

Implementation of QR code on Vending Machines

Pelaksanaan Kod QR pada Mesin Layan Diri

Riki Bayu Fhadilla¹, Fitrah Satria Fajar Kusumah², Ritzkal³

^{1,2,3} Informatics Engineering, Faculty of Technology & Science, Universitas Ibn Khaldun Bogor
Jl. Sholeh Iskandar, RT.01/RW.10, Kedungbadak, Kec. Bogor City, West Java 16162 Indonesia.

Email: ¹fhadillabayuriki@gmail.com, ²fitrah@uika-bogor.ac.id, ³ritzkal@ft.uika-bogor.ac.id

ABSTRACT

The rapid development of technology is marked by the presence of various automatic control machines, one of which is a vending machine. Vending machines are vending machines that distribute products such as snacks, drinks, tickets, or other items through certain payment mechanisms. In the previous study, the vending machine designed by students only supported the payment method using paper money. To keep up with technological advances and changes in user behaviour in digital transactions, this study aims to add a QR code-based payment feature by utilizing Arduino Mega as a control module. The methods used include hardware design, QR scanner module integration, reloadable card system manufacturing, as well as testing the accuracy of the QR reading process and balance validation. Experimental results show that payment systems using QR codes can run stably with a reading success rate of more than 95% in various lighting conditions. The main findings of this study confirm that QR code integration is able to increase the flexibility of payment methods, speed up the transaction process, and provide a more efficient alternative to cash payments on vending machines.

Keywords: Vending Machines; QR codes; Arduino Mega2560

ABSTRAK

Perkembangan teknologi yang semakin pesat ditandai dengan hadirnya berbagai mesin kontrol otomatis, salah satunya adalah vending machine. Vending machine merupakan mesin penjual otomatis yang membagikan produk seperti makanan ringan, minuman, tiket, atau item lainnya melalui mekanisme pembayaran tertentu. Pada penelitian sebelumnya, vending machine yang dirancang mahasiswa hanya mendukung metode pembayaran menggunakan uang kertas. Untuk mengikuti kemajuan teknologi dan perubahan perilaku pengguna dalam transaksi digital, penelitian ini bertujuan menambahkan fitur pembayaran berbasis kode QR dengan memanfaatkan Arduino Mega sebagai modul pengendali. Kaedah yang digunakan meliputi perancangan perangkat keras, integrasi modul QR scanner; pembuatan sistem kartu isi ulang (reloadable card), serta pengujian ketepatan proses pembacaan QR dan validasi saldo. Keputusan eksperimen menunjukkan bahwa sistem pembayaran



menggunakan kode QR dapat berjalan stabil dengan tingkat keberhasilan pembacaan mencapai lebih dari 95% pada berbagai kondisi pencahayaan. Dapatan utama kajian ini menegaskan bahwa integrasi kode QR mampu meningkatkan fleksibilitas metode pembayaran, mempercepat proses transaksi, dan memberikan alternatif sistem yang lebih efisien dibandingkan pembayaran tunai pada vending machine.

Kata kunci: Vending Machine; Mesin Jual Otomatis; QR code; Arduino Mega2560

INTRODUCTION

Technology in this day and age has entered industry 4.0 and is developing very rapidly so that people have to think more modernly. With the entry of the industrial revolution 4.0, many sectors have changed. For example, many companies today already use technology for a job compared to human labor. Initially, many companies used a large amount of labor, but with the development of the labor era, it was replaced by technology (Prasetya, Piarsa, & Sri Arsa, 2021). The biggest challenge facing the Industrial 4.0 revolution is creating new technologies and approaches that combine the physical and digital worlds. In this era, collaboration is very important, especially in the process of commercializing the right research results conducted by academics that can be applied and marketed by business or industry people (Aldianto et al., 2018).

The goal of the project is to create a system that allows users to purchase vending machines for goods by taking pictures with their phones. This will allow for a safe non-cash recommendation to purchase for most people. Many people carry cell phones, and many of them are equipped with cameras. Using these cameras for cashless purchases will be convenient for many people who don't carry cash (Fischer, n.d.).

In a group of researchers from the University of Washington recently developed a system that uses mobile phones and QR codes to be used to help with microfinance in rural India. In rural India, there isn't much technology, so QR codes are a relatively secure way of transfer. Some of their initial concerns about the curved image also plagued the project. However, there is a fundamental weakness in their work. QR codes are not very secure. Only requires basic internet access and a printer to create a QR code. (Alkausar & Husnaini, 2021).

QR Codes, since they were first developed by Denso-Wave in 1994 for automotive parts tracking, have now evolved into a crucial part of modern *traceability* systems ; through integration with Blockchain technology and smart contracts, QR Codes allow for unique identification on each product or component, where code scanning triggers automatic recording to a decentralized ledger — thus the origin history, The production, distribution and assembly process can be tracked permanently and transparently. This kind of system — as described in the study "Potential use of RFID and QR code in the supply chain based on Blockchain and Smart contracts" (2023) — shows that the combination of QR Code + Blockchain not only improves transparency and accountability, but also strengthens data security and traceability reliability across various supply chains.

PROBLEM STATEMENT

The main problem faced in the conventional Vending Machine system is the limitation of payment methods that generally still rely on cash, such as coins or banknotes, so that it often causes obstacles such as illegible money, inappropriate nominal, limited availability of small money, to the transaction process that runs slowly and inefficiently. As the need for fast and convenient automated services increases, there is a need to integrate digital payment technology that is more modern and accessible to users. Therefore, problems arise regarding how to apply QR Code technology to Vending Machines to facilitate the transaction process so that users can make payments non-cash, faster, safer, and no longer depend on physical money. This problem also includes how Vending Machines can accurately read and verify QR data, ensure sufficient user balances, reduce the potential for transaction errors, and support the overall operational efficiency of the machine through smarter and more responsive automation. Thus, the implementation of QR Code is an important solution to increase user

comfort while adapting the Vending Machine to the development of today's digital technology.

LITERATURE REVIEWS

Table 1: Literature reviews

No	Author Name, Journal Name, Year	Research Title	Intention	Conclusion
1.	V. A. Prasetya, I. N. Piarsa, and D. M. Sri Arsa, "Designing and Building a Prototype of an Internet of Things-Based Vending Machine Monitoring System, (2018)	Designing and Building a Prototype of an Internet of Things Based Vending Machine Monitoring System	Mechanical testing aims to compare the design results in chapter 3 with the final results in manufacturing. In this Final Project design, the Arduino Mega microcontroller is used as the system's control center. TCS32000-DB sensors, servo motors, relays, and DC motors The design of the system will be packaged in prototypes in the form of boxes. The mechanical box used is in the form of a block with a length of 50 cm, a width of 30 cm and a height of 40 cm	Based on the tests that have been carried out, the results of the design and testing of the tool are in accordance with what is expected. For the nominal test of banknotes of Rp. 1000, Rp.2000 and Rp.5000 respectively with 5 experiments gave a success rate of 80%, 80% and 100% respectively The success rate of the tool in recognizing the banknotes tested as a whole reached 100%.
2.	L. Aldianto, I. Raafaldini Mirzanti, D. Sushandoyo, and E. Fitriana Dewi, Indonesian Journal of Management, (2018).	The Development of Science and Technopark in the Face of the Industrial Era 4.0 – A Literature Study	This research aims to analyze the role of Science and Technopark (STP) in supporting the transformation towards the Industry 4.0 era through strengthening innovation, collaboration, and knowledge-based technology development.	Science and Technopark has an important role in accelerating innovation and increasing industrial competitiveness in the 4.0 era. To optimize its function, STP needs to be supported by strategic collaboration between the government, industry, and academia, as well as strengthening a sustainable innovation ecosystem.
3.	Esra Eroğlu 1 , Esma Ergüner Özkoç 2 1 Department of Computer Engineering,	Mobile QR Code App for Articles:	The goal of the mobile app is to help scientists gain access to articles faster,	So, if the link is changed by Unauthorized person, the link will not be given to the user via QR-tickel because

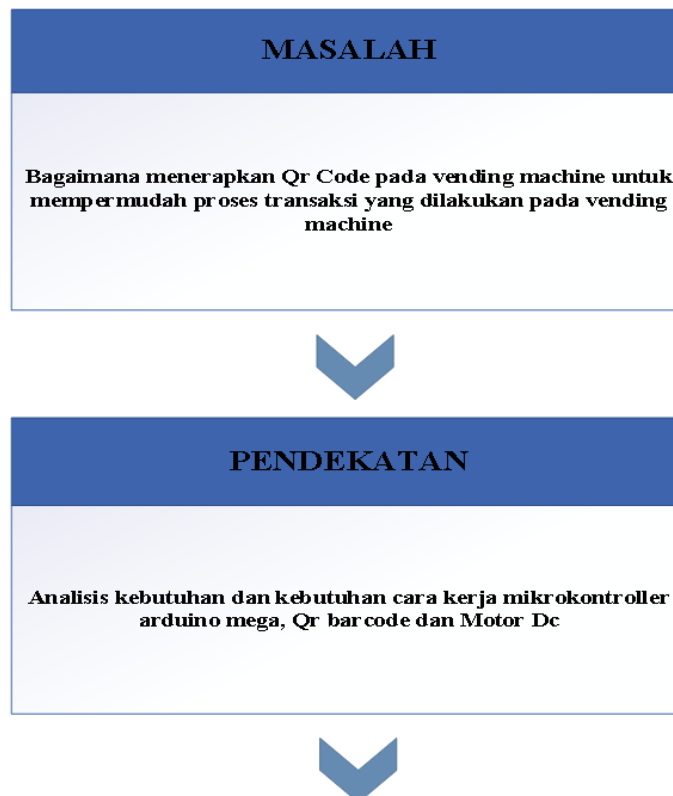
	Hacettepe University, Ankara, Turkey 2 Management Information Systems, University of Baskent, Ankara, Turkey Correspondence: Esra Eroğlu, Department of Computer Engineering, Hacettepe University, Ankara, Turkey. (2020)	QR-ticle	easier, and more reliably. With QR-ticle, scientists can create and share QR codes for their own articles, as well as access to their desired articles scanning the QR code. While QR-tickel facilitates access to articles, QR-tickel also checks access integrity link. The generated QR code contains the title, abstract, and access link of the article.	it does not match the previously created hash. Citation analysis is a numerical analysis of publications produced by individuals or institutions at a given time topics within a specific period and region. It tests the relationship between the cited articles. The results of the analysis, the frequency of cooperation between institutions and authors and the relationship between subjects what is learned can be revealed.
4	Vicky Mora Alkautsar, rma Husnaini	Designing a Vending Machine Using Arduino-Based Banknotes	Aims to design a vending machine that can detect the nominal amount of banknotes entered. All the working processes of this machine are controlled using Arduino.	Based on the tests that have been carried out, the results of the design and testing of the tool are in accordance with what is expected. For the nominal test of banknotes of Rp. 1000, Rp.2000 and Rp.5000 respectively with 5 experiments gave a success rate of 80%, 80% and 100% respectively The success rate of the tool in recognizing the banknotes tested as a whole reached 100%
5	Transportation Research Procedia (2023).	Potential use of RFID and QR code in the supply chain based on Blockchain and Smart contract.	Presenting a blockchain-based supply chain theoretical model that integrates RFID and QR Codes—from manufacturers, suppliers, carriers, retailers to end consumers—thus enabling real-time and automated tracking of goods using smart contracts and IoT.	The integration of RFID+QR Code with blockchain & smart contracts can enable full traceability: historical production → distribution → sales — with transparency, data security, and real-time tracking.

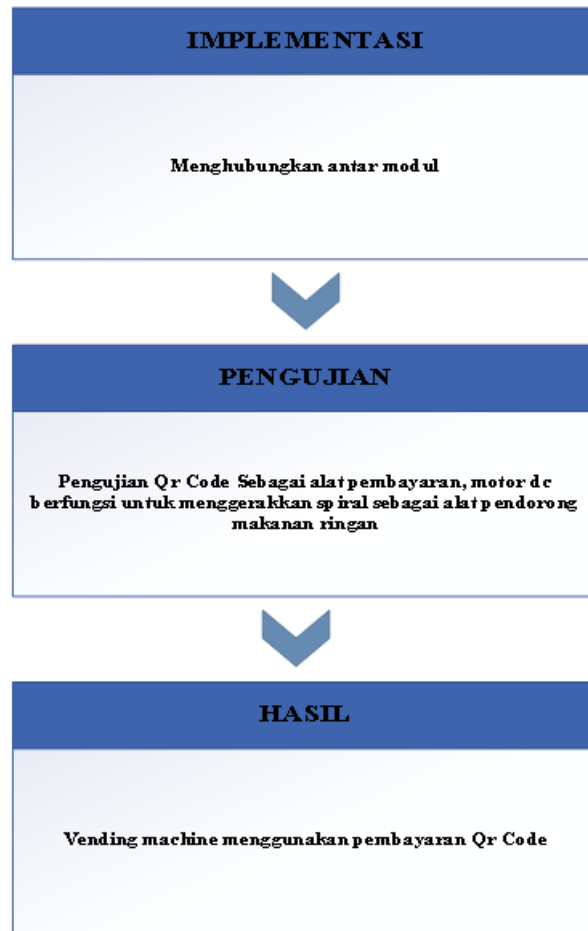
METHODOLOGY

This research method is a framework for carrying out an action or a frame of thought to formulate an idea that is directed and related to the purpose and objectives of the method used in this study as shown in figure 1. The chronology of this research begins with the preparation of research materials that include hardware such as Arduino Mega 2560, QR scanner modules, motorcycle drivers, and a series of vending machines that have been developed in previous research. In addition, software such as Arduino IDE and QR generators are set up to support the programming and testing process. Once all components are available, the research continues with the design stages which include conceptual design, functional design, and hardware and software design. At this stage, the system workflow is formulated starting from product selection, QR scanning, balance verification, transaction execution, to distributing goods. Furthermore, algorithms and pseudocodes are created as an implementation reference, which describes the systematic process from QR reading to transaction log recording.

The next stage is the implementation of research procedures through a series of tests that include functional testing, testing QR readability under various conditions, response time testing, and security testing to detect the potential use of fake or duplicate QRs. At this stage, data was also collected related to the success rate of QR reading, transaction errors, response times, and changes in user balances. All data is recorded in a structured table and analyzed based on the theory underlying the research, such as the theory of automatic control systems, digital payments, QR Code structures, and microcontroller programming. Thus, the chronology of this study provides a detailed overview of the methodological steps taken to develop a more modern QR Code-based vending machine system and in accordance with technological developments. The following is an explanation of the stages in the research method or frame of mind.

Figure 1: Frame of mind





Explaining the chronology of research including how to prepare research materials, research design or design, research procedures (in the form of algorithms, pseudocode or others), testing methods and data collection. In this section, it is also possible to provide a theoretical basis. The Table and Figures are created in the middle as below and referenced in the manuscript. The text size on the table contents is 10pt. The image should be clear, not shadowy and not shattered at a 200% magnification scale.

Similarities and Differences Research

The similarities of the above ten literature studies with the Vending Machine snack with the use of QR codes to make payment transactions in the Vending Machine and to find out the price of the product and the QR code is used as identification. The difference from the ten literature studies with snack vending machines with the use of QR codes is that the microcontroller is partially Arduino Uno, the vending machine is used to sell raincoats, while the snack vending machine is used with the use of QR codes, the microcontroller used is Arduino mega and the payment method uses QR codes.

QR Code Payment System

Recent research shows that QR Codes have become a fast, cheap, and easy-to-implement digital payment method in various automated services. QR facilitates transaction verification without physical money, while supporting the cashless ecosystem that continues to grow in Asia and globally (Maulana et al., 2024).

IoT-Based Vending Machine

A recent study explains that the integration of IoT in vending machines allows online monitoring of stock, transactions, and machine status. IoT technology also allows vending machines to work

automatically with digital payment systems and integrated sensors to improve reliability and accuracy (Alam et al., 2021).

Non-Cash Technology

The latest generation of vending machines reported in the literature have switched to cashless systems such as QR, e-wallets, and app-based transactions. The combination of sensors, automatic controls, and digital payment methods makes vending machines an important part of digital transformation and technology-based economy (Xia et al., 2021).

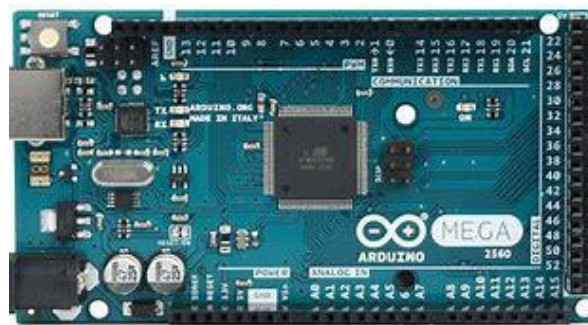
Powered by E-mail

QR codes have been used in the industry for many years in the form of classic barcodes and product tracking. After that, with the development of technology, classic Barcodes are still not enough to meet the ever-increasing needs. Barcodes are dimensional sary codes and can create data as much as 20-40 characters, but QR codes can contain more characters. Different capacities and data types (Taveerad, 2015). Therefore, QR code technology has been developed and can be coded as high capacity. The type of data and its size are small and quickly resolved even though it is damaged, the area of use is increasing day by day, especially in media such as books, magazines, posters, websites, etc. Web pages are used to allow users to be directed to a page without typing in a long URL address.

Arduino Mega2560

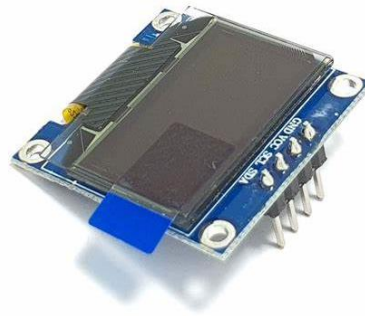
The Arduino Mega 2560 is a Microcontroller board based on the Atmega 2560. The Arduino Mega 2560 has 54 digital input/output pins, where 15 pins can be used as PWM output, 16 pins as analog inputs, and 4 pins as UART (Serial Hardware Port), 16 MHz Crystal Oscillator, USB Connection, Power Jack, ICSP Header, and Reset buttons.

Figure 2: Arduino Mega 2560



LCD OLED 0,96 inci 128x64

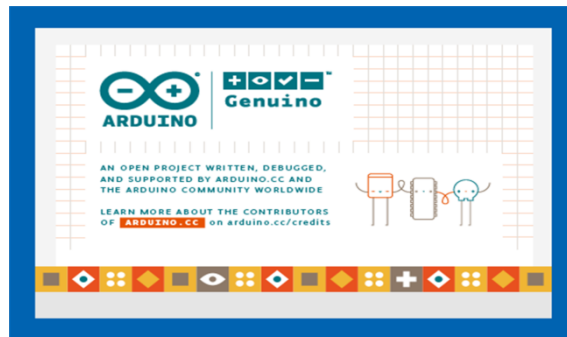
The 0.96-inch 128x64 OLED Display or Organic LED is a 0.96-inch graphic display and has a resolution of 128x64 Pixels using OLED technology, usually made of Carbon and Hydrogen. OLED screens can generate their own light from each of their Pixels and no longer require a Backlight. So that the OLED screen display looks brighter and clearer and the black colour is completely black so that the data usage is relatively more economical for OLED compared to LCD, so OLED and Display have different technologies.

Figure 3: LCD Oled

Programming language

In connection with the discussion for now, the Arduino Software that will be used is Drivers and IDEs, although there are still some other Software that is very useful during the development of the Arduino. Arduino IDE is a very advanced software written using Java. The Arduino IDE consists of:

- Program Editor, a window that allows users to write and edit programs in the Processing language
- A compiler, a module that converts program code (a processing language) into Binary Code. However, the Microcontroller will not be able to understand the Processing language. What Microcontrollers can understand is binary code. That is why a compiler is needed in this case
- Uploader, a module that loads Binary Code from a computer into Memory inside an Arduino board.

Figure 4: IDE Arduino

Motor DC

DC motors are a type of motor that helps in the industrial world. In a DC Motor, a system is needed to operate it, the goal is to adjust the speed of the DC Motor to keep it stable and in accordance with the function of the DC motor used. The speed operation is controlled by the PWM (Pulse width modulation) value. DC motor speed control systems are currently widely used because in their use there are often instability or disturbances in the rotational speed. In the operation of a DC motor, there are references that include the motor speed, motor output voltage, and motor output current.

Along with the development of the times and technological advancements, the process of measuring parameters has become easier, for example using the measurement of the speed of a DC motor by using a measuring tool first, now users can make it easier by creating a program using the Arduino IDE whose measurement process results will be visible on the LCD.

Figure 5: Motor DC**Lolin Wemos D1 R2 Mini**

Wemos D1 R2 is one of the products that has a standard shape and pin out like Arduino Uno. So it makes it easier for us to connect with other Arduino Shields. From the definition of Microcontroller that has been explained, it can be concluded that a Microcontroller is a computer system in which in essence most of its elements are packaged in one IC Chip. One of the Arduino Compatible Development boards that is assembled specifically for IoT (Internet of Thing) needs is Wemos. The WiFi Type chip ESP8266 used by Wemos. Wemos has 11 digital I/O, 1 analog input with an optimal voltage of 3.3V, and is capable of operating with a voltage supply of 9-24V.

Figure 6: Lolin Wemos D1 R2 Mini**L293D Driver Motor**

The L293d motor driver is a circuit used to regulate the movement or rotation of a DC motor. This L293d has 4-channel drivers and can be used at high voltage or current. This driver has a maximum power of 36v and can transmit 600mA current to each channel.

Figure 7: L293d Driver Motor Shield**Push button**

The Press Button is used to provide input to the microcontroller that functions to select the food contained in the Vending Machine. In this tool, there are three push buttons that are used to select food 1, food 2, and food 3.

Figure 8: Push button

FINDINGS AND DISCUSSION

In this section, the results of the research conducted are given and discussed comprehensively. The result can be in the form of images, graphs, tables and others that make it easier for the reader to understand and refer to the manuscript. If the discussion is too long, sub-sub-headings can be created, as in the following example.

Approach

In the existing problem, it can be concluded that some system needs regarding the implementation of a QR code-based snack vending machine using Arduino Atmega that has been explained earlier requires several necessary needs, among others.

Needs Approach

At this stage, what the researcher will do is a need stage analysis, the analysis that will be done on some of the hardware needed by the researcher to create a QR code-based snack vending machine using Arduino Atmega can be seen in the table below.

Table 2: Hardware requirements analysis

No	Requirements Analyst (Hardware)
1	Arduino Atmega
2	QR code
3	Motor DC
4	LCD Oled
5	Button
6	Jumper Cable
7	Bread cutting board
8	Driver Motor Shield293D
9	Olin Wemos
10	Computer
11	Adaptor 5V
12	Kawat Spiral

Approach to Work

At this stage of how it works, it will be explained from the system that runs in this study. An explanation of the analysis of how this system works will be explained in the figure below.

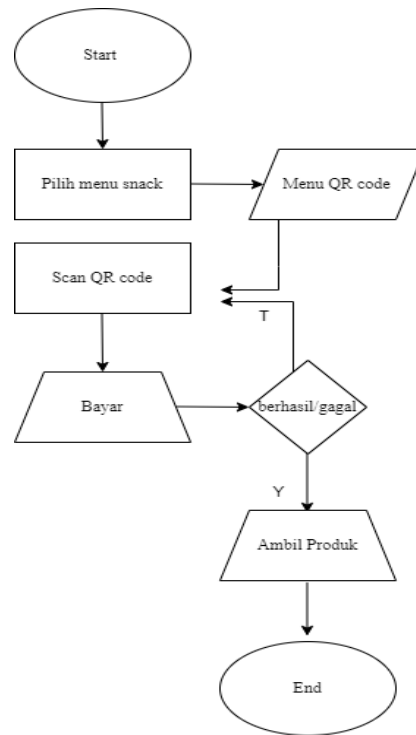
Figure 9: Flowchart how it works

Figure 9 explains how the system works in this study, starting with (1) The user presses the Button to select food. (2) After selecting the QR code Scan detected food, then the L293D Motor Shield Driver connected to the DC Motor will push the food that has been selected by the user. (3), then the QR code will send commands to Arduino Atmega and Lolin Wemos, pre-generated Source Codes stored on the server. (4) Then scan the QR code to make the payment.

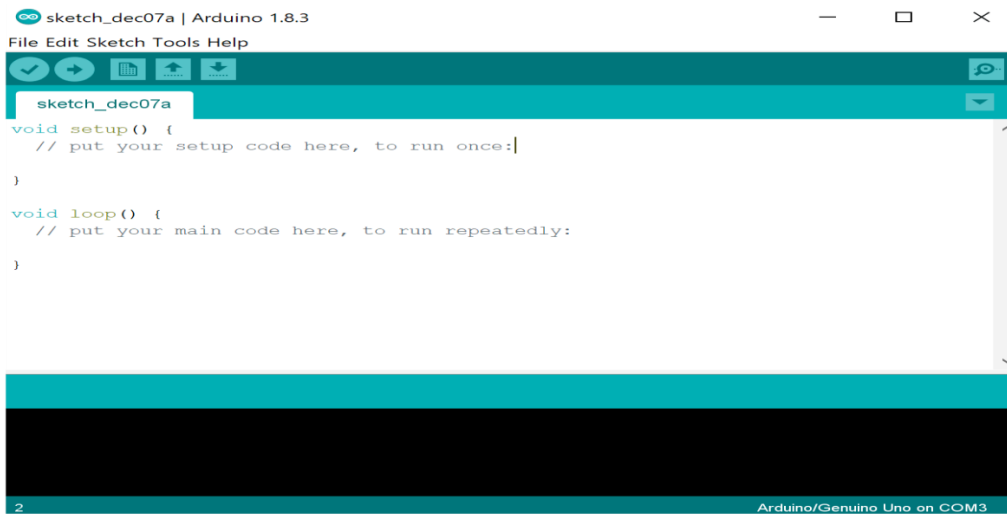
Development

At this stage, we will explain the developments in this study. Here are some stages of development in this study.

Arduino IDE Software

Arduino IDE (Integrated Development Environment) is an application used to create, edit, verify, and upload program code to Arduino. Arduino uses its own language in programming. The Arduino IDE consists of a text editor for creating and editing program code, a Text Console, a message area, and a Tool Bar as well as buttons with common functions. In the Arduino programming process, the program code used is named Sketch.

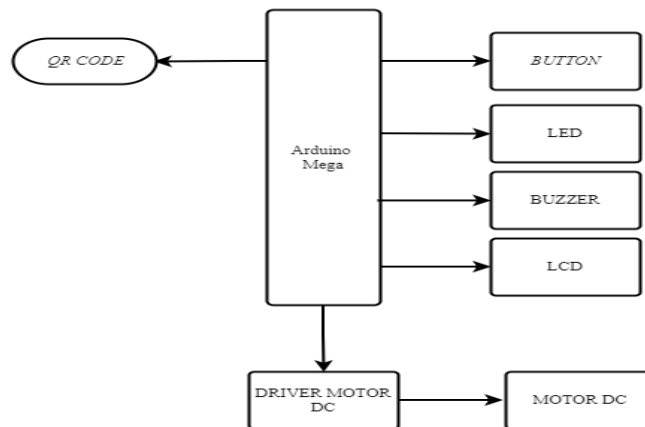
Figure 10: Arduino IDE software display



Hardware Development

At this stage, hardware development is carried out in accordance with the research conducted, in the whole of this research is divided into several implementations of hardware systems (Hardware) which are described in the block diagram below:

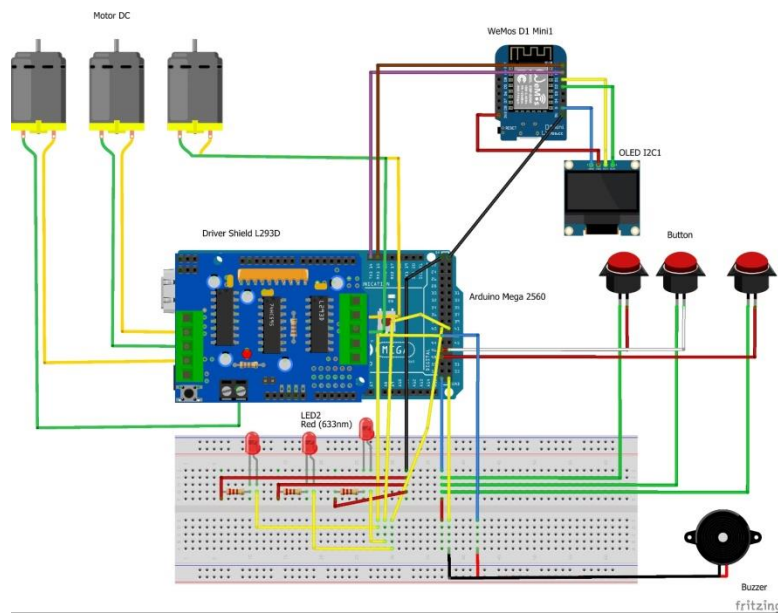
Figure 11: System Functional Block Diagram



Hardware Schematic Design

In this schematic design of hardware, it describes relationships in the form of components that are interconnected with predefined pins.

Figure 12: Hardware schematic design



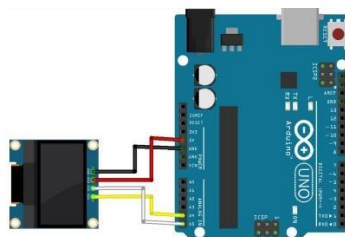
In Figure 12 it is divided into several stages, the first stage is the QR code schematic design series with Arduino Mega 2560, the second stage is the Arduino Mega 2560 design series with I2C LCD, the third stage is the Arduino Mega 2560 schematic design series with Buttons, the fourth stage is the Button design series with Arduino Mega 2560, and the fifth stage is the Arduino Mega 2560 schematic series design with Lolin Wemos D1 R2.

1. Schematic OLED LCD QR CODE with Arduino Mega 2560

Table 3: Pin LCD OLED with Arduino Mega 2560

No	Pin LCD OLED	Pin Arduino Mega 2560
1	Vin	5V
2	GND	GND
3	SCL	A5
4	SDA	A4

Figure 13: Schematic Design of OLED LCD with Arduino Mega2560



In Figure 3 and Table 3 it can be seen that the OLED LCD has 8 Pin Outs, namely VIN, GND, SCL, SDA, Then, the pin is connected to the Arduino Mega 2560 so that it can function and be used by users.

2. L293D Motor Shield Driver Scheme with Arduino

Figure 14: Motor Shield L293D Driver with Arduino

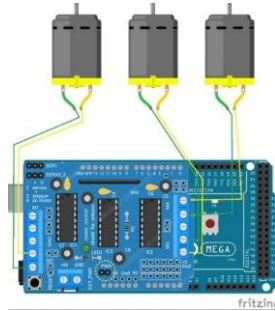


Figure 14 shows that the L293D Motor Protective Driver is connected to the Arduino Mega 2560. Then the dc motor 1, the dc motor 2, the motor 3, are connected to the Driver Shield Motor L293D which has been installed on the Arduino Mega 2560.

3. Schematic Arduino Mega 2560 with 0.96 Inch 128x64 OLED LCD

Table 4: Pin Out Arduino Mega 2560 with I2C LCD

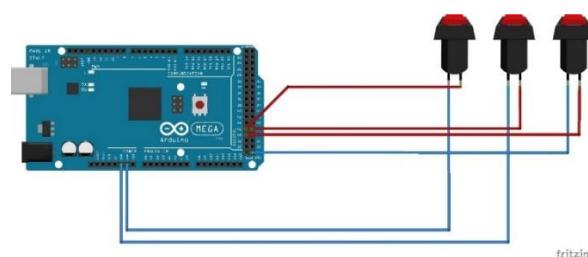
No	Pin LCD	Embed Arduino
1	ANGGUR	5V
2	GND	GND
3	SCL	A5
4	SDA	A4

4. Schematic Keys with Arduino Mega 2560

Table 5: Keys with Arduino Mega 2560

No	Button Name	Embed Arduino
1	Food Button 1	Pin 46 dan GND
2	Food Button 2	Pin 47 dan GND
3	Food Button 3	Pin 48 dan GND

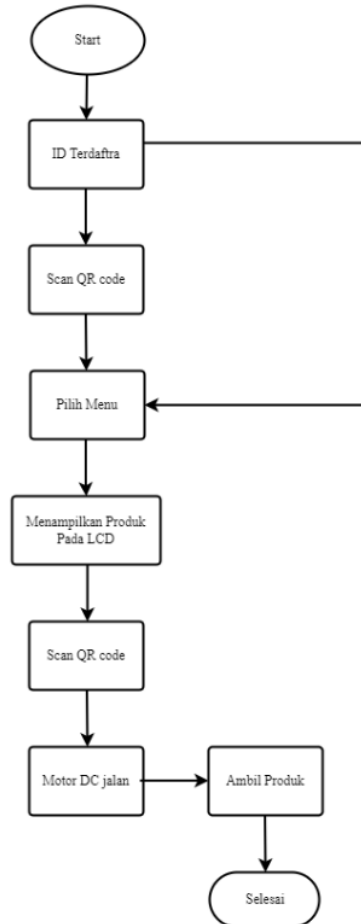
Figure 15: Buttons with Arduino Mega 2560



Implementation

At this stage, several designs related to the research are carried out. The following are some of the stages of system design in this study.

Figure 16: System Workflow



Implementation of Connecting Between Modules

The following are the stages of component implementation that will be carried out. In the process of component implementation, it is done by connecting between modules using jumper cables and declaring pins

a. Powered by ZIP

The first stage of the implementation of this tool is to connect the QR code with the Wifi module and Arduino Mega. In order for the Arduino Mega to connect with each other with QR codes, you need to add the Source Code to the Arduino Mega.

In the next process, namely by connecting the Arduino mega with a QR code using a jumper cable, connect the jumper cable to the predetermined Arduino Mega pin. The Source Code of the Arduino program is as follows:

b. LCD OLED

At this stage of implementation, it connects OLED with Arduino Mega. In order for the Arduino to interconnect with the OLED, it is necessary to add the Source Code to the Arduino Mega. In adding the Source Code, you must use the Arduino IDE Software.

Furthermore, by connecting the Arduino Mega with OLED using a jumper cable. To display the OLED screen, you need to enter the Source Code as below

c. Module Wi-Fi Wemos D1 ESP8366

In the next stage of implementation, this is to connect the Arduino Mega with the Internet. At this stage it is necessary to have the help of a Wifi module device that functions to connect the Arduino Mega to the local network through the Wifi signal, the next process is to set the input and output pins used in the system, the initialization process begins by calling the Wifi module Library, which can be seen in the following Source Code:

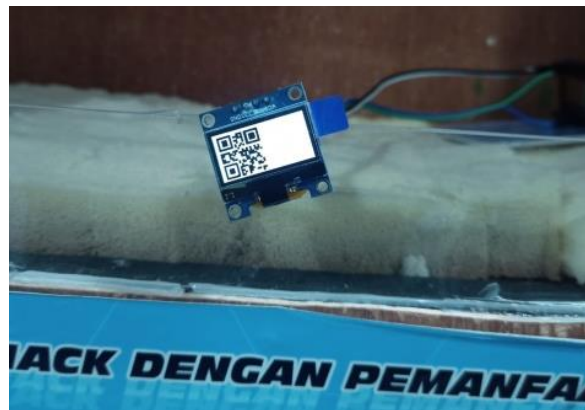
Tool Function Testing

At this stage, a function test will be carried out on the Vending Machine Snack tool using a QR code. This test is carried out to get results or goals as expected. The following are the stages of testing the function of the Vending Machine Snack tool series using QR codes.

QR code function testing

At this stage, it will test the QR code's functionality. The first QR code uses a QR code that has been registered, the second QR code uses a card that has been registered but does not yet have one.

Figure 17: QR code function testing



OLED LCD function testing

This stage is to test the OLED LCD. This test was carried out to display text on the OLED LCD and display the QR code on the Vending Machine.

Figure 18: OLED LCD function testing



DC Motor function testing

This stage is to test the function of the DC Motor. This test uses 3 DC Motors to drive 3 spirals where each DC Motor is filled with one spiral. To control the rotation and speed of the DC motor to rotate forward to push the snack down to the place it was made, i.e. using the L293D Driver Shield. If

the rotation and speed of the DC Motor are controlled, then the Arduino with the L293D Driver Shield is connected correctly. There are 3 types of snacks used, namely Pocky, waffello, and Superstar.

Figure 19: DC and Spiral Motor Testing



Results of Snack Purchase Testing Using QR Code

In this test, the machine will be tested by testing the time it takes for the tool to perform a QR code detection once. In the test, ten QR code detection tests will be performed. By doing three samples, you will know more about the accuracy of the machine being made.

CONCLUSION

Based on the results of this study, the physical design and implementation of food vending machines with QR code technology have been carried out using modern methods. The use of QR codes on this machine makes it easier for consumers to make transactions, displaying incoming QR code information, food sold, and displaying price text and the name of the food sold. Payment systems with registered QR codes also simplify the transaction process. For further development, it is hoped that the use of QR codes can be expanded to other payment methods, as well as improving the quality of snack vending machines to be more optimal.

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