E-Basura: A Solar-Based Automated Solid Waste Segregation Bin with Object Detection Using Arduino Uno

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Waste segregation is an effective method for minimizing the volume of waste and ensuring that garbage is properly managed. By classifying waste as biodegradable, recyclable, or residual, segregation facilitates the correct placement and disposal of materials, making collection and recycling more efficient. However, studies have shown that waste segregation is not always applied effectively in developing countries, such as Tanzania, where garbage is often mixed, leading to difficulties in recycling and disposal (Aleena et al., 2016). This lack of segregation at the source creates inefficiencies in handling and complicates the recovery of recyclable materials. As recycling remains essential in reducing waste volume, proper segregation at all stages of waste management is necessary.

Technological innovations have introduced intelligent solutions to address this problem. For instance, Jayson et al. (2018) described the development of a Smart Bin presented at the Second International Conference on Advances in Electronics, Computer, and Communications, which offers a practical and economical method of separating wet and dry waste. This system reduces the need for interpersonal contact while promoting efficient collection and disposal. Similarly, Angin (2018) proposed the Design and Development of the Trash Splitter with Three Different Sensors, which utilized infrared, metal, and light sensors to automatically detect and sort garbage into categories such as metal, organic, paper, and plastic. The design, based on system specifications and developed using the Arduino IDE, includes modules for detecting objects and sorting various waste types, thereby automating and enhancing waste management processes.

Advanced approaches using artificial intelligence and computer vision have also been explored. Shah et al. (2021) introduced a weakly supervised deep learning method (DCNN-GPC) for detecting and classifying waste objects from unlabeled Red Green Blue Depth (RGBD) images. This technique demonstrated that even with minimally annotated data, deep convolutional neural networks can significantly improve waste detection and classification, including identifying common items like plastic bottles, which often contribute to environmental hazards. The study emphasized the potential of AI-based systems in addressing large-scale waste segregation and management challenges.

At the policy level, Republic Act No. 9003 establishes the legal framework for solid waste management in the Philippines. This law emphasizes proper collection, storage, and disposal practices to safeguard public health and promote environmental sustainability. By enforcing structured waste management procedures, it provides guidelines that complement technological innovations in garbage segregation.

In line with these developments, the main objective of this study is to design a waste segregation system that efficiently determines the appropriate category of garbage and directs it to the correct bin. The proposed model employs a conveyor belt system with integrated sensors to detect, identify, and separate waste materials such as plastic, plastic bottles, paper, and metal. By combining practical design with modern technology, the system aims to demonstrate that garbage segregation can be made more effective, sustainable, and economically viable.

Theoretical Framework

AI and Deep Learning Approaches

Artificial intelligence and deep learning have transformed waste segregation by providing higher accuracy and adaptability compared to traditional sorting methods. Vo et al. (2019) introduced the DNN-TC model, an improvement of the ResNext architecture, which effectively classifies garbage images into organic, inorganic, and medical waste. By training on the VN-trash dataset of nearly 6,000 images, the model achieved a classification accuracy of 94% on Trashnet and 98% on VN-trash, surpassing state-of-the-art benchmarks. Such results prove that deep learning models are not only scalable but also adaptable to different datasets and waste categories. Similarly, Hu and Zhang (2021) demonstrated the practical application of TensorFlow and OpenCV in automatic garbage sorting. Their framework reduced reliance on human intervention and significantly enhanced sorting precision, making it more efficient and less hazardous compared to manual waste handling. Collectively, these studies highlight that AI-driven waste segregation is a step toward sustainable and intelligent waste management systems, with potential applications in both urban communities and industrial environments.

Sensor- and Arduino-based Systems

Alongside AI solutions, low-cost hardware-based approaches using sensors and microcontrollers have been widely explored for practical waste segregation. Durrani et al. (2019) developed the Automated Waste Control Management System (AWCMS), which uses Arduino microcontrollers, infrared sensors, GPS, and GSM modules. This system not only identifies the amount of waste in bins but also communicates the data in real-time, allowing for efficient collection scheduling and reducing unnecessary trips. Sunehra et al. (2021) presented another system using Arduino Uno that classifies waste into dry, moist, and metallic categories, with additional layers for paper and plastic segregation. This was further supported by Angin (2018), who proposed a trash splitter equipped with infrared, metal, and light sensors to separate metals, organics, paper, and plastics. These systems illustrate that sensor-driven models provide a feasible and cost-effective alternative for waste segregation, particularly in developing countries where resources are limited. While not as sophisticated as AI-based models, their affordability and simplicity make them highly practical for grassroots-level implementation.

IoT-Enabled and Smart Trash Bins

The integration of IoT (Internet of Things) technologies into waste segregation has added significant value by enabling real-time monitoring, data collection, and system automation. Pamintuan et al. (2019) introduced i-BIN, an intelligent trash bin combining machine learning and sensors to distinguish between biodegradable and non-biodegradable waste using over 2,000 samples. This system exemplifies how IoT can link waste classification with larger smart city infrastructures. Similarly, Baras et al. (2020) proposed a cloud-based smart recycling bin that achieved 93.4%

accuracy in sorting household waste, demonstrating the potential of cloud integration in ensuring centralized monitoring and data-driven collection strategies. Sohail et al. (2019) designed the Intelligent Trash Bin (ITB), which reduced waste collection costs by optimizing truck routes and minimizing human involvement through IoT-enabled sensors. Additionally, Ndakara et al. (2020) emphasized renewable energy integration by designing a solar-powered automatic waste bin that relies on ultrasonic sensors and microcontrollers for hygienic and sustainable waste management. Collectively, these innovations highlight how IoT-enabled systems combine efficiency, sustainability, and environmental consciousness, making them highly relevant for modern urban ecosystems.

Incentive-Based Waste Management Systems

While technology enhances accuracy and efficiency, behavioral compliance is equally important in ensuring effective waste segregation. Castro et al. (2020) addressed this gap by integrating Artificial Neural Networks with a reward system known as "Basura Advantage Points." Each time a user disposed of waste correctly, the system awarded points that could later be redeemed for tangible benefits. Despite achieving only 80% classification accuracy, the study demonstrated that public participation improved significantly when incentives were introduced. This highlights the role of psychological and social motivators in complementing technological solutions. Incentive-based systems encourage individuals to change their disposal habits, create a sense of responsibility, and provide measurable rewards for environmentally friendly behavior. Such approaches are particularly effective in urban communities where behavioral change is often more challenging than technological adoption.

Educational and Policy Perspectives

Technology-driven systems alone cannot fully address waste management challenges without supportive policies and education. The Ecological Solid Waste Management Act (RA 9003) provides the legal framework for systematic collection, segregation, and disposal of solid waste in the Philippines, emphasizing both compliance and community involvement (Coracero et al., 2021; Paña-Tautho et al., 2025). Madrigal and Oracion (2017) expanded on this by stressing the importance of integrating waste segregation into school curricula and institutional practices, noting that early education fosters lifelong environmental awareness and sustainable habits. Mamarinta and Abarquez (2025) further confirmed that awareness campaigns and school-based interventions directly influence waste management practices among students and households. From a governance perspective, Effective waste management requires political will, adequate resources, and multi-stakeholder participation (Shamu et al., 2025; Debrah et al., 2021; Joseph, 2006; Salvia et al., 2021), particularly at the local government level. Soliman et al. (2025) reinforced this by showing how smart dustbin monitoring systems reduce manual labor while ensuring compliance with municipal policies. These findings underscore the importance of embedding waste management not only in technology but also in education, law, and governance frameworks to ensure holistic sustainability.

Research Framework

This study gathered data through a survey involving 30 respondents. The Slovin formula was used to determine the sample size, while a random sampling method was applied to distribute the questionnaires. The survey instrument was designed to assess four key aspects: correctness, speed, functionality, and operational ability. A four-point Likert scale was employed, with the following response categories: Strongly Agree, Agree, Disagree, and Strongly Disagree. These options provided the basis for respondents' answers to each survey item.

Table 1

Characteristics of solid waste materials

Waste	Characteristic
Paper	Made of wood pulp or another recycled paper.
Plastic Bottle	Made of polymers.
Plastic	Made of high-density polyethylene.
Metal	Made of atomic materials.

Table 1 presents the characteristics of the solid waste materials utilized in the system project. Understanding these characteristics is essential for designing an effective waste segregation system, as it allows the system to accurately detect, classify, and process different types of waste. Each material, such as paper, plastic bottle, plastic and metal, has unique physical properties, which influence how sensors and detection mechanisms respond.

Table 2

Characteristics of solid waste materials

Data Set	Description	Unit of Measurement
Paper	Width	Inches
	Height	Inches
Plastic Bottle	Height	Inches
	Weight	Grams
	Area	Inches
Plastic	Width	Inches
	Length	Inches
Metal	Length	Inches
	Width	Inches

Table 2 presents a set of data and the corresponding characteristics of the garbage based on the items thrown into the system. The table includes detailed descriptions of each item's length, width, height, and overall dimensions. Understanding these physical properties is essential for calibrating the system's sensors and mechanisms, ensuring accurate detection, classification, and proper placement of waste into the appropriate bins. By analyzing the dimensions of each waste material, the system can optimize its sorting process and improve overall efficiency and reliability.

Experimental Design

The experimental design of the study was developed to outline the process required to achieve the research objectives. It illustrated the logical flow of activities, from identifying the problem to evaluating the effectiveness of the proposed system. The first step in the design was to identify the problem, which focused on the challenge of properly segregating waste materials. The next step involved defining the objectives of the study and determining the appropriate recommendations that could address the identified problem. Data collection followed, as it was considered a vital step in creating a more effective system. Information was gathered both manually and from individuals with relevant expertise and background knowledge.

Once sufficient data had been collected, the researchers proceeded with the design phase, which presented the experimentation process and the integration of the gathered data into the proposed system. The data were utilized to guide procedures on how waste materials should be segregated into their proper bins. The analysis was conducted through machine learning techniques to ensure accuracy and reliability. The operational process determined whether garbage was correctly classified and directed into the appropriate bins, which played a significant role in validating the system's performance. The results of the analysis and segregation were displayed on a screen for monitoring purposes.

To assess the effectiveness of the system, questionnaires and test runs were conducted. The questionnaires were used to collect participants' feedback regarding the system's functionality, usability, and overall performance. Gathering opinions and suggestions from respondents was considered essential, as it provided insights into possible improvements and innovative features that could make the system more unique and efficient. Moreover, challenges and limitations encountered during testing were documented to identify areas that required enhancement. Feedback gathered from respondents contributed to the refinement and optimization of the system, ensuring that it operated smoothly and effectively.

Ethical Considerations

The study also took ethical considerations into account to ensure the welfare of both the users and the community. The waste segregation system was designed and tested with the intention of providing accurate detection and proper classification of waste materials. Users were expected to receive adequate training on how to properly operate the system and respond to alerts generated during its use. The system was required to be implemented and maintained effectively to maximize its benefits and minimize potential risks.

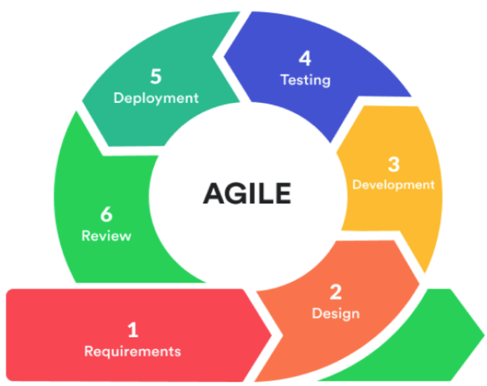
Safety and risk reduction were prioritized to ensure that the system consistently delivered positive results. Proper testing of waste segregation functionality was emphasized to improve accuracy and reliability. Additionally, user training was highlighted as a necessary measure to ensure smooth operation and to promote system longevity. By prioritizing effectiveness, efficiency, and sustainability, the study underscored the importance of building a system that could deliver long-term benefits to both users and the environment.

Modeling

Model selection was identified as a critical factor in the system's testing and development. It determined not only how testing was planned but also which available techniques would be applied. The researchers adopted the agile methodology for system development, as it was considered the most appropriate approach for the proposed project.

Figure 1

Agile method



The agile method allowed for iterative development, enabling the system to be constructed, tested, and improved before full deployment. This approach facilitated early identification of issues and provided opportunities for rapid resolution, thus reducing the risk of major errors during the later stages of development. By applying agile principles, the researchers ensured that the system was flexible, adaptive, and capable of addressing the needs of the study in a structured yet responsive manner. Ultimately, the agile method contributed to building a more reliable and efficient waste segregation system.

Procedures of the Different Phases

The procedural framework of the study on solid waste detection followed a structured series of phases, each contributing to the systematic development of the proposed system.

Design phase. The design phase involved defining the research questions or hypotheses and establishing the objectives and aims of the study. This step also included a comprehensive review of related literature to gain a deeper understanding of existing knowledge in the chosen field and to identify research gaps that could guide further investigation. The agile methodology was adopted, beginning with an analysis of system requirements. This ensured that the system incorporated essential details, aligned with user expectations, and met stakeholder requirements. The researchers also reviewed the necessary equipment and resources to guarantee that the project could be completed within the expected timeframe. The collected information served as the foundation for moving forward to the system's design and development.

Design development. During this phase, a simplified conceptual design of the solid waste detector was created. This design functioned as an outline or blueprint that illustrated the primary features of the system. Although it did not yet present the complete technical details, it served as a preliminary model that allowed researchers and potential users to visualize the system's intended functions.

System development. In the development phase, the researchers constructed a working prototype of the solid waste detector. This stage involved programming specific activities and tasks to enable the system to perform its intended functions. The prototype acted as a representation of the final product and provided a near-conclusive demonstration of how the system would function under real conditions.

Testing phase. After development, the prototype underwent rigorous testing to determine its operational effectiveness. The researchers observed potential errors, identified weaknesses, and resolved issues that could hinder performance. The testing process ensured that the solid waste detector functioned reliably and accurately, eliminating major flaws before publication and final deployment.

Deployment phase. In this stage, the system was considered fully functional and ready for field application. Deployment demonstrated the overall functionality of the solid waste detector, confirming that it met user requirements and performed as expected in practical scenarios. This phase also provided validation that the system was capable of delivering accurate results in real-world waste segregation tasks.

Review phase. The final stage involved gathering user feedback and evaluating the system's overall performance. This stage highlighted user ratings and perceptions of the system's functionality, reliability, and usability. The review process not only assessed the degree to which the system met user expectations but also provided valuable insights for future improvements. Ultimately, this phase confirmed whether the solid waste detector could be highly recommended for broader use.

Technical Framework

Materials

The software and hardware were required for the development of the product. This section defines and explains how they were used in the system's processes.

Software

Table 3 shows the software used in creating this project.

Table 3

Software requirement

Software	Description
Arduino IDE (Code Editor)	Contains a text editor for writing codes, a message area, a text console, a toolbar with buttons for common function. Arduino IDE latest version 1.8.19
Operating System	A Microsoft Windows operating system that run into 64 bit architecture used in the development of the system.
PyCharm IDE	Is a essential tools for python developers, tightly integrated to create a convenient environment for productive Python. PyCharm Ide version – 2022.3.3

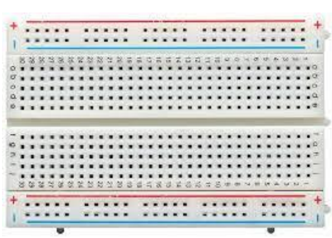
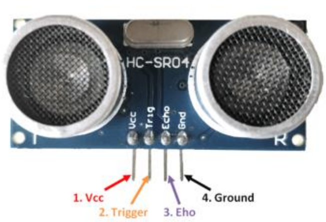
These software components were used in the system project to operate the waste segregation system effectively. They enabled the software elements to perform their tasks in coordination with the hardware components. The most critical aspect of the system was the code, which executed specific functions and ensured that the system operated smoothly and efficiently. Properly designed software played a key role in maintaining the system's performance and achieving accurate and reliable waste segregation.

Hardware

Table 4 shows the hardware used in creating this project.

Table 4

Hardware requirements

Hardware	Description/Specification
Desktop Computer	Core i5 500GB HDD 8 GB Ram
Arduino Uno 	It is a microcontroller board. Specs: Microcontroller: ATmega328P Operating Voltage: 5V Input Voltage (recommended): 7-12V Input Voltage (limit): 6-20V Digital I/O Pins: 14 (of which 6 provide PWM output) PWM Digital I/O Pins: 6 Analog Input Pins: 6 DC Current per I/O Pin: 20 mA DC Current for 3.3V Pin: 50 mA Flash Memory: 32 KB (ATmega328P) of which 0.5KB used by bootloader SRAM : 2 KB (ATmega328P) EEPROM: 1 KB (ATmega328P) Clock Speed: 16 MHz LED_BUILTIN :13 Length : 68.6 mm Width: 53.4 mm Weight : 25 g
Breadboard 	It is used for building a permanent or temporary circuit. Specs: Full-size breadboard 830 holes Standard 2.54mm (0.1) spacing between two holes Dimensions 16.5x5.5.5cm Rating is 5Amps
Ultrasonic Proximity Sensor 	It is an instrument that measure the distance to an object using ultrasonic sound waves. Specs: Power Supply: DC 5V Working Current: 15mA Working Frequency: 40Hz Ranging Distance: 2cm – 400cm/4m Resolution: 0.3 cm Measuring Angle: 15 degree Trigger Input Pulse width: 10uS Dimension: 45mm x 20mm x 15mm

Hardware	Description/Specification
Jumper Wires 	It is an electric wire that connects circuits use for printed circuit board. Specs: Wire Quantity: 20 Length: 300mm / 30cm Connector Type: Female – Male/Male-Male/Female-Female Color: Combined
Servo Motor 	It is an electronic device and rotary or linear actuator that rotates and pushes parts of machine with precisions. Specs: Dimensions: 40.8 x 20.1 x; 38 mm Weight: 40 g Operating Speed: 0.18sec/60degrees (4.8V) 0.16sec/60degrees (14V) Stall Torque: 5kg.cm/69.56oz.in (4.8V) 6kg.cm/83.47oz.in(6V) Operating Voltage: 4.8V~6V Control System: Analog Direction: CCW Operating Angle: 360 degrees Required Pulse: 500us-2500us Bearing Type: 2BB Gear Type: Plastic Motor Type: Metal Connector Wire Length: 30 cm
Dc Motor 	It is a class of electrical motors that convert direct current electrical energy into mechanical energy. Specs: Operating Voltage(V): 12. Rated Speed (RPM): 200. Rated Torque(kg-cm): 1.5. Stall Torque(kg-cm): 5.4. Load Current (A): 0.3. No Load Current (A): 0.06.

Hardware	Description/Specification
Solar Panel board 	A solar panel is actually a collection of solar (or photovoltaic) cells, which can be used to generate electricity through photovoltaic effect. Specs: Item Type: Solar Panel Material: Monocrystalline Silicon+ABS Product Size: Approx. 21.5x18.5cm / 8.5x7.3in Weight: Approx. 321g / 11.3oz Waterproof Rating: IP65 Voltage: 12V Current: 1APower: 24W Conversion Rate: 23-24% Output: USB
Conveyor Belt 	Belt Dimension: 43.4 x 9x9cm LWH Chassis Dimensions: 46 x 10.5 x 11 LWH
Rechargeable Battery 	Capacity: 2.9AH Voltage: 12V Battery Type: Rechargeable Lead Acid Battery
Camera	HD ready (720p or 1280 x 720 pixles), full HD (1080p or 1920 x 1080 pixels),
LED Light 	Width: 15 mm Length: 48 mm Color: white Wattage: 0,60 W Voltage: 12 V

Table 4 specifies the hardware materials used in the system project. These components were essential for constructing the waste segregation bin. Among them, the inductive proximity and ultrasonic sensors were particularly important, as they played a critical role in detecting and identifying waste materials, ensuring that each item was placed in the correct bin. Additional hardware components were also incorporated to enhance the overall performance and reliability of the system.

System Design

In the system design, all requirements of the project, including both hardware and software, were incorporated into the operational framework. The system design also illustrated the overall system flow, demonstrating how each component interacted to achieve the desired functionality.

Figure 2

System architecture/design of a solar-based automated waste segregation

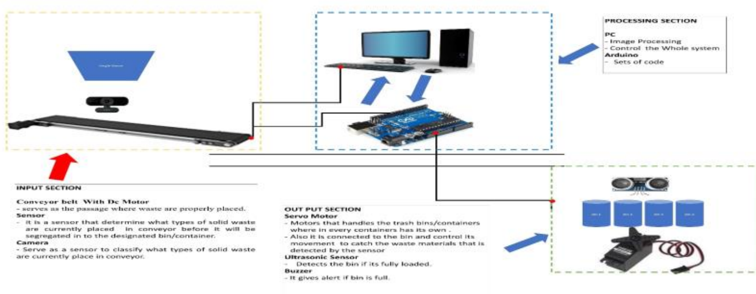
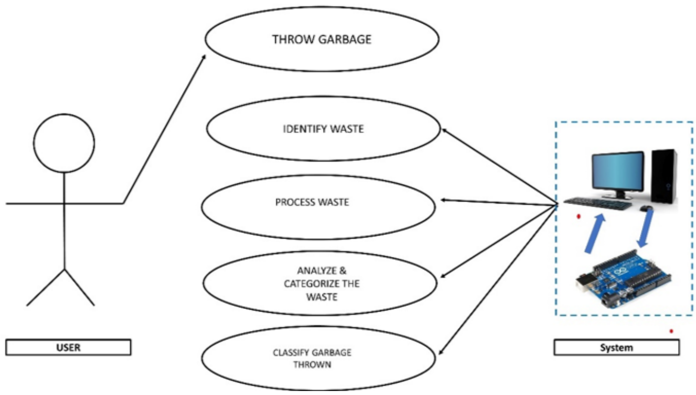


Figure 2 depicts the system architecture of the waste segregation system. The process begins when waste is placed into the funnel (one waste material at a time). The waste then moves along the conveyor belt, where the sensor detects and identifies the type of material. Based on this detection, the servo motor automatically directs the waste to the appropriate bin. The entire system plays a crucial role in waste segregation, as it is responsible for both detecting and accurately classifying the garbage.

The process is illustrated in the Use Case diagram in Figure 3, which provides a detailed overview of how the system classifies garbage.

Figure 3

Use case diagram of automated waste segregation



The system automatically identifies the waste provided by the user and executes a series of steps to analyze and process the input. These steps include detecting the waste, determining the appropriate bin for disposal, and directing the item into its correct location. This diagram highlights the sequential flow of actions that ensure accurate and efficient waste segregation.

Figure 4

Project system flow

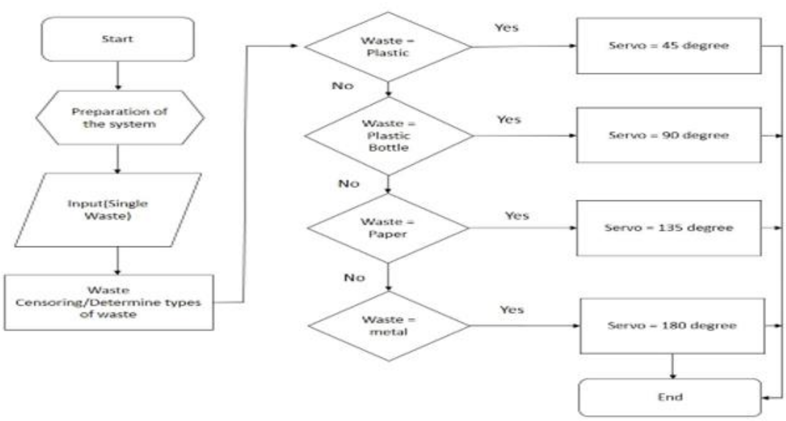
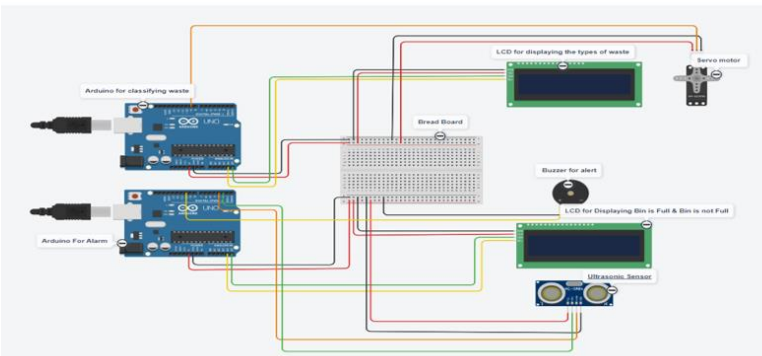


Figure 4 illustrates the system flow of the project, showing how the system functions and identifies waste materials. First, when the users activate the system via the switch, all hardware components become operational. Waste materials, one at a time, are placed into the funnel and then dropped onto the conveyor belt. As the waste moves along the belt, the sensors detect and classify the material. Based on this detection, the servo motor automatically directs the waste into the appropriate bin, ensuring proper segregation.

Figure 5

Circuit diagram of solar-based automated waste segregation



As shown in Figure 5, the system utilizes two Arduino Uno boards to perform its functions. The first Arduino is connected to a laptop, where the code is uploaded to control the detection of solid waste materials. The second Arduino is responsible for managing the notification alert or alarm, which indicates when a bin is full. Both Arduinos are connected to a breadboard to coordinate their tasks.

The system also includes two LCD displays: the first shows the type of solid material detected, while the second indicates when a bin is full. A buzzer functions as an alarm, set to a high volume to inform users that the bin has reached capacity. An ultrasonic sensor measures the level of solid waste stored in the bin. Lastly, a servo motor, also connected to the Arduino, performs rotational movements to position the bins correctly. The rotation is controlled by specifying precise angles in the code to ensure smooth and accurate operation.

Figure 6

Detailed circuit diagram of solar-based automated waste segregation

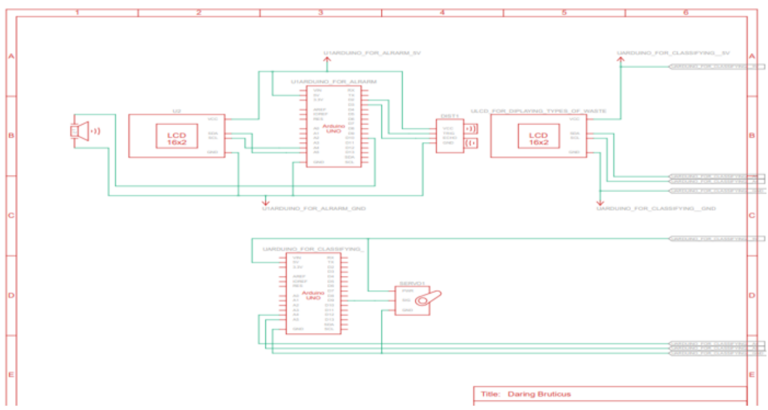


Figure 6 illustrates the detailed circuit diagram of the solar-based automated solid waste segregation system. This diagram provided users with a clear understanding of the system's operation. The main components included two Arduino Uno boards, a servo motor, a buzzer for alarms, and two LCD displays. In addition, software components were integrated to coordinate with the hardware, ensuring the proper functioning of the system. The circuit diagram played a critical role in demonstrating the function of each system component and their interaction within the overall system.

Figure 7 illustrates the completed waste segregation system. It represents the integrated output of both hardware and software components used in its development. The researchers also utilized recycled and low-cost materials to complete the project, making it a practical and cost-effective solution. This system serves as a reference for future researchers who wish to develop innovative and impactful studies on waste segregation.

Figure 7

Whole system/prototype of automated solid waste segregation bin

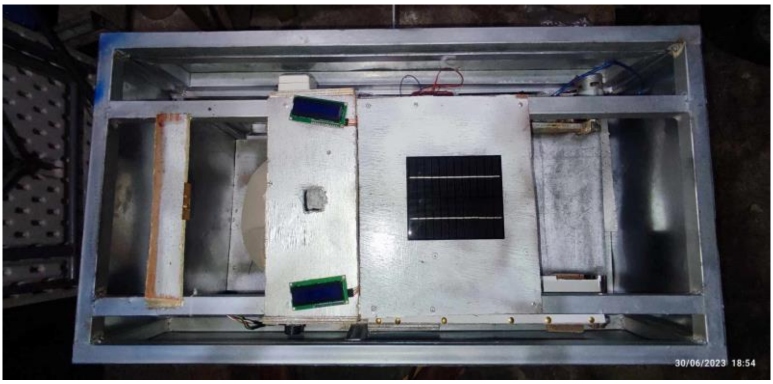


Figure 8

Plastic waste detected

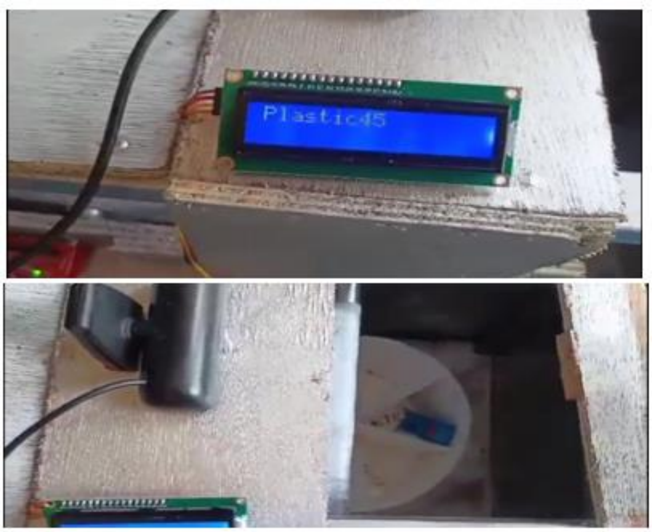


Figure 8 shows that the solid waste material tested was plastic. The camera successfully detected and confirmed the plastic as the targeted waste material. Based on this detection, the servo motor rotated to the specified angle to capture and direct the plastic into the appropriate bin.

Figure 9

Plastic bottle waste detected

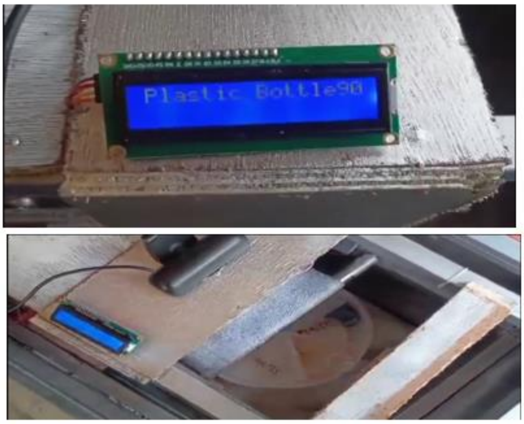


Figure 9 shows that the tested waste material was a plastic bottle. The camera successfully detected and confirmed the plastic bottle as the targeted solid waste material. The servo motor then rotated to the specified angle to capture and direct the plastic bottle into the appropriate bin.

Figure 10

Paper waste detected

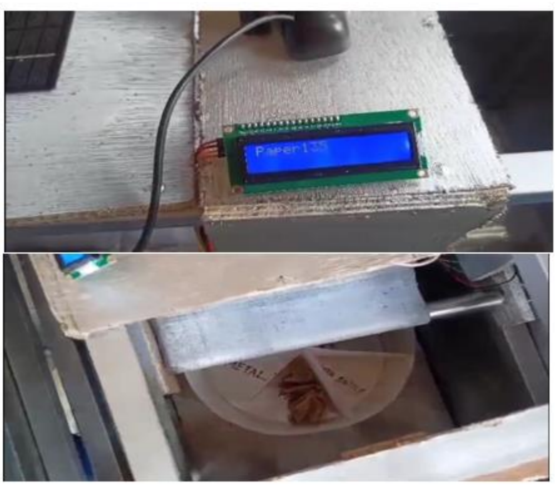


Figure 10 shows that the tested solid waste material was paper. The camera successfully detected and confirmed the paper as the targeted waste material. The servo motor then rotated to the specified angle to capture and direct the paper into the appropriate bin.

System Testing

System testing was conducted to evaluate the performance and functionality of the waste segregation system. Researchers performed manual testing to assess system quality, detect errors, and identify potential failures. Each component of the system was tested individually and collectively to ensure proper operation. The identification of errors during testing was crucial, as it informed improvements and refinements to enhance the system's performance. This approach allowed researchers to validate the system's effectiveness and prepare for subsequent testing cycles efficiently.

The system's operation was the primary focus during testing, guided by the system design specifications. The system was simulated, and the outputs were compared with expected results to validate functionality. All requirements defined in the model were used as benchmarks for testing. Validation of the system output confirmed that the proposed system operated correctly and met its intended objectives.

Regular inspection and maintenance were essential for the effective functioning of the waste segregation system. Routine checks ensured that sensors, conveyor belts, and servo motors operated correctly and remained clean, preserving system efficiency and reliability. Proper maintenance also contributed to the system's longevity and ensured that all components functioned optimally. Daily inspections and user training enhanced system performance and promoted responsible operation. Furthermore, maintaining high-quality parts and proper handling provided by users contributed to the accuracy and reliability of the waste segregation system. Overall, these procedures ensured that the system operated smoothly, delivered consistent performance, and maximized user benefits.

System Evaluation and Testing

This section presents the overall results of the survey conducted with 30 respondents. The questionnaire assessed the system based on four key aspects: correctness, speed, functionality, and operational ability.

Table 5

Weighted mean distribution of the criteria for the developed system

Criteria	Weighted Mean	Remarks
Correctness of waste Segregation	3.80	Strongly Agree
Speed	3.18	Agree
Functionality	3.82	Strongly Agree
Operation Ability	3.80	Strongly Agree
Average	3.65	Strongly Agree

Table 5 presents the evaluation results of the system, which achieved an overall average weighted mean of 3.65. This indicates that the respondents generally rated the system positively in terms of correctness, speed, functionality, and operational ability, demonstrating that the system was capable of performing the required tasks.

In terms of correctness, the system performed appropriately and accurately, with waste segregation carried out flawlessly. The average weighted mean for correctness was 3.80, corresponding to the remark "Strongly Agree," indicating that respondents were satisfied with the system's performance.

Regarding speed, the system functioned with proper acceleration, although some observations noted minor timing inconsistencies. The average weighted mean for speed was 3.18, with the remark "Agree," showing that the system performed satisfactorily in this aspect.

The system was highly functional and beneficial to users, serving as an effective tool for proper waste segregation. The average weighted mean for functionality was 3.82, with the remark "Strongly Agree," reflecting its positive impact.

Finally, the system operated accurately and reliably, providing users with a clear understanding of proper operational procedures. The average weighted mean for operational ability was 3.80, with the remark "Strongly Agree," confirming that the system performed its tasks efficiently and effectively.

The researchers employed an overall system changeover scheme to implement the prototype effectively. Although the prototype functioned properly in waste segregation, alternative methods were considered for situations where certain waste materials could not be easily detected. This contingency ensured that the system could maintain accuracy and efficiency under varying conditions.

Economic feasibility. Economic feasibility was evaluated by examining the system's projected costs relative to its benefits. The assessment of advantages and disadvantages provided insight into the system's cost-effectiveness and overall value. This analysis allowed for a comparison of the system's performance and benefits against its implementation costs.

Technological feasibility. Upon project completion, feedback indicated that the materials used were cost-effective and well-designed, making the system accessible and useful to many people. The evaluation highlighted areas where materials could be further improved to enhance the system's uniqueness and overall performance.

Operational feasibility. The developed system proved to be operationally feasible. It was user-friendly, allowing users to operate it effectively and with satisfaction. Evaluations and surveys confirmed that users could easily understand the system's functions, and proper demonstrations ensured that clients were able to use the system correctly. The findings demonstrated that the system could be successfully deployed and maintained in real-world conditions.

Conclusion

Proper waste segregation is essential for maintaining cleanliness and environmental health, and the developed waste segregation system using Arduino Uno proved to be an effective solution for this purpose. The system successfully integrated hardware and software components, including sensors, a conveyor belt, and a real-time alert system, to detect and properly categorize waste materials. Testing results showed that the prototype performed efficiently in terms of correctness, speed, functionality, and operational ability, demonstrating its reliability and user-friendliness. The system not only facilitated proper waste management but also promoted awareness and environmental responsibility among users. Its practical design, cost-effective materials, and ease of operation ensure that it can be widely adopted in schools and other communities, offering a sustainable and impactful approach to addressing solid waste challenges.

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