An indoor and outdoor parking using Embedded Systems and IoT

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Abstract*– Smart cities are very important current and future trend in the world, and one of the most prevalent systems is smart parking system. Smart parking System saves time consuming in searching for available areas for parking and it reduces street accident. Moreover, it provides cities owners and administrators with the ability to monitor and control the streets and parking areas. Thus, we present a modified design like the old corner systems, to increase the quality of lifestyle and make it easier and smarter using modern innovations such as the embedded system and the Internet of Things (IoT) to develop this project. Furthermore, our smart parking solution is concerned with several aspects that has a great effect on people, drivers, and the whole city in general. These main aspects are time, the most important, and money by providing a smart indoor and outdoor parking solution, as well as paying attention to save energy, whether in the streets outside or inside the parking spaces. Finally, we develop a web application which it could be accessible for users to inform him with the updated areas for indoor and outdoor parking nearby. A mobile application is also provided to search and book a free parking spot.

Keywords—Smart Parking, Smart City, IoT, Embedded System

I. INTRODUCTION

According to Borgonovo et al. [1], smart parking systems are set to bring positive changes to different urban people, who suffer from haphazardly managed parking areas. Smart parking systems will positively affect the traffic accident rates, as driver attention deficits when they are concentrating on searching for parking areas [1]. When drivers can quickly and effectively find spots available using their smartphone apps, accidents will decrease, and drivers won't have to compete for free spots [2]. Moreover, smart parking systems are anticipated to assist parking facility managers and owners in increasing the use of available spaces and resources in a way that increases their profit and enhances the parking experience for their clients [3]. Also, Sajeev et al. [4] pointed that adopting a smart parking system would enable managers to set parking charges proportionate to the facility's current occupancy. As a result, owners, politicians, and urban planners will benefit from these parking schemes in terms of both finances and logistics [5]. Furthermore, smart parking systems would be able to determine peak times of parking violations and, hence, facilitate the implementation of countermeasures [5]. The overall result would be a better quality of life with fewer health issues and more environmentally friendly habits [6].

Various smart parking systems are already in part of the world around us, including those in Barcelona, Busan, Riga, Santander, and Valletta. Through investments in Internet of Things (IoT) for urban systems, including smart parking technologies, Barcelona, a Smart City, has achieved a wide range of benefits [7]. The first-generation IoT-enabled smart city pilot project in Busan, South Korea, is another example of how IoT technology has been applied [8]. Between 2015 and 2017, the proposed intelligent parking services got yearly improvements. Another illustration is the city of Riga, which provides parking services for a fee. The city has 167 underground parking areas, which are administered by automated parking ticketing machines positioned at the entry and exit of the parking, where cars can obtain a ticket with a QR code and time stamps [9]. A smart parking solution with parking lots equipped with inductive sensors was also tested in the Spanish city of Santander. To monitor the availability of parking spots, more than 250 outdoor parking sensors were put in the city's main parking facilities [10]. Valletta, which presents a unique scenario due to its walled perimeter and limited parking infrastructure, is another city that provides a practical observation on how smart parking systems operate [11].

In attempt to deploying smart parking in Egyptian smart cities, we propose an indoor and outdoor parking solution where a modified design like the old corner systems is presented. using embedded systems and the IoT.

In the following sections, we illustrate the proposed solution. Then, the hardware implementation and Prototype. Section III presents the communication and IoT. The designed web application and mobile application are presented in Section IV and Section V. Finally, a conclusion of our work.

II. THE PROPOSED SMART PARKING SOLUTION

We propose some ideas to implement the smart parking indoor and outdoor. First, to control the number of cars in the indoor parking area, we design an automated gate. Then, an application is developed to simplify the reservation of parking spot and monitoring the parking process. Also, the idea is extended to outdoor reservation parking spots.

Moreover, a power saving scenario is proposed for the parking lights and smart sensors. In following subsections, we illustrate each item.

A. Automated gate

Using automated gate is very useful for the administrators to monitor and control who enters the parking and whether he has a permission to enter or not. Also, to prevent cars from entering when the parking is full.

B. Monitoring vehicles and website

After a car enters the parking and stops in its spot, it is detected by Ultrasonic sensor. The sensor communicates with a cloud server which is accessible by drivers to be updated by the availability of spots in the parking.

C. Outdoor parking areas

Like indoor parking solution, the idea could be extended to outdoor parking in smart cities. Using the same way, the car presence is detected outdoor by suitable sensors, and they communicate with a server to automatically update the availability of parking spots. This information could be announced at display around the city.

D. Online reservation

Drivers can easily use the application or the website to reserve a parking slot for a certain amount of time, that will save time and effort of finding an available area.

E. Energy Saving

Using a low power consuming sensors and reducing the inefficient sensors reduces the energy that reduce the overall cost for owners and administrators of the smart city.

A smart street light system incorporates a cluster of streetlight lamps that can communicate with each other and provide lighting data to a local concentrator. It allows facility managers to remotely control streetlights while keeping track of electrical power consumption in the lamps and in the driving circuits.

Smart street light systems save energy comparing to the old style of lightening, and lighting could be managed remotely.

II. Prototype and Hardware Implementation

In this section, we present the implementation of the proposed ideas. First, we design an indoor parking area as a prototype. Fig 1 shows the prototype and the deployed sensors and the automated gate. We use an IR sensor in and a Servo motor to automatically opens and closed the gate while there is a car in front of it. Fig 2 shows the automated gate in our prototype. The gate, the green stick, opens automatically when

Fig 1 The smart parking prototype.

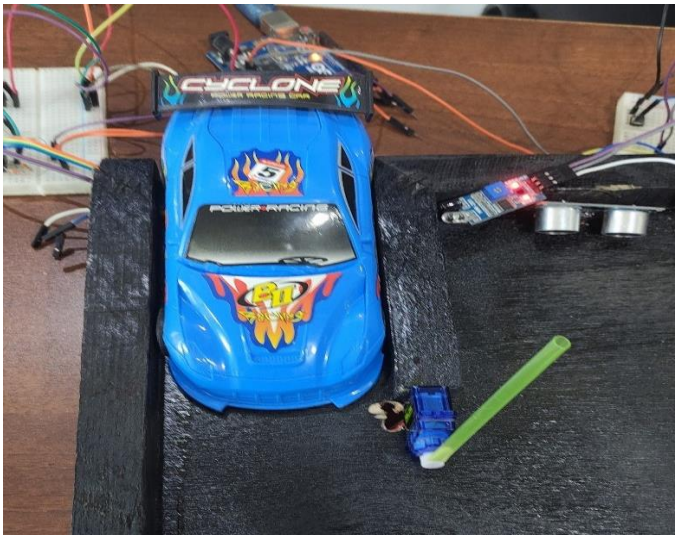

Fig 2 Car detected by IR sensor when entering the gate

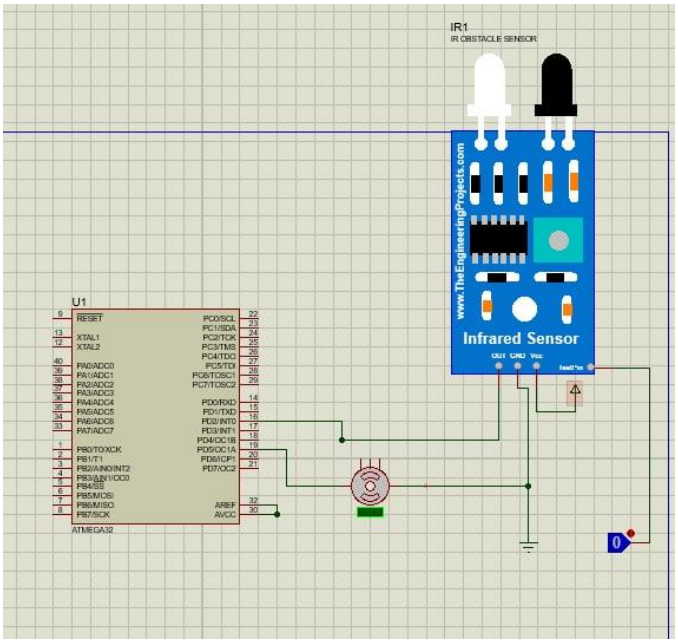

Fig 3 IR sensor and Servo motor connections for the automated gate

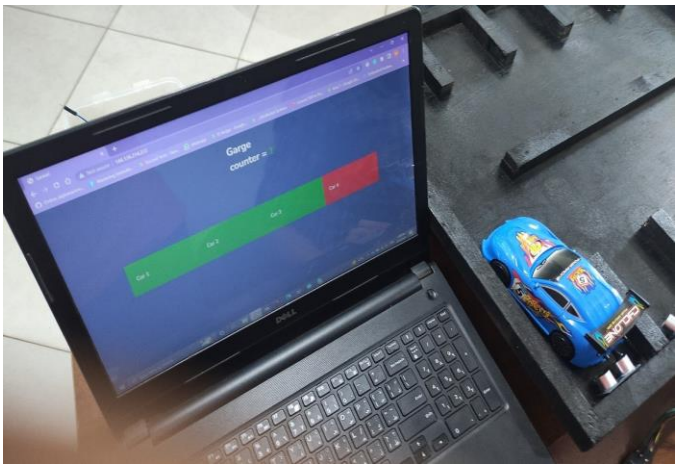

Fig 4 Parked car detected by the Ultrasonic Sensor.

a car is detected. Fig 3 shows the connection of the IR sensor and the servo motor for the gate in Proteus software.

Ultrasonic sensor is used to detect the existence of a car in specific spot. Sensor readings are sent to a cloud server to be updated by the status of the parking area. These readings are available for administrators and for drivers searching for a free spot. For example, a screen shows the status of the parking area shown in Fig 4 that the first spot is taken but the other three spots are free. Ultrasonic is connected to AVR ATmega32 Microcontroller, in addition to an ESP8266 they perform the communication with the cloud sever. Fig 5 shows the connection of Ultrasonic sensor in Proteus Software.

The proposed IoT based system provides a solution for energy saving. We use IR sensor, Light Intensity sensor board to design an intelligent system. We use IR sensor for detecting vehicles on the road, Light sensor for detecting light intensity. Based on vehicles present on the road and light intensity, we control streetlights. We can automatically ON/OFF lights or we can control brightness of the lights. Fig 6 shows the connection of the proposed smart lightening system in Proutus Software.

This project is implemented with Arduino UNO which controls the streetlights based on detection of vehicles or any other obstacles on the street. Whenever the obstacle is detected on the street within the specified time the light will get automatically ON/OFF according to the obstacle detection and the same information can be accessed through internet. The real time information of the streetlight (ON/OFF status) can be accessed from anytime, anywhere on the real time dashboard. There are three cases. Case 1: In the daylight, the LED (3) in Fig 7 is turned off. Case 2: In the night, if the IR (1) in Fig 7 detects a movement around, the LED turns on max lightening (green light). Case 3: In the night, if the IR doesn't detect any movement around, the LED turns a slightly light (blue light). The light is detected by LDR Sensor (2) in Fig 7.

III. IoT and Communication

In this section we discuss the sensors and AVR connections to the cloud server and the web page that displays by the car drivers to see what available places in this parking.

NodeMCU is used which is an open-source Lua based firmware and development board specially targeted for IoT

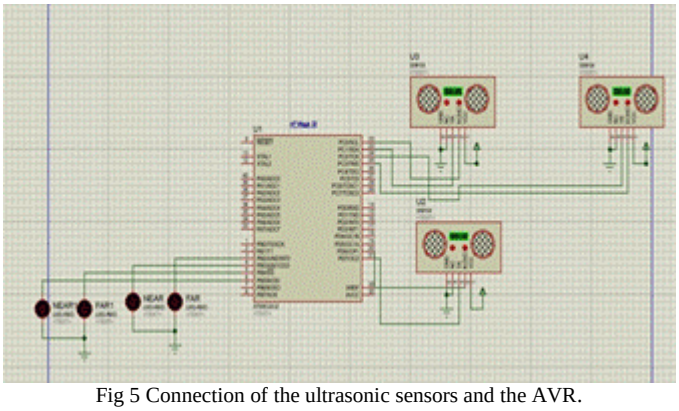

Fig 5 Connection of the ultrasonic sensors and the AVR.

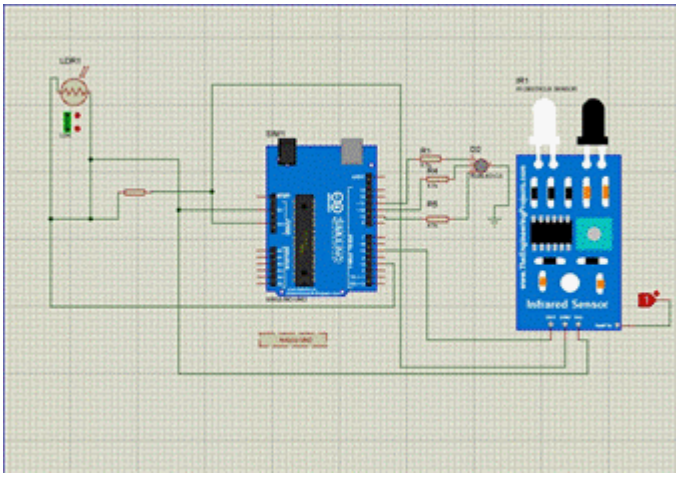

Fig 6 Connection of the smart lightening system.

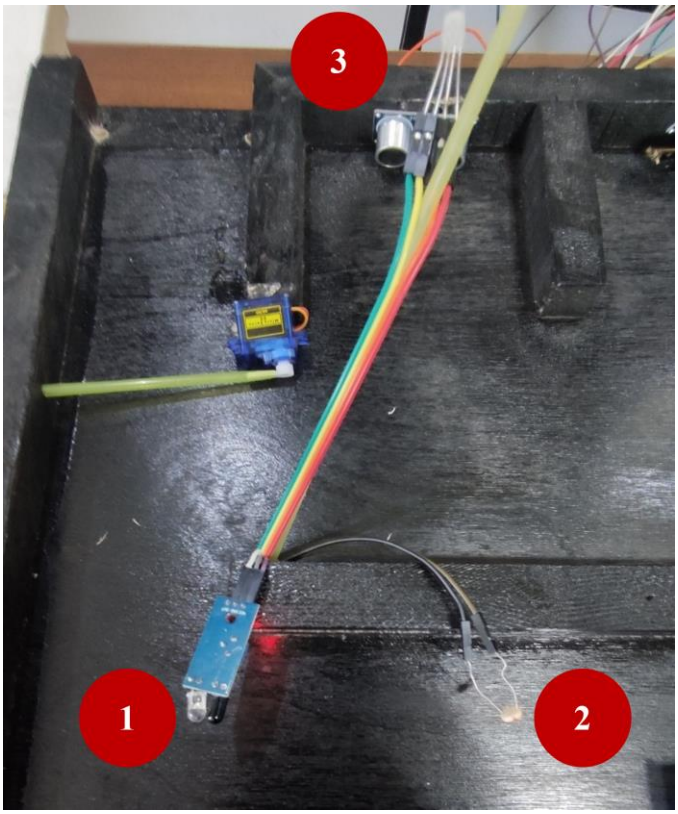

Fig 7 Smart Lighting System (1) IR Sensors, (2) LDR Sensor and (3) LED.

based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. ESP8266 is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software.

In implementation, we make the AVR as a node between sensors and cloud, also we perform some pre-processing on the data that will be transmitted, as we make the AVR sends the readings of the ultrasonic sensors in a 4-bit number that will be transmitted to the cloud.

IV. Web Application

In this section, we present the interfacing of the smart parking through web application so that users can reserve their parking spots. The main purpose of the web application is to process HTTP requests coming from the client and return a response. The main elements for this are the request and the router. This application developed using Laravel framework version 8.75 with php version 7.3 and for database we use MySQL version 5.7 this application based on MVC structure.
in Fig 4-6, the GUI of the developed mobile application where the use can easily look for nearby parking, book and select the parking spot.

A. Front-end

Front-end shows how the web application appears to each user as, every slot/spot in the parking/garage has a number and colour in the web application as (green colour means this slot is empty & red colour means this slot is fill with a car or reserved) and Garage Counter shows the number of cars in the garage as shown in Fig 8 which illustrate that there are no cars in the garage. Garage Counter is zero and all slots are in green.

B. Back-end

Using MySQL version 5.7 consists of (1table ,1record, 5columns) 4 columns for each car and the last one for the counter of car which is (0 to 15) 4 Bits “the number of slots.
There are 4 main functions for the back end. The first function is responsible for dealing with database. If the slot is empty, then the column will get default value of (0). Second, The APIs. Since, we have 2 APIs the first one is responsible for updating data in the database and the second one is for getting data /return it to web page. Third, storing in database function which is responsible for updating any changes in the real garage (car gets in or car gets out). The last function is responsible for delivering data to the web page if there is any change. It takes the data from database then, represents it to the used the system in the form of colours (green &red) and Garage Counter depends on the numbers previously stored in the database table.

V. Mobile Application

To make it easier for the user to see the available parking areas nearby and to book a parking slot before he goes to its place to make it easier and more direct. The user could search for nearby parking area as shown in Fig 9. Users can book a slot Fig 10 and then, a verification code is generated to verify the booking Fig 11.

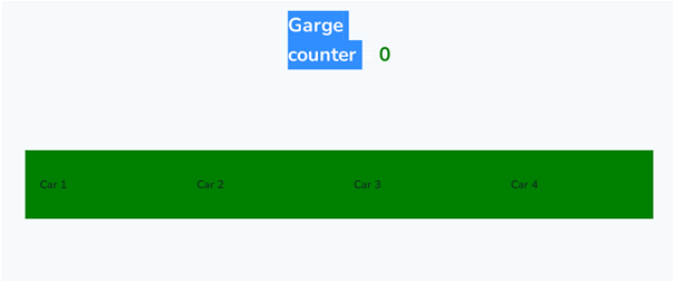

Fig 8 Front End

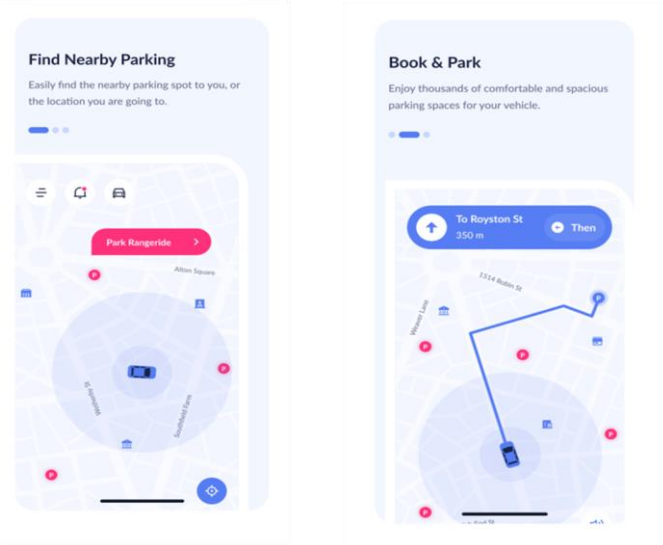

Fig 9 GUI of Find available parking spot.

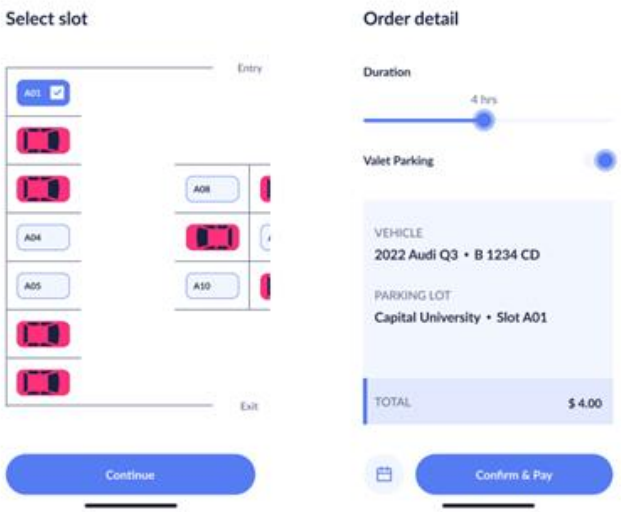

Fig 10 GUI of Selecting and booking a parking spot.

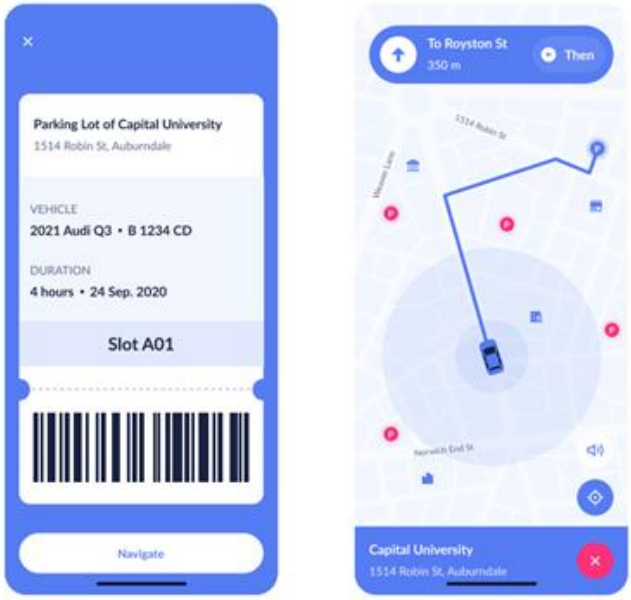

Fig 11 GUI of verification Code.

CONCLUSION

World's population is growing rapidly in big cities and parking area is not. Limited parking areas complicate the searching for a parking spot. Smart parking with the help of the growing technologies such as IoT, image processing and computer vision that will save a lot in time, energy and reduce pollution.

Thus, we proposed an indoor and outdoor parking solution. We implemented a prototype for the indoor parking area. We develop a web application or mobile application, which is updated automatically using sensors in the parking area, so the user can easily interact with and have a parking slot easily. Providing a management system for the indoor parking area. Extending the idea to an outdoor parking that is very useful in the smart cities.

ACKNOWLEDGMENT

We would like to thank Dr. Basma Gh. Elkilany for her appreciated support and great efforts.

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