Jurnal Teknologi Informasi dan Pendidikan
Volume 17, No. 1, March 2024
https://doi.org/10.24036/tip.v17i1.792

P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
tip.ppj.unp.ac.id

Design of An Internet of Things-Based Intelligent Cutlery Cleaning Tool

Lindawati[1*✉], Irma Salamah[1], Devina Astari[1]
[1]Electrical Engineering, Politeknik Negeri Sriwijaya, Palembang, Indonesia
*Corresponding Author: Lindawati@polsri.ac.id

Article Information

Article history:

No. 792
Rec. September 20, 2023
Rev. January 12, 2024
Acc. January 13, 2024
Pub. February 18, 2024
Page. 243 – 256

Keywords:

- *Internet of Things (IoT)*
- *Intelligent Cutlery Cleaning*
- *Arduino Mega 2560*

ABSTRACT

Technology that continues to develop gives rise to many new technologies that help humans work; one example is the creation of an automatic dishwasher based on the Internet of Things (IoT). This tool aims to build a tool that can help homemakers complete one of their chores, namely washing cutlery. This research was conducted by designing a prototype using Arduino Mega 2560 and NodeMCU, supported by Android applications using the XML programming language. The application has control and monitoring features. The control feature in the application will control the number of rounds of water used, while the monitoring feature is used to monitor the water discharge used during washing. In addition, this tool also uses Firebase as a database used to store data. By incorporating sensors and technology into this appliance, a more efficient, programmable, and customizable washing experience is possible. The device has undergone 27 tests, with an overall success rate of 88.89%.

How to Cite:

Lindawati, Salamah, I., & Astari, D. (2024). Design of An Internet of Things-Based Intelligent Cutlery Cleaning Tool. Jurnal Teknologi Informasi Dan Pendidikan, 17(1), 243-256. https://doi.org/10.24036/jtip.v17i1.792

1. INTRODUCTION

Technological advancement is unavoidable in this life; it will develop in tandem with the advancement of human knowledge[1]. If technology is implemented effectively, it will positively affect humans[2]. As an example, the development of new technologies that help people do a lot of different tasks more easily[3].

Nowadays, most human activities are centered outside the home, resulting in many household chores being neglected. Therefore, an integrated system is needed that can assist in completing household chores[4]. Washing dishes is one of the chores that requires special attention. Besides being caused by busy routines outside the home, awareness of keeping cutlery clean is also an urgent concern[5].

Washing cutlery is a household duty to remove food residue from soiled cutlery[6]. Tableware must be kept clean because maintaining the cleanliness of tableware can prevent food contamination[7]. Dishes are typically washed with hands that come into contact with water and detergent. If this process is done on a large scale, it takes a lot of time, water, and detergent. Hands can also become dry and dirty afterward[8]. This makes the procedure ineffective, time-consuming, tiring, and boring[9].

A dishwasher can be one of the solutions to help with the dishwashing procedure. This tool was created to speed up the washing process and improve the cleanliness of tableware washing[10].

This dishwasher operates using an Arduino Mega 2560 microcontroller. Also, NodeMCU functions so that this tool can connect to the Internet, known as the Internet of Things (IoT). With that, the machine can be recognized via Android.

A study by [11] in 2021 called Design of an Automatic Glass Washing System Based on Arduino Nano inspired the author to make this device for washing cutlery. This project uses Arduino Nano as a computer, and photodiodes to run DC motors and pumps when they feel glass. When the dc pump is operational, the cleansing procedure will commence. Two showers are used to clean the top and underside of the glass. This functions to thoroughly clean the glass. After the glass cleaning procedure, an FC 51 proximity sensor determines the glass's level of cleanliness.

From the description above, the author develops a project by previous researchers. The author will make a tool that can be used to clean glasses, plates, bowls, and spoons. The main components for making this dishwasher are Arduino Mega 2560, NodeMCU, ultrasonic sensors, and magnetic door sensors. Arduino functions as a control system. NodeMCU connects the cutlery washer with Android so that the cutlery washer can be controlled via Android. The magnetic door sensor detects the door's closing to activate the ultrasonic sensor. The ultrasonic sensor detects the presence of plates to carry out the washing process.

2. RESEARCH METHOD

The model utilized in the creation of this application is a prototype model[12]. A prototype is an early version of a system stage used to present an overview of the idea, experiment with the design, identify problems, and find solutions[13]. This method of system development is known as prototyping. In this research, the author will design an intelligent cutlery cleaning tool based on the Internet of Things divided into two stages, namely hardware design and software design.

In hardware design, the schematic design circuit in this design, is represented through block diagrams and flowcharts. The block diagram of this design can be seen in Figure 1. The block diagram method will make it easier to read the overall flow of the tool to be made[14]. This stage involves designing input, process, and output components[15]. Based on the block diagram in Figure 1, it can be described that in the input section, there is a DC power supply that functions as a power provider [16], UBEC serves to reduce[17] 12V power to 5V voltage, the magnetic door sensors detect door opening and closing based on the electromagnetic principle. Under normal circumstances, the sensor is not in the adjacent state, and the switch is in the open circuit state. In contrast, for active conditions, the sensor is adjacent to or on the closed door, and the switch is in the closed circuit condition[18]. When the specified condition is met, the ultrasonic sensor will function. Then the waterproof ultrasonic sensor functions to detect the presence or absence of cutlery. And NodeMCU ESP8266 is utilized to link Arduino to the internet.

Then, in the "process," there is an Arduino Mega 2560, a microcontroller[19]. Using NodeMCU, Arduino can communicate with the internet, and at the nodeMCU's output, there is an Android application that can control and display the monitoring results. At the output, two relays are connected to two DC pumps, each equipped with a water flow sensor and a solenoid valve for regulating and directing the water flow. These two relays turn the DC pump and solenoid valve on and off[20]; a stepper motor driver is also connected to the output. The motor controller controls and drives the stepper motor[21], which moves according to discrete steps[22]. This stepper motor will move the nozzle using lead screws and bolts.

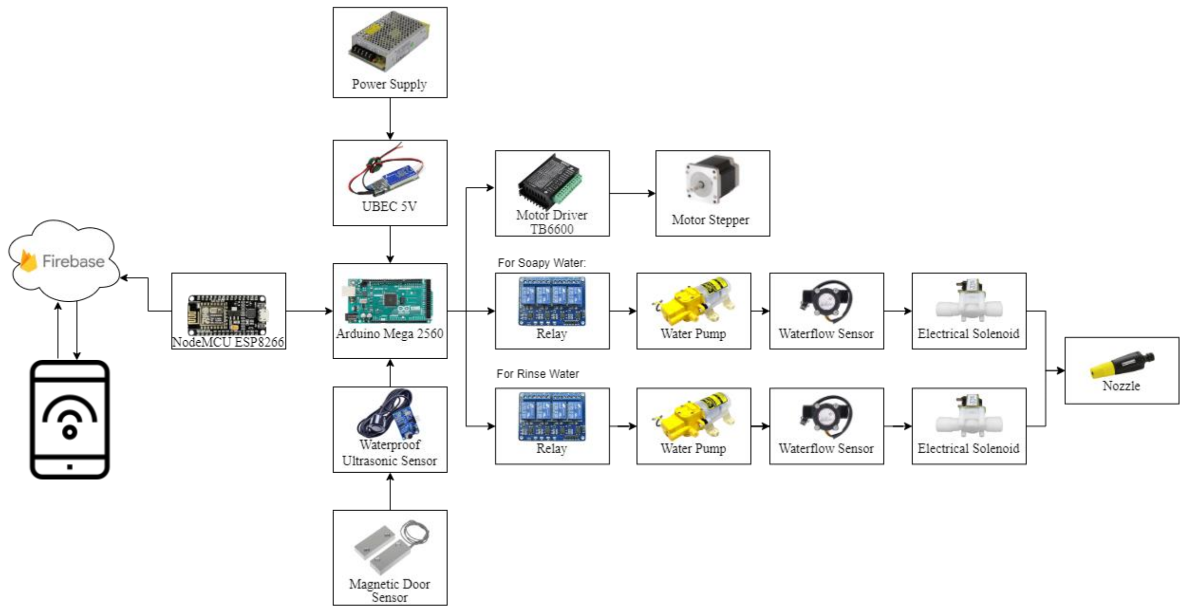

Figure 1. Diagram Block Hardware

Furthermore, the flowchart design can be seen in Figure 2. A flowchart is a chart that shows the flow of a program or system procedure being built. In a flowchart, symbols indicate the flow of system instructions that run sequentially[23]. This design describes the mechanism of the tool system starting when the tool is connected to electricity; then, the cutlery washer will immediately initialize the sensor, read the relay, and read the stepper motor. Next, the magnetic lock door sensor will detect whether the door is closed or open. If open, the device will continue to read the sensor until the door is closed, and when the door is closed, the ultrasonic sensor will activate to detect the presence or absence of cutlery. If not detected, the appliance will not perform the washing process. But if detected, the machine is in "ready to wash" status. For the washing process to be carried out, the device must be controlled using an Android by pressing the "ON" button.The washing process is divided into three streams; first, the tableware will be cleaned with clean water. Then, the tableware will be given soapy water, and finally, the tableware will be rinsed with clean water again. Especially for the second and third processes, the number of nozzles can be controlled using Android. In addition, this Android-based application can also monitor how much soapy and rinsed water is used. The second and third processes can be controlled using Android: the number of nozzle rotations used. In addition, the Android-based app can also control how much soapy water and rinse water is used. The settings can be made before pressing the "ON" button.

P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
tip.ppj.unp.ac.id

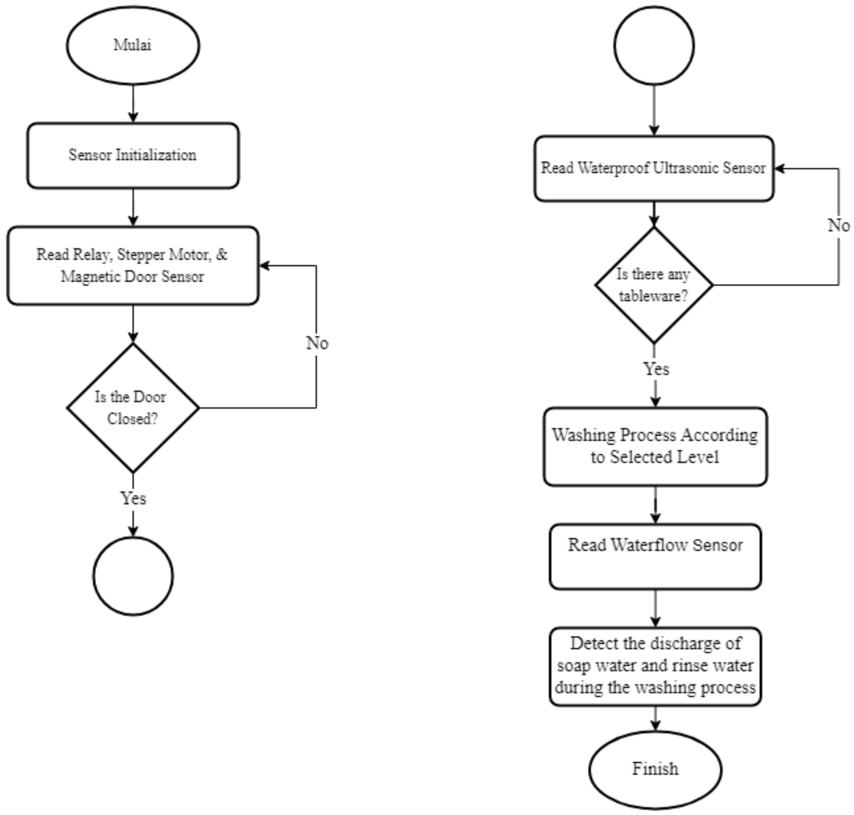

Figure 2. Flowchart Hardware

In the software design, it is made to control and monitor the device using an Android-based application. This application is designed using Android Studio. Android Studio is software that can create and modify Android applications[24]. The programming language used in Android Studio is Java and XML. Software design on Android can be seen in Figure 3. namely the flowchart of the Android application.

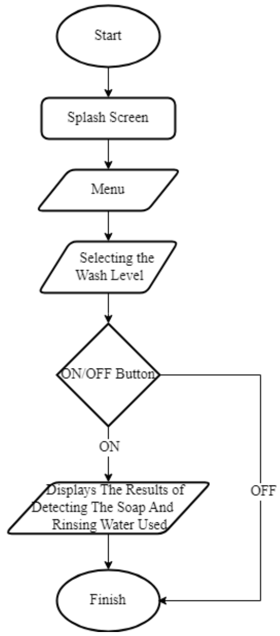

Figure 3. Android Deployment Flowchart

This android application is a medium that can control and display data sent via Firebase.

3. RESULTS AND DISCUSSION

Software results based on the flowchart design that has been made are generated as follows:

Figure 4. Splash Screen

Jurnal Teknologi Informasi dan Pendidikan
Volume 17, No. 1, March 2024
https://doi.org/10.24036/tip.v17i1.792

Figure 4 is a splash screen or the initial display when the application is opened.

Figure 5. Menu

Then the menu display will appear with the login button as shown in Figure 5. When the login button is then pressed, the settings page will be displayed, as illustrated in Figure 6.

Figure 6. Selecting the Nozzle Round Level

Based on Figure 6, the settings page has nine buttons: three water rotation level buttons, three soap rotation level buttons, and a finish button. The rotation level button is used to adjust the rotation of soap water and rinse water to be used. Then, there is an ON/OFF button to turn the device on/off. Meanwhile, when pressing the finish button, a display of the results of detecting the water discharge used will appear, as shown in Figure 7.

Figure 7. Detection Results of Used Soap and Rinse Water Discharge

The results of the hardware design of the prototype cutlery washing tool are as follows:

Figure 8. Hardware Design Results

The washing process will run when the dishwasher is ON, the dishwasher door is closed, and the ultrasonic sensor detects objects about 20-25 cm away inside. In the washing stage, three steps occur. First, an initial flush occurs; second, soapy water is applied; and third, rinse water is sprayed. To carry out these three stages, two DC pumps are involved. One pump is used to pump water mixed with soap, while the other is involved in the initial watering and rinsing process. Since the pre-watering and rinsing use clean water, they are managed by one shared pump.

These two DC pumps are controlled through a relay so the soapy and clean water can flow alternately through the nozzle. This nozzle will move back and forth using a stepper motor connected to a 50 cm long thread, assisted by a nut component. A motor driver controls this stepper motor movement. In this study, one complete nozzle movement means it will move forward to about 45 cm from its initial position and then return to its original work.

In spraying soapy water and rinsing water, the option is to set the desired rotation level through the Android application. Three rotation levels can be selected for both. The level selected on the Android device will be sent to the Arduino device via the Firebase platform so that the washing process will run according to the level that has been selected.

Please note that soap and rinse water rotation levels have different values. In soapy water, the number of nozzle rotations corresponds to the level selected in the application. For example, the nozzle will move one full rotation if the desired level is one. As for rinse water, the number of rotations will work double the selected level value. For example, if the level chosen in the application is three, the nozzle will move six full rotations.

So from the above statement, if both use the same level, the amount of soapy water released will be less than the rinse water. This is due to the difference in the rotation pattern between soapy water and rinse water.

Once the washing process is complete, a notification will appear on the Android device that the washing has been done successfully. After that, the app will automatically switch to a display showing the water debit used during the washing process.

Tests were conducted on various aspects, including testing the communication delay data between the device and the application, testing the device, and black-box testing. For testing the communication delay data between the device and the application is shown in the following table:

Tabel 1. Testing communication delay between android and device

Testing To-	Sent Time	Receive time	Delay (ms)
1.	17:17:06.756	17:17:07.626	867
2.	17:17:08.169	17:17:08.856	687
3.	17:17:13.222	17:17:13.951	729
4.	17:17:14.384	17:17:15.171	787
5.	17:17:15.634	17:17:16.159	525
6.	17:17:21.939	17:17:22.481	542

7.	17:17:22.481	17:17:24.778	2.297
8.	17:17:25.368	17:17:25.987	619
9.	17:17:34.324	17:17:34.834	510
10.	17:17:45.778	17:17:48.952	3.174
	Average		**1181,5**

This test measures how fast the IoT-based cutlery washer responds to commands sent through the Android application. Based on the results of 10 trials, it was found that the delay time varied from the fastest of about 525 milliseconds (ms) to the longest of about 3.174 ms. Meanwhile, the average delay time of the ten trials was about 1181,5 ms. This varying delay time is influenced by the internet network conditions used.

Further testing of the device is shown in the table below:

Table 2. Tool Testing

No.	Round	Result	Soap Water Discharge (L)	Rinse Water Discharge (L)	Length of Time (s)
1	1 Soap Water 1 Rinse Water	Clean	2,27	6,00	187
	1 Soap Water 1 Rinse Water	Clean	2,48	5,98	180
	1 Soap Water 1 Rinse Water	Not Clean	2,31	6,05	184
2	1 Soap Water 2 Rinse Water	Clean	2,62	10,03	276
	1 Soap Water 2 Rinse Water	Clean	2,39	10,19	196
	1 Soap Water 2 Rinse Water	Clean	2,43	10,38	271
3	1 Soap Water 3 Rinse Water	Clean	2,52	15,42	366
	1 Soap Water 3 Rinse Water	Clean	2,39	15,20	360
	1 Soap Water 3 Rinse Water	Clean	2,64	15,31	368
4	2 Soap Water 1 Rinse Water	Clean	4,49	6,12	237
	2 Soap Water 1 Rinse Water	Clean	4,72	6,26	242
	2 Soap Water 1 Rinse Water	Clean	4,61	6,21	246
5	2 Soap Water 2 Rinse Water	Clean	4,76	11,04	321
	2 Soap Water 2 Rinse Water	Clean	4,62	10,58	326
	2 Soap Water 2 Rinse Water	Clean	4,51	10,79	330
6	2 Soap Water 3 Rinse Water	Clean	4,74	15,28	413
	2 Soap Water 3 Rinse Water	Clean	4,54	15,01	395
	2 Soap Water 3 Rinse Water	Clean	4,60	15,86	406
7	3 Soap Water 1 Rinse Water	Not Clean	6,62	6,23	259
	3 Soap Water 1 Rinse Water	Not Clean	6,95	6,29	264
	3 Soap Water 1 Rinse Water	Not Clean	6,84	6,43	405
8	3 Soap Water 2 Rinse Water	Clean	6,71	10,54	431
	3 Soap Water 2 Rinse Water	Clean	6,95	10,49	436
	3 Soap Water 2 Rinse Water	Clean	6,74	10,43	437
9	3 Soap Water 3 Rinse Water	Clean	6,94	15,51	513
	3 Soap Water 3 Rinse Water	Clean	6,84	15,49	515
	3 Soap Water 3 Rinse Water	Clean	6,79	15,43	506

This test analyzed the device's performance regarding washing efficiency and water usage by varying specific parameters. The table provided shows the series of tests performed for each spin combination, ranging from one to three spins for soapy and rinse water. Each variety was tested three times, making nine tests for each level button. The results showed that each level had relatively consistent discharge values for soapy and rinse water. For example, when testing using three rounds of soapy water with level 1, it was found that the detected water discharge ranged from 2,20 to 2,64 liters.

The table also shows that four wash results were declared "Not Clean". One result occurred in the first parameter, which used one round of soap and one round of rinse water. The other occurred in the seventh parameter: three rounds of soap and one round of rinse water.

This "Not Clean" result could be due to several factors. First, stains may be difficult to remove on the tableware, and the level used needs to be more effective to deal with the stains. In addition, "Not Clean" results can also occur due to an unsuitable combination of levels, such as in the seventh parameter. This condition resulted in unclean results in all tests. This test indicates that this configuration is ineffective in cleaning tableware stains. This problem may be caused by an imbalance between the amount of soap used and the volume of rinse water available. The results show that all tests in this setting produced inadequate and unclean results.

Next is testing the tool against the Android application that has been made.

Table 3. Texting Black-Box

No.	Testing Section	Tested Function	Input	Output	Test Results
1.	Menu Page	Control Button	Click The Button	Enter The Control Page	Accepted
		About Me Button	Click The Button	Enter The About Me Page	Accepted
2.	Control Page	Button 1 Water	Click The Button	Send Data to Firebase That The Water Round Level Is One	Accepted
		Button 1 Water	Click The Button	Send Data to Firebase That The Water Round Level Is Two	Accepted
		Button 1 Water	Click The Button	Send Data to Firebase That The Water Round Level Is Three	Accepted
		Button 1 Soap	Click The Button	Send Data to Firebase That The Soap Round Level Is One	Accepted

		Button 2 Soap	Click The Button	Send Data to Firebase That The Soap Round Level Is Two	Accepted
		Button 3 Soap	Click The Button	Send Data to Firebase That The Soap Round Level Is Three	Accepted
		Finish Button	Click The Button	Display Soap Water and Rinse Water Discharge Data	Accepted
3.	Finish Page	Back Button	Click The Button	Return to Menu Page	Accepted
4.	About Me Page	Back Button	Click The Button	Return to Menu Page	Accepted

In Black Box testing, the main focus is on the input given and the output produced, so this test helps ensure that the software behaves according to expectations and functional requirements without needing to know the details of its internal implementation. From the black box testing that has been carried out, the application has functioned properly and efficiently, indicating that the system that has been designed and thrived meets the needs and expectations set.

Based on Table 2, the test has been carried out 27 times with a test error of 4 times; the success of the tool can be calculated as shown below:

$$\text{Success Rate} = \left(\frac{Number\ of\ Correct\ Data}{Total\ Data}\right) \times 100\%$$

So the test success rate in Table 2 is as follows:

$$\text{Success Rate} = \left(\frac{24}{27}\right) \times 100\% \ = 88.89\%$$

4. CONCLUSION

Growing technological advances have led to the emergence of new ideas that can help simplify human life. One is assisting humans in various activities, such as washing tableware. Therefore, the idea arose to create a tool that can help humans wash cutlery.

The making of this cutlery washing tool uses the prototype method. The main components used in this cutlery cleaning tool are Arduino Mega 2560, NodeMCU, Ultrasonic Sensor, and Magnetic Door Sensor, each with its function.

These cutlery washers deliver a more efficient, controllable, personalized washing experience. Nevertheless, successful implementation still depends on careful settings and selecting the correct parameters to achieve optimal washing results.

In addition, from the tests conducted, both the device and the supporting application that controls and monitors the machine can run well. This is evident from the tool tests; the success rate is around 88.89%.

REFERENCES

[1] Satrinawati, D. Irfan, and Efrizon, "Augmented Reality-Based Programming Using Atmega 2560 Microcontroller Trainer Kit Support," *Jurnal Teknologi Informasi dan Pendidikan*, vol. 15, no. 2, p. 2023, 2022, doi: 10.24036/tip.v15i2.

[2] Habibullah, H. Saputra, and W. Mariatul Kifti, "Implementation of CRM to Retain and Attract New Customers at Yusni's Clothing Store," *Jurnal Teknologi Informasi dan Pendidikan*, vol. 15, no. 2, 2022, doi: 10.24036/tip.v15i2.

[3] M. Arif, R. Rosyidi, M. Maulidina, M. Dewi, and M. Puspitasari, "Efektivitas Alat Pencuci Gelas Otomatis (Pilot) Berbasis Arduino Nano," *Jurnal Nusantara Of Engineering*, vol. 5, no. 1, 2022, [Online]. Available: https://ojs.unpkediri.ac.id/index.php/noe

[4] D. Agustin, A. Permana, M. Taufiq, and L. Ambarwati, "Design Smart Home Application Using Rapid Application Development (RAD) Method On Hybrid Mobile," *Jurnal Teknologi Informasi dan Pendidikan*, vol. 16, no. 1, 2023, doi: 10.24036/tip.v16i1.698.

[5] P. P. Prima, Turahyo, and Zaini, Rancang Bangun Robot Pembersih Lantai Berbasis Mikrokontroller Dengan Kendali Ponsel Pintar.

[6] N. Azrina, A. Z. Hasibuan, and A. Sembiring, "Mesin Cuci Piring Semi Otomatis Berbasis Mikrokontroler," *SNASTIKOM*, 2020, [Online]. Available: www.snastikom.com

[7] A. N. Ma'unah and L. Ulfa, "Hubungan Antara Personal Hygiene, Fasilitas Sanitasi dan Teknik Penyimpanan Peralatan Makan dengan Kebersihan Peralatan Makan di Kantin dan Makanan JajananTeknik," 2020. [Online]. Available: http://ejournal.urindo.ac.id/index.php/jukmas

[8] W. Widiatmoko and M. Hablul Barri, "Penerapan Sistem Kendali Pada Mesin Pencuci Piring dengan Menggunakan Metode Logika Fuzzy Application Of Control System On Dishwasher Machines Using Fuzzy Logic Method," *e-Proceeding of Engineering*, vol. 9, no. 4, 2022.

[9] M. H. Parikh *et al.*, "Design And Development Of Semi Automatic Cleaners For Utensils."

[10] Sholeman Taufix Zainnuri, "Alat Pencuci Piring Otomatis Berbasis Arduino," 2018.

[11] A. O. Arviano *et al.*, "Pengembangan Rancang Bangun Alat Pencuci Gelas Otomatis Berbasis Arduino Nano," *Jurnal NOE*, vol. 4, no. 2, 2021, [Online]. Available: https://ojs.unpkediri.ac.id/index.php/noe

[12] Zulfiyan and R. Marta, "Design and Build a Web-Based Public Service Administration System Using the CodeIgniter Framework," *Journal of Information Technology and Education*, vol. 15, no. 2, pp. 74–86, 2022, doi: 10.24036/tip.v15i2.

[13] E. W. Fridayanthie, H. Haryanto, and T. Tsabitah, "Penerapan Metode Prototype Pada Perancangan Sistem Informasi Penggajian Karyawan (Persis Gawan) Berbasis Web," *Paradigma - Jurnal Komputer dan Informatika*, vol. 23, no. 2, Sep. 2021, doi: 10.31294/p.v23i2.10998.

[14] I. B. I. Purnama, I. K. E. Sutawan, I. G. A. A. Putra, I. P. A. K. Suika, I. G. K. S. Budarsa, and I. M. Purbhawa, "Design of Controlling and Monitoring System for Room Temperature, Lighting, Power, and Energy Using Internet of Things," *Jurnal Ecotipe (Electronic, Control,*

Telecommunication, Information, and Power Engineering), vol. 9, no. 2, pp. 140–148, Oct. 2022, doi: 10.33019/jurnalecotipe.v9i2.3014.

[15] A. J. Maulana, E. Alimudin, V. Prasetia, and M. R. Hidayat, "Snack Vending Machine Using QR Code as Payment Method," *Jurnal Ecotipe (Electronic, Control, Telecommunication, Information, and Power Engineering)*, vol. 10, no. 1, pp. 1–11, Apr. 2023, doi: 10.33019/jurnalecotipe.v10i1.3357.

[16] A. A. Kuncoro, "Power Supply."

[17] C. Tjahyadi, "DC-DC Converter," 2015, Accessed: Aug. 21, 2023. [Online]. Available: http://christianto.tjahyadi.com/elektronika/ubec.html

[18] S. Amini, "Perancangan Keamanan Ruangan Dengan Sensor Pir Dan Magnetic Door Switch Berbasis Web," *JULI*, vol. 4, no. 2, pp. 126–132.

[19] TEGUH SETIADI, "Belajar Arduino Untuk Pemula Lengkap Penjelasan Program." Accessed: Aug. 17, 2023. [Online]. Available: https://sistem-komputer-s1.stekom.ac.id/index.php/informasi/baca/Belajar-Arduino-untuk-Pemula-Lengkap-Penjelasan-Program/dcc5f53d9ca4c21d6ff0315473f3221b0c55f110

[20] Anonim, "5V Four-Channel Relay Module." Accessed: Aug. 21, 2023. [Online]. Available: https://components101.com/switches/5v-four-channel-relay-module-pinout-features-applications-working-datasheet

[21] WatElectronics, "TB6600 Stepper Motor Driver : Pin Configuration, Interface with Arduino, Working & Its Applications." Accessed: Aug. 21, 2023. [Online]. Available: https://www.watelectronics.com/tb6600-stepper-motor-driver-module/

[22] Builder Indonesia, "Stepper Motor Nema 17, Spesifikasi dan Aplikasi Penggunaannya."

[23] A. Setiawan, A. Tri Prastowo, D. Darwis, J. Z. Pagar Alam No, L. Ratu, and B. Lampung, "Sistem Monitoring Keberadaan Posisi Mobil Berbasis Gps Dan Penyadap Suara Menggunkan Smartphone," *Jurnal Teknik dan Sistem Komputer (JTIKOM*, vol. 3, no. 1, p. 2022, 2022.

[24] Oriza, "Mengenal Android Studio : Pengertian, Manfaat, fitur, dan Cara Install."

P.ISSN: 2086 – 4981
E.ISSN: 2620 – 6390
tip.ppj.unp.ac.id