LOW COST RFID-BASED SECURITY SYSTEM FOR PARKING LOTS

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ABSTRACT

The rapid advancement of technology is reflected in improvements to equipment that facilitate human work, such as the parking system employing RFID (Radio Frequency Identification). The RFID technology is able to record incoming and outgoing data for short-distance data transfer. The intended audience for this work's development is junior or senior high school students. Finally, students are expected to be able to develop effective parking solutions with little cost and expertise. Two registered cards and one unregistered card are used to test this tool, with ten tests being run on each card. Some of the tests that have been carried out include the efficiency of RFID and ultrasonic sensors in reading registered cards and detecting heading vehicles, as well as the use of RFID obstacles to test the extent to which the frequencies in RFID can operate, even when they are still obstructed by other objects. The test results show that the system could work properly, and read with the right level of precision with 0.3 seconds an average delay. Additionally, the resulting RFID reader can still detect registered cards at a distance of 1.5 cm even with a border thickness of up to 2.0 mm.

Keywords: *Parking Gate, Sensor, RFID, Low cost parking system*

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1. INTRODUCTION

The modern world is rapidly evolving, driven by scientific inventions and technological breakthroughs that enable the development of a varied range of smart devices, equipment, and systems. Human life has become more accessible, flexible, and comfortable as a consequence of the advancement of technology. Today, modern technology and its benefits have a significant impact on many aspects of human life. Along with the rise of technology around us, technology must be able to help and facilitate our daily work.

In terms of parking systems, it continues to grow and evolve, initiating with manual data collection and progressing to barcodes, which will eventually be replaced by RFID systems [1] [2]. The parking system is divided into two categories based on the type. First, there are common parking systems, which still use parking tickets as proof of parking, and computerized parking systems, which automate the parking process with the help of computers. Both types of parking systems have benefits and drawbacks.

The advantage of common parking systems is that their use is familiar, considered manageable, and does not necessarily imply technological investment. On the other hand, this system has a weakness: frequent errors in ticket writing by parking attendants, resulting in long service times due to the duplication process or requiring the parking officer to rewrite the ticket. Another disadvantage is the waste of packaging paper and the loss of transaction data.

Barcode technology is commonly used in computerized parking systems, which can be implemented by using Radio Frequency Identification (RFID) technology as an authentication medium. Barcode technology has advantages such as automation of data realization through the use of barcode scanners, accuracy of data reading, and ease of use, resulting in more accurate information and data processing [3]. RFID technology is becoming more advanced, especially in the fields of electronics, telecommunications, and IT development [4]. This device can also assist with the creation of the smart school or smart campus concept. By implementing these concepts, it will not only improve the productivity of one of its facilities, but it will also improve the assessment of educational facilities and infrastructure [5].

Many studies have been conducted to address the issue of parking systems using various technological options, but the lot of the work has introduced advanced technology with complex and extensive features, as described in the Table.1.

Table.1 Matrix Data Literature Review

Journal	The Detail Components	Implementation	The Different
[4]	RFID Reader, RFID Tag, IC L293D, Stepper Motor, MP3, AVR ATmega 8535 Microcontroller, InfraRed Transmitter, InfraRed Receiver, Power Supply, and LCD.	Prototype	Parking tools with semi-conventional using human operators. related to the author's but has differences in the infrared sensor used
[6]	RFID Reader, RFID Tag, L293D IC, Servo Motor, Arduino uno and LCD.	Prototype	Related to the author's property but has the difference of not using Ultrasonic sensors
[7]	RFID Reader, RFID Tag, UML Diagram, MySQL Data Web Application	Software, Simulation	Use different components and use the software as an IoT medium
[3]	Transponder, RFID Reader ultra-high frequency (UHF), RFID tag, Parking bar, computer database, MySQL	Real Device	Using the same way tools work but with different components and equipped with an IoT database

There are some differences in each device created compared to the previous research as described in the Table.1 The authors of journals 1 and 2 developed a similar mini prototype, but there are differences in the sensors used. While the authors of Journal 3 focus more on IoT software development. In the journal 4, the author creates a device of actual size and directly tests it in the field and pinned IoT technology, but the author did not use Arduino as a microcontroller. At last, the fifth authors use Arduino on the device in the journal, IoT technology uses ESP8266.

This work aims to propose a practical and low-cost method for designing RFID-based parking systems that can be used by high school students. Students who are not yet advanced can benefit experience in building parking systems with this practical parking system concept, which can be improved in the future by adding more sophisticated and smarter functionalities or technology.

2. RESEARCH METHOD

2.1 Overall System Design

This section describes the implementation of the hardware and software of the system. The block diagram describes the entire system's processes as described in Fig.1, and can be further detailed by the flowchart to the corresponding methods as represented by Fig.2.

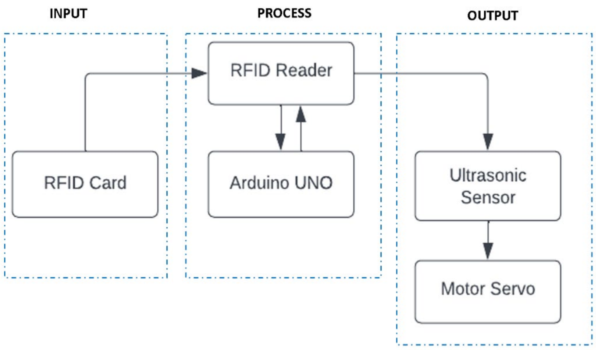

Figure.1 Block diagram of the system

When the circuit is turned on, the ID card is detected by the reader, and a unique card number assigned to each individual is sent to the microcontroller, as shown in Fig.1. If the card number matches a saved number in the microcontroller or database, the card is recognized as the authorized person, and the system continues to activate the motor servo to open or close the gate. The ultrasonic sensor will prompt the motor servo to open and close the gate.

The author used an experimental method to develop and test the system. The prototype, as shown in fig.1, uses Arduino as the primary microcontroller to accommodate component system commands. The RFID sensor is the primary sensor in this tool because it serves as an RFID reader and reading the RFID chip emitting card. We use RFID chip cards as a medium to provide access to the staff and students concerned. Not all RFID chip cards are able to gain access to and opening doorstop RFID readers. In order to gain legal access, we had to register an RFID chip card. Only registered cards are allowed to enter and open doorstops.

As seen in the Fig.2, when entering the parking area with the user's vehicle, the user must use a card that has been registered with the RFID reader. Access is granted when the card is pasted and the doorstop opens.

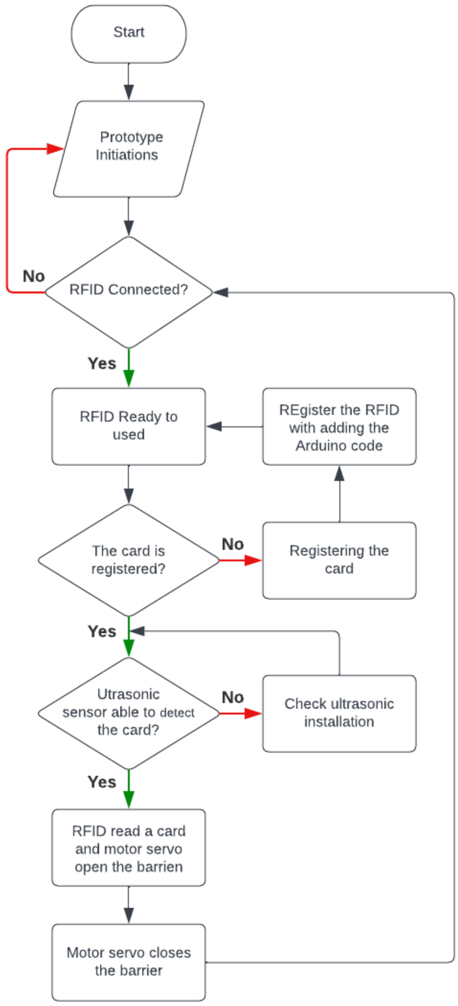

Figure.2 Flow chart of the system

If the affixed card does not open the doorstop, this indicates that access is denied, and the user must register the card on the RFID reader. After having access and passing through the doorstop, the user will proceed to walk until he reaches the ultrasonic sensor. The RFID card will be detected by the ultrasonic sensor. Since the RFID card identification process was completed earlier, if the RFID card brought closer to the ultrasonic sensor is registered, the ultrasonic sensor will trigger the servo motor to open or close the gate. However, if the RFID Card is not identified with the owner's authorization, the gate will not open.

2.2 Arduino Uno

The Arduino Uno is a microcontroller board that is based on the ATmega328 (datasheet). It has 14 digital output input pins, 6 of which can be used as PWM output and 6 analog input pins, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [8]. To use microcontrollers, simply connect the Arduino Uno board to a computer via USB or power cable with an AC-to-DC adapter or battery to power it. Arduino is a basic open-source microcontroller system that is widely used to create simple electronic projects.

Figure.3 Arduino Uno

2.3. HC-SR04 Ultrasonic Sensor

An ultrasonic sensor is a sensor that works on the principle of sound wave reflection and is used to detect the presence of a specific object in front of it, with its working frequency ranging from 40 kHz to 400 kHz [9].

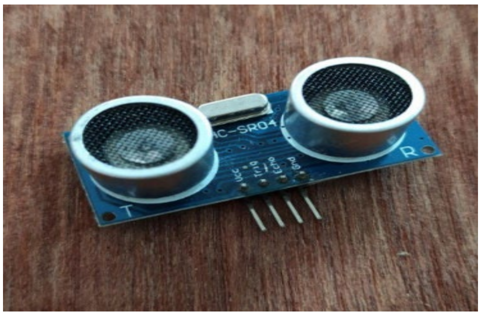

Figure.4 HC-SR04 Ultrasonic Sensor

2.4 RFID-RC522

RFID (Radio Frequency Identification) is a radio frequency identification system that attaches tags or labels to the object to be identified. RFID makes use of barcodes to identify objects. [10].

Figure.5 RFID-RC522 [11]

A checker or reader is a two-way radio transmitter-receiver that sends a signal to the tag and then reads the response. In general, readers transmit data to computer systems running RFID or intermediate software. Barcodes are binary codes made up of parallel rows and columns of bars and slots.

2.5 RFID Tag Card

An RFID label or card is a device that can be installed or inserted in a product in the form of a card or other form for radio wave identification. Each tag has a unique ID of ten digits, allowing tag tracking via radio waves [7].

Figure.6 RFID Chip Card

Cards that have been implanted with Passive RFID technology and registered on the device can be used to access Active RFID devices. Passive RFID does not have its own resources and will only activate when tapped or carried to the reader (RFID chip reader). ID cards are intended to include chips with high-security authentication, encryption, and digital signature capabilities, allowing them to be registered on an RFID chip reader. In addition to ID cards, ATM cards and E-toll cards have payment chips.

2.6 Servo Motor

Servo motors are electronic devices that use a closed-loop control system (servo) as a drive in a circuit to produce torque and speed based on a specific electric current and voltage.

Figure.7 Servo Motor

Servo motors are used to push or rotate objects with high precision control over angular position, acceleration, and speed, which ordinary motors lack. Due to various benefits such as energy savings, high power-to-weight ratio, low cost, simple structure, and ease of maintenance, servos are widely used in many industrial position control scenarios [12] [13].

2.7 LCD I2C

The I2C LCD is a serially controlled LCD module that operates in accordance with the I2C/IIC (Inter-Integrated Circuit) protocol. The I2C LCD is a serially controlled LCD module that operates in accordance with the I2C/IIC (Inter-Integrated Circuit) protocol [14].

Figure.8 LCD and I2C

3. RESULT AND DISCUSSION

3.1 RFID Card Reading Testing

The RFID card reading test is intended to show how far the system can accurately read RFID. Furthermore, this test is designed to ensure that the system can distinguish between two types of RFID cards: those that have been authorized by the system and ones that have not been authorized by the system. In accordance with the system, only authorized RFID cards will be accepted, while those that are not will be rejected.

The test is performed on two registered cards (Card-1 and Card-2) as shown in Table.1. The testing results show that the prototype can read all of the cards listed, but with varying time delays. The authors also included RFID barrier trials in this test to determine the extent to which RFID frequencies can work even when they are still blocked by other objects, with the result that RFID readers can still read cards registered at a distance of 1.5 cm and barrier thicknesses of up to 2.0 mm. with a 0.3 second an average delay. The reader frequency can be read from a distance up to 3 cm, as described in Table.2

Table.2 Registered RFID Card Testing Result

Card 1 (ID Tag : F3 50 2A 13)			
Distance (cm)	Responsive (sec)	Barrier (mm)	Result
5.0	-	No	No
4.5	-	No	No
4.0	-	No	No
3.5	-	No	No
3.0	-	No	No
2.5	0.70	No	Read
2.0	0.57	No	Read
1.5	0.95	0.5	Read
1.5	1.21	1.0	Read
1.5	1.34	2.0	Read

Card 2 (ID Tag : 23 96 63 0D)			
Distance (cm)	Responsive (sec)	Barrier (mm)	Result
5.0	-	No	No
4.5	-	No	No
4.0	-	No	No
3.5	-	No	No
3.0	-	No	No
2.5	0.65	No	Read
2	0.51	No	Read
1.5	1.12	0.5	Read
1.5	1.19	1.0	Read
1.5	1.32	2.0	Read

The second test is performed on one unregistered card with the result that the RFID reader reads accurately. It prevents unregistered cards from accessing doorstops and doorstops from opening. After repeating the ten times experiment, it is possible to conclude that the prototype worked well, as described in Table.3.

Table.3 Unregistered RFID Card Testing Result

Card 3 (ID Tag : 14 34 99 7A) (No register)			
Distance (cm)	Responsive (sec)	Barrier (mm)	Result
5.0	-	No	No
4.5	-	No	No
4.0	-	No	No
3.5	-	No	No
3.0	-	No	No
2.5	-	No	No

Distance (cm)	Responsive (sec)	Barrier (mm)	Result
2.0	-	No	No
1.5	-	0.5	No
1.5	-	1.0	No
1.5	-	2.0	No

3.2 Ultrasonic Sensor and RFID Card Response Testing

To ensure that the device is accurate, the author tests the sensor before it is assembled on the prototype. Ultrasonic and RFID sensor experiments were carried out prior to the creation of the prototype. The authors start by placing the Ultrasonic sensor (HC-04SR) to the test by precisely positioning the object on the ruler at 10 cm and the Ultrasonic sensor at 0 cm, as described in Fig.9.

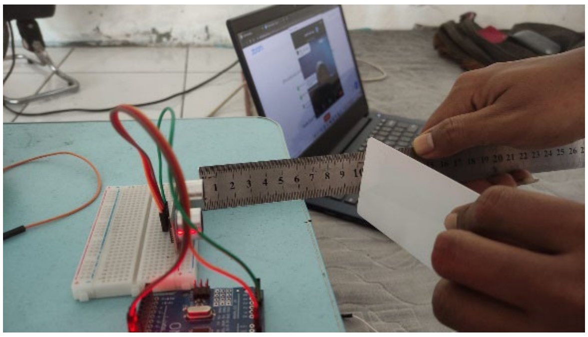

Figure.9 Ultrasonic sensor test

As a result, there are 37 data points in total, with an accuracy rate of 98%, as shown in the Fig.10. Based on these findings, the sensor in use was determined to be in good working order and accurate.

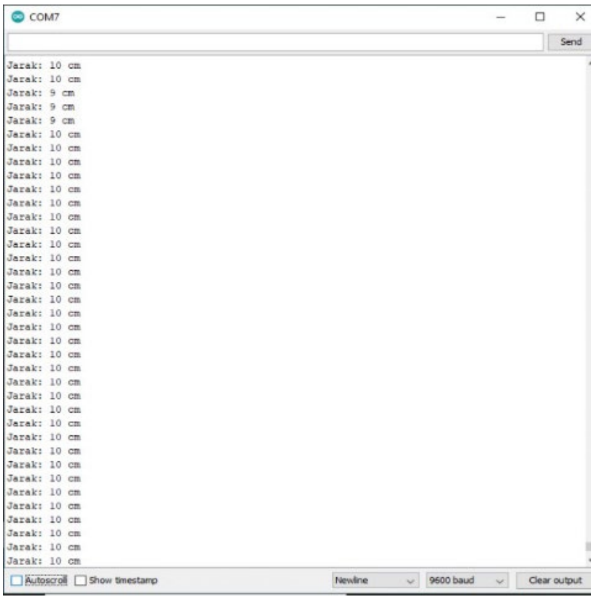

Figure.10 Result for Ultrasonic Test

Furthermore, the author tested the RFID reader to be used for the prototype by providing a program to read several RFID card tags, and the result can read two cards well up to ten times with a maximum distance of 3 cm.

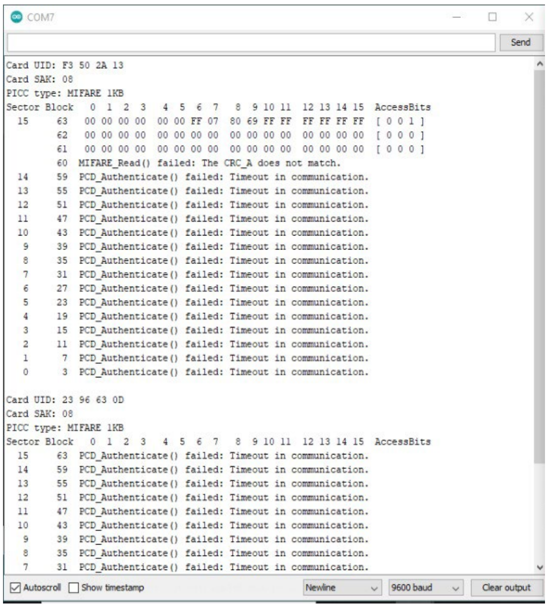

Figure.11 Result for RFID reader Test

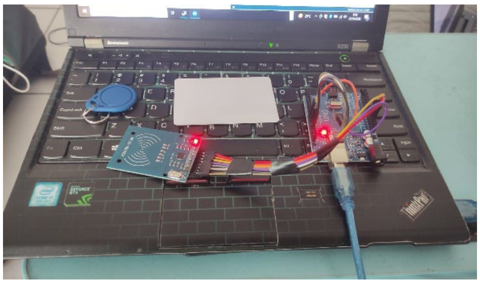

Figure.12 RFID reader Test

3.3 Overall System Response Testing

After ensuring that both sensors are operational, configure the device to fit the plan. In short, the device is complete and ready for testing, as shown in the Fig.13.

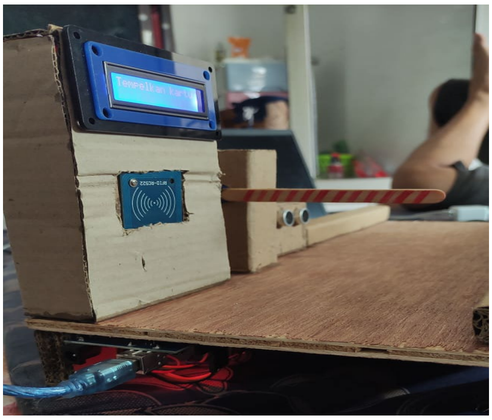

Figure.13 Prototype Smart Doorstops

The author will begin testing the prototype now that the device is complete. The author first connected the prototype to 5V voltage electricity, and then the trial was performed with the doorstops closed. The author moves the object closer to the doorstops, then attaches the RFID tag to the RFID reader, which sends data and processes it in Arduino.

Figure.14 Scanning RFID tags on RFID reader

When the RFID reader reads the RFID tag with the registered number, the data is verified correctly and Arduino sends an order to the doorstop to open, then the door is stuttered again. The author tested three different RFID card tags with ten times testing, using two registered RFID tags and one unregistered RFID tag. The author also ran the trial with distance parameters to see how far away the RFID reader could read data. Furthermore, the author tested the RFID reader with other parameters, specifically a barrier thickness of 0.5 mm - 2.0 mm, yielding the following results.

4. CONCLUSION

The accuracy of the sensor was tested before prior to the creation of the prototype with 37 data points in total. As a result, the sensor in good working order and accurate with the accuracy rate of 98%. The RFID reader was tested with ten times testing, with the result it can read two cards well up with a maximum distance of 3 cm. Furthermore, the author used two registered RFID tags and one unregistered RFID tag to test three different RFID card tags ten times. When the RFID reader reads the RFID tag with the registered number, the data can be correctly verified, and Arduino sends an order to the doorstop to open, after which the door is stuttered again. In addition, the author tested the RFID reader with different parameters, specifically a barrier thickness of 0.5 mm - 2.0 mm, as the result the RFID still can be read by the system. The author tested the RFID reader with various parameters, specifically a barrier thickness of 0.5 mm - 2.0 mm, and found that the RFID could still be read by the system.

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