license plate recognition, which is vital for services such as online vehicle location.

To find a balance between affordability and quality of service a suggested approach involves monitoring parking lots using a distributed network of cameras connected through a self established WiFi mesh network.This approach lets each camera monitor an area of focusing on specific parking spaces. It supports features, like vehicle monitoring and extracting characteristics, such as identifying license plates using cameras with zoom lenses and motorized heads [1].

II. LITERATURE REVIEW

In recent years, urban parking solutions have advanced significantly, particularly in regions like India where the urban space is scarce. Prominently featured among these are technologies such as automated multilevel parking systems developed by industry leaders like Wohr Robotics, Tangshan Baole Intelligence and He-Man Robotics [2]. These include Advanced technologies like PIR sensors, motion detection sensors, CCTV cameras, IOT platforms, RFID cards and GSM messaging services [3]. Therefore, their main objective was to optimize parking management by giving real time updates on availability of parking and then automating tasks that were time sensitive so as to bring about reducing waiting times and minimization of human interaction [4].

An excellent example of this technology is a live monitoring system for car parks that utilizes GSM messaging services to automate park management processes; it also simplifies license plate recognition as well as recording entry and exit times. [4] Another innovative approach incorporates IoT Technology involving PIR Sensors, Motion sensors and CCTVs for systematic Parking Management with improved security measures. [5] Common challenges faced with traditional smart parking systems are what these initiatives are intended to solve.

III. METHODOLOGY/EXPERIMENTAL

Our proposed approach involves both object detection and classification, necessitating two distinct types of datasets detailed below.

A. Dataset for Object Recognition

To classify objects we used publicly available datasets that were already developed for parking lots. The PKLot dataset [13] consists of 12,417 images of parking lots and 695,899 segmented parking slot images, which have been adjusted for perspective. Moreover, there is an expansion of PKLot called CNRPark [10], which provided about 12,000 photos taken in different weather conditions including partially occluded or non-persective-transformed ones. Unfortunately, these datasets do not have images containing certain types of specialized parking signs such as those for disabled people or car pools. To fill this gap, we acquired some photographs from San Jose State University's campus parking lot.

We produced our own dataset by labeling individual parking slots on video frames using MIT's LabelMe tool [14]. This ensured that every image of a slot was subjected to a perspective transformation in order to make all models work equally well irrespective of the capture angle. This keeps the model from failing when making inferences on images taken at angles other than those used during training. Section V presents performance comparison among all trained models while Figure 4 shows images before and after perspective transform. The training set took up 75% of the data while the other 25% was used for validation.

B. Object Detection and Tracking Dataset:

For the object tracking project, raw images from Nvidia AI City Challenge 2017 [15] were used without any annotations. The dataset was annotated using Nvidia's annotation tool to give a total of 150,000 labeled images that could be extracted from eighty hours of traffic video. These images were then split into training and validation sets. Labels were reformatted according to the needs of our preferred models; for example, the YOLO model required Darknet-formatted images. After it was converted, the dataset consisted of 59,482 training image and 19,272 validation images with each having a size of 1920 x 1080 pixels for training purposes.

C. The Model of C. YOLO based on Darknet Framework

According to [17], YOLO (You Only Look Once) is a kind of object detection model based on regression techniques. Every image inputted into this model is broken down into grids. Within each grid cell, the model attempts to predict bounding boxes and assign a confidence score reflecting the presence of an object; however, it does not determine what this object is at this stage. On the other hand, for classifying each cell predicts a probability distribution over 20 predefined classes using pre-trained weights. Essentially, these box and class predictions help in identifying objects more accurately in the picture.

D. License Plate Number Recognition and Vehicle Tracking

Optical character recognition (OCR) through OpenALPR uses Tesseract OCR library. OpenALPR bindings have been used with Python in combination for identification of characters within images aimed mainly at license plates as discussed herein. A Raspberry Pi platform serves as the host system where this system has been deployed and both OpenALPR operations are managed and its python integration. The main task here lies in vehicle tracking until parked so that they can be identified according to which parking slot they occupy.

E. Website

The software components used in this system are HTML, CSS, and JavaScript for creating an interactive user interface for the website. Flask (version 2.3.3), integrated with Flask-SocketIO, serves as the web framework connecting the Python backend, enabling the retrieval of real-time parking lot data. SocketIO (version 5.1.4) facilitates real-time bidirectional communication between web servers and web clients, using functions like 'emit' to send events from the server. Stripe, specifically the stripe. Charge module, provides APIs and tools for businesses to accept online payments, manage subscriptions, and handle other financial functionalities. The project also employs React

IV. RESULTS AND DISCUSSIONS

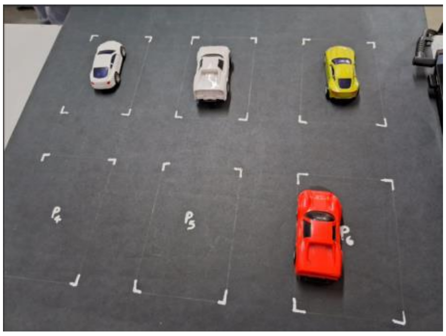

Fig 1 – Demonstration of the system running on a real camera

A) Hardware integration:

For the purpose of LIDAR car parking occupancy assessment, we located the LIDAR at fixed distances from the parking slots and derived the anticipated distance it should measure for every slot. We measured how far two parked vehicles were from each other on average to decide what degree of rotation that was required so as to point the LIDAR towards the next slot.

The system's efficiency was gauged in terms of correctly classified cars, that is, those whose reading by the LIDAR equals or is less than expected when a slot is occupied.

B) Website Integration:

Figure 2 shows login page for website provides an easy way for users and admins to access their respective features. Users can log in to find and book available parking slots quickly. Admins have separate access, allowing them to monitor the parking lot, view live feed updates, and manage slot availability.

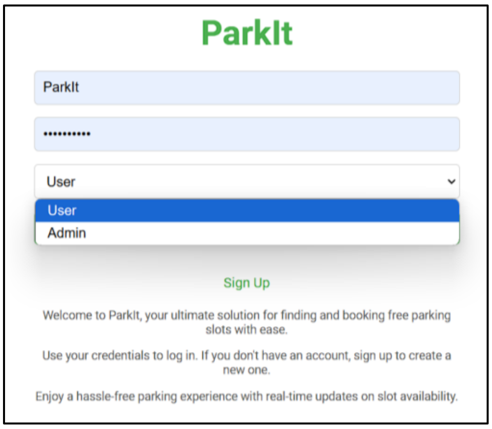

Fig 2 – Website login Page for User and Admin

The booking interface enables users to seamlessly identify and reserve available parking slots. Free slots are distinctly indicated in green, while occupied or unavailable slots are highlighted in red, providing a clear and user-friendly visual cue for selection as in Figure 3.

Upon successful login, the user is prompted to select a parking slot, followed by the specification of date and time for the reservation. The system also allows the input of the desired duration of the parking period. Once all the required information is entered, the user can proceed to the payment gateway to finalize the reservation. This streamlined process ensures an efficient and intuitive booking experience.

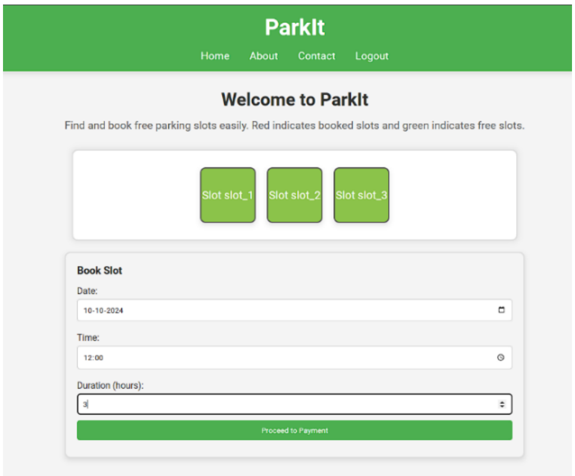

Fig 3 -User Interface for Real-Time Parking Slot Booking and Availability Monitoring

C) Payment and Ticket generation:

Upon selecting a parking slot and specifying the booking details such as date, time, and duration, users proceed to the payment interface. The system enables seamless payment processing and generates a digital ticket as confirmation. The ticket includes all relevant booking details, such as the slot number, time of reservation, and duration, ensuring users have a clear reference. This interface finalizes the transaction, confirming the successful reservation of a parking slot and providing an easy-to-access receipt or ticket for user convenience as shown in Figure 4.

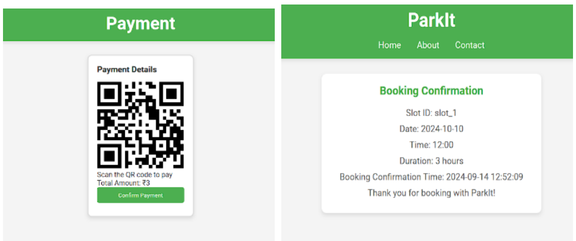

Fig 4 – Payment and Booking confirmation

V.FUTURE SCOPE

1.Integration with Smart Cities: As cities continue to evolve into smart cities, a smart parking system will be crucial to making life easier and saving precious time.

2. IoT Integration: The Internet of Things (IoT) plays an important role in the future development of smart parking systems. By using integrated sensors that can communicate real-time data, we can widen the scope of the project and increase its accuracy.

3. AI and Machine Learning Enhancements: By using AI and ML models, we can enhance the system's

efficiency and algorithms. This could lead to even more efficient space allocation, improved predictive analytics for parking demand, and better adaptability to changing traffic patterns. 4. Mobile App Development: Developing a mobile app that can help in booking and checking empty slots in advance through the app can enhance user convenience and contribute to reducing traffic congestion

VI. CONCLUSION

Park It effectively tackles parking congestion and time waste through advanced technology and real-time data. By reducing the time spent searching for parking, Park It alleviates traffic congestion, contributing to a more efficient and sustainable urban environment.

Our user-friendly LCD interface and efficient parking management website, including a pre-booking system, enhance accessibility and convenience. Users can easily find and reserve parking spaces, improving their overall experience.

Secure payment gateways streamline transactions, enhancing user convenience and system efficiency. In summary, Park It revolutionizes parking management with a technologically advanced, user-centric solution, fostering a more sustainable and efficient urban landscape.

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