Journal of Industrial Automation and Electrical Engineering
Vol. 01, No. 02, December 2024, pp. 28~33
ISSN: 3089-1159

Prototype of smart parking system for Bukittinggi city parking buildings based on Arduino

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Article Info

Article history:

Received August 22, 2024
Revised October 10, 2024
Accepted November 20, 2024

Keywords:

Prototype
Smart Parking
Arduino Uno
Bukittinggi Parking Building

ABSTRACT

The parking system currently used in the Bukittinggi City parking building is not effective in managing parking, because it does not provide real-time information about the availability of parking spaces. As a result, use of parking spaces is often suboptimal, with some parking spaces remaining empty while others are full. This research aims to develop and test a system that is able to manage parking availability in real-time to maximize the use of existing space. Test results show that this system functions well and provides accurate results, which is very much needed in a tourist city like Bukittinggi. Overall, this system offers an efficient and practical solution to overcome parking challenges in big cities, and has the potential for further development, including integration with automatic payment systems and the use of more sophisticated sensors. This research shows that the Arduino-based Smart Parking system Uno in the Bukittinggi City parking building has succeeded in increasing the efficiency of parking space management. By using components such as push buttons, thermal printers, servo motors, limit switches, and LCD I2C displays, this system provides real-time information about parking availability, making it easier for motorists to find parking spaces quickly.

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1. INTRODUCTION

Parking facilities are an important part of the modern transportation system [1]-[5]. In Bukittinggi City, which is known as a national and international trade and tourism center, the need for an efficient parking system is increasingly urgent. Bukittinggi City receives very high tourist visits, with 1.03 million people recorded visiting paid tourist attractions in December 2017, not including visits to free tourist attractions which are estimated to be much higher. The increasing number of vehicles, along with the increasing population and economic activities, puts significant pressure on existing parking facilities [6]-[8]. Therefore, innovative solutions to manage parking spaces better and more efficiently are very important. Transportation as an important facility that facilitates the movement of people and goods plays a central role in the evolution of modern life [9]. Every year, the transportation sector experiences significant progress, with innovations that facilitate people's mobility [10]. According to data from the Central Statistics Agency, the number of registered motorized vehicles in Indonesia increased from 141,992,573 units in 2021 to 148,261,817 units in 2022, indicating a continuous increase in the number of vehicles. This increase has led to a high demand for efficient and organized parking spaces, especially in cities with high tourist arrivals such as Bukittinggi. Therefore, innovation in parking systems is becoming increasingly important to overcome these challenges, ensure smooth transportation, and provide convenience for visitors.

Facing this challenge, innovation in smart parking systems is a promising solution. The prototype of a smart parking system based on Arduino Uno is designed to optimize the use of parking space in the

Bukittinggi City parking building. Arduino Uno is a multifunctional microcontroller [11]. With additional components such as push buttons to open the barrier, thermal printers to print tickets, servo motors as barrier drivers, and limit switches to detect vehicles entering and exiting each floor. The LCD display is used to display parking availability on each floor in real-time. The use of this system allows efficient monitoring and management of parking spaces. When a vehicle enters the parking building, the limit switch will detect at each level of the parking building and reduce the number of available parking spaces, which are then displayed on the LCD display. Conversely, when the vehicle exits, the limit switch will detect and add back the number of available parking spaces. Thus, drivers can easily find out the availability of parking on each floor without having to search manually, reducing the time and energy spent looking for parking spaces. The implementation of this smart parking system can increase the efficiency of parking space use in the Bukittinggi City parking building which has 4 floors for parking. Currently, the parking system implemented is still manual and only uses a time calculation system to determine rates, which is considered less effective because it does not provide adequate parking availability information. As a result, users have difficulty knowing the status of available parking spaces. With the smart parking system, information about parking availability will be available in real-time.

Research on smart parking systems has been conducted by [12]-[18]. Smart parking that has been developed uses infrared sensors and Arduino as a microcontroller. Infrared sensors are used to detect the presence of cars, while the Information Board (Digital Signage) functions to display the number of parking spaces available on each floor of the building in real-time [13]. This research method is considered effective because it is able to provide adequate parking availability information, so that users have no difficulty in knowing which parking spaces are still available. However, when this method is applied directly, there are shortcomings in the use of Arduino pins for sensors. This is due to the need for a large number of pins if this system is applied directly.

Based on the results of previous research on smart parking systems, the author wants to modify the smart parking system that has been developed by previous research, by using components such as push buttons to issue tickets and open portals, thermal printers to print tickets for each vehicle entering the parking lot, servo motors to open and close parking barriers, ultrasonic sensors to close the portal automatically after the vehicle has passed the portal, limit switches to detect vehicles entering and exiting at each level of the parking building, and LCDs used to display parking status directly to drivers who will enter the parking lot.

2. METHOD

In making a prototype, the first thing to do is design. Tool design is a planning process before making a tool. The purpose of this design is to make it easier to make the tool. Because in the design, the selection of the right circuit and calculations and selection of components will be carried out. In principle, systematic tool design will make it easier to make the tool. Figure 1 shows a block diagram of the smart parking system which explains how the tool works as a whole from input, process, to output. In this block diagram there is only a path relationship between the blocks, but each block has main components and supporting components.

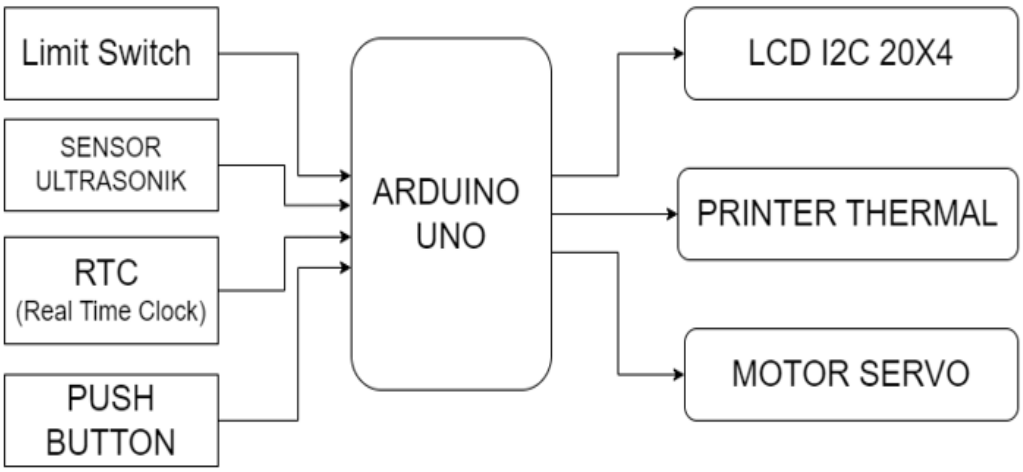


Figure 1. Block diagram of the Arduino Uno-based smart parking system.

The System Block Diagram consists of input, process and output. The system input consists of: a) Push Button. The first push button functions to issue a parking ticket and open the entrance portal with a servo motor. Meanwhile, the second push button is used to open the exit portal with a servo motor after the payment process is complete, b) two ultrasonic sensors, the first sensor is placed near the entrance portal to detect incoming vehicles and send a signal to the Arduino to close the portal after the vehicle passes. The second sensor is placed near the exit portal to detect outgoing vehicles and send a signal to the Arduino to close the portal after the vehicle passes the exit portal, c) Eight limit switches, with two limit switches on each parking floor: one in the entrance area and one in the exit area. The limit switch in the entrance area sends a signal to the Arduino when a vehicle enters, reducing the number of available parking spaces. Meanwhile, the limit switch in the exit area sends a signal when a vehicle exits, adding back the number of available parking spaces, d) RTC (Real-Time Clock) which is used to provide accurate time to record the time of entry and exit of vehicles. This data is used to calculate parking duration and fees automatically, as well as manage parking slots more efficiently. In the process, there is an Arduino Uno as the main controller that integrates various components such as ultrasonic sensors, push buttons, servo motors, thermal printers, and LCD screens. Arduino Uno receives data from sensors and other components to manage processes such as detecting parking space availability, printing parking tickets, and controlling the movement of entrances and exits. In the output section, there are several components, namely: 1) Servo Motor to move the entrance and exit portals based on signals from Arduino via push buttons, 2) LCD I2C Display to display the availability of parking spaces on each floor in real-time, based on signals from Arduino received via limit switches, 3) Thermal Printer to print using heat on special paper and is used to print parking tickets when vehicles enter, based on signals from Arduino via push buttons.

Figure 2 shows the flowchart of smart parking proposed in this study. Flowchart is a diagram that shows the sequence of logic or instructions from one step to the next. Flowcharts facilitate understanding of the tool by clearly showing the control of the algorithm and the process of implementing the activity or work system to be created.

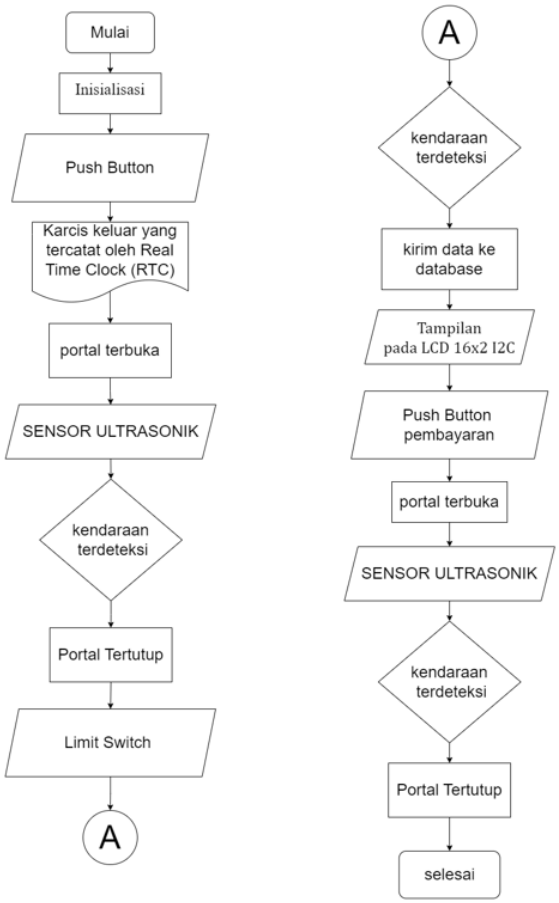


Figure 2. Flowchart of Arduino Uno-based smart parking system

Figure 3 is a combination of all the components used when assembled with each other. In the picture you can see the PIN that connects the Arduino Uno to the Push Button PIN, Servo Motor, Ultrasonic Sensor, Limit switch, and I2C LCD PIN.

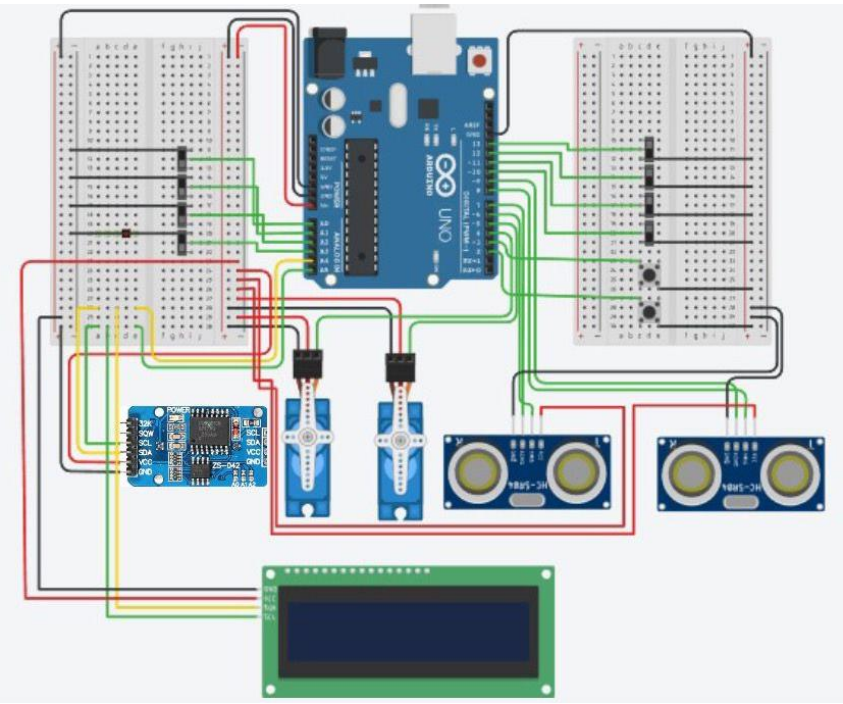
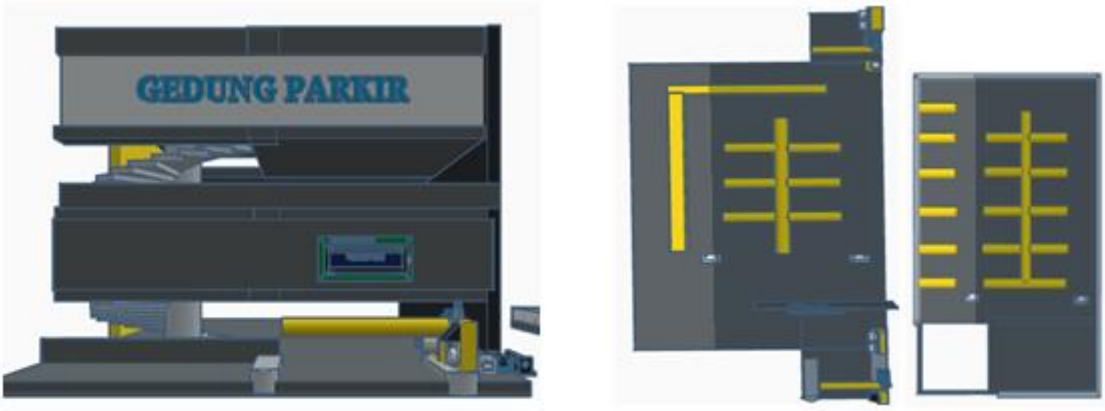


Figure 3. Circuit schematic of the Arduino Uno-based Smart parking system to optimize the use of parking spaces in the Bukittinggi city parking building

The proposed smart parking prototype design is shown in Figure 4. Figure 4(a) shows the front view design and 4(b) shows the parking floor design.

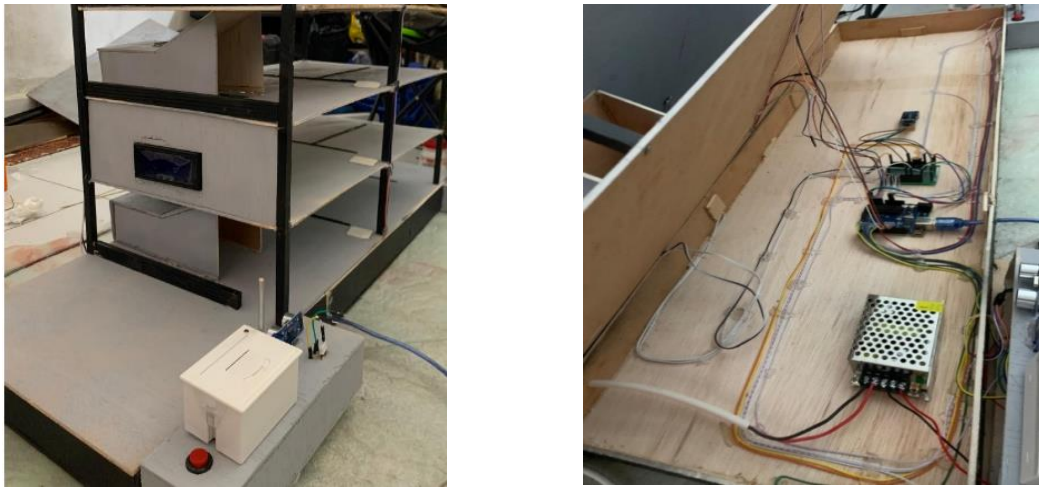


(a) (b)

Figure 4. Design of proposed smart parking (a) Front view, (b) Floor form.

3. RESULTS AND DISCUSSION

The mechanical form of the electrical energy monitoring and control device can be seen in Figure 5(a). This design uses a box measuring 60 x 30 x 10 cm. The wiring on this device uses a NYA cable measuring 1.5 mm in the AC circuit and uses a ribbon cable measuring 0.12 mm in the DC circuit. The wiring design can be seen in Figure 5(b).



(a) (b)

Figure 5. Results of smart parking prototype, a) Front view, b) Installation of component circuits

Testing was carried out on all components connected to the Arduino Uno, namely Push Button, Thermal Printer, RTC DS3213, Servo Motor, Ultrasonic Sensor, Limit switch, and LCD. After the program is uploaded, the components can be directly connected according to what is made on the Arduino IDE. The first component program testing was carried out for the Limit Switch. Figure 6 (a) shows the smart parking prototype testing process. Figure 6 (b) shows the LCD display as an indicator of the condition of the parking building.

(a) (b)

Figure 6. Experimental process. a) Car placement in the smart parking prototype, b) LCD display.

The results of the Limit Switch test in the Smart Parking system show that each limit switch functions optimally in detecting vehicles entering and exiting each floor after two presses. The LCD also successfully displays real-time information on the number of vehicles entering and exiting each floor and the floor capacity status (15). The data displayed is proven to be accurate and makes it easier to monitor parking capacity on each floor. Table 1 describes the results of the limit switch testing.

Table 1. Experimental results of limit switch test

No	Limit Switch	LCD								Filled	Full
		1	2	3	4	5	6	7	8		
1	Floor 1 IN	ON	-	-	-	-	-	-	-	1	15
2	Floor 1 OUT	-	ON	-	-	-	-	-	-	0	15
3	Floor 2 IN	-	-	ON	-	-	-	-	-	1	15
4	Floor 2 OUT	-	-	-	ON	-	-	-	-	0	15
5	Floor 3 IN	-	-	-	-	ON	-	-	-	1	15
6	Floor 3 OUT	-	-	-	-	-	ON	-	-	0	15
7	Floor 4 IN	-	-	-	-	-	-	ON	-	1	15

8	Floor 4 OUT	-	-	-	-	-	-	-	ON	0	15

This Smart Parking System is designed to improve efficiency and ease in parking space management in Bukittinggi city parking buildings. Using Arduino-based components, this system includes various features to monitor, control, and report parking status in real-time. The main features of this system include Push Button to open the parking barrier, Thermal Printer to print parking tickets, Servo Motor as a driver of the parking barrier, Limit Switch to detect vehicles entering and exiting each floor and LCD Display to display parking availability on each floor in real-time. Testing was conducted to ensure system performance under various operational conditions. Table 2 describes the test results on parking tickets.

Table 4. Parking Ticket Data

Ticket Number	Entry Time	Exit Time	Parking Duration (hours)	Parking Fee (Rp)
01	10:30:00 21/08/2024	13:30:00 21/08/2024	3	15,000
02	11:15:00 21/08/2024	14:15:00 21/08/2024	3	15,000
03	14:00:00 21/08/2024	17:00:00 21/08/2024	3	15,000
04	09:00:00 21/08/2024	11:00:00 21/08/2024	2	10,000

4. CONCLUSION

This study proves that the Arduino Uno-based Smart Parking system implemented in the Bukittinggi City parking building has successfully increased the efficiency of parking space management. This system uses various components, such as push buttons, thermal printers, servo motors, limit switches, and LCD I2C displays, to provide real-time information on parking availability, making it easier for drivers to find available parking spaces. By detecting vehicles entering and exiting, the system automatically adjusts the parking capacity displayed on the screen, reducing the time and energy required to search for parking. The test results show that this system functions well and provides accurate results, which are much needed in a tourist city like Bukittinggi. Overall, this system offers an efficient and practical solution to overcome parking challenges in big cities, and has the potential for further development, including integration with automated payment systems and the use of more sophisticated sensors..

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