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Automated Trash Organizing Management System (A.T.O.M.S): Proposed Self-Segregating Trash Bins

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Abstract

Waste segregation is the process of sorting and separating different types of waste in order to permit recycling and proper disposal. Technology businesses are attempting to address the garbage problem from a variety of angles, including improving recycling systems and developing novel materials for compostable single-use items. However, many people today do not adequately separate their wastes, particularly in congested areas where people and transactions move at a rapid pace, such as malls, airports, local supermarkets, etc. The researchers propose a project termed A.T.O.M.S., or Automated Trash Organizing Management System, which is a Multi-sensorial Self-Segregating Trash Bin that will be made up of several electronic components, sensors, and computer languages, and automatically classifies the waste being disposed of into specific classifications. As part of this ongoing study, the initial testing of the prototype manages to perform its initial function by detecting the type of trash and segregating it accordingly and appropriately. The results will positively impact society since the waste management system is improved. Recommendations to modify the dimensions of some parts of the device and usage of alternative power were made. The implication of this research

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project is the contribution of innovative solutions toward waste management process enhancement.

***Keywords*:** waste management, segregation, innovation, experimental research.

Introduction

Humans produce a staggering quantity of garbage: about 2 billion tons each year, or over 4.5 trillion pounds yearly and that number is only going to rise. Global waste is predicted to amount to 3.4 billion tons by 2050 (*World Bank Open Data*, n.d.). Recycling is not a cure-all. Furthermore, there is a significant gap between what can be recycled and what is actually recycled. Dry recyclables such as plastic, paper and cardboard, metal, and glass account for 38% of municipal waste, but only 13.5 percent of that waste is recycled globally (Kaza et al., 2018). Technology businesses are attempting to address the garbage problem from a variety of angles, including improving recycling systems and developing novel materials for compostable single-use items. Even in developed countries, manual sorting may be necessary, and automated sorting systems using appropriate technology can supplement, if not completely replaced, manual sorting. Magnets, flotation, wind sifters (to separate light and heavy debris), and cameras, among other approaches, are used in automated sorting, and such equipment can be purchased off the market and integrated into recycling processes (Clifford, 2021).

Waste segregation is the process of sorting and separating different types of waste in order to permit recycling and proper disposal. Sorting your trash makes it easier to understand how to reduce your overall waste output, discover goods that can be reused, and set aside recyclable products. Beyond that, though, there is a moral obligation to be responsible with your

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trade waste management. Failure to properly segregate trade trash means it will wind up intermingled in landfills, just as it did in your bins. Food scraps, paper, and liquid waste can combine and decay, releasing run-off into the soil as well as toxic gasses into the environment (Davies, 2023). Citizen social responsibility (CSR) places the act of sorting your trash at the top of the list of personal responsibilities. Local governments advise residents to take responsibility for the rubbish they generate. When garbage is not adequately segregated, it all ends up in landfills. Waste segregation refers to the separation of wet and dry wastes so that dry trash can be recycled and wet waste can be composted. According to the Solid Waste Management Rules, generators are responsible for sorting waste into three categories: wet, dry, and hazardous. We must also physically deliver the three distinct categories to authorized collectors (Department of Environment and Natural Resources, 2018).

Biodegradable, non-biodegradable, plastic, cans, and paper are just a few of the options available to people when disposing of their trash. It is a reality that our planet is currently experiencing environmental issues such as global warming, flash floods, and so on. People's misconduct toward waste management, or what we call improper trash disposal, is a major contributor to these events. People who do not properly segregate their garbage and simply dump it away in inappropriate places are committing improper waste disposal. Every human being is obligated to properly dispose of their trash and categorize it according to their classification. However, it has been observed that many people do not properly segregate their trash, particularly in congested areas where people and transactions move at a rapid pace, such as malls, airports, local supermarkets, etc., and where wastes are not properly disposed of despite

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trash bins having signage to easily classify trash before throwing it in. This is the problem that the researchers hope to address with their project proposal, which will allow trash bins to detect the type of waste and deposit it in the appropriate classification without the need for human intervention. This can be accomplished by developing a device characterized as a Multisensorial Self-Segregating Trash Bin. Through the use of several electronic components, sensors, and computer languages, this system automatically classifies the waste being disposed of into specific classifications.

Since the project proposal and the prototype are meant to improve the country's segregation system using automation and as little human intervention as possible, its development will be particularly beneficial to the community, dynamics, environment, waste management, and future researchers. The researchers discovered that just labeling trash cans does not guarantee proper waste separation for recycling and other purposes. As a result, the proposal's output should create a waste segregator system that can automatically segregate waste accordingly to their types; ensure the minimal risk from hazardous waste to the environmental conditions and human health; accelerate the extensive time required to segregate waste manually; develop an innovative disposal of waste at the source itself instead of relying on the large scale of industrial waste segregator; and to promote a cheap and easy to use solution for an automated process in order to make the segregated waste be processable already.

The scope of this proposal is to develop a device that can maintain cleanliness as it evolves through automation. It comprises the design of proper waste segmentation into several categories soon after disposal in trash bins (plastics, metals, dry waste, wet waste, etc.).

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Furthermore, the design of the bins allows individuals to determine whether they are empty or full due to the sensors within them. The researchers conducted and evaluated this project in an accessible area where trash bins are normally situated. The researchers adapted the Raspberry Programming Language to create programs that will power the device's mechanism. Due to the item being a prototype rather than a fully manufactured unit, the design is admittedly not ergonomic or well-designed. The design of the device will only allow one trash at a time to segregate it properly for the initial testing of its functionality which will be used by the researchers as basis for its development and future production. The project's sole goal is to produce a device that does not require the use of respondents or questionnaires.

Materials and Methods

The researchers used the experimental technique in this research proposal. First, the researchers designed and created the device in accordance with the study's goal. The researchers then conducted experimental testing to determine the device's performance, and based on the findings of the experiments, conclusions and recommendations were drawn. This part explains the materials used, the designed process and framework, and the costing.

Materials/Internal Parts

1. Power Supply - 9V-12V adapter will be used for the prototype to function properly. Compared to batteries, it will cost a lot and sometimes it also affects the system performance when it loses charge.

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2. Raspberry Pi - a credit-card sized microcontroller that allows users to learn basic computer science such as robotics. This will be the main source of movements of the product. It serves as the brain of the prototype. It has both digital and analog for both input and output for interfacing the components and circuits that are required for the system of the prototype.
3. Servo Motor - Servo motor functions in the prototype for proper segregation. It is attached to the arm of the prototype. It is used to separate a certain material to either plastic bottles or aluminum cans. It can be used to position the motor shaft at a specific position or angle.
4. Inductive proximity sensors- Inductive sensors will be used for the detection of conductive objects such as metals and carbon. It operates by producing an oscillating electromagnetic field, the sensor is able to detect changes to this field due to the presence of a conductive material.
5. Capacitive Proximity Sensor - Unlike the inductive proximity sensor which operates by producing an oscillating electromagnetic field, capacitive sensors produce an electrostatic field. Thus, it can detect both metallic and non-metallic objects. Capacitive sensors have the ability to adjust or change the threshold level of the oscillator. In this method, the accuracy of certainty of an object will increase.
6. Ultrasonic proximity sensor - An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. Thus, it can differentiate whether the object is plastic or other material. It can also function to detect the level of a certain area such as the water level and storage level of a bin.

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7. TFT Screen Display - It is a type of display where the graphical user interface (GUI) will be displayed. This will allow the microcontroller to show the status of the system such as the number of plastic bottles collected or if the bin is already full.
8. Other Materials: Wires (Male to Male, Female to Female, Male to Female, Solid Wires), Casing, Arm (connected to Servo motor. Used to segregate the trash) and Trash bins.

Materials/External Parts

1. Enclosure - is made up of the chassis and the outer covering or casing. It is made up of aluminum metal and its assets are considered medium-life assets, which means only consisting of roofs and walls. Its main purpose is to keep the inner environment isolated from the outside environment.
2. Chassis - is the system's back framework that structurally supports the installment of the circuit boards and other electronics for the system. This is where the power supply, wirings, and control circuit are. It is mounted in an enclosure that protects the whole system from the outside environment.
3. Open Top - The Automated Trash Organizing Management System (A.T.O.M.S) has an open-top mechanism, meaning without a lid. This is where the trash will be put and transferred into the sorting section. This type of bin top makes throwing waste quickly, easily, and more sanitary as there is no need for contact for opening a lid.
4. Automated Dispenser - is programmed to release trash into the appropriate category. The sensor system, servo motor, motor shaft, and conveyer belt are all part of it. It operates by relaying the findings of the sensors that have been installed and employed in the system,

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such as Inductive Proximity Sensors, Capacitive Proximity Sensors, and Ultrasonic Proximity Sensors, to the servo motor. This is where the segregation and transportation of waste occur.

5. Trash Bins - The trash will be sorted and placed in the Trash Bin. Wet Goods, Dry Goods, Plastics and Glass, and Metals were the four (4) categories. It uses an Ultrasonic Proximity Sensor to measure the storage bin level and sends a notification and warning to the screen display when it is nearly full. This is where the handling, disposal, and monitoring of waste occur.

Figure 1:

A.T.O.M.S. External Parts

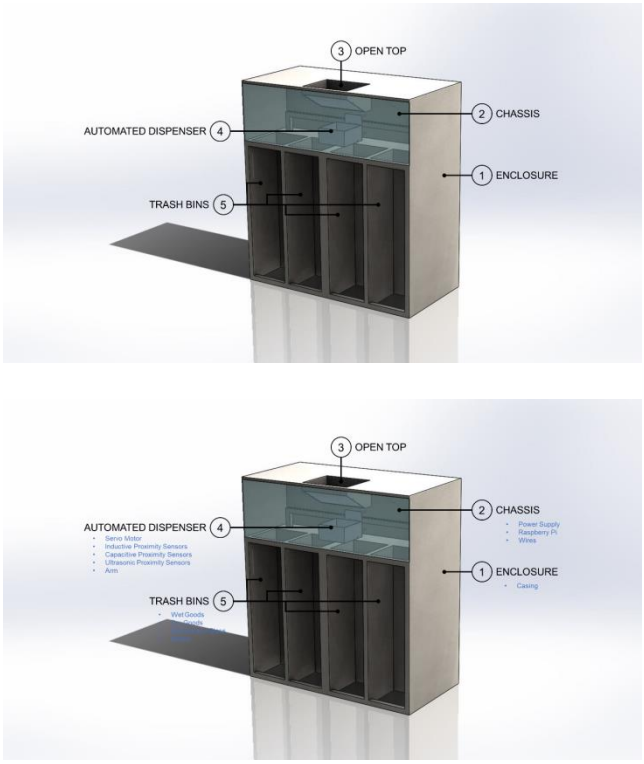

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Figure 1 shows the external parts and the actual configuration of the Automatic Trash Organizing Management Systems (A.T.O.M.S.)

Experimental Process Set-up

The Input-Process-Output (IPO) Conceptual Framework was used in this experiment. Different waste materials will be placed in trash bins by design. The sensors will assess the waste's classification and place it in the appropriate location depending on that classification. An additional sensor is installed to determine whether the trash bins are already full. The sensors' signals will be transferred to a laptop or desktop computer for correction.

1. Input - A variety of wastes will be the device's primary input. Solid and liquid wastes will be separated from this waste. Solid waste is divided into four categories: plastic waste, metal and tin garbage, paper waste, and ceramic/glass waste.

    a. Plastic - is material consisting of any of a wide range of synthetic or semi-synthetic organic compounds that are malleable and so can be molded into solid objects.

    b. Metal and tin - steel can, tin can, tin, steel packaging, or can is a container for the distribution or storage of goods, made of thin metal. The cans hold diverse contents such as food, beverages, oil, chemicals, etc.

    c. Paper - a thin material produced by pressing together most fibers of cellulose pulp derived from wood, rags or grasses, and drying them into flexible sheets. It is a versatile material with many uses, including writing, printing, packaging, cleaning, decorating, and a number of industrial and construction processes.

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d. Ceramic and glass - a solid material comprising an inorganic compound of metal, non-metal or ionic and covalent bonds. Common examples are earthenware, porcelain, and brick. The crystallinity of ceramic materials ranges from highly oriented to semi-crystalline, vitrified, and often completely amorphous.

2. Process - This section covers the whole program flow in the project. It displays the various components of the program, which are organized per function. The system and flow are discussed in detail below:

a. Gather the needed materials for the project.

b. Design the project according to its purpose.

c. Once the design is done, load cells and inductive sensors are installed into it.

d. The sensors installed are arduino uno.

e. After being installed, connect it to a laptop or desktop.

f. Program the sensors in accordance with its purpose.

g. Initialize ports for the following:

h. Inductive Sensor

i. Arm Location Indicator

j. Run System Diagnostics

k. If system diagnostics is rated passed, proceed to step m.

l. If system diagnostics is rated not passed, return to step h.

m. Go to inductance measurement.

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Figure 2:

System Flowchart of A.T.O.M.S.

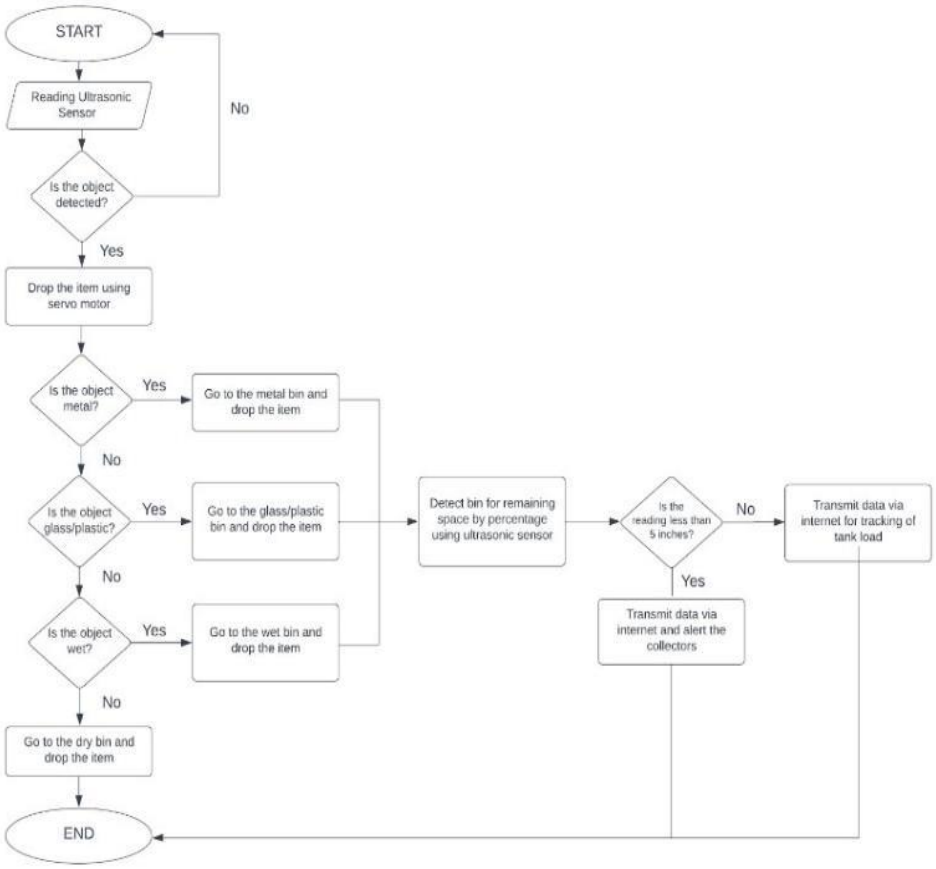

Figure 2 shows the flowchart that is followed for the implementation of the process of the A.T.O.M.S. system.

3. Output **-** Using several types of proximity sensors, an automated and properly segregated waste system was created. There will also be a graphical display on the screen showing the current state of each waste container.

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Results and Discussion

The researchers then conducted experimental testing to determine the device's performance, and based on the findings of the experiments, conclusions and recommendations were drawn.

Results of Initial Testing

The research team put the device to the test with various forms of waste to see if it could sort it into the following categories: metal, plastic, glass, dry goods, and wet products. Although the testing was successful, because the waste was placed one at a time, the device had difficulty detecting the type of waste when multiple types of waste were placed at the same time.

Conclusions

Based on the findings that were acquired, it was therefore conclude that it is efficient to use the Automated Trash Organizing Management Systems or A.T.O.M.S. in helping to reduce waste as a climate action, developing alternate solution to responsible consumption and production of materials eventually turned into waste, and as providing good health and well-being to everyone by means of automated segregation of trashes compare to the typical disposal of garbage.

Recommendations

Based on the conclusions obtained, the following recommendations are made:

1. The design of some of the parts of the prototype should be modified as follows:

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a. The open top should be widened to allow bigger trash to enter the device to the dispenser; and

b. For the reason described in letter (a), the dispenser should be redesigned also to have a wider area;

2. Modifications of the program should be made in order to detect segregation of recyclable and not recyclable plastics and glasses inside the trash bins; and

3. Since the prototype is connected to a Direct Current voltage output and actually needs more power, future researchers should try to innovate the project by adding solar panels or renewable sources of energy.

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