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Implementation of Smart Parking using IoT Modules and Aspects of Computer Vision

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***Abstract*—** *Some elemental problems faced by the parking lots in large cities include the difficulty in locating a free parking spot, security of the parked vehicle as well as people parking in a reserved parking spot. In this paper we propose a blended use of the mobile application, computer vision and IoT technologies to counter these problems and if it is implemented, it will surely save some valuable time. We will also be able to guarantee the security of the parked vehicle using automatic security bollards. We will be using Node MCU as a microcontroller and ultrasonic sensors as proximity sensors. We will also be using CCTV camera live footage for verifying readings from the IoT devices to eliminate all the false positives. At all times the system will display the live status of the parking spaces in the parking lots to all the users of the mobile application.*
Keywords*—Internet of things (IoT), Security, Mobile application, Computer Vision, Smart Parking*

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I. INTRODUCTION

A significant problem faced by the population of developing countries like India is complexity in finding a parking spot. The number of people using vehicles to travel is considerably rising and thus as time passes by, people will take a longer time to find a parking spot for their cars. This results in additional problems like people parking their vehicles in another person's reserved parking spot. The proposed idea also increases the security of the parked vehicle. As in Figure 1, you can see the flow chart of how this currently deployed system works. In the flow chart, you can see that the driver has no other option other than to drive around to find a parking spot. Another concern with the current system is people don't accurately know, before reaching the parking lot, if there is any space available in the lot. For instance, if the parking lot is already occupied and a visitor visits the parking lot then he could be denied entry as the parking lot is already full. Several times in case of large parking lots at times the owner of the car tends to forget the position where they parked their car thus people waste time and energy in searching for their car. In the year 2016, according to the Indian Ministry of Statistics and Programme Implementation, 27 million cars were registered. From the statistics, it is evident that the number of cars registered per year is progressing and the growth is linear. Due to the ascent of the automobile industry, we are facing a budding problem of traffic even when it comes to parking lots.

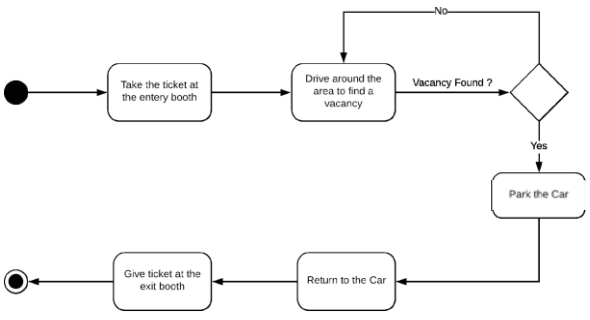

Figure 1: Currently Deployed parking system activity diagram

The smart parking system proposed in this paper solves all the problems mentioned above using a wide range of available technologies like Android, Internet of Things, and Computer Vision. In the proposed system the video feed from the CCTV cameras is processed, updating the cloud database in real-time. Similarly, the IoT devices at the parking spots use a proximity sensor to recognize if a car is present in the parking spot or not. As far as the energy requirements of the project is concerned it only needs 5V power supply for both the ultrasonic sensors and the Node MCU.

A. Related Work

In previous works, several solutions have been proposed in [1], [2], [3], [4], and [5] for improving the parking process. The summary of each solution is discussed as follows.

In paper [1] Mahendra B M presented an IoT device for detecting the vehicles in the parking spot which uses low-cost Infrared Sensors and Raspberry Pi model 3b for each parking lot. The weakness of this system is it doesn't take into account the people who don't own a smartphone for the android application. If a person doesn't have the android application then he cannot park at the parking spot. By the end of the year, 2019 only twenty-nine percent of the population in India own a smartphone. Thus, this solution will only work for twenty-nine percent of the population.

In paper [2] Dharmini Kanteti presented an algorithm for smart parking and proposed the use of IoT devices for processing vehicle detection, software working OCR, Arduino as microcontroller and Raspberry Pi to interface all the components. The paper focuses on better placement of vehicles

in the parking spots using the algorithm but in case all the parking spots are full then the user won't be able to park the car after arriving at the parking lot. Also, the amount of hardware used in the proposed idea considerably increases the installation expense.

In paper [3] Ravi Kishore Kodali proposed the use of the LoRa Esp32 module for transmitting the status of parking spots to the Wi-Fi. The proposed idea in the paper only provides information about the parking spots but does not involve security features in case the vehicle gets stolen. Moreover, IBM Watson is not so cost-effective when it comes to scaling the applications to the industrial level.

In the paper [4] Meenaloshini.M presented a Smart Parking model that only uses the IoT device to determine the presence of a vehicle at the parking spot. The shortcoming of this system is if there is anything else as an obstacle at the parking spot for instance if a person is standing at the parking spot, then too the mobile application will show the parking spot as occupied even though there is no vehicle at that particular parking spot.

In the paper [5] Khaled Zaatouri proposed a traffic light control system using YOLO. YOLO is a full convolution network which applies a single neural network to the full image and is a state-of-the-art system. The feature of only viewing once makes YOLO very fast.

B. Contributions

The above-mentioned parking systems, have both pros and cons of the system. In our proposed system industrial grade ultrasonic sensors are being used which are durable and long- lasting in severe conditions. An industrial stable version of Node MCU for the microcontroller is being used as it is reliable when connected to the internet and is relatively affordable compared to the costly raspberry pi. We are using the YOLO algorithm with the CCTV footage directly so it will not incur any extra cost. For reserved parking spots, the automatic security bollards will become active by default. A person who has access to the reserved parking spot can use the android application to unlock that particular parking spot. For normal parking spots, a user needs to authenticate once after installing the android application, using OTP. Then after parking the car, the ultrasonic sensors detect the object and updates the database. The CCTV cameras use YOLO to detect the car and they too update the database simultaneously. When the android application reads both the flags as positive from the database then it marks the parking spot as occupied in the database and then the user uses the android application to activate the security bollard which raises from the ground and thus keeps the vehicle safe and prevents the vehicle from being stolen.

II. PROPOSED ARCHITECTURE

A. System Overview

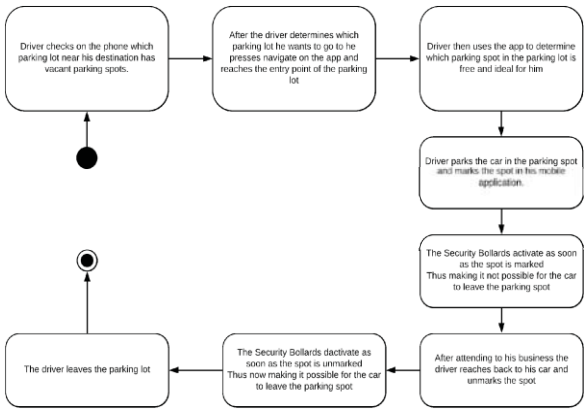

Figure 2 Shows the improved parking system

In Fig. 2 a total of 8 processes are mentioned on how exactly the proposed system will work.
Process 1: *The driver checks on the phone which parking lot near his/her destination has a vacant parking spot.*
Process 2: *After the driver determines which parking lot, he wants to go to he presses navigate on the app and reaches the entry point of the parking lot.*
Process 3: *The driver then uses the app to determine which parking spot in the parking lot is free and ideal for him/her*
Process 4: *The driver parks the car in the parking spot and marks the spot in his/her mobile application.*
Process 5: *The Security Bollards activate as soon as the spot is marked. Thus, making it impossible for the car to leave the parking spot.*
Process 6: *After attending his/her business, the driver reaches back to his/her car and unmarks the spot.*
Process 7: *Deactivation of Security Bollards makes it possible for the parked car to leave the parking spot.*
Process 8: *The driver leaves the parking lot.*

B. Required Technologies and Techniques

- *Industrial grade Ultrasonic Sensors:* These proximity sensors should be able to withstand the harsh climate and should be durable and long lasting.
- *Industrial stable Node MCU:* This microcontroller will be used as the Wi-Fi module which will send the data from the ultrasonic sensor to the cloud service.
- *CCTV cameras:* The CCTV cameras will be used to double check if there is actually a car at the parking spot or not.

Second Part, the software system consists of the real- time cloud database and the [5] YOLO data set used to identify the cars, it also consists of the Android application which will display the data in real-time.

- *Mobile Application*: On the software side of the proposal the driver uses a mobile device that runs on the Android operating system. The application communicates with the cloud database using a 3G/4G network connection. The application authenticates the user on the first install.
- *Camera Video Processing*: Live video feed of the CCTV cameras will be used to process the video frame by frame to determine when the parking spot is occupied with a car. It will use YOLO on each frame of the video and keep on updating the database if there is a change in the state of existence of the car in any particular spot.

C. System Hardware Architecture

There are two main set of hardware which are vital for the proposed idea.

- *IoT Device:* The IoT device which is planted at the surface behind the parking spot has two steps of working. First step is to use the ultrasonic sensor to determine if there is a car in front of the IoT system or not. The second step of the IoT device is to upload the current state of the ultrasonic sensor to the cloud, thus it connects and transmits information to the cloud.
- *CCTV Cameras:* The CCTV cameras which are currently deployed at the parking lots for security purposes can be used to pass the video feed to a server which converts the video stream into

bytes which is then processed and the cloud database is updated accordingly after processing the video taken by the CCTV.

III. SYSTEM ALGORITHM

A. IoT Hardware and CCTV Operartion

We propose an algorithm for the IoT device which uses Node MCU and Ultrasonic sensors for performing the check if there is a car present in the parking spot or not. The IoT device is planted at the wall facing the parking spot. The ultrasonic sensor emits ultrasonic sound waves using a transmitter which then reflects from the surface of the car and the receiver receives the reflected ultrasonic waves. The Node MCU, which is connected to the ultrasonic sensor gets the time from the sensor at which the sound waves were transmitted and received. The Node MCU then calculates the time difference between each transmission and receiving of the sound waves and then it multiplies that time difference with the speed of sound in the air. This gives us the distance travelled by the sound waves to reach the car and reach back. This distance is then halved which gives us the distance between the sensor and the car. After calculating the distance, the Node MCU checks if the distance value is less than a certain threshold, then it means that the car is close to the sensor and thus it is parked in the parking spot. So, if the value of the distance is less than the threshold value then the Node MCU updates the "physical" flag in the cloud database with the string "Yes".

The live CCTV footage is passed through a python script which processes the live feed frame by frame. The python code first just loads all the COCO classes which represent the various objects on which the YOLO model was trained on. Then the paths of the yolo weights and the model configuration is loaded on the write memory of the servers. After the weights and the configuration are loaded, the object detector which works on YOLO is loaded from the disk which determines the output layer that we require from YOLO. When the loading of the detector completes, the live video stream of the CCTV is converted into open cv video capture format by using the open cv library. Then, the parking spots are marked with rectangular boxes in the video frame. Whenever the object detector detects a car in the video frame, it makes a bounding box around the car and also marks the centroid of the bounding boxes of each detected car with a red dot. Each rectangular box represents a unique parking spot. When a red dot comes inside the rectangular box the server updates the "camera" flag in the cloud database as "Yes". If there is no red dot inside the rectangular box then the server updates the "camera" flag in the cloud database as "No".

B. Android Application

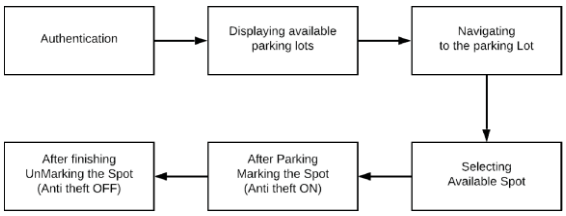

Figure 3 : Android Application Algorithm

IV. EXPERIMENTAL RESULTS

This part shows the prototype of the working system based on the idea proposed in this paper. The app first authenticates the user by using his/her phone number and sending the OTP.

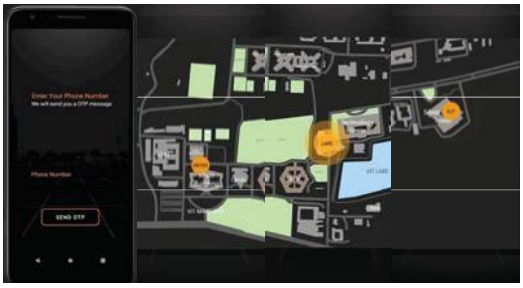

Figure 4 : Android Application with OTP and map screen

After authenticating, you will be able to see a map which will show you various parking lots. A parking lot in which a space is available, will pulsate the button. For an instance, in the Figure 6, the Lake button pulsate because parking is available but the SJT and ENTER button doesn't.

You can click on any parking lot to see the details that which parking slots is available and which is not available.

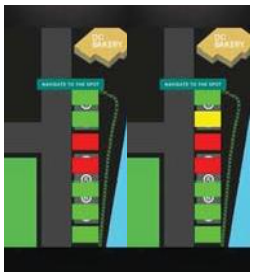

Figure 5 : Android Application with live status of parking spots

When the user parks the car then, the spot turns red, and then the user can click on the parking spot, just occupied by him/her to mark it and it will turn yellow and the anti-theft system for the spot will get activated.
The IoT device will work in real-time and the status of the parking spot would be updated in the cloud database constantly.

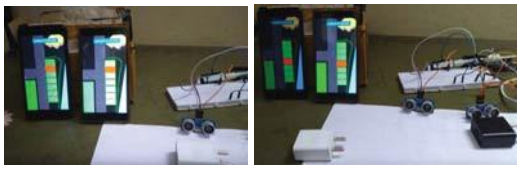

Figure 6 : Working IoT Hardware with android application

In the images above, it depicts the working of the IoT system with the android application. As soon as the Ultrasonic sensors detect an object in front of them, the cloud database is updated and the update is then notified to the android applications.
The CCTV footage is also processed in real-time to detect and update the status of the parking lots.

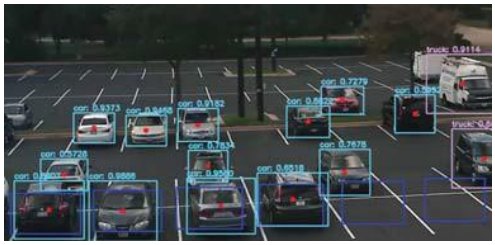

Figure 7 : Realtime processing of a CCTV video frame Table I. TABLE EXPERIMENTS RESULTS

Test Scenarios	**Test Results**		
	IoT Device	***CCTV Scan***	***IoT Device and CCTV***
Any object other than a Car in the parking spot	Yes	No	No
A Car passing by is in the line of sight of the CCTV and The Parking Spot	No	Yes	No
Car Parked in the parking spot	Yes	Yes	Yes

Table I. TABLE EXPERIMENTS RESULTS

In case of dark environments [6] Night-Time Vehicle sensing algorithm can be used to determine the location of parked vehicles by the CCTV cameras.

V. CONCLUSION

This paper proposes a completely feasible idea that can tackle and solve some of the severe issues faced by the people of developing nations due to the currently employed parking systems. The proposed idea not only saves time for the users but also gives certainty to its users that they will get a parking spot to park their car, even before reaching the spot and their car will be safe when they activate the anti-theft security bollard system.

The smart parking system confirms if actually there is a car at the parking lot by using IoT devices and the CCTV camera. The reason for using two different hardware to cover every parking spot is to make sure that there is no inaccuracy when it comes to detecting a car.

The android application shows live data of the status of each parking spot so that the user can pick whichever free parking spot he/she wants to park the car. The anti-theft system guarantees the security of the vehicle which is parked in the parking lot.

Comparing to existing techniques the proposed technique is robust as it using two methods i.e. the CCTV and the IoT hardware to determine the presence of cars in the parking spots while showing the real-time presence of car in all the parking spots.

As shown in table 1, you can see that we have tested the parking system with multiple scenarios and the reason for which we are using both the IoT device and the CCTV computer vision is to minimize all the false positives.

The proposed method has been tested for different scenarios and the tests have provided positive results inferring that the proposed method is a viable and more advanced alternative of the currently deployed system.

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