

Design and Implementation of Different Types of Smart Dustbins System in Smart Campus Environments

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ABSTRACT

In Indonesia, waste is still a very serious problem. Garbage causes bad odors, air pollution, disease, and even flooding. Whenever and wherever each individual produces waste, waste can come from households and industries which have various types and forms. Public awareness to dispose of trash in the right place tends to be very lacking, laziness is increasingly formed when dustbins are not widely available, very dirty, the open and close system is still manual so that the hands can easily catch bacteria when interacting with the trash. This study aims to start from a small scope, namely implementing smart dustbins for the campus environment and educating the campus community so that their interest in disposing of garbage in the right place is higher. The recommended smart dustbin system has various types, namely mini-smart dustbin and super-smart dustbin. The waterfall method is used for the process of designing and implementing the system. Methods of data collection using observation, interviews, literature study, and questionnaires. The test results state that the smart dustbin system can function as expected. A total of 50 respondents were involved in evaluating the application of smart dustbin, with the result of an average score of 87.80% who stated strongly agree that the existence of this smart dustbin provides benefits and attracts interest in awareness of throwing garbage in the right place. Furthermore, it is recommended to improve the system and better cooperation by all campus communities which are a shared responsibility.

Keywords: *Smart Dustbin, Smart Campus, Smart City, Smart Environment, Smart System*

1. INTRODUCTION

Garbage in Indonesia is a very serious problem and also becomes a social, economic, and cultural. Almost all cities in Indonesia experience problems in waste management. The highest focus is the accumulation of plastic waste. This rubbish issue will also be raised in government activities namely the Indonesia Environment Week 2020 in Palembang.

Every individual would want everything that looks clean and beautiful, one of which is environmental cleanliness. There are still many individuals who tend to be less aware of the cleanliness of their environment. This is reflected in a large amount of garbage scattered on the streets and in city parks. This situation certainly creates unrest for public facility users. Dustbins that have been provided by the sanitation department are only a mute decoration on roads that are not maintained, are not attractive [1], and are very dirty. Maybe this is also a

factor that causes people not to throw garbage in the right place and the level of laziness to throw garbage is getting higher. Feeling lazy arises because the existing dustbins still use a simple method, namely by opening the lid and the dustbins are still manual. This will cause the hands to be very susceptible to bacteria from the trash.

The Politeknik Negeri Banjarmasin itself also feels the same way, where there is still a lot of garbage scattered about, students tend to litter, this is also caused by the waste that is very minimal, unattractive, traditional, dirty, and poorly maintained. Then for lecturers/educational staff also tend to be lazy in throwing garbage into the right place, because the location is very far from reach.

In raising awareness of our concern for environmental cleanliness, we assume that there needs to be a unique way so that each individual is interested and is not lazy to throw garbage in the right place. The unique way is to

design and implement a smart dustbin. This is a smart dustbin can for dry trash, the lid can be opened automatically and when the trash is added, it closes automatically. The smart dustbins that we recommend are of two types, namely a mini-size smart dustbin that will be used on every work desk for lecturers/campus employees and a super-size smart dustbin for use in every room. Our research is started and applied in a small area first as a reference to support smart campuses and smart environments in welcoming the 5.0 industrial revolution with a variety of information technology and machine intelligence that continues to evolve.

1.1. Related Work

In recent years, many issues and research on solid waste have been carried out, by developing a smart dustbin system and conducting socialization to the community. However, these studies must always be improved and carried out so that the waste issue in Indonesia can be reduced and become positive. What's even worse is the issue of plastic waste that continues to increase and flooding as a result of littering into rivers. As for some of these studies such as from studies [1] that developed smart dustbins for the university environment, but this research has not reported about the effects that occur after the implementation of smart dustbins, the improvement found is the need for special care for smart dustbins and recommendations for dustbins placed outside the room.

Furthermore, [2] designed a mobile-based waste handling tool, using a proximity sensor and a weight sensor. In short, when the garbage is full, the system will automatically report the condition to the garbage officer. To be handled and also able to send information on the location of garbage, research has been carried out at several points in Makassar City, but the impact caused by this system has not been reported. Research by [3] which developed a smart dustbin to connect waste information with scavengers and authorities are using the Internet of Things (IoT) to create a clean and tidy city sustainably.

Research by [4] developed a smart dustbin monitoring system using a wireless sensor network that has been tested in the village, but the impact has not been reported. Then from [5] the application of IoT-based smart dustbins that are placed in the corner of the outdoor street, infrared sensors are used to detect objects, make alarms sound and report the condition of the trash when it is full, and report that the smart dustbin is very useful for the environment and for supporting the smart city system in the future. Also, [6] proposes the use of two smart dustbins that are effective for placing in public places in waste management in smart cities with a control system using GSM. Furthermore, [7] explained that in the future there will be a smart city, it must be supported by smart systems, such as smart dustbins. In India, especially for metro stations as tourist arrivals, strived to keep the environment clean, the importance of smart dustbins is

recommended in waste management and helping to monitor the cleanliness of a smart city.

Furthermore, [8] who proposed a prototype of a smart dustbin system for a smart city because it has very good motivation and effect in waste management in the modern era, especially in India. A recent study from [9] proposed designing a smart dustbin using a fuzzy logic algorithm based on Arduino, using two sensors, namely the Passive Infra-Red (PIR) sensor to detect objects and an ultrasonic sensor to detect the height of the trash. Fuzzy logic algorithms are used to determine indicator lights and alarms for garbage height information. However, the impact of the proposed system has not been reported, whether it can solve the waste problem in the environment that has been studied.

The research proposed at this time is to design and implement several types of smart dustbins, namely mini sizes which will later be used on each desk for lecturers/academic staff and in large sizes placed in each room. Then the detection test is carried out, the conditions that occur in the system, and the effects that are generated when the system is implemented to support a smart campus environment.

2. METHOD

The method used in this research is to use the Waterfall development model. The Waterfall Model according to Royce in [10] is a model with a form flowing down and down with several phases that must be passed to meet the success in the development of computer software. All phases must be passed perfectly, one by one phase must be completed then the next phase is carried out, the waterfall has a strict nature and must be ordered. In [11], the phases of the Waterfall model consist of requirement analysis, design, implementation and unit testing, integration and system testing, and maintenance.

The needs analysis stage involves digging out the problems that occur to be resolved, namely the accumulation of garbage, awareness to throw garbage in the right place, reducing laziness to throw garbage, and the absence of automatic tools such as smart dustbins to be placed on the table and in the corner of the room. The design stage includes designing a sketch image and a system prototype as a reference for the size of a smart dustbin, followed by designing a smart dustbin, as well as electrical design. The implementation and unit testing stages tend to be called the coding process/tool programming carried out on the Arduino IDE software which will be used with the Arduino programming language, after which the coding is entered into the Arduino (upload process). The next stage is system integration and testing, namely testing the incoming coding, namely by testing one by one before testing as a whole and integrated. Finally, the maintenance stage includes the process of maintaining the smart trash by

placing it in the right and good place, minimizing unwanted things that can damage the smart dustbin.

Then for the method of data collection conducted in this study consists of:

- (1) Observation, namely collecting data directly on the Politeknik Negeri Banjarmasin through observation, recorded, and reduced then presented systematically to describe the object under study.
- (2) Personal interviews are the best instrument for obtaining information. In this study, the data collected through questions and answer verbally with the source concerned directly.
- (3) Literature review, in addition to observations and interviews, collect reference data relating to the design of smart dustbins through books, scientific articles in relevant proceedings, and journals.
- (4) A questionnaire as a data collection tool used to explore user perceptions when the implementation of smart dustbins is carried out, this questionnaire serves to find out the effects produced and to what extent the proposed problem resolution can be recommended.

3. RESULTS AND DISCUSSION

3.1. System Design Overview

The design of a smart dustbin system with an Arduino microcontroller and ultrasonic sensor (HC-SR04) consists of two designs, namely hardware design, including device design, and software design including Arduino source code.

3.2 Diagram Block

The design of an Arduino Uno R3-based smart dustbin consists of an Arduino, an (HC-SR04) ultrasonic sensor to detect distances, and a servo. The circuit block diagram is presented in Figure. 1.

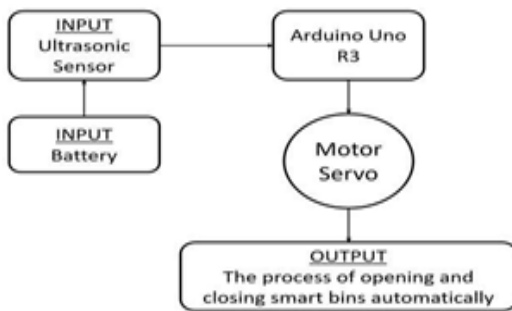


Figure 1 The circuit block diagram

Based on Figure. 1 that the main system design is a battery that functions as a power control in turning on and off smart dustbins; Arduino Uno R3 that functions as a conduit of programs from smart dustbins; Ultrasonic sensor (HC-SR04) functions to detect hand movements when disposing of garbage; and Servo motor as opening the lid of the smart trash can and closing it again automatically.

3.3. Mechanical and Electrical Design

As for the equipment used to make smart dustbins, Arduino Uno + Cable, Ultrasonic Sensor, Battery Socket, 9V Battery, Micro/Servo Motor, Male Cable, Female Cable, Used Cardboard/Cardboard, Clear Duct Tape, Gift Wrapping Paper, Gift Paper Paper Glue, Gun Glue, and Wire. Figure. 2 is the result of making a smart dustbin with mini size.



Figure 2 Design of mini-smart dustbin

Furthermore, Figure. 3 is the initial design for the large/super-smart dustbin.

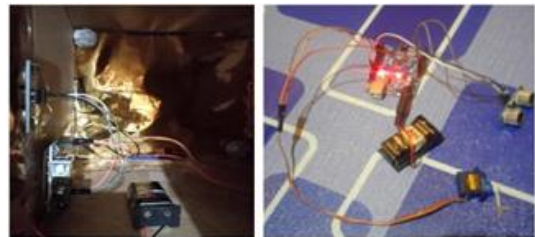


Figure 3 Design of super-smart dustbin

Figure. 2 and Figure. 3 have a different order, as they adjust to the scale of the proposed smart dustbin. However, all the equipment used was the same.

3.4 Coding

After doing the hardware design, the next step is to design the software. Software programming using the Arduino IDE (Integrated Development Environment) before starting programming the board settings in the Arduino application through the tools menu and adjusting. The program code below is specific to the mini-smart dustbin system.

```

#include <Servo.h> Servo servo;

int trigPin = 5;
int echoPin = 6;
int servoPin = 7;

long duration, dist, average;
long aver[3]; //array
for average void setup(){

servo.attach(servoPin);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
servo.write(0);
delay(1000);

servo.detach();

}

void measure(){
digitalWrite(trigPin, LOW);
delayMicroseconds(5);
digitalWrite(trigPin, HIGH);
delayMicroseconds(15);
digitalWrite(trigPin, LOW);
pinMode(echoPin, INPUT);
duration = pulseIn(echoPin,
HIGH); dist = (duration/2) / 29.1;

}

void loop(){

for (int i=0; i<=2
;i++){ measure();
aver[i]=dist;
delay(50);

}

dist=(aver[0]+aver[1]+aver[2])/3;
if (dist<20){
servo.attach(servoPin);
delay(1);
servo.write(90);
delay(3500);
servo.write(0);
delay(100);
servo.detach();

}

}

```

Then for the program code below is specific to the super-smart dustbin system.

```

#include
//servo library
Servo servo; int
trigPin = 5; int
echoPin = 6;
int servoPin = 7;

long duration, dist, average;
long aver[3]; //array for
average void setup() {
Serial.begin(9600);
servo.attach(servoPin);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);

servo.write(0); //close cap on
power on delay(100);
servo.detach();

}

void measure() {
digitalWrite(10,HIGH);
digitalWrite(trigPin, LOW);
delayMicroseconds(5);
digitalWrite(trigPin, HIGH);
delayMicroseconds(15);
digitalWrite(trigPin, LOW);
pinMode(echoPin, INPUT); duration
= pulseIn(echoPin, HIGH);
dist = (duration/2) / 29.1; //obtain distance

}

void loop() {
for (int i=0;i<=2;i++) { //average
distance measure();
aver[i]=dist;

delay(10); //delay between measurements
}

dist=(aver[0]+aver[1]+aver[2])/3;

if ( dist<50 ) {
//Change distance as per your need
servo.attach(servoPin);
delay(1);
servo.write(0);
delay(3000);
servo.write(150);
delay(1000);
servo.detach();

}

Serial.print(dist);

}

```

After setting up Arduino, the IDE starts the program immediately. After the program is created, the next step is to check whether the program is in accordance with the Arduino standard by clicking the Verify menu, then the final step is to upload the program to the microcontroller by clicking the upload menu on the Arduino IDE.

Before the implementation phase is carried out in an actual campus environment, a black-box testing phase is recommended for its application to ensure that the features available in the two types of smart dustbin function as expected. The results of black-box testing are presented in Table I.

Table 1. Black-box testing results

ID	Test Features	Expected Action	Test Result
SD-1	Sensor Ultrasonik (HC-SR04)	Detect objects (garbage) right in front of it with an optimal distance with a minimum of 2 cm and a maximum of 50 cm.	Successfully
SD-2	First Position Servo Motor	Automatically opens the smart dustbin cover with a certain delay time.	Successfully
SD-3	Second Position Servo Motor	Automatically close the smart dustbin cover, after the opening delay time is over.	Successfully
SD-4	Source Voltage (9 Volt Battery)	Saves power to flow on the Arduino and lasts approximately 2-4 weeks.	Successfully

Based on Table 1, are the results of black-box testing for all the features available on the two types of smart dustbins. The test was carried out three times. For object detection with the ultrasonic sensor, it is very sensitive to surrounding movements and even heavy winds can affect the detection of the ultrasonic sensor. The black-box testing that has been carried out provides a decision that all the features expected are functioning properly so that they can be implemented in a campus environment.

3.5 System Implementation

The smart dustbin system based on Arduino Uno and ultrasonic sensor (HC-SR04) is a simple system that functions to open and close the trash can automatically. This tool will be active when a voltage source is connected to the circuit because the program has previously been uploaded to the microcontroller. This can be seen from the operation of the ultrasonic sensor which can read hand movements so that it becomes input data to Arduino so that the servo motor will work to open and close the smart dustbin automatically. The results of the implementation of the mini-sized smart dustbin are presented in Figure. 4.



Figure 4 Implementation of mini-smart dustbin

Based on Figure. 4, it is an implementation of a mini-sized smart dustbin that is placed on each lecturer/academic staff table, which will most likely eliminate laziness in disposing of garbage, the tendency of this mini-smart dustbin function is for small trash such as candy wrappers or tissue. Furthermore, the implementation of the super-smart dustbin is presented in Figure. 5.



Figure 5 Implementation of super-smart dustbin

Based on Figure. 5, it is an implementation of a super-smart dustbin that is placed in every room, canteen, and prayer room. Most likely it will eliminate laziness in taking out the trash, the tendency of this super-smart dustbin function for large trash such as snack wrappers, drink bottles, and others.

3.6. Evaluation Results of the Smart Dustbin

To evaluate the application of smart dustbins in the campus environment, questionnaires were distributed to 50 respondents consisting of lecturers, students, and academic staff at Politeknik Negeri Banjarmasin. The distribution of data on the results of respondents' responses to the evaluation of implementing two types of smart dustbins is presented in the form of a bar chart in Figure. 6.

Based on Figure. 6, it is the response from 50 respondents to the results of the implementation of two types of smart dustbins, the highest value is in statement number ten, 95% of respondents feel that this smart dustbin is very useful and its performance must be further improved.

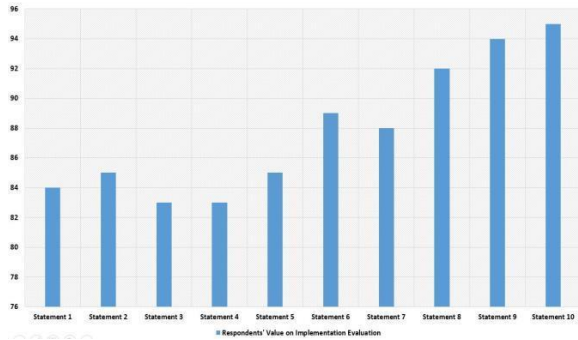


Figure 6 Distribution of implementation evaluation result data

Then the lowest values are in statements number 3 and 4, namely, there is still a shortage of smart dustbin and cannot select whether it is organic and inorganic waste. The rest of the respondents are satisfied with the presence of this smart dustbin to reduce laziness, increase awareness of environmental cleanliness, and of course reduce waste circulation carelessly, especially in the room.

Furthermore, it can be confirmed that the average results obtained from the evaluation of the implementation of this smart dustbins are at 87.80% which states that they strongly agree with the existence of this smart dustbins, they are very enthusiastic in using the trash and providing benefits. Then they are also diligent and become interested because the smart dustbins are made very much, available in many rooms, clean, and beautifully patterned. The benefits are also felt by reducing scattered waste. This has a good impact on a clean and tidy campus environment.

4. CONCLUSION

The development of smart systems, especially in the development of smart dustbins tends to increase, this is due to the trend of the existence of intelligent technology. The test results state that overall the mini and super-smart dustbins system works and functions properly. The results of the evaluation of the application for smart dustbins with an average value of 87.80% of the 50 respondents involved stated that the presence of smart dustbins spread in the room strongly agreed to provide benefits and attracted very high interest in awareness of disposing of trash in the right place, however, it is necessary to improve the smart dustbin system to improve its performance as well as cooperation with all the academic community which is a shared responsibility.

Because this research is the first pilot on campus and has many shortcomings. So the future work is to improve the performance of smart dustbins, detect the fullness of waste, monitor waste, manage real-time information, be able to detect organic and inorganic waste, and maximize it for further implementation in collaboration with the

Internet of Things (IoT) devices and other smart systems, to create a smart campus environment in the future.

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