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Smart Parking System Based on Arduino SD Card Ajax Web Server

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Abstract The modern age implies a vehicle per capita which leads to many problems in traffic. Some of the problems of increased number of vehicles on the road are: an increase of traffic accidents, impeded traffic, large losses of time in finding a suitable place for parking vehicles, etc. This paper is based on problem of finding a suitable place for parking the vehicle because a waste of time is one of the things that modern people cannot afford. For large parking areas, such as huge shopping centers, drivers always hardly find a free parking place, especially during peak days such as holidays and free working days. This paper describes the smart parking system which is based on two technologies, Arduino and Ajax, i.e. control using a web server. This system uses ultrasonic sensors HC-SR04 which are connected to the Arduino board and which are used to find the free and taken parking places in the parking area. The characteristics of smart parking system include detection of free parking places, reservation and display of available parking places. The goal is to reduce the losing of time for divers while searching for free parking place and reducing the flow of traffic in the parking lots.

Keywords: Smart parking system, Ultrasonic sensor HC-SR04, Arduino, Ajax, detection, microcontroller

1. Introduction

Traffic crowds, caused by too many vehicles are a huge problem in all major cities. Almost every cosmopolitan city in the world suffers from traffic congestion, which causes drivers frustration especially when searching for a parking place. Solving such a problem or even trying to alleviate it will certainly offer several benefits, such as reducing drivers' frustration and stress by saving time and fuel, and reducing gas emissions, which in turn, will affect levels of pollution [1].

The problem of parking vehicles grows exponentially with the increasing number of vehicles. Searching allowed parking place for most drivers is very difficult to find especially during the striking hours in day.
The term “smart parking” is broadly defined as the integration of technologies to streamline the parking process—from dynamic place availability information to simplified payment methods [2].
Smart parking system has the purpose of facilitate and speed up parking vehicles for drivers to designated places, i.e. specially constructed parking or closed garage which also can be part of the parking system.
The current smart parking systems only obtain the availability information of parking places from deployed sensor networks, and simply publish the parking information to direct drivers. However, since these systems cannot guide the drivers to their desired parking destinations, even sometimes make the situation worse, they are not “smart” enough [3].
In urban areas, one-third of cars which have reached their destination and are circling around looking for a parking place thus leading to problems like pollution and traffic congestion. In a recent survey, researchers have found that in one year, car cruising for parking created the equivalent of 38 times trips around the world, burning 1.7 litre of fuel and producing 730 tons of CO2. So, it is essential to control the air pollution using a robust parking system that will be used for the reservation of parking spot as well as parking spot allocation in on spot resource allocation scenario. Reservation can be made using multiplatform tools such as Android application, iOS application, Windows applications or even Web Portal allowing user to have a hassle free parking experience. Recommender system will help user find the right parking lot closest to his location [4].
In this paper we design and implement the prototype of smart parking system using Arduino SD card Ajax Web server. In paper is explained how to set up an Arduino with Ethernet shield to work as a web server.

2. Smart parking system

Smart parking system helps drivers find a free parking place for their vehicles. Using a variety of methods to detect whether there is a parked car, i.e. signal drivers for the available parking place.

2.1.The methods used in smart parking system,

Depending on the purpose and scope of the project for parking there are two types of methods used in smart parking system. The first method is *Vision-Based Method* that uses so-called *Closed – Circuit Television* or CCTV. It has a camera that is responsible for more than one parking place and image editing software that will detect the status of the parking place. The second method is *Sensor–Based Method* and uses a single sensor for each parking place [5]. Various factors affect the choice of types of sensors. These factors are: the size of the parking, the reliability of sensors, adapting to changes in the environment and price [6]. Sensors can be divided into *Intrusive Sensors* and *Non-intrusive Sensors*. Intrusive sensors must be installed directly on the surface of the road. These sensors include magnetometers, pneumatic tubes, inductive sensors, piezo-electric cables and others. Non-intrusive sensors only require attaching on the ceiling or on the ground. The infrared and ultrasonic sensors are categorized as non-intrusive sensors [7]. Ultrasonic sensors can be used for counting vehicles and assessment of availability of each parking place [8]. The advantages of ultrasonic sensors are low cost and easy installation. Disadvantage of ultrasonic sensor is sensitive to temperature changes and strong air turbulence. This paper is used ultrasonic sensor HC-SR04.

2.1.1. Ultrasonic distance sensor HC-SR04

Ultrasonic sensors, known as sonars, belong to the so-called. a group of sensors for measuring distances, and is shown in Figure 2.1.

Fig 2.1. Ultrasonic distance sensor HC-SR04

They are used to measure the distance based on the velocity of propagation of ultrasonic waves through the air. The working principle of these sensors as shown in Figure 2.2 is based on the reflection of sound wave from the object to which it encounters. The transmitter emits fast, short ultrasonic signal and measures the time that elapses from of sending up to receiving ultrasonic signals [9].

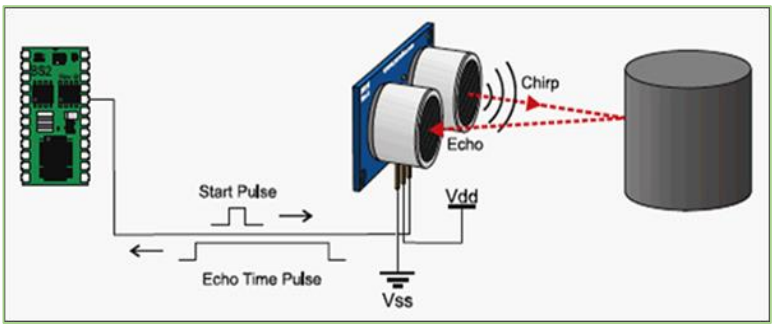

Fig 2.2. Working principle for ultrasonic distance sensor HC-SR04

Ultrasonic sensors for measuring distances are used to measure the distance between the sensor and the object that is in front of him. These sensors have good precision and easy to use.
Ultrasonic sensors allows non-contact measurement of the distance in the range from 2 cm to 400 cm with precision measurements of about 3 mm in optimal conditions. The ultrasonic ranging module HC-SR04 consists of an ultrasonic transmitter, an ultrasonic receiver and control electronics.

To calculate the distance it is necessary to measure the length of the return pulse. Distance is obtained by the equation [9]:

$$\boldsymbol{d} = \boldsymbol{T} \cdot \frac{\boldsymbol{v}}{\boldsymbol{2}} \tag{2.1}$$

where is:

d – distance, T - the return pulse duration in seconds, v - speed of sound *340 m/s*

Table 2.1. The parameters of the ultrasonic sensor HC-SR04 [10]

Operating voltage	*5 V*	Min range	*2 cm*
Operating current	*15 mA*	Measuring angle	*15°*
Operating frequency	*40 kHz*	The control pulse	*10 us*
Max range	*4 m*	Echo signal	The pulse length is proportional to the distance

In Table 2.1 are listed the parameters of ultrasonic sensor HC-SR04. Benefits for which is very often used are simplicity, low weight, low power consumption, low cost and excellent properties at avoiding obstacles. The biggest disadvantages are large beam width, low speed of sound, attenuation, large minimum distance measurements, limited the maximum distance, specular reflection, etc. [9].

2.2.The types of smart parking systems

Currently in the world are several types of smart parking systems. Parking systems are implemented in an open place (such as shopping centers) and indoors (such as underground garages) and thus the availability of places can be determined before entering the garage or parking. These types of systems reduce traffic and air pollution, reduce the time required to search for a free parking place. The next part of the paper describes the types of parking systems.

2.2.1. Parking guidance system

Parking guidance system is designed to provide parking guidance in real time. Disadvantage of parking guidance system is that at the same time more drivers go to the same accessible parking place, thus creating congestion on arrival and use of parking places becomes unbalanced [11].

2.2.2. Smart payment system

The system allows for quick and convenient payment. They are used all contact methods (debit, credit card), contactless methods (smart cards, RFID cards) and mobile devices for communication parking system and the user. When driver pay parking place on the Internet, he reserve a parking place in the parking lot, and that parking place is than reserved. The modern way of parking is done via smart phones, when user send a message to reserve a parking place and make parking payments [12].

2.2.3. E-parking system

E-parking uses advanced methods for easier parking reservations. The driver can inquire about the availability of reserved parking place at a given destination and pay on the way out. The system is accessed via mobile phones or the Internet [13].

2.2.4. Automated parking system

Automated parking system represents mechanical computer-controlled system that allows users to operate their vehicles. Automated parking system allows efficient use of expensive and limited parking place. The advantage of the automated parking system is the efficacy and safety of vehicles. Using visual navigation is carried out strict control over the movement of vehicles across the parking lot. It is important that the flow of vehicles divided into departure and arrival. The driver monitors all parking rules, monitors the work at the entrance, billing and so on. The essential characteristics of the automatic counting of vehicles, various identification methods, flexible system of tariffs for different users, removing the possibility of theft, control of entry and exit of vehicles [14].

2.2.5. Transit-based system

Transit-based systems provides information on parking lots and public transport timetable. The main purpose is to encourage drivers to park their vehicles and use

buses or trains for transport. This in turn will reduce traffic congestion, pollution and fuel consumption [15]. These types of parking systems make it easier for drivers to find a parking place, and each in its own way has good and bad sides. The logic for smart parking is essential for optimization and better development of the project, starting from the programming sequence. The basis of optimizing the programming scenarios park with a view of the display panel, entering the parking lot, parking, automatic change of information about the owner of the place at all times and exiting the parking lot. Flowchart event for parking is reflected in the programming code on the physical platform such as the Arduino development environment, used in this paper.

3. Designing smart parking system

This chapter describes design of smart parking system. Smart parking system is crated using two Arduino boards with microcontroller ATMega2560, which are programmed in Arduino IDE. On one Arduino board is connected an Ethernet shield that is used to establish a connection to the web server. On second Arduino board are connected electronic components used in designing smart parking system: 12x LEDs, 7x ultrasonic sensors HC-SR04, servo motor and switch button. Figure 3.1 shows the block diagram of Web based parking system.

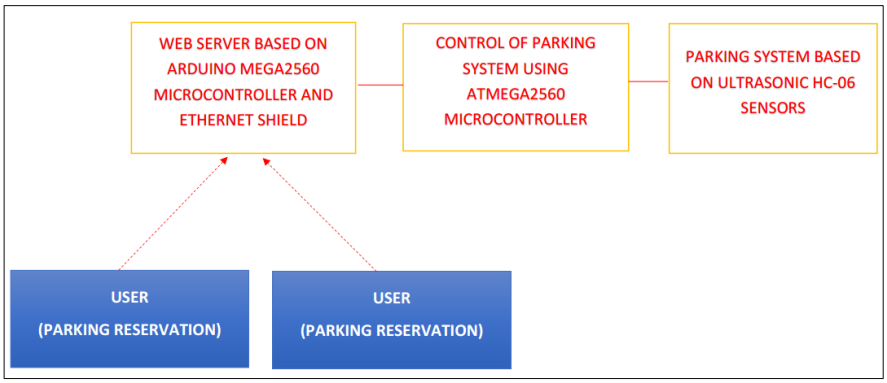

Fig 3.1. Block diagram of Web based parking system

The Arduino environment is performed initialization of each element that is directly connected with wire to a certain pin on the Arduino ATMega2560 board. Digital or analog pin with the Arduino is linked to a specific component of the smart parking and also enables communication between the computer and Arduino board. Green LEDs are turned on if the parking place is free, while the red LEDs are turned on when the car is parked on one of the free parking places. Ultrasonic sensors are used to detect if the car is parked on one of six parking places. Sensors are the devices which senses from the physical world and stimuli on the environment. The system uses Ultrasonic distance HC-SR04 sensors to detect the vehicle above it. Sensors respond to system to the availability of the vehicle above the Ultrasonic distance HC-SR04 sensors. If the vehicle is present above the Ultrasonic distance HC-SR04 sensor, it will return value false and the voltage goes low, If the vehicle is not present above the Ultrasonic distance HC-SR04 sensor, it will return value true and the voltage remains high. If the parking place is reserved the LED glows red. In another case parking place is free then LED glows green. Functional block diagram of designed parking system is shown in Figure 3.2.

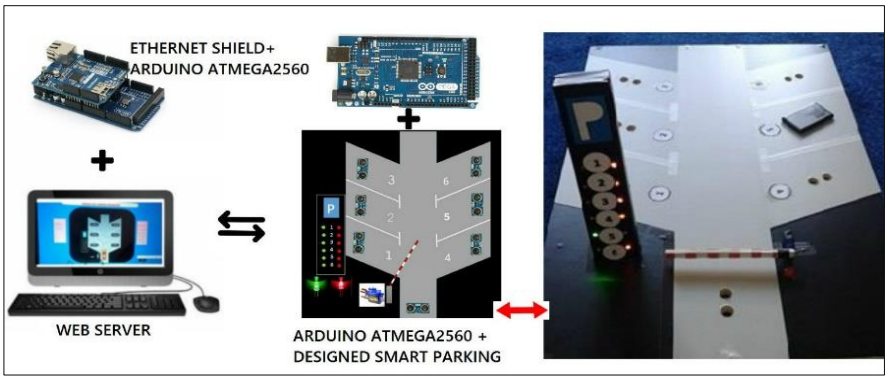

Fig 3.2. Functional block diagram of designed system

In Figure 3.1. can be seen that is used a PC as client by which we access to Web server. Web server is located on SD card placed on Ethernet shield which is connected on Arduino board and is used for communication between the Arduino board and a Web server. In Figure 3.1. also can be seen appearance of designed smart parking system with all associated components.

The web server is used to serve up web pages that can be accessed from a web browser running on any computer, regardless of the location i.e. it is not necessarily to be a local area network. To built a web server is required a knowledge of HTTP, HTML, CSS, JavaScript, Ajax etc. We used JavaScript to implement Ajax for sending data to the SD card placed on Ethernet shield connected on Arduino board, from any web browser used as client. and getting data back from the SD card behind the scenes. Ajax enables parts of the web page to be updated. This reduces the amount of data that needs be sent from the Arduino making the updates faster because the entire web page does not need to be reloaded every time new data is to

be displayed on it. Another advantage of using Ajax is that the web page does not flicker when data is updated as occurs when the entire page is refreshed [16].

4. Testing the designed smart parking system

Testing designed smart parking system described is by example from the arrival the vehicle, parking the vehicle to the time when the vehicle leaves the parking lot, as shown in Figure 4.1.

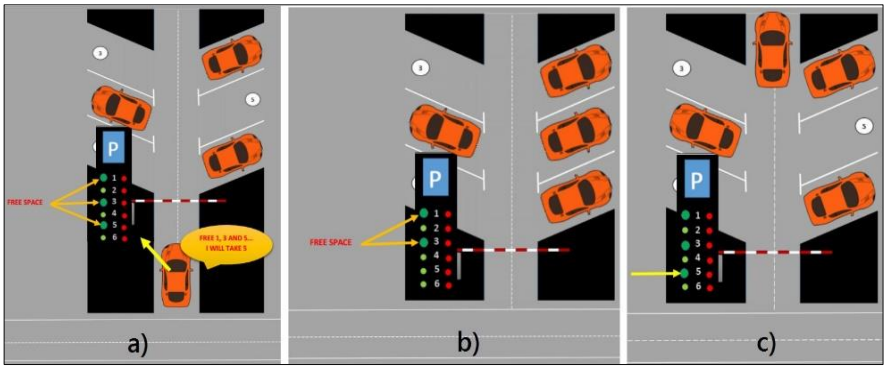

Fig 4.1. Testing the designed system

In Figure 4.1. a) driver comes to parking lot. When the driver decides to park in the parking lot first driver sees a display board which consists of label for parking places and LEDs, red and green, which indicate the driver status of parking places. If place is available, the driver moves the parking lot and encounters a ramp that automatically raises. After driver found a parking place which is free for the vehicle needs to be parked in the appropriate parking place, figure 4.1. b). When the vehicle is parked, the sensor will detect that parking place is no longer free and then will change the situation on the display board, Figure 4.1. c). When the driver decides to leave the parking lot, it is necessary to remove the vehicle from the parking place and to move towards the exit of the parking lot where the ramp rises after push on button. On the other hand, the website is a real-time view of activity in the parking lot, i.e. display status for parking places, shown in Figure 4.2.

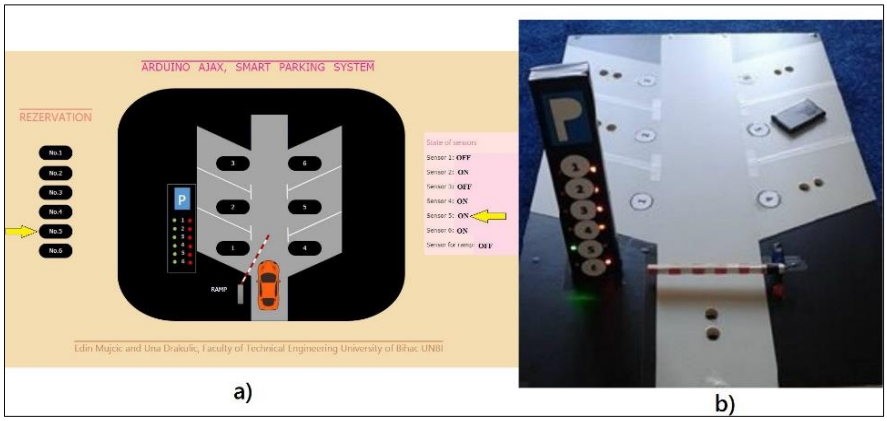

Fig 4.2. Testing the designed smart parking system: a)Web server, b)designed system

Figure 4.2. a) shows the state of parking place at the time described in Figure 4.2. b) when the vehicle enters the parking No.5. Figure 4.2. shows the state of parking place, i.e. changes in the display board. The web server is also enable to reserve parking place so that on the display board the red LED turn on for a reserved parking place.

5. Conclusion

In this paper is described way to design smart parking system using Arduino board with ATMega2560 microcontroller attached Ethernet shield with SD card. Control of smart parking system, turning on diodes depending on the state of HCSR04 sensor, is controlled by Web server. Based on the significantly shorten time for find a free parking place that is enabled from the view on the panel for free and busy parking, we conclude that the proposed smart parking system can alleviate traffic congestion caused parking searching and reduce the amount of traffic volume searching for parking.

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