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Microcontroller Based Parking Lot Monitoring System Prototype

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Abstract. Parking area is one of the facilities that must be available in specific or public places such as parks, recreation areas, malls, offices, business areas and agencies, and other places. Currently, the existing parking facilities generally do not provide information on the presence or absence of vacant parking spaces. This often causes problems in finding parking spaces, where vehicle users, especially four-wheeled vehicles (cars) will look for empty parking spaces by walking around so they can spend a lot of time. This study aims to create a parking lot monitoring system that is equipped with a microcontroller-based monitoring system so that vehicle users can find out how many parking spaces are available and where the parking lot is located. This parking monitoring system was developed using the prototyping method so that determining the need for the actual system is easier to realize. The test results of this device show that this prototype can provide information regarding the number of vacant parking lots and their locations. The impact of this research is that it can eliminate the accumulation of vehicles in front of the parking lot entrance, because vehicle users can easily and quickly find a parking location.

Keywords: Parking System, Microcontroller, Parking Prototype

1. Introduction

Parking is a situation where the vehicle is stationary in a place because the owner has left it [1]. Vehicle parking is the act of temporarily maneuvering a vehicle in to a certain location [2]. Parking area is one of the facilities that must be available in specific and public places such as recreation areas, *malls*, office areas, and others. Currently, many people use private vehicles for daily activities [3]. According to the Central Statistics Agency (BPS) through its official *website*, the total number of motorized vehicles in Indonesia reached 133.62 million units in 2019. If grouped by type, it becomes 15.59 million passenger cars, 5.02 million goods carrying vehicles, 231.56 thousand buses, and 112.77 million motorcycles. This number increased by 5.61% from the previous year. (Source: https: //www.bps.go.id/indicator/17/57/1/sum-kendaraan-bermotor.html, accessed on 07 September 2021) [4]. The increasing number of use of motorized vehicles is often cause of traffic congestion. One of the places that often experience traffic congestion is parking lot, where the traffic congestion is caused by the increasing number of vehicles so that the need for parking spaces also increases [5].

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Besides being expensive, currently the available parking facilities generally do not provide information regarding parking *lots* that are still available or have already been filled [6]. This often causes problems where vehicle users, especially four-wheeled vehicles (cars) spend their time walking around looking for empty parking spaces [7]. As a result, vehicle users can spend a lot of time just looking for parking spaces [8]. In addition, because parking lot users do not have information regarding the availability of parking spaces, vehicle users continue to enter the parking lot even though the parking lot is fully occupied so that it can cause congestion or accumulation of vehicles at the entrance, because the number of available parking spaces with the number of vehicles entering the parking lot is not balanced [9].

Quickly finding a vacant space in a parking lot is difficult if not impossible, especially on weekends or public holidays [10,11]. Seeing these conditions, this study seeks to create a parking *monitoring* system that functions to display the number of quotas and the location of empty parking *lots*, so that it is expected to eliminate vehicle buildup at the parking entrance and also assist users in finding the location of the available parking locations.

In the last three decades, many studies have been carried out to help overcome parking problems [12], various approaches have been taken such as technological approaches, sensors used, network technology, user interfaces, computing approaches, and services provided. Smart Parking Systems (SPS) used [13-16] Internet of Things (IoT) technology facilities including microcontrollers and other sensor devices are to identify available parking spaces [17]. Several studies explore IoT [6,18,19] and internet technologies to connect physical objects with the help of mobile phones and Google APIs, controllers, sensors, Wi-Fi modules [20], and cloud databases to store users [21]. Likewise, the use of microcontrollers to design SPS has been widely used by including various hardware devices such as Arduino Mega, Arduino Uno, Ethernet Shield, PN532, Radio Frequency Identification (RFID) [22], Light Dependent Resistor (LDR), Near-Field Communication (NFC), ultrasonic sensors, and infrared sensors [23-26].

In line with some of the studies mentioned above, in this study the parking lot *monitoring* system is used to monitor how many vehicles can still be accommodated by displaying the number of parking quotas on the *Liquid Crystal Display (LCD)* screen which is placed in front of the entrance to the parking area, where to detect the number of vehicles entering and leaving using *Infrared (IR)* sensors and ultrasonic sensors that function as input by detecting objects to be displayed on the floor plan and *Light Emitting Diode (LED)* light indicators, what distinguishes it from previous research is the addition of features that provide information on the location of vacant parking lots directly by using LEDs placed in each parking lot so that it serves as a marker whether the parking lot is still empty or has been filled.

2. Method

The methodology used in this research is *prototyping*. Ogedebe and Jacob [27] argue that *prototyping* is an early version of the system in the form of a physical model. The result of the *prototyping* method is a system prototype that functions as an intermediary for developers and users so that both parties can interact in the system development process. The prototyping method can be applied to all system developments, both small systems to large systems, with the aim that the development process can run well and complete as planned. Protype is created with the aim of providing equal perception and initial understanding of the basic processes of the system to be developed, so that there will be good communication between developers

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and system users [28]. The steps of the *prototyping* method consist of requirement gathering, determining the objectives, functions, and operational requirements of the system involving system developers and users [29]. The prototyping steps can be seen in Figure 1 below:

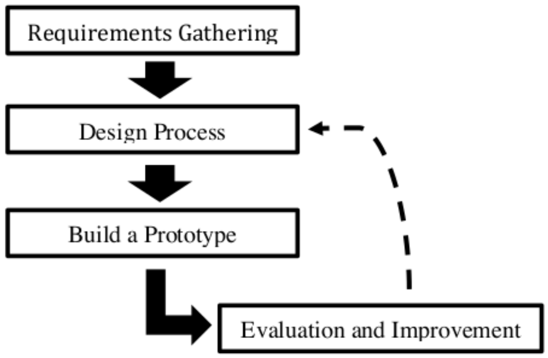

Figure 1. Prototyping steps

Based on the explanation above, the prototyping steps can be described as follows: 1) Requirements gathering – is the process of collecting and analysing what tools are needed in the prototyping process, 2) Design process – is the process of making prototype designs starting from system modelling to device design such as the process of making the system display, 3) Build a prototype - is the process of assembling the tools used into a device consisting of making system programs and making prototype tools, and 4) Evaluation and improvement - is the process of checking and improving the function of the device, which in the first test, the device still has many shortcomings, so it is necessary to make improvements to the results of previous tests, then the checking and repair process is carried out again and again until there are no deficiencies or errors in the prototype device so that it can function optimally according to with what was planned.

3. Results and Discussion

3.1. System functionality modelling

In this study, the system functionality modelling is described by using a *use case diagram* which is a description or representation of how a system interacts with its environment.

The following is a use case diagram of the parking lot monitoring system:

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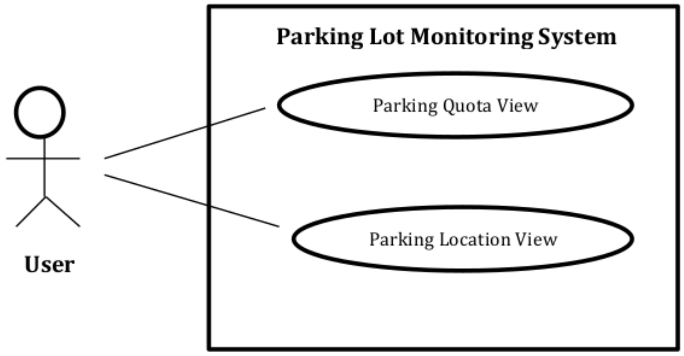

Figure 2. Usecase Diagram of Parking Lot Monitoring System

In Figure 2. Above, it can be seen that the actors in the system are parking lot users who have a need to see the number of parking quotas, and the location of the empty parking slots. While the part or function of the parking lot monitoring system can be seen from the block diagram with the relations between blocks connected by lines as a pointer to the relationship between blocks. The following is a block diagram of the parking lot monitoring system.

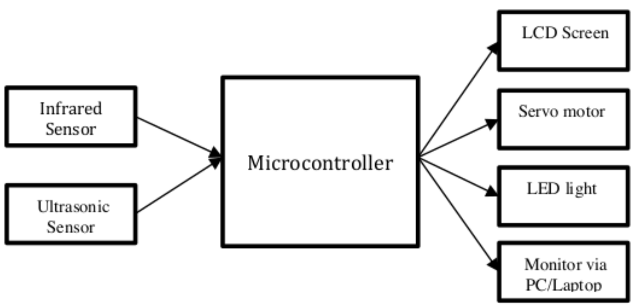

Figure **3**. Block Diagram of Parking Lot Monitoring System

Based on Figure 3 above, it can be seen several components contained in the system, as follows: 1) Infrared sensor: used to detect the presence or absence of an object is also used as input to run the servo motor. This infrared sensor is placed at the parking entrance portal, 2) Ultrasonic sensor: is used to detect the distance between the sensor and the object, also functions as input for the *LED* light indicator as well as the parking slot status on the monitor, 3) Microcontroller: is used as the brain (place) for processing input and also output, 4) *LCD* screen: is used to display the number of available parking quotas, 5) Servo motor: is used as a driver of the parking entrance portal, 6) *LED* lights: is used as an indicator of whether or not the parking slot is empty, and 7) Monitor via PC /laptop : is used to display the floor plan as well as the status of the existing parking slots.

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3.2. View Quota and Parking Location

The following is a flowchart diagram that illustrates the process flow of a system, which can show quotas and parking locations, as follows:

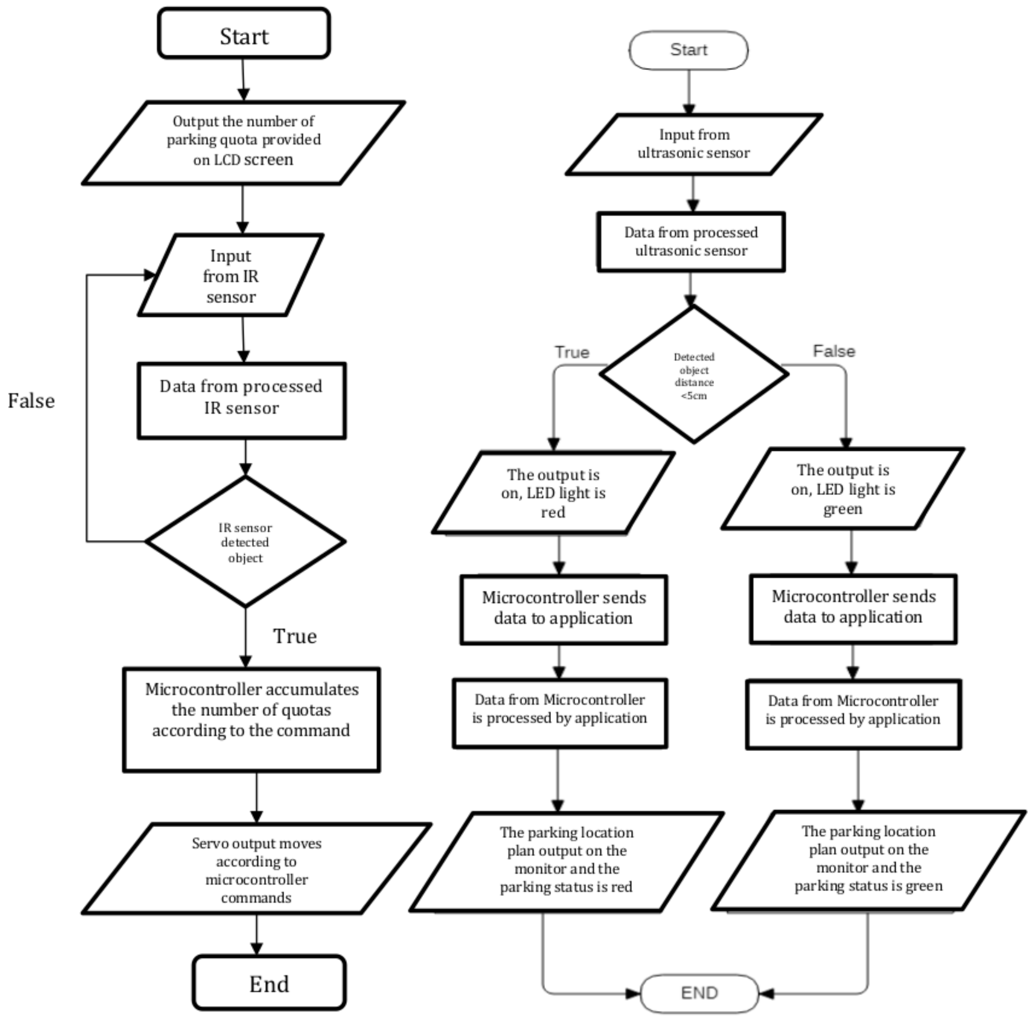

Figure 4. a. Flowchart Parking Quota View b. Flowchart Parking Location View

In Figure 4 (a) it can be seen that there is a flow from the parking quota view where the microcontroller displays the number of quotas available for parking users, besides that the microcontroller can also process data from input and produce output according to the code command. While Figure 4 (b) describes a series of flowcharts from the parking location view where the microcontroller checks the input value from the ultrasonic sensor, then the input from the ultrasonic sensor will be processed. If the input value is less than 5cm then the *LED* light and status on the parking location plan are red, and if the input is more than 5cm then the *LED* light and status on the parking location plan are green. The results of the implementation of the prototype device interface are as follows:

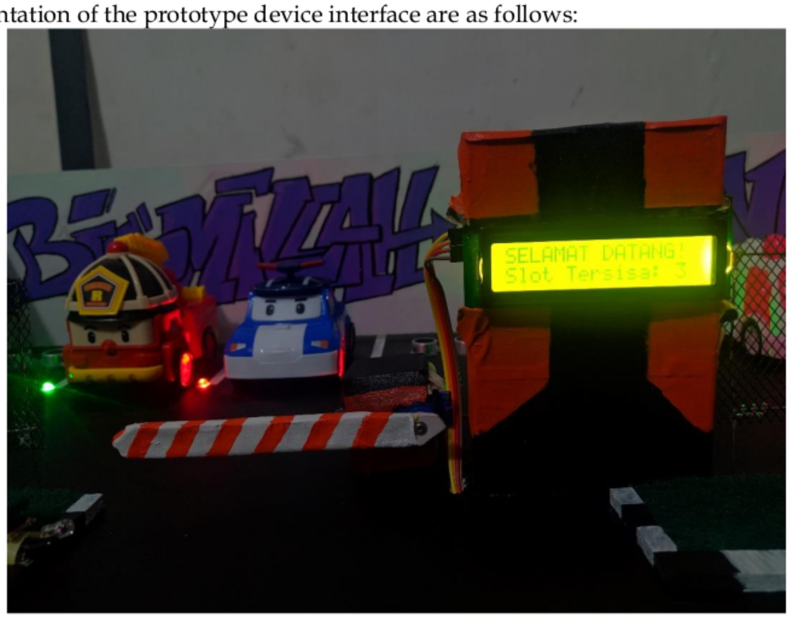

Figure 5 Parking Quota on LCD Display

Figure 5 above, shows the parking lot users about the parking quota available in the parking lot, while the parking plan can be monitored by displaying Figure 6 as follows:

Figure 6 Partially Filled Slot Implementation View

In Figure 6 above, it can be seen that the parking space slot has been partially used, where the green color indicates the parking space slot is still available, while the red color has been filled by parked vehicles.

3.3. Test Result

In this study, testing was carried out using the *Black-box Testing* method. *Black-box testing* is done by giving a number of inputs which will then be processed by the system according to its function with the aim of knowing whether the system can produce outputs as expected or not based on a number of inputs received [30] and ignores the internal mechanisms of a system [31]. The test results using the black box testing method, can be seen in Table 1 below:

Table 1. Test Results

No.	Test Function	How to Test	Expected Results	Test Results	
				Explanation	Status
1	Parking quota function test	Testing of incoming objects with a number exceeding the parking quota.	When the number of incoming objects has not exceeded the quota limit, the quota number will be reduced by 1, and when the incoming object has exceeded the quota limit, a full parking notification will appear and the parking portal will not open.	When the incoming object has not exceeded the quota limit, the number of parking quotas is reduced by 1, and when the incoming object exceeds the quota limit, a "Parking full" notification will appear and the parking portal is not open.	In accordance with the expected results, where the test results include objects whose number has not exceeded the quota limit, the quota number is reduced by 1, and when entering objects with a number exceeding the quota limit, a full parking notification appears and the parking portal will not open.
		Testing of exiting object with a number exceeding the parking quota.	When the outgoing object has not exceeded the quota limit, the number of quotas will be increased by 1, and if the number of outgoing objects exceeds	When the exit object has not exceeded the quota limit, the number of parking quotas increases, and when the number of exit objects exceeds the quota limit, the parking	Not in accordance with the expected results because when the number of outgoing objects exceeds the quota limit, the number of parking quotas still increases by 1.

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			the quota limit, the parking quota will not increase from the predetermined number of quota.	quota number still increases by 1.	
2	LED indicator function test	Keep the object on top of the ultrasonic sensor for 5 minutes.	As long as the object is still detected above the sensor, the LED will continue to be red.	When the object is still above the ultrasonic sensor for 5 minutes, the LED light remains red.	In accordance with the expected results where the test results when the object is placed on the ultrasonic sensor for 5 minutes, the LED light remains red.
3	Parking status function test on desktop application	Keep the object on top of the ultrasonic sensor for 5 minutes.	As long as the object is still detected above the sensor, the parking status in the application remains red.	When the object is still above the ultrasonic sensor for 5 minutes, the status of the parking slot in the application remains red.	In accordance with the expected results where the test results when the object is placed on top of the ultrasonic sensor for 5 minutes, the status of the parking slot on the application remains red.

4. Conclusion

After implementing and testing the tool, it can be concluded that the tool made can display the location of the empty parking location through the *LED* light indicator, as well as a floor plan for the application that is displayed on the monitor screen with input from the ultrasonic sensor to determine whether or not a parking lot is empty. With the result that users no longer need to go around looking for an empty parking lot. The tool made can display the number of parking space quotas remaining on the *LCD* screen and can calculate the number of quotas by either increasing or decreasing the number of vehicles entering and leaving using input from the infrared sensor. With this tool, it cannot eliminate the accumulation of vehicles in front of the parking entrance, because the parking quota feature still has a drawback, namely the vehicle still has to stop to see the number of quotas, thus allowing the accumulation of vehicles.

For further research, it is hoped that it will be able to fix problems in the addition of parking quotas, try wireless connectivity methods that can be run online, connect other devices that can access applications such as mobile devices, or use the concept of a system without a stop process to anticipate the accumulation of vehicles.

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