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An Autonomous Car Parking Space Location System

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Abstract: ***Locating a parking spot in big cities, especially during peak hours, is always a big challenge. A lot of productive time can often be spent searching for spots which could be a source of stress. To address this issue, this work explores the idea of an intelligent car parking management system which helps to provide real-time detection of parking space occupancy via sensors and guidance system within parking facilities. To achieve this smart car park we used LCD displays, motors, sensors, keypads, microcontrollers (Arduino and ESP WiFi Module) amongst other devices. The system is also linked to a mobile app that will provide direct services to users such as reserving car slots, providing OTPs for each user, electronic payment/billing and parking duration limit reminder.***

Keywords: Automation, Smart Systems, Smart Devices, Smart Cities, Internet of Things

I. INTRODUCTION

With increasing population in urban centres around the world, [1] there is increased pressure on social amenities in the urban areas. There is noticeable scramble on resources such as spaces to park vehicles [2]. [1]. It is therefore important to develop systems which help in the efficient management and utilization of these resources. A beneficial system would be one that would help to manage and increase the utility of the sparce parking spots in populated cities.

The intelligent car park system presented in this work helps with this by directing vehicle owners to available parking spaces around a particular location. This will help to reduce traffic congestion and time spent in locating parking spots. The App also has the function of providing each user with a specific OTP (One-Time Password) that will allow the user exit from the parking lot. The OTP is inputted into the system via a keypad.

The system in this work utilizes a microcontroller that works with other hardware components (IR sensors, keypads, motors, etc). The sensors are used for detection of empty or filled car spaces and are placed at the entry/exit and at each car slot.

II. METHODOLOGY

The system was implemented using an Arduino connected to peripheral components such as IR sensors, servo motors and LCD. The IR sensor at each car slot is connected to the analogue pins of the Arduino and those at the entry/exit are connected to the digital pins of Arduino. The purpose of the sensors is to indicate the real-time condition whether empty or occupied of the parking slot. The LCD is also connected to the analogue pins of the Arduino and its purpose is to display the available or occupied parking spaces in the lot. Figure 1 shows this configuration and Figure 2 shows the implementation of the connections in the parking slots.

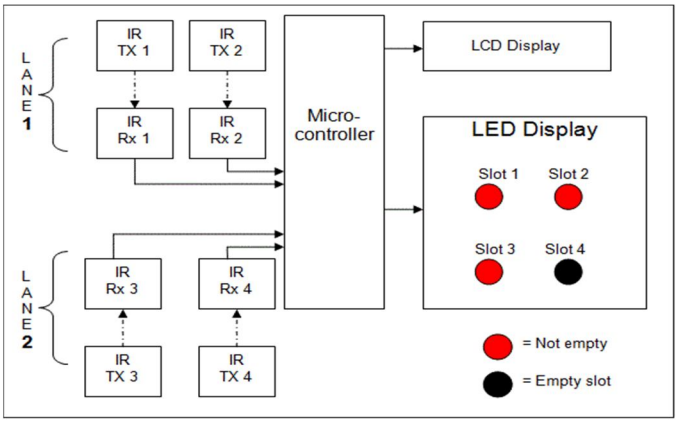


Figure 1: This shows the block diagram of the microcontroller (Arduino) connection to the IR sensors, LCD display and LED display. [3]

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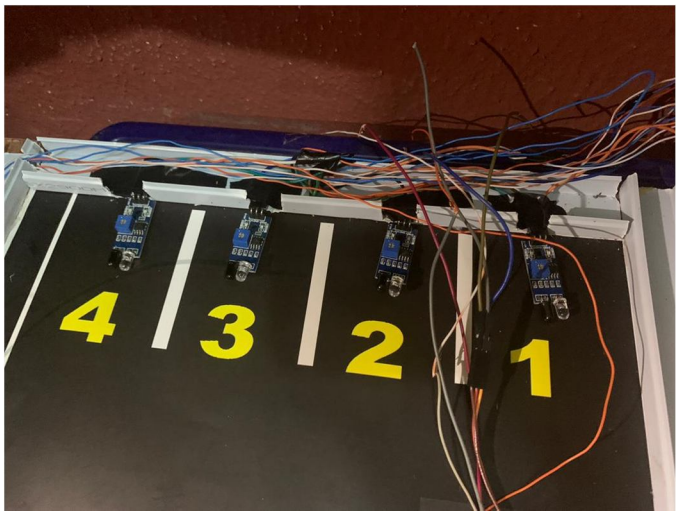


Fig. 2 Infra-Red Sensors in Parking Slots

The servo motors are connected to the Arduino so that they can be used as the gate controller. For this project, their main function will be to receive information from the Arduino to open or close the barricade at the entry/exit of the parking lot depending on the status information they get. The servo motors are connected to the pulse width (PWM) pins of the Arduino.

Besides an electrical power supply to the microcontroller, there are several ways to power the microcontroller and not all of them provide the benefit of on-board regulation. The microcontroller can be powered with 5V or 3.3V power where the designer can apply the appropriate voltage to the 5V or 3.3V power pins of the Arduino. These pins are tied directly to the power pins of the microcontroller unit (MCU) on the Arduino board. However, applying power to these pins will cause the MCU of the Arduino to be susceptible to the line loss and contact resistance loss from the power source mentioned earlier. The microcontroller can also be powered via the 'Vin' or 'Raw' pins depending on the variant of Arduino being used. However, a common error which must be avoided is to apply a 5V or 3.3V power source to this pin. The problem with this is that not only do you have the line loss and contact resistance loss mentioned earlier but that this pin is the input to the on-board regulation circuit. Like any voltage regulator, you need to supply slightly more voltage into the device than you expect to get out of it. If we applied 3.3 Vdc to Vin, we would lose about 0.5 volts through the regulator. The implication is that the microprocessor and connected peripheral devices would only be running on 2.8 Vdc, at best. Combined with our noted line loss and contact resistance loss, we can be running well below our required voltage level. A 6-12V dc battery can be supplied to the Vin and GND port of the Arduino to reduce the losses mentioned. The clock diagram of the power schematic of the device is shown in figure 3.

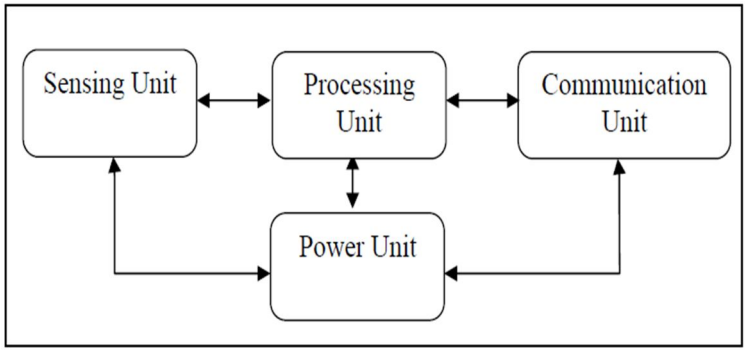
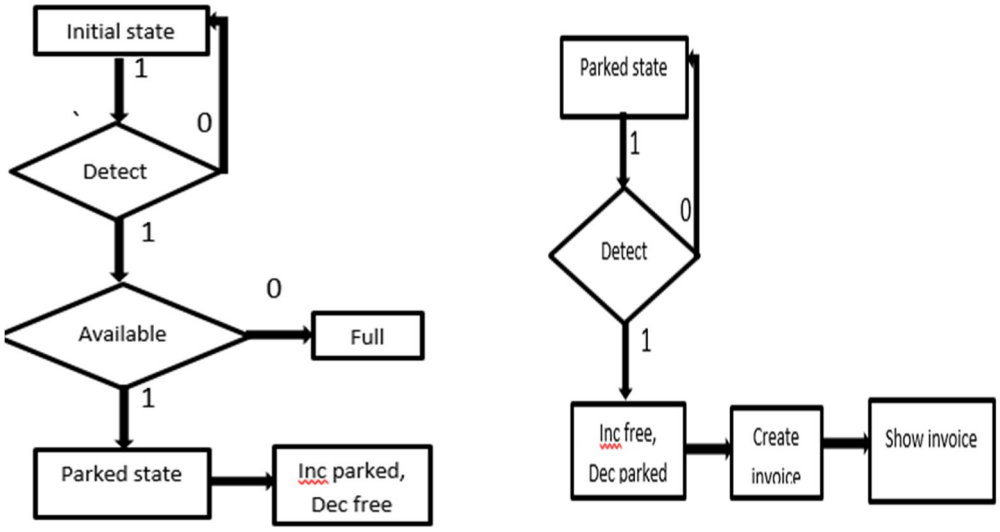


Fig. 3 Power Schematic of the System

The gate control system monitors and allows input of the access codes using a keypad. Verification and validation of the code is done by querying the database server. A result is returned to the controller; if the status result is "1" the servo motor opens, else if "0" the servo motor remains closed whilst prompting a message to the user. The parking system server receives this information and processes it to determine the total available parking in the specified location. The information is also saved as historical data, of which can be retrieved using the application program interface website where a payment invoice can be generated on exit.

For the entrance the flow starts from the initial state [EMPTY], when it is HIGH [1], the sensor detects a car. At the detection stage, when a car is detected, and a slot is available, it is a HIGH (1) and when it is LOW (0) it goes back to the initial state and waits till a car is detected. When a slot is not available, it means it's FULL i.e. a LOW (0). If a slot is available (1), it goes to the parked state meaning the vehicle can successively park. When a car is parked, the number of available slots would decrease (Dec free), and the number of parked cars would increase (Inc parked). At the exit, when a car wants to leave the lot after being detected. The number of available slots is increased (Inc free) and the number of parked cars is decreased (Dec parked) and an invoice for payment is created and inputted into a keypad. These operations are shown in Figure 4a and 4b.



a b

Fig. 4 a. Entry operation. B. Exit Operations

III.SYSTEM IMPLEMENTATION

Intelligent Parking System mainly consists of four modules:

1) Access Control Module
2) User Module
3) Administrator Module
4) Booking Module

The Access control comprises of an LCD, a 4*4 keypad and a servo motor that is attached to the microcontroller and thereafter sends data to the network module to get input from a user on entry and exit of the car park. When a car arrives in parking lot, it is sensed by an ultrasonic sensor which is one of the components of the sensor level. The use module of the application deals with the user interface/ user experience. This module provides the user with the flexibility of registering, logging in, booking and making the payment. If the user is new to the application, then the user must register in the application by providing the user's details. After registration, the user logs in using the user-id and password. The registration is done just once and upon login, the user checks for an available parking lot, books the lot and/or make payment after usage of the parking lot. The block diagram of the user module is shown in figure 5.

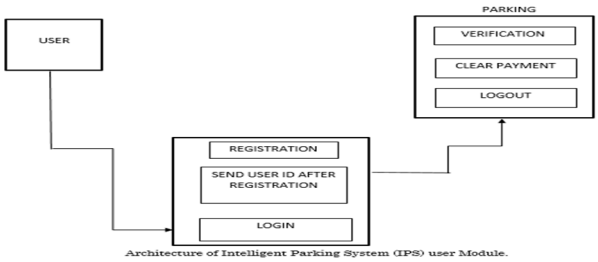


Fig. 5 User Module Block Diagram

The Administrator module is the operative module of the application. It works in the backend for managing the database and performs various operations on it. The administrator stores all the user's data in the database as soon as he gets registered with the application. Administrator maintains the details of all parking slots (empty and reserved), their price for booking, user details in database and the modification on these data can be done by the administrator. The administrator also provides the payment method to the user.

The booking/invoice module is the main module of the application, and it deals with booking and generating payment invoice for the user of the parking lot. The system requires payment through a debit card. Hence, the user needs to give all his card details to book his desired slot. In Invoice Module, as the car exits the lot, the payment details are displayed to the user, who leaves the car park. If a day or the time allocated had elapsed, then the invoice changes accordingly. An algorithm is developed from an application program interface which keeps track of the time spent by each car in the Parking Lot.

A. Slot Allocation Method Text Font of Entire Document

The slot allocation method follows a sequence as stated below:

1) Step 1: Initially the slot selection is made by the user from his mobile phone. He checks for the availability of a parking spot that is nearest to his location. If it is available, he moves to the next stage or else go to the initial state.
2) Step 2: Transfers request for parking slot from the mobile using the Android application.
3) Step 3: The Parking Control Unit (PCU) gets the OTP requested by the user.
4) Step 4: If the payment is done successfully, then the requested slot is reserved in the parking area.
5) Step 5: After reserving a particular slot by the user then the status of that respective slot will be marked as RED=RESERVED and the remaining will be GREEN=EMPTY.
6) Step 6: As soon as the vehicle gets into the parking lot, the timer gets ON and measures the total time.
7) Step 7: As soon as the vehicle moves out of the parking slot, the timer gets OFF and the total cost will be displayed.

The mobile app provides users with an OTP that allows them exit from the lot. This OTP is inputted at this exit via a keypad. After the OTP is confirmed, the servo motor lifts the barricade and allows the user to leave the parking lot.

The implemented hardware system is shown in figure 6.

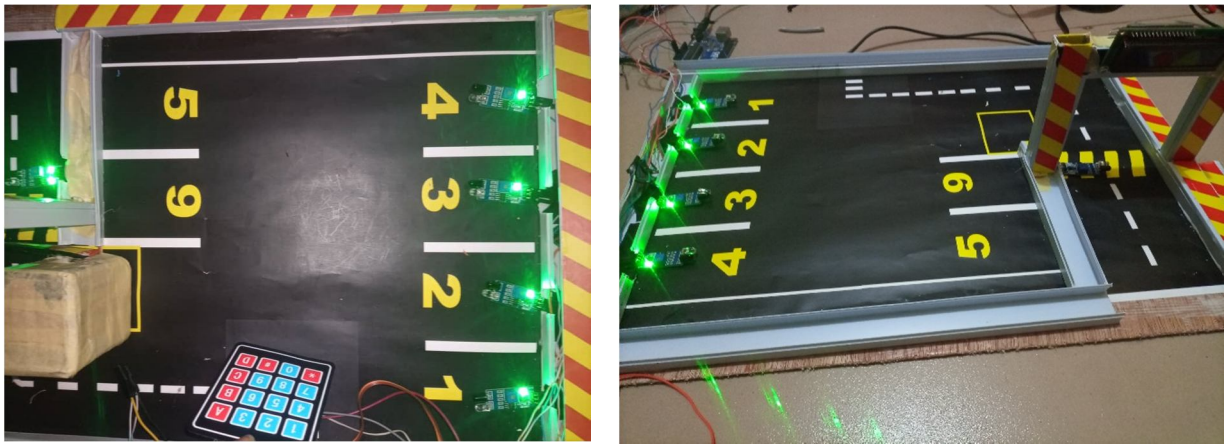


Fig. 6 Implementation of Hardware of Car Parking Systems

B. System Reliability and Performance

The hardware communicates with the mobile application in real time via a WiFi module. The data from the hardware is sent via this module. The data sent is received at the application within the duration of 2-5seconds. For instance, when a slot(s) is occupied or reserved, the real time condition of that slot(s) can be observed on the app and this data is sent within a few seconds. This implies that the interface between the hardware and the mobile app is reliable seen there is minimal delay and no lag in performance.

The microcontrollers used had very negligible delay times as they started operation almost instantly. The peripheral components like (the sensors, motors, LCD, resistors, etc) failure times were minimal and little to no problems we experienced with these components as they worked very effectively. When a slot is occupied, the LCD takes 2-3seconds to display the remaining available slots. The system's overall performance was very good because the individual components had minimal to no delay at all. The only lag in performance was seen at the exit where the user must input the OTP in a keypad before allowed exit from the lot.

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IV. CONCLUSIONS

This work has presented the design and implementation of an automated car parking system which is aimed at saving time wasted in searching for parking spaces. The system utilized a microcontroller which attached peripheral devices to enable indication of available parting slots as well as booking and payment for these slots.

To further improve the system, a reliable security system and a vehicle type and vehicle registration number detection system can be added to it.

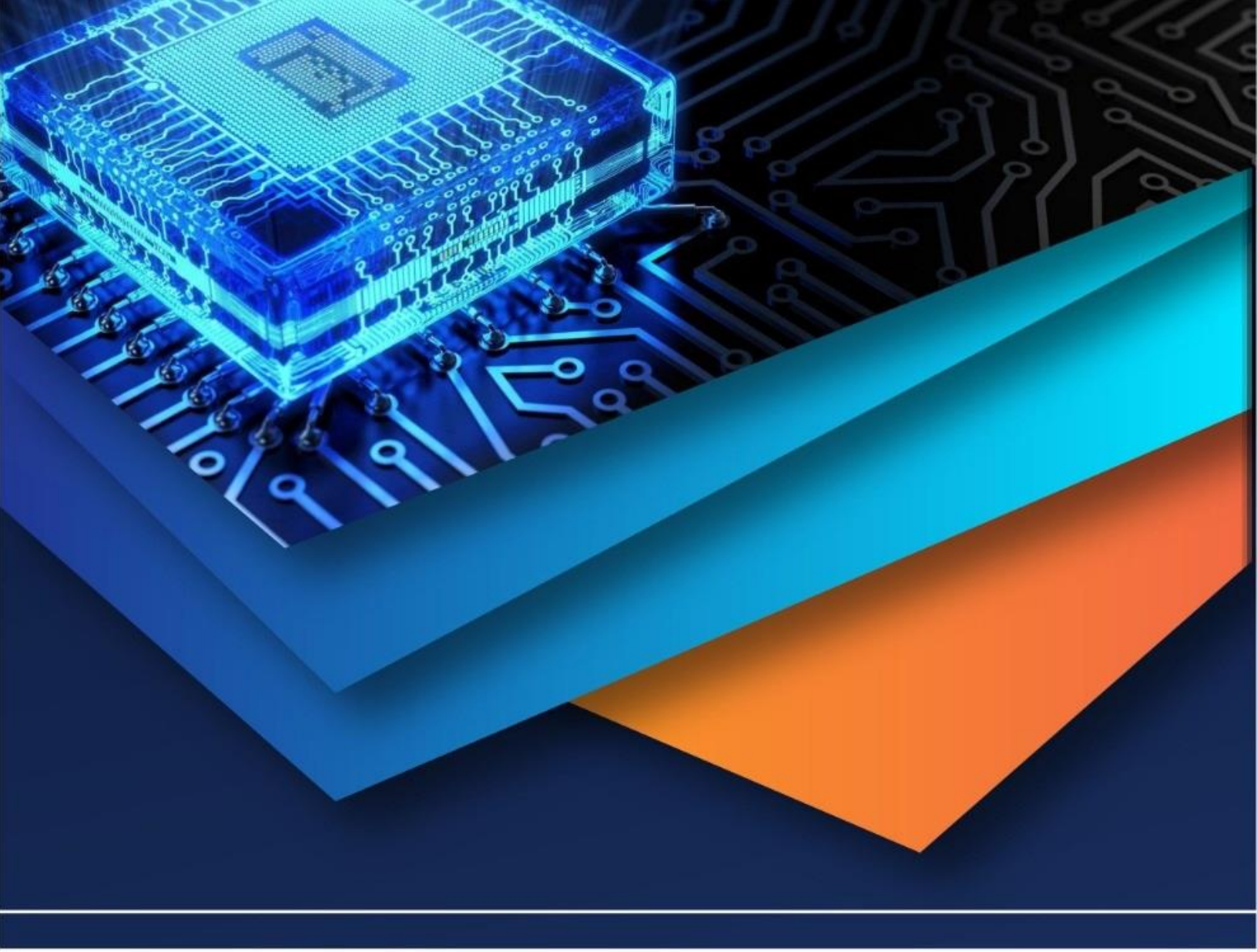
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