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Automated plastic trash bin with alcohol dispenser using PIR Motion Sensor and Arduino Uno

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Abstract

This science investigatory project aimed to produce an automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno. The objective was to benefit workplaces and schools by promoting sanitation and hygiene. Descriptive statistical techniques were employed to assess the accuracy of the automated trash bin across several parameters, including range, precision, efficiency, amount of waste, and amount of alcohol dispensed. The researchers also used Pearson's Sample Correlation Coefficient to determine the correlation between the PIR motion sensor's detection capability and the hand's distance. They also used T-Test analysis to determine the significant difference between using the automated plastic trash bin and traditional trash bin. The study's findings revealed that the product is effective and efficient in the detection capability of the PIR motion sensor, effective in the correct operation of the product, efficient to use, and effective in determining the amount of waste that can be stored. It also determined a moderately positive correlation between the distance of the hand and the detection capabilities of the PIR motion sensor. The automated plastic trash bin is more efficient than the traditional trash bin. The T-test results support the conclusion that there is a significant difference between the mean times of the two groups. The researchers recommend employing a bigger servo motor, adjusting the sensitivity of the PIR motion sensor, utilizing a large battery and alcohol dispenser, and using a plastic bag inside the trash bin.

Keywords: automated trash bin, Arduino Uno, PIR motion sensor, plastic trash, alcohol dispensed

Automated plastic trash bin with alcohol dispenser using PIR Motion Sensor and Arduino Uno

1. Introduction

The automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno is an innovative solution aimed at mitigating contamination and curbing the transmission of germs, particularly in high-traffic public areas. This research draws inspiration from the work of Aisyah et al. (2022) in their study on developing a smart rubbish bin connected with an SMS gateway based on an Arduino Uno, highlighting the significance of maintaining cleanliness and hygiene in public areas. The proposed system, powered by Arduino Uno and integrated with a PIR motion sensor, is designed to detect hand movements and, through meticulous code and programming, administer isopropyl alcohol for effective hand disinfection. Prioritizing cleanliness, especially in dynamic environments such as schools and workplaces, underscores our commitment to addressing environmental health and community disease prevention. This endeavor sought to provide a straightforward yet innovative solution, allowing individuals to sanitize their hands promptly after disposing of trash, thereby contributing to a healthier and more hygienic community.

Moreover, Aquilah et al. (2021) state that according to the National Waste Management Information System based on data from the 2020 census, Yogyakarta has the greatest percentage of garbage per population. With a proportion of 50.21%, the kind is organic waste, which includes food waste. This high percentage of organic waste in Yogyakarta indicates a need for effective waste management strategies to reduce environmental impact. Implementing composting programs and promoting awareness about proper waste disposal can address this issue and encourage sustainable practices within the community. One of the issues addressed is garbage combined with other forms of waste, resulting in a need for more public awareness and understanding of waste sorting. To address these issues, adequate treatment is required. This automated plastic trash bin uses advanced technology to sort and separate different types of waste automatically. It helps educate the public about proper waste disposal and encourages responsible recycling practices. The chosen science investigatory project topic tackles a range of critical problems. Based on the study of Tirkolaee & Aydin (2021), waste materials should be appropriately disposed of in a suitable location, following hygienic conditions and considering hygiene measures throughout the operational stages. Ensuring the prompt collection, transportation, and disposal of waste materials is crucial. Additionally, regular trash bins can serve as a habitat for dangerous microbes, escalating the potential for spreading diseases in shared spaces. Moreover, individuals' lack of active participation in proper waste disposal increases littering and environmental harm. Lastly, the issue of inadequate hand cleanliness is also a concern, as people often forget to clean their hands after using public waste bins, promoting the further spread of germs and diseases.

This researcher designed an automated plastic trash bin with an alcohol dispenser, a PIR motion sensor, and an Arduino Uno. Combining waste management and hygiene measures, this innovative approach aimed to foster hand hygiene in public areas and promote responsible trash disposal. Building on the work of Aqilah et al. (2021), who explored the challenges of traditional trash cans in supporting Sustainable Development Goals (SDGs), this study addressed issues such as waste separation, inadequate trash capacity, and the need for hand hygiene awareness. By integrating hand sanitizer and waste sorting capabilities, the automated plastic trash bin with an alcohol dispenser with a PIR motion sensor, the Arduino Uno aspired to contribute to global SDG objectives by enhancing public understanding and engagement in environmentally responsible waste management practices.

Statement of the Problem - This study aimed to produce an automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno. It produced a hands-free, self-disinfecting trash bin that promotes cleanliness and reduces the risk of disease transmission. The primary objective of this project was to

address the following inquiries: (1) What is the level of accuracy of an automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno in terms of range, precision, efficiency, amount of waste, and amount of alcohol dispense? (2) Is there a significant relationship between the detection capability of the PIR motion sensor and the hand's distance? (4) Is there a significant difference between using the automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno and a traditional trash bin?

Significance of the Study - Due to increased global concern regarding improper waste management, developers are creating new solutions to address the challenges of waste management systems. The invention of an Arduino Uno-based sound sensor system for waste metal and non-metal significantly contributes to preserving the environment. This study enhances the lives of numerous individuals. The study aimed to assist all individuals and corporate entities: For local governments, this study's effective garbage sorting will save them money in the long run by lowering the cost of processing and waste disposal. Ineffective waste management frequently results in the contamination of recyclables with non-recyclable elements. This study can reduce environmental damage by educating people and incorporating the community into waste sorting.

For food corporations, this study could enhance the sustainability and efficiency of food firms' waste sorting operations. This system enables the quick identification of food waste that requires sorting. It enhances resource use while reducing individual errors. In addition to saving money, the system promotes corporate social responsibility goals. For companies, this study can minimize the manual labor of the workers because of automatic waste sorting. It leads to an increase in productivity and cost savings for companies that use our product. Companies can also benefit from this study due to its effect on their environmental sustainability, as this product will enhance it. This study can benefit communities by lessening health risks and improper waste segregation, which leads to water source pollution and disease transmission. It can also encourage the community by teaching them proper waste sorting management, reducing expenses. Optimizing their resources will significantly increase waste management facilities. Schools.

This study can help improve school waste segregation and prevent trash from being left on school property. It can also be implemented in the classroom, giving pupils infinite knowledge from this research on environmental sustainability and technology. Since the study and product relate to their strand, incorporating it into the STEM curriculum can promote experiential learning in electronics and programming. This study can help households segregate the waste in their homes. Utilizing automatic garbage can decrease the manual labor required by households for garbage sorting, resulting in increased cost savings and productivity. This study can also teach the family in the household correct waste sorting management. Future researchers. This study can be helpful as guidance for conducting research similar to investigatory. They might get inspiration for their study from it. It can benefit the system's low cost and the product's availability, which make it a valuable device for researchers working in a resource-mannered environment and facilitate elevation in sustainable waste sorting management exercises.

Scope and Delimitation of the Study - This research aimed to produce an Arduino Uno-based waste sorting system for metal and non-metal waste that could be implemented in homes and other environments where waste segregation has become an issue. This research distinguishes between standard waste products, including glass, metal, paper, plastic, and organic rubbish, using sensor capabilities. Listening to the sound lets People determine whether the trash is correctly sorted. A sound indicates that the garbage is in the correct category, while no sound indicates it is in the wrong category. Furthermore, this study aids in cleaning up and rectifying incorrect waste segregation in homes, workplaces, communities, and other areas. Additionally, this study helped clean up and rectify incorrect waste segregation in homes, workplaces, communities, and other settings. The system could collect data on waste composition and provide valuable insights for waste management strategies. It could educate people about waste segregation and promote sustainable waste management practices. The study's limitations were that it limited the waste categories to those often used and included only the metal and non-metal categories. The system might have required a constant power source, limiting its usability in remote locations. It might not have been able to handle hazardous waste or other specialist rubbish types. By defining the scope and delimitations in

this way, the research intends to significantly contribute to producing an Arduino-based waste sorting system under the exact parameters of the study's constraints. The researchers conducted this science investigatory project at the Divine Word College of San Jose, Occidental Mindoro. It started in August 2023 and is to be completed in April 2024.

2. Methodology

Research Design - The study, which focused on an automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno, utilized an experimental research design to examine its effectiveness and functionality. As part of the design process, the automated plastic trash bin was compared to a traditional trash bin to identify any significant differences in hygiene and usability. The researchers modified the independent variable using the automated bin and compared it to the control group using the traditional bin. This experimental design allowed for establishing a cause-and-effect relationship and determining whether the automatic bin had any usability or hygienic benefits. By employing an experimental research design, this study aimed to provide valuable insights into the benefits and functionality of the automated trash bin with an alcohol dispenser compared to traditional bins.

Data Gathering Procedure - The researchers obtained primary data through direct observations. They carefully evaluated the equipment to make sure it was reliable and unbiased. They recorded all important information about the device's progress, predicting how well it would perform. To ensure accuracy, the researchers documented each stage and prepared the materials needed to build the product, including taking photos and videos. This thorough documentation allowed the researchers to analyze and interpret the data accurately. Additionally, they kept a detailed logbook to record any challenges or unexpected findings during the data collection process. Once the machine was completed, they tested its functionality and accurately documented all the information for accuracy. The experiment was conducted from January 26, 2024, to March 20, 2024, for coding, and from March 20, 2024, to March 23, 2024, for building the product. The data collection process involved recording various parameters such as the range, precision, efficiency, amount of waste, and amount of alcohol dispensed. Multiple trials were conducted within the given time frame to ensure reliable results. The data was then analyzed to identify patterns and make necessary improvements to optimize the system.

Research Process: Stage 1 Preparation and Gathering of Materials - The product cost is eight hundred and twenty pesos (₱820). They purchased the remaining materials online, particularly those not available in the physical stores in the area. The materials needed to produce the automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno are as follows:

- For the machine: Arduino Uno, Arduino Uno Cable, Breadboard, Jumper Wires, PIR Motion Sensor - Power Bank, and Servo Motor.
- For cover and attachments: Alcohol Sanitizer, Copper Wire, Illustration Board and Plastic Trash Bin

Stage 2: Building and Development of the Project - The researchers focused on reducing contamination and spillage of trash in establishments by using an Automated Plastic Trash Bin with an Alcohol Dispenser using a PIR sensor and Arduino Uno. In this analysis, the PIR sensor was used to detect the hand, operating the product to keep it hands-free and reduce unsanitary practices. It detected the hand's movement and body temperature, making throwing trash seem easier. The PIR sensor also served as the key to telling the servo motors to function; the servo motors then made a strong pull and went in a preferred direction for both the dispenser and the plastic trash bin. This was made possible by the researchers' programming. They coded the pins and connected the circuits using jumper wires to the breadboard to process this. They then used male-to-female wires to increase the reach of the cables. After that, they assembled the parts until the product was created. As the product was finalized, the researchers still anticipated its improvements in the future. It took almost a month to finish the coding of the Arduino IE and three days to finish the case of the product.

Figure 1. Actual Product of Automated Plastic Trash Bin with Alcohol Dispenser Using PIR Motion Sensor and Arduino Uno

Stage 3: Experimental Stage, Observation and Data Recording - The researchers focused on producing an automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and an Arduino Uno. The researchers tested and programmed the sensor to see if it could manipulate the movements by sending signals to the servo motors while undertaking the production of other necessities. The researchers evaluated, tested, and observed the product to determine if it was accurate, precise, and efficient by directly observing the final product. The researchers utilized direct observations. Moreover, they were presented with the validated evaluation checklist after testing the device. Expert validity was done with the help of the professors at Divine Word College of San Jose. Testing the device and answering the validated evaluation checklist took two days.

Statistical Treatment of the Data - The statistical data analysis in this research study involved using various methods to assess the accuracy of an automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and an Arduino Uno. Descriptive statistical analyses such as frequency and weighted mean were employed to assess the accuracy of the automated trash bin across several parameters, including range, precision, efficiency, amount of waste, and amount of alcohol dispensed. The researchers also used Pearson's Sample Correlation Coefficient to determine the correlation between the PIR motion sensor's detection capability and the hand's distance. Additionally, the T-test was used to compare the automated plastic trash bin to a traditional trash bin.

1. Results and Discussions

Table 1

Mean level of effectiveness of an automated plastic trash bin with alcohol dispenser using a PIR motion sensor and Arduino Uno in terms of range, precision, efficiency, amount of waste, and amount of alcohol dispense

Indicators	4 (SA)	3 (A)	2 (DA)	1 (SDA)	Weighted Mean	Descriptive Indicator
The product is effective in terms of the detection capability of the PIR motion sensor in the automated plastic trash bin with an alcohol dispenser.	3	4	0	0	3.43	Strongly Agree
The product is effective in the correct operation of the alcohol dispenser mechanism in the automated plastic trash bin.	2	5	0	0	3.29	Agree
The alcohol dispenser mechanism in the automated plastic trash bin is efficient.	1	6	0	0	3.14	Agree

The product is effective in determining the amount of waste that can be stored in the automated plastic trash bin before it needs to be emptied.	2	5	0	0	3.29	Strongly Agree
The product is effective in quantifying of alcohol dispensed by the automated plastic trash bin.	2	5	0	0	3.29	Strongly Agree
Overall Mean					3.29	Strongly Agree

Legend: 3.26 - 4.00 Strongly Agree, 2.51 - 3.25 Agree, 1.76 - 2.50 Disagree, 1.00 - 1.75 Strongly Disagree

Table 1 shows the mean level of effectiveness of an automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno regarding range, precision, efficiency, amount of waste, and amount of alcohol dispensed. Results reveal that the product is effective and efficient in the detection capability of the PIR motion sensor in the automated plastic trash bin with an alcohol dispenser, effective in the correct operation of the product, efficient to use, and effective in determining the amount of waste that can be stored. Thus, PIR sensors are used for many purposes, including tracking wildlife movements and recognizing people. This is consistent with the findings of Mukhopadhyay et al. (2018), who discovered that the digital output of PIR sensors is also successful in outdoor applications despite their inability to work in outdoor environments.

Table 2

Pearson's Sample Correlation Coefficient r in terms of distance of the hand from the PIR Motion Sensor (m) and duration of detection (s)

X *distance of the person from PIR Motion Sensor (m)*	Y *duration of detection (s)*	xy	x^2	y^2
0.0254	0.57	0.01	$6.45x10^{-4}$	0.3249
0.0508	0.81	0.04	$2.58x10^{-3}$	0.6561
0.0762	0.85	0.06	$5.81x10^{-3}$	0.7225
0.1016	0.85	0.09	0.01	0.7225
0.127	0.80	0.10	0.02	0.64
0.1524	1.18	0.18	0.02	1.3924
0.1778	0.92	0.16	0.03	0.8464
$\Sigma\Sigma_x = 0.7112$	$\Sigma y \Sigma y = 5.98$	$\Sigma\Sigma_{xy}$ = 0.64	$\Sigma\Sigma_{x^2}$ = 0.089035	$\Sigma\Sigma_{y2}$ = 5.3048
Pearson's r Coefficient	r = 0.57			
R^2(Effect Size)	0.3249 or 32.49%			
t-value	0.519			
P-value	0.0063- Significant			

*Legend:x -distance of the person from PIR Motion Sensor (m) ;y – duration of detection (s) *Significant: p-value < 0.05*

According to the statistical result of the Pearson correlation coefficient, a moderately positive correlation has been found between the hand's distance and the PIR motion sensor's detection capabilities. The correlation coefficient, ranging from -1 to +1, demonstrates both the strength and direction of the relationship between the variables. In this instance, the correlation value of 0.57 indicates that the PIR motion sensor's time to detect and dispense alcohol grows in tandem with the hand's distance from the sensor. The p-value of 0.0063 proved the rejection of the null hypothesis. Therefore, there is a significant relationship between the detection capability of

the PIR motion sensor and the hand's distance. This means that the developed product can be affected by the PIR motion. Moreover, Yun & Lee (2014) suggested that the analog output signal of PIR sensors encompasses various factors beyond the mere presence of individuals. These factors include the distance between the body and the PIR sensor, the velocity of the movement (including direction and speed), and the individual's body shape and gait (the specific manner or style of walking).

Table 3

t-Test Results on Comparison of Time Taken for Throwing Waste

t-Test: Two-Sample Assuming Unequal Variances		
	Automatic Plastic Trash Bin with Alcohol Dispenser Using PIR Motion Sensor and Arduino Uno	Traditional Plastic Trash Bin
Mean	0.97	2.422857143
Variance	0.4388	0.14542381
Observations	7	7
Hypothesized Mean Difference	1.4271	
Df	10	
t Stat	-9.968858208	
P(T<=t) one-tail	8.1782E-07	
t Critical one-tail	1.812461123	
P(T<=t) two-tail	1.63564E-06	
t Critical two-tail	2.228138852	

Legend: *Highly Significant at p≤0.01 *Significant at p≤0.05

Table 3 shows the t-test results that provide a comprehensive analysis of the comparison between using the automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno and the traditional trash bin. The T-test results reveal a p-value of 0.000, less than 0.05 alpha level. This further supports the rejection of the null hypothesis. Therefore, there is a significant difference between the mean times of the two groups. Strong evidence to reject the null hypothesis is provided by the incredibly small p-values (8.1782E-07 and 1.63564E-06, respectively) for both the one-tailed and two-tailed tests. The observed t-statistic is higher (in absolute value) than the t-critical values for the one-tailed and two-tailed tests, which are 1.81 and 2.23, respectively. This additional evidence strengthens the case for rejecting the null hypothesis. The automated plastic trash bin is more efficient, with a significantly lower mean time for throwing waste and less performance variability than the traditional trash bin. According to Sohag & Podder (2020), the suggested waste management system is significantly more efficient compared to traditional methods by reducing the need for human work, stopping trash from overflowing, saving time, being economical, and functioning as a completely automated system.

3. Conclusions

Based on the study's findings, the researchers concluded the following: the findings from the data analysis provide strong evidence that the automated plastic trash bin with an alcohol dispenser using a PIR motion sensor and Arduino Uno is perceived as accurate and functional, as assessed by the researchers. A clear connection between the hand's distance from the motion sensor and the detection duration indicates a relationship between these variables. Moreover, the automated bin outperformed the traditional bin in terms of efficiency and performance, with significantly lower mean times for waste disposal. Overall, these results support the effectiveness and practicality of the automated plastic trash bin in improving waste management processes.

Recommendation - The following recommendations are based on the study results and the data collected. The researchers recommend that the school and establishments employ a stronger servo motor to serve two main

functions: aiding the trash bin's opening mechanism and ensuring efficient alcohol spraying capability. This recommendation lies in the necessity for a robust and powerful motor capable of effectively executing both tasks with precision and reliability. The researchers recommend that the users adjust the sensitivity of the PIR motion sensor to a level that does not detect incidental movement from passing objects or individuals near the trash bin. This recommendation aims to refine the sensor's settings to specifically target significant movements indicative of intentional interaction with the bin, thereby preventing unnecessary activations and optimizing its functionality. The researchers recommend using a larger battery to extend the operational duration of the trash bin. This recommendation stems from the acknowledgment that a larger battery capacity will significantly prolong the bin's usability, ensuring prolonged functionality and reducing the frequency of recharges or replacements.

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