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DESIGN AND BUILD AN IOT-BASED SMART PARKING SYSTEM

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Abstract

A parking area is a place where consumers or the public can park their cars or vehicles in the empty spaces provided in the parking lot. Usually the parking area is filled with quite a lot of vehicles, so it is difficult to find empty parking spaces that are still available in the parking area, due to the density of cars or vehicles passing around the parking area who also want to find empty spaces that are still available to park their cars. This thesis aims to create a parking system that can be monitored via smartphone to determine the availability of parking slots. The parking system uses a raspberry pi microcontroller, an infrared sensor which functions to detect cars entering each parking space, LEDs are used as indicator lights to notify the status of each parking space. The results obtained from system testing are that the system has been successfully implemented as expected based on respondents' responses to the feasibility of an IoT-based intelligent parking system application using questionnaire data from 40 respondents indicating "Strongly Disagree = 0%", "Disagree = 0.5%" , “Neutral = 20.5%”, “Agree = 93.5%”, “Strongly Agree = 88%”. The maximum distance for infrared sensor detection is 80 cm. Meanwhile, the speed of obtaining data values from the sensor also depends on the distance and voltage applied to the sensor.

Keywords: Parking, Raspberry pi, Smartphone, Infrared Sensor, LED

INTRODUCTION

Technology is currently increasingly needed, both in terms of economics, business, education and other things that can be supported by technological assistance. Technology is a form of intelligence created by humans to be used as a tool or media that can help human work in solving and resolving certain problems. Parking a car in a limited space requires good handling. This is to prevent congestion in the parking area. In commercially managed parking areas, a good parking system is needed to prevent congestion in the parking area and also to get maximum results from vehicle parking services. Currently, many parking lots in malls and office buildings are made multi-storey. On each floor of the parking lot, blocks are built and numbered, this makes it easier for car owners to find their vehicle if they want to leave the parking area.

In this case, the parking system has also begun to utilize technology as a parking support tool in a parking area. For example, utilizing sensors in each available parking space and providing red and green lights as a means of notifying the availability of spaces for parking. This really helps the public in finding available parking spaces in the parking area. However, such a parking system can only be used when in the parking area. Therefore, the author wants to develop this research so that it can be accessed or viewed anywhere and at any time provided it is connected to an internet network. The author wants to create a parking system that can be accessed via the Android platform to be able to see the availability of parking spaces in a parking area online to make it easier for the public to find out the availability of the parking space they are going to.

METHOD

The method of this research is divided into several stages, the first stage is literature study, the second is system design, the third is system testing, the fourth is analyzing the system and finally the conclusion.

A. System planning

In system design, several things are done to explain the process of making the tool to be designed, in this case the system design is carried out in various stages of completion, so that in the end it will produce an output/final result of the program that is in accordance with the purpose of creating the system. The system design can be seen in Figure 1 as follows.

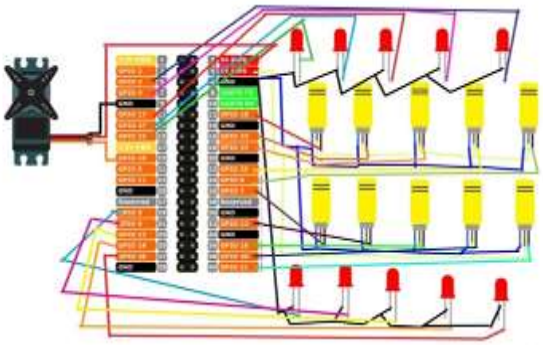

Figure 1. Raspberry Pi System Design

Using a Raspberry Pi has many benefits, including being a computer that is usually used to carry out light daily activities, such as watching HD movies, word processing, listening to music, and other activities. Raspberry Pi can be connected to various sensors such as light, temperature and movement sensors. Raspberry Pi can also be made into a web server and used as a server for hosting HTML, PHP and MySQL based websites. There are several amazing operating systems that can be used on Raspberry, namely: Debian Linux-based Raspbian, Arch Linux ARM, Raspbmc, OpenELEC, and the necessary components.

Raspberry pi

Raspberry Pi is a microcomputer module that also has digital input output ports like on a microcontroller board. One of the advantages of the Rasberry Pi compared to other microcontroller boards is that it has a port/connection for a display in the form of a TV or PC monitor and a USB connection for the keyboard and mouse. The Raspberry Pi was made in England by the Raspberry Pi Foundation. Initially the Raspberry Pi was intended for computer science learning modules in schools. Raspberries and pins can be seen in Figure 2 below.

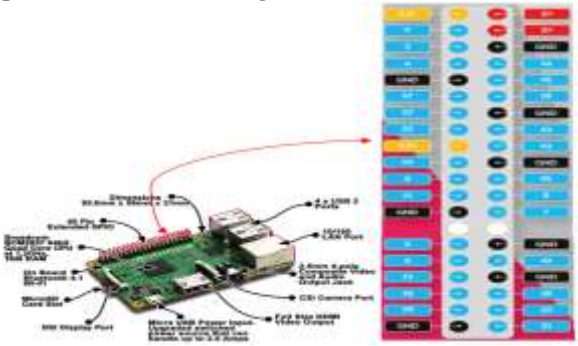

Figure 2. Ultrasonic Sensor

Adjustable Range Infrared Sensor

Adjustable Range Infrared Sensor (Infrared Switch) is a set of transmitters and receivers in one of the photoelectric switch sensors. The detection distance of this sensor can be adjusted according to demand. This sensor has a detection range of 3-80cm. This sensor is small, easy to use, and easy to assemble with robots for obstacle avoidance, interactive media, assembly on industrial machines, and many others [7]. The infrared sensor can be seen in Figure 3 below.

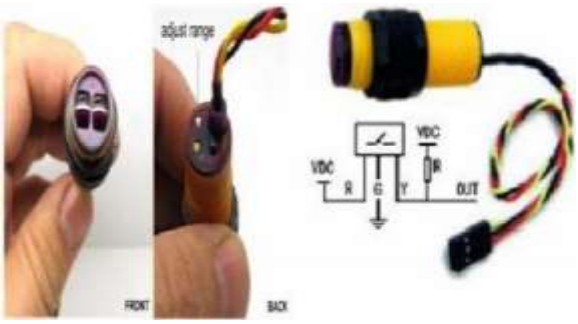

Figure 3. Adjustable Range Infrared Sensor

DC Servo Motor

A DC servo motor is a tool for converting electrical energy into mechanical energy, the permanent magnet DC servo motor converts electrical energy into mechanical energy through the interaction of two magnetic fields. One field is produced by a permanent magnet and the other is produced by the current flowing in the motor coil. The resultant of the two magnetic fields produces a torque that generates rotation of the motor [9]. The servo motor can be seen in Figure 4 below.

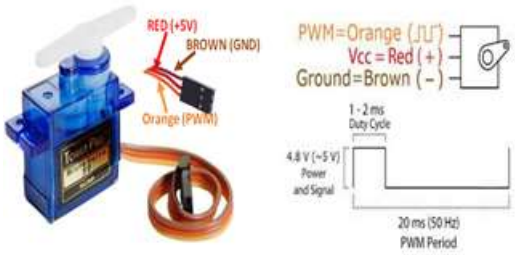

Figure 4. DC Servo Motor

Webcam

A webcam or web camera is a small digital video camera that is connected to a computer via a USB port or COM port. A simple web camera consists of a standard lens, mounted on a circuit board to capture image signals, a casing (cover), including a front casing and side casing to cover the standard lens and has a lens hole in the front casing which is useful for inserting images, support cable, which is made from flexible material, one end is connected to a circuit board and the other end has a connector, this cable is controlled to adjust the height, direction and viewing angle of the web camera. The webcam itself consists of 3 important parts, namely the image sensor, color filter, and also ADC [10]. The webcam can be seen in Figure 5 below.

Figure 5. Web Cam

Android

Android is a mobile device operating system that uses Linux as its base. Android was developed by Google Inc and is open source so anyone can develop applications for Android. The Software Development Kit (SDK) is the software needed to create Android applications using the

Java programming language. Even though it uses Java, Android does not use the Java Virtual Machine (JVM) like Java applications in general. Android has its own Virtual Machine called the Dalvik Virtual Machine which is a software stack.

Android is an operating system for Linux-based mobile devices that includes an operating system, middleware and applications. Android provides an open platform for developers to create their applications. Android is a new generation of mobile platform, a platform that gives developers the ability to develop as expected.

The operating system underlying Android is licensed under the GNU General Public License Version 2 (GPLv2), often known as a "copyleft" license where any third party improvements must continue to fall under the terms.

Android is distributed under the Apache Software License (ASL/Apache2), which allows for second and subsequent distributions. Commercialization developers (handset manufacturers in particular) may choose to improve the platform without having to provide their improvements to the open source community. Instead, developers can benefit from enhancements such as improvements and redistribute their work under whatever license they wish. Android application developers are allowed to distribute their applications under any licensing scheme they wish. Android can be seen in Figure 6 below.

Likert Scale

The Likert scale is a psychometric scale that is commonly used in questionnaires and is the scale most widely used in research in the form of surveys. The scale is named after Rensis Likert, who published a report explaining its use. When responding to questions on a Likert scale, respondents determine their level of agreement with a statement by choosing one of the available options.

B. Use Case Diagram of Parking System

When monitoring a parking lot, the admin or operator must log in first, then he can control the parking gate and parking space. If the desired parking is still empty, the operator/admin will click on the desired parking button. On the web page it can only be accessed by the admin and on Android users can only see whether the parking lot is empty or not. shows that it is possible for admins to see the parking system working directly (real time) via the website, while users can only see empty slots or not use the Android application that has been created.

The application interface is made with a simple appearance, this aims to ensure that every user can easily use it and also understand the display menu that has been designed.
The working process of the system can be seen in Figure 7 below.

Figure.7 Use Case Diagram of Parking System

System Work Process Flowchart

The following is the workflow for designing and building an IoT-based intelligent parking system, as seen in the following image.

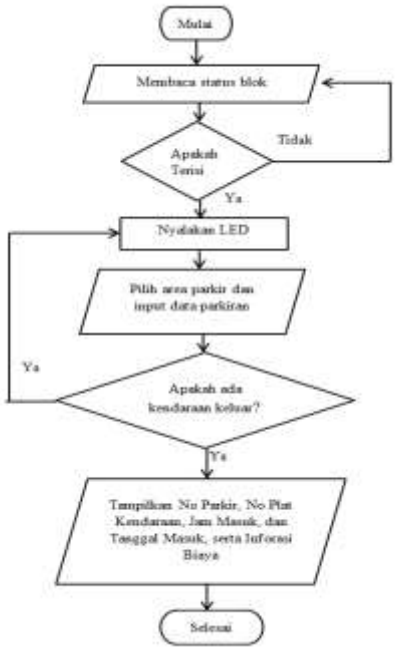

Figure 8. Flowchart of Smart Parking System Design

RESULTS AND DISCUSSION

A. Miniature View of Parking Lot

The creation of a miniature parking lot is carried out in order to simulate a parking system that has been designed to support the process that will be carried out in the design of the equipment. A miniature parking lot can be seen in Figure 9 below.

Figure 9. Miniature Parking Lot

It looks like the miniature is ready to simulate the tool that has been designed. The miniature has installed several parking attributes that are usually found in real parking lots.

B. System testing

System testing is carried out to try and find out how the system that has been designed works. The test is carried out by simulating a car parking in the available parking space in a miniature parking lot and the complexity found in carrying out the system design for system testing. The system test results were tested by simulating the design of the tool on a miniature parking lot that had been designed. In testing the system several important things are needed, namely an internet connection, a connecting LAN cable, a miniature parking lot and the components to be used, a toy car, and a raspberry pi which has been designed according to the system requirements.

C. Parking Space Availability Testing

The test was carried out by placing the car in the parking space provided, in this test the cars were placed on the 1st floor and 2nd floor, on the 1st floor 3 cars were placed and on the 2nd floor 3 cars were placed. As seen in Figure 10 below.

Figure 10. Parking System Testing

In Figure 10 you can see that the car has been parked in the parking slot being tested. In Figure 10 you can also see that the indicator light is on which indicates that the parking space is filled or already in use. This condition will also be updated on the website so that users know the parking space. which is still available. In this test, if the parking space is still available, the indicator light does not come on. The condition of all parking spaces or slots will always be updated on the website with real-time conditions, so that the data displayed by the website can be used as accurate information, but with the condition that the device designed, namely the Raspberry Pi, must always be connected to the internet network, so that the system runs well and stable. The system testing conditions and website appearance in this test can be seen in Figure 11 below.

Figure 11. Condition of Parking Lot on the Website

D. Testing Using Questionnaires

At this stage, an application feasibility test will be carried out by obtaining data from users. Testing was carried out on 40 users to use the application that had been created by the researcher and fill in the questionnaire sheet that had been prepared. Data from user responses can be seen in table I below.

TABLE I
QUESTIONNAIRE TESTING RESULTS

No	Question	Mark				
		STS	TS	N	S	SS
1	Is the application easy to operate?			5	23	12
2	The application can be easily learned ?			3	20	17
3	Is the menu display in the application easy to recognize?		1	5	19	15
4	What about the information provided by the application that is easy to understand?			5	21	14
5	Menu function according to the desired purpose?			3	17	20
6	Is this application suitable for your needs?			6	19	15
7	The application is comfortable to use, what do you think?			2	22	16

8	Does the application have an attractive appearance?	5	18	22
9	Overall, is the use of this application satisfactory?	4	15	21
10	Is the application useful for users?	3	13	24

The following table will show the results of responses from 40 users to the question "Is the application easy to operate?" the value will then be calculated using the Likert scale formula.

TABLE II
RESPONDENT TEST RESULTS QUESTION 1

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	5	15
4	Agree	4	23	92
5	Strongly agree	5	12	60
Amount			40	167

Based on the data in table II it can be calculated based on the following formula

$$P = \frac{167}{40\ x\ 5}\ x\ 100\% = 83{,}5\ \%$$

Based on these calculations, a percentage result of 83.5% was obtained, so it can be concluded that users strongly agree with the ease of operation of this application.

The following table will show the results of responses from 40 users to the question "Can the application be easily learned?" the value will then be calculated using the Likert scale formula.

TABLE III
RESPONDENT TEST RESULTS QUESTION 2

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	3	9
4	Agree	4	20	80
5	Strongly agree	5	17	85
Amount			40	174

Based on the data in table III it can be calculated based on the following formula

$$P = \frac{174}{40\ x\ 5}\ x\ 100\% = 87\ \%$$

Based on these calculations, a percentage result of 87% was obtained, so it can be concluded that users strongly agree with how easy this application is to learn. The following table will show the results of responses from 40 users to the question "Is the menu display in the application easy to recognize?" the value will then be calculated using the Likert scale formula.

TABLE IV
RESPONDENT TEST RESULTS QUESTION 3

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	1	2
3	Neutral	3	5	15
4	Agree	4	19	76
5	Strongly agree	5	15	75
Amount			40	168

Based on the data in table IV it can be calculated based on the following formula.

$$\mathrm{P} = \frac{168}{40\ \mathrm{x}\ 5}\ \mathrm{x}\ 100\% = 84\ \%$$

Based on these calculations, a percentage result of 84% was obtained, so it can be concluded that users strongly agree with the easy-to-recognize appearance of the application menu.

The following table will show the results of responses from 40 users to the question "Is the information provided by the application easy to understand? How is the information provided by the application easy to understand?" the value will then be calculated using the Likert scale formula.

TABLE V
RESPONDENT TEST RESULTS QUESTION 4

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	5	15
4	Agree	4	21	84
5	Strongly agree	5	14	70
Amount			40	169

Based on the data in table V it can be calculated based on the following formula.

$$P = \frac{169}{40 \text{ x } 5} \text{ x } 100\% = 84{,}5\ \%$$

Based on these calculations, a percentage result of 84.5% was obtained, so it can be concluded that users strongly agree with the ease of understanding the information provided by the application. The following table will show the results of responses from 40 users to the question "The menu function is appropriate to the desired goal?" the value will then be calculated using the Likert scale formula.

TABLE VI
RESPONDENT TEST RESULTS QUESTION 5

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	3	9
4	Agree	4	17	68
5	Strongly agree	5	20	100
Amount			100	177

Based on the data in table VI it can be calculated based on the following formula.

$$P = \frac{169}{40\ x\ 5}\ x\ 100\% = 84{,}5\ \%$$

Based on these calculations, a percentage result of 84.5% was obtained, so it can be concluded that users strongly agree with the ease with which the information provided by the application is understood. The following table will show the results of responses from 40 users to the question "The menu function is in accordance with the desired goal, what is your opinion? You?" the value will then be calculated using the Likert scale formula.

TABLE VII
RESPONDENT TEST RESULTS QUESTION 6

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	6	18
4	Agree	4	19	76
5	Strongly agree	5	15	75
Amount			100	169

Based on the data in table VII it can be calculated based on the following formula.

$$P = \frac{169}{40\ x\ 5}\ x\ 100\% = 84{,}5\ \%$$

Based on these calculations, a percentage result of 84.5% was obtained, so it can be concluded that users strongly agree with the suitability of this application's needs. The following table will show the results of responses from 40 users to the question "Is the application comfortable to use?" the value will then be calculated using the Likert scale formula.

TABLE VIII
RESPONDENT TEST RESULTS QUESTION 7

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	2	6
4	Agree	4	22	88
5	Strongly agree	5	16	80
Amount			100	174

Based on the data in table VIII it can be calculated based on the following formula.

$$P = \frac{174}{40\ x\ 5}\ x\ 100\% = 87\ \%$$

Based on these calculations, a percentage result of 87% was obtained, so it can be concluded that users strongly agree with the convenience of this application.

The following table will show the results of responses from 40 users to the question "Does the application have an attractive appearance?" the value will then be calculated using the Likert scale formula.

TABLE IX
RESPONDENT TEST RESULTS QUESTION 8

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	5	15
4	Agree	4	18	72
5	Strongly agree	5	12	60
Amount			40	147

Based on the data in table IX it can be calculated based on the following formula.

$$P = \frac{174}{40\ x\ 5}\ x\ 100\% = 87\ \%$$

Based on these calculations, a percentage result of 87% was obtained, so it can be concluded that users strongly agree with the convenience of this application. The following table will show the results of responses from 40 users to the question "Does the application have an attractive appearance?" the value will then be calculated using the Likert scale formula.

TABLE X
RESPONDENT TEST RESULTS QUESTION 9

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	4	12
4	Agree	4	15	60
5	Strongly agree	5	21	105
Amount			40	177

Based on the data in table X it can be calculated based on the following formula.

$$P = \frac{147}{40\ x\ 5}\ x\ 100\% = 73{,}5\ \%$$

Based on these calculations, a percentage result of 73.5% was obtained, so it can be concluded that users strongly agree with the appearance of this application.

The following table will show the results of responses from 40 users to the question "Overall the use of this application is satisfactory?" the value will then be calculated using the Likert scale formula.

TABLE XI
RESPONDENT TEST RESULTS QUESTION 10

No	Information	Score	Respondent	Respondent Score
1	Strongly Disagree	1	-	-
2	Don't agree	2	-	-
3	Neutral	3	3	9
4	Agree	4	13	52
5	Strongly agree	5	24	120
Amount			40	181

Based on the data in table 4.11 it can be calculated based on the following formula.

$$P = \frac{181}{40\ x\ 5}\ x\ 100\% = 90{,}5\ \%$$

Based on these calculations, a percentage result of 90.5% was obtained, so it can be concluded that users strongly agree with the benefits of this application.

CLOSING

Based on the results of testing and analysis in research that has been carried out with the title "Design and Build a Smart Parking System Based on the Internet of Things", several conclusions can be drawn as follows:

1. The IoT-based intelligent parking system application from the first run until the end of the system was successful as expected. Based on respondents' responses to the feasibility of an

IoT-based smart parking system application using questionnaire data from 40 respondents, it shows "Strongly Disagree = 0%", "Disagree = 0.5%", "Neutral = 20.5%", "Agree = 93.5%", “Strongly Agree = 88%”.

2. Testing of the Adjustable Range infrared sensor was carried out to determine the voltage and distance required, according to the design made, it can be concluded that if the distance to the infrared sensor detection is a maximum of 80 cm, a greater voltage is needed to be able to detect obstacles/objects that will hit the light. infrared from the sensor. Meanwhile, the speed of obtaining data values from the sensor also depends on the distance and voltage applied to the sensor.

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