Simplified Intelligent Parking System using ESP32 Microcontroller

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Abstract*: *Internet of Things, IoT, provides a cloud-enabled platform for devices to send and receive information over the internet. This study is based on the design and construction of a real-time cloud enabled automated parking system. The model is characterized by using a node MCU ESP32 microcontroller with IR sensors, servo motors, LCD display with I2C and buzzer. When the IR sensor at the gate senses the presence of a car, the servo motor at the entry gate enables opening of the gate and a counting sequence is initiated. When the count gets to the specified number nine, the entry gate no longer opens. When the car parks at the slot, signal is sent from the IR sensor at the slot to the ESP32 microcontroller which updates its server and also updates the website. The ESP32 web server is also is equally updated whenever a car leaves its slot which in turn updates the web server. The IR sensor at the exit gate senses and sends signal to the servo motor which aids opening of the exit gate anytime a car wants to exit and this also leads to a deduction in count which is displayed by the LCD. The developed system simplifies the requisite intelligent operations for automated parking garage in addition to making information available on parking slots sent over the cloud through the internet.

***Keywords*: IoT, Cloud, ESP32 Microcontroller, IR Sensor.**

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I. INTRODUCTION

With the current advances in science and technology coupled with what can be termed as basic necessities of modern age, a large percentage of the working populace now own personal vehicles. It has been established statistically that the use of vehicles is increasing rapidly and significantly every year [1]. According to a recent survey, the number of vehicles will be increased to over 1.6 billion around 2035 [2]. Due to this rapid growth, one of the major concerns which are to be taken into consideration is parking these vehicles especially in urban areas where the available vehicles outnumber the parking spaces [2,3].

Currently, most car parks do not have a good management and monitoring system. Most of them are manually managed with little efficiency. Another problem is the lack of real-time information on available car parks at different locations. When a car park is eventually found, it might be fully occupied. Also, time is spent searching for free parking slots in car parks. These activities are tiring and time wasting. These inefficient conditions exist because of poor implementation of available technologies.

Modern-day car parks are built inside shopping malls, big companies and multipurpose buildings to provide parking spaces to drivers [4-6]. These types of car parks will be very efficient if it has a parking guidance and monitoring system that can be interfaced with the internet to give drivers information about availability of parking slots inside the car park.

Sensors are placed in parking slots that counts the number of vehicles in the car park. The information of available parking slots in the car park is displayed on a display board at the entrance of the car park.

This project is ESP 32 micro controller based, it uses infared sensors to detect vacancy in each parking slot, sends input signal to micro controller which processes the signal and sends output by displaying available parking spaces on an LCD display. It is also connected to the internet via a custom made web app where the car park can be monitored and available parking spaces are also displayed.

Internet is a network that can be made to connect devices to servers. Internet allows information to be sent, received or even interacts with devices over the cloud. Without engaging human interactions, IoT has the capacity to send data through network [7-8]. It also helps users to transfer data into the cloud.

Smart parking system provides information on vacant parking spaces which helps to reduce time consumption and time consumption and wastage of fuel.

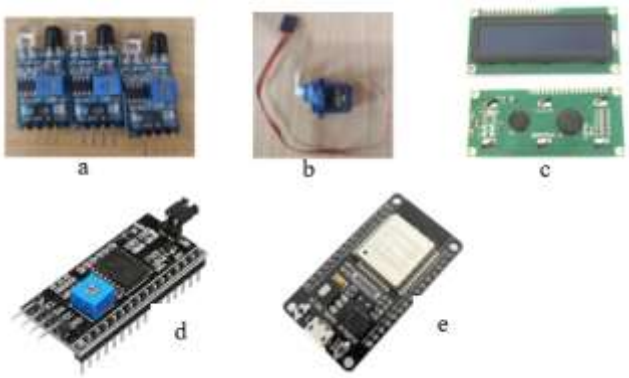

Fig. 1: Hardware Components Used

a): IR Sensor b): Servo Motor c): LCD Module
d): I2C Serial Interface Adapter Module for LCD
e): ESP32 Development Board

II. MATERIALS AND METHODS

A. The Parking Garage Platform

The parking garage made use of sensors at the gates (entry and exit) to send signals that will aid automatic gate opening, sensors were placed at each parking slots to send signals to the ESP32 micro controller which sends information about the parking system to the cloud to be monitored by the user over an interface.

B. Hardware Specification

The hardware specification of the IoT based automated parking system are as listed in the following sub-sections including their justification.

i) IR Sensors

The IR sensor module is an infrared radiation sensor which consists mainly of the IR Transmitter and Receiver. It is used at the entry and exit to the parking lot to detect presence of vehicles at the gate to aid entry and exit. It is also used to sense the presence of vehicles at each parking slot and sends signal to the controller. The image of IR sensor is shown in Fig.1a and it has an operating range of up to 20cm with adjustable sensing range.

ii) Servo Motor

This is used to aid the control of either angular or linear motion and specifically for the opening and closing of the gate. Servo drive transmits electrical signals to the servo motor to produce motion and this is shown in Fig. 1b. It has an operating voltage and speed of 5V and $0.1s/60^0$ respectively.

iii) LCD Module

The module is a liquid crystal display module, a flat panel that makes use of liquid crystals as its primary means of operation. It is used to display information about the number of slots occupied and free at the modelled car park. It is an alphanumeric LCD display module, consisting of two rows and each row with capacity to print 16 characters. Each character is built by a 5×8 pixel box and the operating voltage is between 4.7V to 5.3V. This is depicted in Fig. 1c.

iv) I2C Serial Interface Adapter Module for LCD

Due to restricted pin assets in a microcontroller/microprocessor, controlling an LCD board might be tasking. Serial to Parallel connectors such as the I2C serial interface connector module with PCF8574 chip makes the work simple with two pins. The serial interface connector is associated to a 16x2 LCD and this gives two flag yield pins (SDA and SCL) which are utilized to communicate with an MCU/MPU. The image of the interface is shown in Fig. 1d and it has an operating voltage of 5V DC while its control uses PCF8574 [10].

v) ESP 32 Controller

The controller has high processing power with an in-built Wi-Fi / Bluetooth and Deep Sleep Operating features which makes it ideal for IoT projects. The embedded microprocessor is Tensilica Xtensa LX6 while the maximum operating frequency is 240MHz. This is depicted in Fig. 1e.

C. Software Specifications

Internet of Things involves the synthesis of interrelated devices such as computers, micro controllers, sensors and actuators which are connected together with the internet to perform specific tasks without human involvement. It helps users to wirelessly control and monitor processes or devices over the internet [3,4].

IOT usually involves:

- Sensors and devices: They get signal or information from the environment such as detecting the presence of vehicles and sends to the micro controller.
- Connectivity: Connecting sensors or devices to the cloud, output information is accessed through the internet. The device is connected through GSM, Wi-Fi or Ethernet.
- Data Processing: When signals or data is sent to the cloud, processes take place such as processing availability of vehicles in parking slot.
- User Interface: This is the interface where humans communicate with the system, it helps users to wirelessly send information to the system. It can either be a web app or a mobile app.

i) ESP 32 Web Server

A Web server is basically a gadget which stores, forms and conveys web pages to web clients, which can run from browsers on our tablets to versatile apps on our smart phones. The communication between client and server employs an extraordinary convention called Hypertext Transfer Protocol (HTTP). The client uses a URL to create a request for a specific page and the server reacts with the substance of that webpage or a mistake message in case the page isn't accessible.

ii) HTML (Hypertext Markup Language)

HTML is the code that is utilized to structure a web page and its substance. For example, substance might be organized inside a set of sections, a list of bulleted points, or utilizing pictures and information tables.

iii) CSS (Cascading Style Sheets)

CSS is a language for laying out, organizing and styling web pages (HTML or XML). It is the designing language for a webpage.

iv) PHP (Hypertext Preprocessor)

A server scripting programming language that permits web designers to make dynamic contents that interacts with databases. It is used to code the backend of the website.

v) JavaScript

JavaScript is commonly utilized for making web pages. It permits us to include energetic behavior to the webpage and include extraordinary features to the webpage.

D. Methodology Overview

The system is mainly used to control and automate parking system and to monitor the status of the parking garage wirelessly through the internet using Wi-Fi. ESP32 is used as the main controller for this system, the infrared sensors are placed at the entry and exit gates to detect the presence of vehicles and sends signal to the ESP32 controller to control the gates. Servo motor controlled by the ESP32 is used to rotate the gate. Infrared sensors are placed at each parking slots to sense the presence of vehicles and signals are sent to the controller and ESP32 which controls the IoT. It serves as the interface between the web interface and the parking garage. The end user which can be a mobile phone or a laptop gets its parking system information from the cloud through the ESP32. The block diagram of the system is shown in Fig. 2 while the circuit diagram is shown in Fig. 3. The flowchart used for the design in as given in Fig. 4

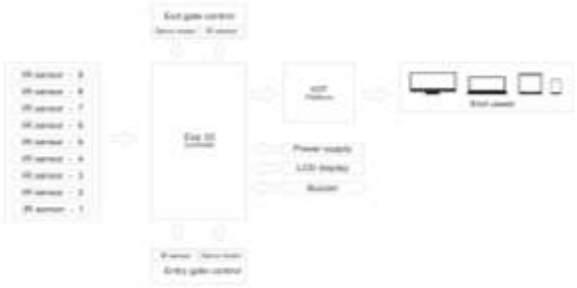

Fig. 2: Block Diagram of the IoT Based Automated Parking System

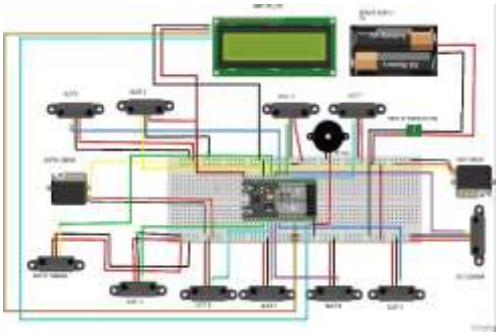

Figure 3: Circuit Diagram of the Automated Parking System

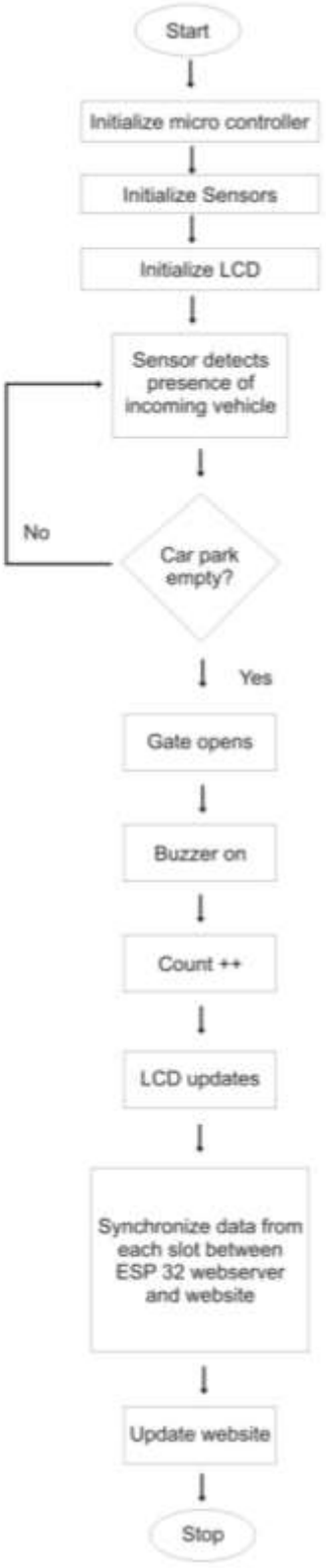

Fig. 4: IoT Based Automated Parking System

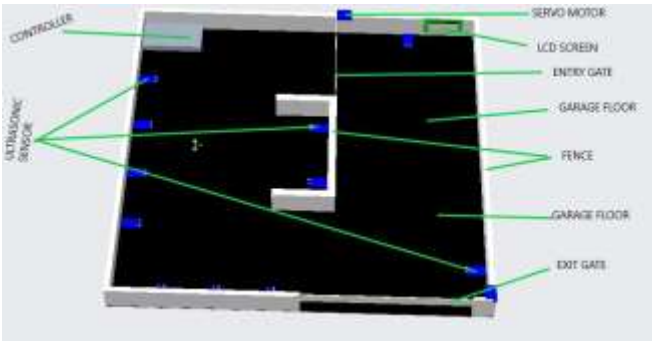

Fig. 5: Labeled CAD Model of the Parking Garage

Fig. 5 shows the CAD model of the design indicating the positional locations of all the major components of the system

III. RESULTS AND DISCUSSION

The IoT based parking system project was designed monitor the live status of car parking slots from any location by the user's webpage, and this is achieved by using internet connection. The user can easily access the car park webpage to know the status of parking slots.

Plate 1 and Fig. 6 show the prototype of the car park system and the home page of the car park website respectively:,

A. Results from different Parking Scenerios

Results obtained from five different scenerios cars occupying spaces in the park and the system responses are as outline

i) Case 1: When the 1st car enters the car park

This case shows that there is only one car in the parking garage which is shown in Plate 2. The web app will also be updated when the car is parked at the slot to show that slot 1 is filled which is shown in Fig. 7.

ii) Case 2: When the 5th car enters the car park

This case shows that there are five cars in the parking garage which is shown in Plate 3. The web app will also be updated when the car is parked at the slot to show that slot 5 is filled which is shown in Fig. 8.

iii) Case 3: When the 9th car enters the car park

This case shows that there are nine cars in the parking garage which as depicted in Plate 4. The web app will also be updated when the car is parked at the slot to show that slot 9 is filled and this is shown in Fig. 9.

iv) Case 4: When a car leaves the car park

This case shows that when a car leaves the car park through the exit gate which is shown in Plate 5, the web app gets updated showing that the slot is now free as illustrated in Fig. 10.

v) Case 5: When a 2nd car leaves the car park

This case shows that when a second car leaves the car park through the exit gate which is shown in Plate 6, the web app gets updated showing that that another slot is now free which is shown in Fig. 11.

Plate 1: Car Park Prototype

Fig. 6: Web Interface Homepage

Plate 2: Slot 1 Filled

Fig. 7: Web Interface Displaying Slot 1 Filled

Plate 3: 5 Slots Filled

Fig. 8: Web Interface Displaying 5 Slots Filled

Plate 4: 9 Slots Filled

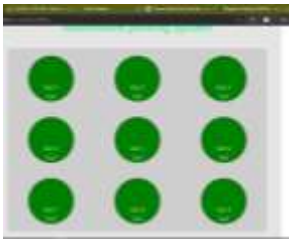

Fig. 9: Web Interface Displaying 9 Slots Filled

Plate 5: A Car Leaving

Fig. 10: Web Interface Displaying 1 Car Exit

Plate 6: 2 Cars Leaving

Fig. 11: Web Interface Displaying 2 Cars Exit

IV. CONCLUSION

The introduction and progression of Internet of Things has heightened new prospects in terms of smart cities. The developed model is characterized by using a node MCU ESP32 microcontroller with IR sensors, servo motors, LCD display with I2C and buzzer. The infra-red sensor mounted at the gate senses the presence of a car, the servo motor at the entry gate enables opening of the gate and a counting sequence is initiated. The system makes the car park smart and it can be monitored to detect free parking slots due to the interface with a web app which provides the facility to access the parking system continuously from anywhere in real time.

The developed system simplifies the requisite intelligent operations for automated parking garage in addition to making information available on parking slots sent over the cloud through the internet.

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