Development of Smart Rubbish Bin Connected with SMS Gateway Based on Arduino Uno

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Abstract. A mechanism must be established so that individuals can dispose of waste properly because many people need to be made aware of how to do so. Garbage is a problem in almost every city and has an impact on the environment, pollution, and the spread of disease. Waste management and understanding of the importance of waste processing in public places is still minimal, especially in a university with many students. The reason is that most of them are too lazy to open the lid of the rubbish bins because it is filthy and smelly. This research aims to design an automatic trash can with an ATMega328 microcontroller, Liquid Cristal Display (LCD), HC-SR04 sensor, buzzer, and SIML800. The HC-SR04 sensor is used to detect the presence of humans and the capacity of the trash can using ultrasonic waves. The buzzer is used for sound notification when the trash can is full. The LCD is used to display data, and then the SIML800 is used as a notification for sending messages to the cleaners to facilitate their work in transporting garbage. The test system results show that the trash can opens and closes automatically, detects the trash can's capacity, and all this is displayed by an LCD that has been adjusted to the system function.

Keywords: ATMega328 microcontroller, automatic trash can, HC-SR04, LCD, buzzer, SIML800.

1 Introduction

In this era, the growth of technology in the world is increasing rapidly, which results in the development of new and inevitable technologies. Significant developments today occur in technological developments and also modernization that is currently touching on electronic devices; this makes changes in human life, where their needs can be met with an automation system so that it is easier to do things and can save time and money during today's harsh life. The emergence of new variations illustrates that technological developments in the Chinese world have no visible limits; this can make us as living beings affected continue to be in development and follow it in the future [1, 2].

Keeping clean is part of faith; that's the slogan that we embrace from an early age. Environmental cleanliness significantly affects the sustainability of human life. Environmental cleanliness is a human responsibility, and cleanliness can be an individual or group responsibility depending on where the person resides [3]. In an organization or institution, cleanliness can be maintained together to create a harmonious group and social life. One of the human needs is an area or a comfortable living environment. Creating a comfortable life can be done by maintaining cleanliness. It is so essential to make people aware of always being

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obedient in maintaining cleanliness, one of which is by throwing dirt or garbage in the places that have been provided, such as rubbish bins [4, 5].

The problem of waste in Indonesia can be seen from the magnitude of the journey in landfilling waste. Then the mindset system of human awareness of the environment is still very minimal, and the number of people who still throw garbage away will not be placed in the provided place. This wrong action often results in overflowing rivers that flood during the rainy season due to clogged garbage drains. The lousy action of throwing garbage at will can be seen in the behaviour of almost all circles of society. Trash cans that have been explicitly given from the janitor's agency have not functioned optimally [5, 6].

On the other hand, the awareness and concern of each individual regarding maintaining environmental cleanliness are minimal and need to be re-evaluated. A person's level of care for the environment can start in a bit place, namely in his own residence with his family, for example, by planting trees around the house or doing experiments by processing organic and inorganic waste. Garbage is currently a problem that needs to be handled carefully. Humans are now required to be extra careful when in contact with a material or leftover item that must be disposed of and is no longer used, which we can call garbage. Because of garbage, germs can move quickly when in direct contact with our hands [7].

The growth of knowledge and science in technology requires humans to seek and solve problems that arise around us to provide solutions to make it easier to carry out daily activities. The sophisticated technology currently in great demand by people is a microcontroller, where the benefits that we can now feel are in intelligent systems attached to equipment intended as controllers in the work to be carried out. The use of microcontrollers can be said to be not small usually many are found for data acquisition, but not infrequently, they are also found in controlling equipment in business places such as factories, some use microcontrollers for work equipment in offices, use for equipment in households, and so on.

Electronic components contain interconnection systems between microprocessors, RAM, ROM, I/O interfaces, and several peripherals. The microcontroller is also called On-chip-Peripheral. The microcontroller is the first choice because it has advantages in terms of price, circuit simplicity, and smaller instrument dimensions. Microcontrollers are usually applied to electronic equipment so that it works automatically. The use of microcontrollers is extensive, not only for data acquisition but also for control in factories, office equipment needs, household appliances, and automobiles [8].

So on this occasion, that encourages the author to conduct research to develop a tool that can be used as a controller of environmental hygiene in the form of an intelligent rubbish bin, which will be designed so that it can have a lid that functions openly by itself when garbage or objects that want to be disposed of are put into the bin [9, 10]. The rubbish bin will be set so that it can close by itself. Too if the garbage is put in a matter of a few minutes, the researchers will design a rubbish can that can detect the amount of garbage contained in the rubbish bins [11]. The detection of a fully filled trash can and the height of the garbage piled up in the trash can is done using an ultrasonic sensor; when the sensor detects a fully filled trash can, it will send a notification signal to the garbage collector via SMS containing the message that "The trash is full, Immediately Do the Disposal". In general, the problem statement is how to make a trash can with a trash can lid that can open and close automatically based on Arduino Uno. How to make a telephone number that can be connected to an ultrasonic sensor when it detects the presence of a full-capacity trash can and then immediately gives a notification in the form of an SMS gateway.

2. Methodology

An SMS gateway is an SMS processing technology carried out in a computerized manner and adds several tools that can operate and control a product by utilizing the SMS service to share their individual needs and objectives. The SMS Gateway is a platform that provides a mechanism for EUA to send and receive SMS from mobile devices (HP, phone, etc.) via the SMS Gateway's shortcode; because SMS is an application, the features contained in the SMS gateway can be modified according to needs [12, 13].

The Arduino is an open-source single-board microcontroller, which is easy to use with an open-source wiring platform, primarily in economic electronics projects. The Arduino Uno is a microcontroller board based on Atmega328, which has 14 digital I/O, and six pins that can be used as pulse width modulation, six analogue inputs, a 16 MHz ceramic resonator, USB connection, ICSP header, connection containing voltage, and a button to reset. Arduino microcontrollers can be called programmable because the bootloader can make it easier to download programs to flash-on-chip memory than other microcontroller boards that use external programmers. Arduino is unique in that it can educate because it can be economical, open source, and be added to other devices. The Arduino integrated development environment (IDE) is a cross-platform typed in Java [14].

The Arduino Uno board can work when the device supplies an external 6 to 20 volts. If the supply is lower than 7 V, the 5 V pin will get a supply lower than 5 V, and the Arduino Uno board may also have an error that it cannot function properly. If using a large voltage of 12 volts, the voltage regulator exceeds the heat capacity and can make errors that impact the Arduino Uno board machine. The recommended difference should be 7 to 12 volts. Arduino Uno has 14 digital pins in it, which can be used for input and output by obtaining the pin and model functions, digital write, and digital read. The workings of these pins work with a power of 5 Volts. Each pin can supply and provide a maximum flow of 40(forty) mA and has one pull-up resistor (disconnected by default) of 20-50 kOhm. The Arduino Uno can be connected to a computer unit, another Arduino, or other microcontrollers as well. The Atmega 328 facilitates UART TTL (5V) serial communication, which is open on digital pins 0 (RX) and 1 (TX). An Atmega 16U2 on the serial channel board communicates with USB, which will appear on the virtual port device to the software on the computer. The 16U2 firmware is used for the standard USB COM driver, and no external driver is required [15-17].

Figure 1 below is a simulation of the design of a tool called a block diagram to find out which tools will be used to manufacture smart rubbish bins with an automatic SMS gateway based on Arduino Uno. The design of this tool is an early stage in research that is useful for knowing the series of systems that will be made with these components are supporting tools such as Arduino Uno, LCD, PIR sensor, SIM 800L, breadboard, servo, and ultrasonic sensor.

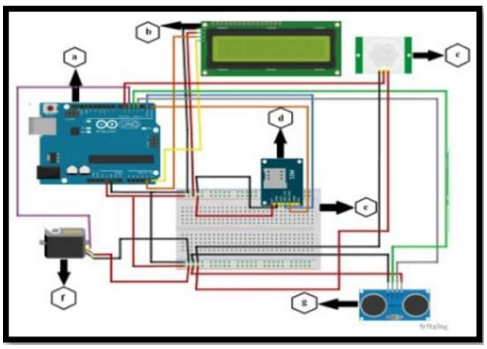

Fig 1. Block Diagram

Table 1. List of Components

No	Component	Image	Description
1	Microcontroller		In this system, Arduino Uno acts as a microcontroller that controls all components.
2	LCD		The LCD as a notification monitor for garbage
3	Buzzer		As an alarm notification when the rubbish is full
4	SIM 800L		SIM 800L as a tool for sending messages.
5	Servo		Servo as a tool to open and close the rubbish.
6	Ultrasonic Sensor HC-SR04		The Ultrasonic Sensor is used as a tool to detect garbage in the rubbish

Software Requirements

The following required software consists 1 unit of computer or laptop device serves to work on the program system for Arduino IDE with the following specifications, Operating System windows 10, RAM: 4GB, Processor: Core i5, HD : 1GB. The Arduino Software IDE, namely the Integrated Development Environment, an application that can be used to carry out a development that can be used in the C++ programming language. Data processing is searching for data in the field or location to be addressed and conducting designs with research characteristics.

The data processing method in our research needs to do the following, data error is a way to reduce or select data already the same as the topic to be designed, where the data was obtained in research. Data coding is the compilation of data obtained for central research or location research as a goal sourced from the problem and the technique of entering the codes and want to input each piece of data generated. The Frizzing application is used to design a simulation of the Arduino Uno tool circuit.

Hardware Requirements

The research was carried out using field studies, namely direct observations. The following is the result of a needs analysis for the manufacture of automatic smart rubbish bins, a list of materials used to design research.

Table 2. Hardware requirements

No	Material Name	Unit	Description
1	Fiber Glass Board	1	As a place to design
2	Bolts and nuts	Customized	For installation adapted to the tool
3	Arduino Uno R3 Module	1	As the main controller of the input data input
4	Servo Motor	1	As a drive and propulsion
5	Pump Module	1	
6	Ultrasonic Sensor	2	To measure the fullness of the trash in the trash can
7	PIR sensor	1	As object detection garbage disposal
8	LED & IC Reagular	1	Screen Display Output
9	Supporting tools needed: cutting pliers and tweezers, power supply, cutter blade, electric drill and grinder, soldering iron, lead and lead sucker, ruler	Customized	As a supporting tool when needed to be used
10	Rubbish Bin 40 L	1	Garbage Dump

Research Stages

The author's scientific development method is developed using the R&D (Research and Development) method, which can provide a product's results. In this method, the development is carried out using instructional design with the ADDIE approach, which means Analysis, Design, Development, Implementation and Evaluation [18, 19]. The steps taken by the researcher are as follows (Figure 2)

A. Analysis

First, analysis of need to be done to find information about problems that occur in the place or area that is the location of research for a product. Furthermore, it can be done by looking for data and information about the need to solve a problem at the research site. Second, literature study. This is what needs to be completed from the development of this method. It is necessary to search for empirical data and information with valid theories and research according to the product to be developed. On this occasion, the author will be directed to be able to develop the product to be produced. Third, small-scale research. This provision aims to identify a result the author must carry out regarding the needed product. To provide maximum results regarding the certainty of the product and whether it is suitable for solving a problem at the research site.

B. The design can include the following:
Design the product you want to develop. Choose what facilities are suitable for research needs and the infrastructure needed when carrying out development, and getting started can determine the stages for a design test at the research site.

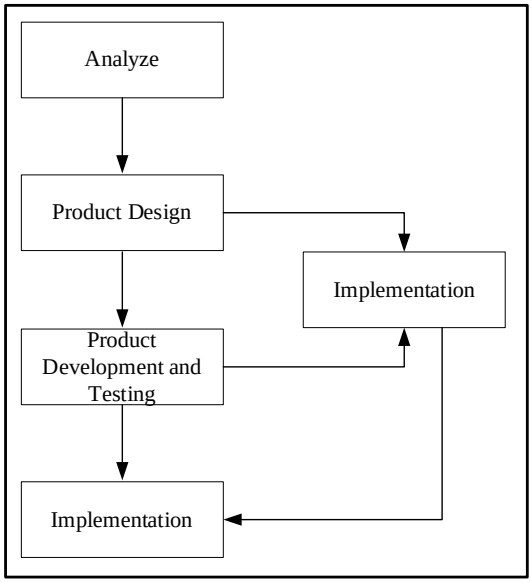

Fig 2. Research Stages

C. Development is the activity stage for design and product testing.
In field testing, there are several stages, including, a trial is conducted on the design of a product, the trial was conducted with limited time and place. In the field, testing must be done repeatedly in order to produce a maximum design.

D. The field trial at the end of this opportunity is broader in nature, which includes:
Trial the effectiveness of the product design, Testing the effectiveness of the design is carried out with experimental techniques. The model of repetition from the results of field testing is a design that has been effective or not, measured from the point of view of its substance or methodology. The results of the data regarding the use of the product are combined to measure the effectiveness and efficiency of the product.

E. Implementation is an activity that needs to be done in the development of a product by testing the feasibility (Operational Field Testing). This activity is carried out by testing the effectiveness and adaptability of the product design that product users must do. This test is carried out with approaches such as interviews, observations, and questionnaires, and then to find out the results, they must be analyzed. Furthermore, the results of the analysis can be published to be developed so that it can be realized for the public, or more broadly.
F. Evaluation is a stage to assess the steps taken and whether the products that have been designed are in accordance with the wishes and specifications.

3. Result and Discussion

After the design of a product that will be implemented, measurement of success is needed, and then testing and analysis of the tool are needed. And as a consideration, an evaluation process is carried out so that a proper arrangement can be obtained and this tool can be directed to better things.

The picture below shows the physical form of the automatic smart rubbish bin device designed with:

1. ATMega 328 microcontroller as an Arduino machine
2. The first ultrasonic sensor was designed to detect the presence of objects.
3. The second ultrasonic sensor is designed to detect the level of trash in the trash can.
4. Servo motor as an actuator of the trash can lid that can open automatically
5. LCD as output viewer
6. Buzzer as an alarm for garbage notification is complete.

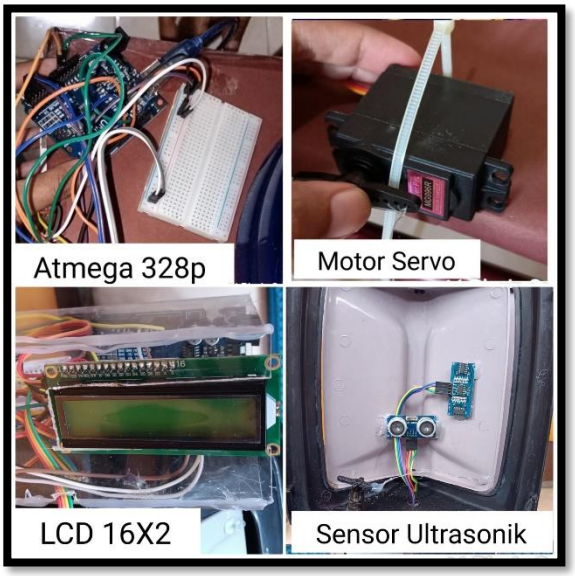

Fig 3. Display of Tools

System testing is executing hardware and software systems to determine whether they are suitable and according to the researcher's wants. Testing is done by conducting experiments to see if possible errors from each process are captured. The testing system used is a black box. In trials with the Blackbox method, namely by testing the device starting from the functional side first, in order to find out whether the way it works and also the output has been running according to the desired goal. Furthermore, in conducting trials, it may be done in the first order, namely testing of devices that have input, for example, testing of ultrasonic sensors.

Tests on ultrasonic sensors are tested by approaching the response obtained from the intensity of the wave distance of a sensor (Fig. 4). The ultrasonic sensor test function is based on the presence of an obstacle that can reflect the ultrasonic waves that have been given. The ultrasonic sensor trial aims to determine the minimum and maximum distances the HC-SR04 ultrasonic sensor can assess. Moreover, it can also be used to compare the actual distance and the distance measured using the HC-SR04 ultrasonic sensor. Testing a series of ultrasonic

sensors HC-SR04 was tested by connecting the HC-SR04 ultrasonic sensor module to a series of ATMega328 microcontrollers and a minimum system circuit. The pins on the HC-SR04 that are brought together include the +5v voltage source pin brought by the positive pole by the supply. The trigger pin is connected to pin 6, the Echo pin is connected to pin 7, and the ground pin is connected to the negative pole on the supply. The working system of the ultrasonic sensor HC-SR04 is that, initially, the HC-SR04 is activated with a trigger pin of at least 10 μs, which can then transfer positive pulses through the microcontroller IC. Then the TX pin will transfer the signal at the time of logic one or high, which detects the obstacle, and RX will receive the reverse signal from the barrier.

Fig 4. Testing on Object Detecting Sensors, Ultrasonic Sensors and Buzzers

When getting a bounced signal, RX is a logic 0 or low, which means the signal from RX can be passed through the Echo pin line. The width of the signal from the echo will be used for distance measurement. Next is to test the distance measurement of the ultrasonic sensor HC-SR04, namely by placing the ultrasonic sensor in front of a barrier and making repeated changes to the measurement distance. The following are the test results of the ultrasonic sensor, with the object distance that can open the lid of the trash can being 5–30 cm. The results of the automatic garbage site testing can be seen in the image and also in the table below:

Table 3. Test Results on the Distance of the Ultrasonic Sensor with the Object

Object Distance to HC-SR04 (cm)	Expected Results	Observation Results	Description Results
5 – 10 cm	cover successfully open	open successful	object detected
11 – 15 cm	cover successfully open	open successful	object detected
16 – 30 cm	cover successfully open	open successful	object detected
30 -45 cm	cover successfully open	open successful	object detected
50 – 60 cm	cover successfully open	open successful	object detected

Next is the LCD test, which aims as a display output which is given as a sign of the work of the tool related to the ultrasonic sensor, which is set as a detection sign following the program listing that has been made.

a. When the I/O initiation is successful, and the machine is on, the LCD will immediately display “MASUKKAN SAMPAH”
b. Furthermore, when the distance of the object that wants to dispose of garbage is less than 30 cm, the Ultrasonic Sensor will read the input and give a signal to the servo motor so that it can open the lid of the rubbish bin.
c. When the trash is fully loaded, the lid of the trash can will not open even though there is an object in front of the rubbish bin. The Ultrasonic Sensor gives a signal to the LCD, which will display "SAMPAH PENUH" then, the buzzer automatically emits an alarm notification sound for the cleaners to transport rubbish immediately.

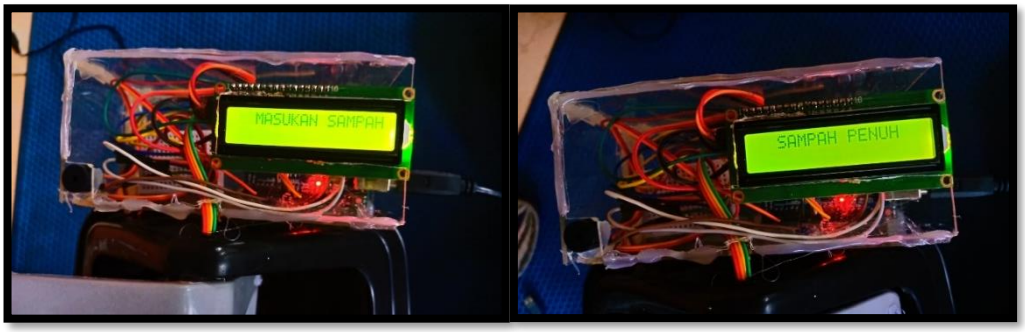

Fig 5. LCD display when the machine is on and bin is full

The results of this study provide benefits for students in disposing of trash on campus because it is easier to operate. The advantages of this trash can are that it uses sensors to open the trash cover, compared to other research studies that use telegram or WhatsApp notifications [20] or use clustering method [21].

The product developed follows the ADDIE development procedure so that it produces a product suitable for application to the community, not only on campus but to the community as a whole. Research development with the ADDIE research model produces the final product in the form of a project-based interactive trash can combined with a microcontroller. The results of the review from several research friends in the community who had seen the results of this study showed interactive validity with well-qualified aspects of the material presented. The use of sensors and microcontrollers functions properly so that the commands given can be responded to immediately so that the tool works very well.

4. Conclusion

From the tests that have been carried out, it can be concluded that an automation tool has been successfully created in the form of smart rubbish bins that can read objects when we want to dispose of garbage. The test results on the tool's performance get a value of 43%, which is calculated using a Likert scale to get a "Good Enough" response for testing the entire tool. Besides being able to be used by students, smart rubbish bins can also be used by cleaners from the SMS Gateway sent as a notification that the trash can is whole

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