Solar Powered Reverse Trash Vendo Machine

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Abstract *–The study was conducted with the purpose of developing a Solar Powered Reverse Trash Vendo Machine that aims to encourage people to engage in recycling and to diminish the practice of improper waste disposal in thePhilippines. The device used a Gizduino X ATMega 1281 as its main processing module along with a Gizduino 644 microcontroller board, anda GSM Shield module for communication. Arduino1.6 IDE is used to program the Gizduinoboards. The device is powered by a 15V rechargeable battery, which is charged by a solar panel retrofitted at the roof of the device, this is to promote energy conservation, and green engineering principles in the development of the study.The device can process empty plastic bottles (500ml. max) with a base diameter of 3.5 inches, and aluminium cans. These recyclable materials are placed inside the machine and is scanned, then crushed and placed in a bin. An inductive sensor is used to detect either the material is a plastic bottle or an aluminium can. To compensate the user for recycling, an equivalent monetary value will be dispensed. The owner of the device can check the status of the coin dispenser and bins through an Android messaging application developed using the Eclipse IDE and the Java programming language, and when a certain limit is reached by the coin dispenser or the trash bins, an automatic text message notification will be sent to the owner.*

Keywords *–Green Engineering, Solar-Powered, Recycling, Reverse-Vendo Machine.*

INTRODUCTION

Waste management has been a major concern in the Philippines for years. Rapid increase in population, increasing consumption and urbanization are the leading causes of the ever growing waste production in the country. Heaps of solid waste are produced per day and only a few percent of these are reprocessed and re-applied. Recycling is one proven path to control problem in the country, but most of the citizens are unconscious of recycling waste products for there is no legal provisions for not recycling. In a study by Ultra et al. (2013) the main obstacle in solid waste management is the deficiency of sufficient attention given by the local government in focusing the waste management problem [8], as discussed also by Irene [5]the problem of solid waste is due to the absence of strong waste management system and wide participation of the stakeholders involved. Recyclable materials like paper, plastic bottles and aluminum cans are often found on dumpsites instead of being recycled and re-used. The raw materials used in the production of these things amplifies the problem even more by depleting the very few natural resources that are left in the country.

According to Boehlke [3] it is imperative to understand the essentials of recycling so that the garbage can be disposed of properly when it does end up in landfills. In the discussion of Cortez et al. [4] with the increasing waste and diminishing number of landfills, it is important to cut waste, particularly now that the environment is suffering great damage due to fast-paced industrialization. One long-approved way to reduce waste is to recycle.

In the manuscript of Behera et al. [2] it is stated that green engineering integrates improvement and application of products, processes, and systems that meet technical and cost objectives while safeguarding human health and welfare, green engineering alters existing engineering disciplines and practices to those that lead to sustainability. As discussed by Wakter et al. [9]solar power is a swiftly developing energy source; as efficiency increases and costs decrease, solar cell systems are becoming increasingly appealing for small and medium scale consumers to invest in Wakter, and Wikerman[9] and cited also by Greenpeace (2013)the Philippines benefits from a long, hot summer period guaranteeing it an economical benefit in terms of solar power applications, with an average solar emission ranging "from 128 to 203 watts per sq.m. or an average of 161.7 watts per sq. m.", there is a possibility to create 4.5 to 5.5 kWh/m^2/day in the country [10] and also discussed by Ahmed (2012) production and use of

photovoltaic cells to generate electricity is an increasingly popular resource solution [1].

In the discussion of Sean (2011) a reverse vending machine (RVM)is an innovative concept which has been introduced to western countries to help collect recycling materials and hence, to boost recycling activities [6], also as stated by Thomas [7] the environmental benefits of reusing our waste are known, the long-standing, small-scale recycling is now getting a modern revamp with the widespread introduction of reverse vending machines.

Thus, the proponent come up with the Solar Powered Reverse Trash Vendo Machine (SPRTVM), with the primary aim of the study is to diminish the practice of improper waste management by providing incentives as a reward for proper disposal of waste materials. This also provided the proponent the opportunity to implement green engineering to the development of the prototype. The Solar Powered Reverse Trash Vendo Machine is a microcontroller based system that employs the ideas behind green engineering and uses solar energy for power and self-sustainability. The project applied different sensors to detect the type of material which is going to be disposed, the material may be classified as plastic, or can. The project dispenses an equivalent amount of the deposited recyclable material. With the utilization of this machine, the amount of recyclable materials which are not being recycled can be lessened and in return may help in lessening improper waste disposal in the country.

OBJECTIVES OF THE STUDY

The purpose of this project is to develop a prototype of a reverse vending machine intended to lessen the improper waste disposal habits of our citizens. It also aims to exhibit the use of modern technology to promote recycling, energy conservation, and green engineering. The following are the specific objectives of the researcher:

- Develop sensors that can properly detect the solid waste inputs (plastic bottles and aluminum cans).
- Implementa solar panel as the primary power source of the system that will be stored in a 15V battery pack.
- Integrate the crushers and coin dispenser to the Arduino microcontroller for the pressing of the bottles and cans and dispensing the correct amount of coins respectively.
- Program the Arduino microcontroller that incorporates a GSM module and Android Messaging Application.

MATERIALS AND METHODS

The paradigm of the study discusses the procedure in constructing the SPRTVM. This system would help to reduce the amount of trash that people discard and dispose improperly by giving them incentives every time they use the system. The researcher will use several components to create the expected output. The input consists of the software one of which is the Arduino v1.6 IDE that must be compatible with the hardware components that is used especially the Gizduino v3.

While the hardware consists of a crusher that is used to crush the recyclable materials to maximize the space of the bins, sensors for the aluminium cans and plastic bottles. When the proposed project is finished, it must be fully working and users should be able to use it with ease and no fear that they won't get the incentive they deserve.

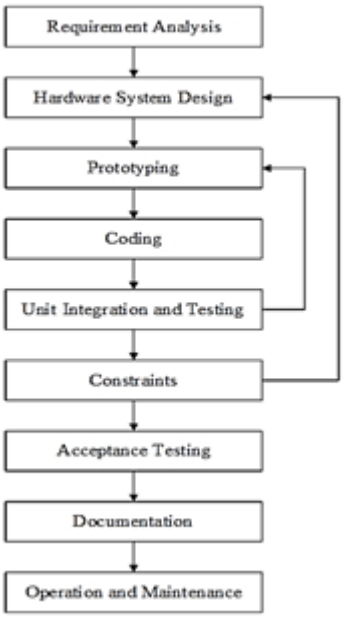

Fig. 1. Project Development

Requirement Analysis

The proponent started the project by researching about the different ways on how to convert solar energy to power with the use of solar panels. The proponent also researched the different kinds of sensor to be used to identify the input material properly, how to program

different microcontrollers to be used and integrate it with sensors, servo motors, GSM module configurations and LCD display.

Hardware System Design

The main goal of the hardware system design is to generate the appropriate design suited for the project. This design includes the mechanisms of servo motors, the motion and handling of the crusher, the flow of the input material through the bins, the dispensing of coins, and lastly, the packaging of the whole project.

Prototyping

The prototyping was done in order for the proponent to validate if the project works in proper condition. Furthermore, it functions as a testing and fault finding step so that errors would be determined and corrected. Prototyping also serves as the refining and finalizing stage of the project.

Coding

The proponent developed a program on how to integrate the sensors, servo motors, GSM module, and LCD display, and on how the sensors is correctly identify the trash that has been scanned into the microcontrollers.

Unit and Integration Testing

The proponent tested each circuit and program to determine if it is working properly. The proponent tested to see if there are errors in the program and circuit so that the proponent could plan how to solve the sighted problem. The proponent used a digital multimeter as testing instruments to test if there is something wrong with a voltage regulator to check if it reaches the required voltage for the whole circuit. Also the proponent verified the system if it delivers the optimum yield required and if it functions suitably all together.

Constraints

The proponent encountered some constraints while doing the proposed project. Some constraints were on the hardware part of the project specifically for the construction of the proposed project. There were also constraints on the program used for the simulation and also the program for the microcontroller module. Several testing was done to patch-up the constraints found and to have smooth running devices which compose the proposed project.

Acceptance Testing

It is the concluding step of the system wherein the project was tested by other users and checked if the system accomplishes its purpose and the problems that was encountered.

Documentation

In every development, the adjustment in every portion of the project was documented in this section. It also includes the theories, the description of materials used, flowcharts, project developments, and other components of documentation.

Operation and Maintenance

This is where the operations and maintenance on the project was being stated and maintained for further improvement and innovation. The system should be checked at least every two (2) weeks to verify if the system and the prototype is functioning properly.

RESULTS AND DISCUSSION

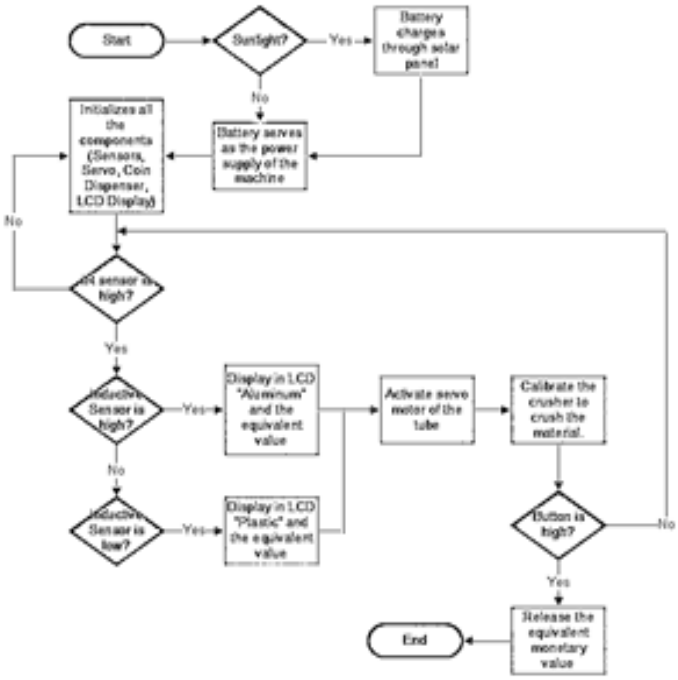

Fig. 2. System Flowchart

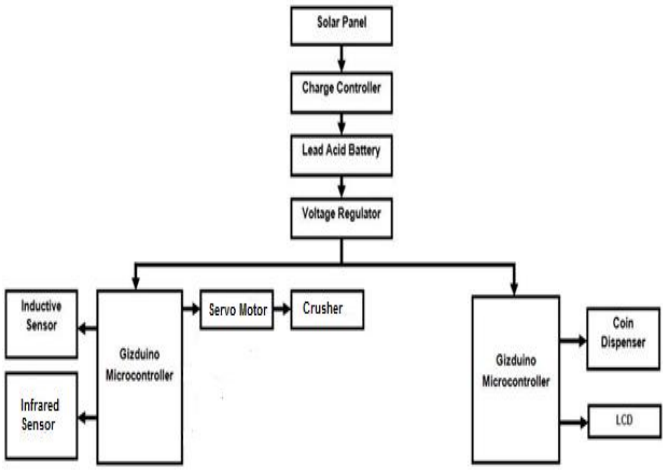

Fig. 3. System Block Diagram

The figures show the setup and operation of the entire system. It is composed of a Gizduino X, Solar Panel, Charge Controller, 15V Lead Acid Battery, Voltage Regulator, Inductive Sensors, Servo Motors, Coin Dispenser, and lastly the LCD Display. First, the solar panel charges the battery, then the voltage regulator attenuates the voltage to be fed to the Gizduino X which is connected along with inductive sensors to recognize the waste material, then the servo motor connected to the device will shift depending on what type of waste material has been identified. The LCD is used to display minor instructions and basic processes for the user.

The following steps were performed to test if the infrared sensor (both transmitter and receiver) and the inductive sensor can properly detect the inputs correctly.

1. Prepare two types of input; plastic bottle and aluminium can; also use two LEDs as indicators either the input is a plastic bottle or an aluminium can.
2. Scan both inputs, one at a time.
3. Observe what LED lights up different LED, different LED should light up for different input.
4. Do these procedures for 2 to 3 times for accuracy and reliability.

The following steps were performed to test if the solar panel can charge the battery:

1. Look for a place where you can get direct sun light and put the solar panel there.
2. Connect the solar panel to the charge controller's ports designated for the solar panel.
3. When connected, check if the indicator in the charge controller lights up.
4. Connect the battery into the charger controller's slot designated for the battery.
5. Check the battery if it is charging by measuring its voltage using a multi - meter every time interval.

Table 1. Voltage gain of the battery when charging

Time Interval	Voltage Rating
Initial State: 11:30 a.m.	12.11 V
12:00 p.m.	12.44 V
12:30 p.m.	12.67 V
1:00 p.m.	12.88 V
1:30 p.m.	13.12 V
2:00 p.m.	13.35 V
2:30 p.m.	13.57 V
3:00 p.m.	13.8 V
3:30 p.m.	14.04 V
4:00 p.m.	14.27 V
4:30 p.m.	14.5 V

Table 2. Voltage loss when operating

Time Interval	Voltage Rating
Initial State: 9:00 a.m.	14.89 V
9:30 a.m.	14.42 V
10:00 a.m.	13.96 V
10:30 a.m.	13.51 V
11:00 a.m.	13.04 V
11:30 a.m.	12.13 V
12:00 p.m.	11.67 V
12:30 p.m.	11.1 V
1:00 p.m.	10.65 V

Table 3. Voltage loss when idle

Time Interval	Voltage Rating
Initial State: 2:00 p.m.	14.89 V
2:30 p.m.	14.74 V
3:00 p.m.	14.58 V
3:30 p.m.	14.42 V
4:00 p.m.	14.27 V
4:30 p.m.	14.11 V
5:00 p.m.	13.97 V
5:30 p.m.	13.83 V
6:00 p.m.	13.68 V

For the crusher or linear motion actuator, the proponent used a 5V relay that serves as the switch of the crusher. The relay is controlled by the Gizduino X with certain delays and switches. For the coin dispenser, the proponent used servo motors to dispense the coins.

The proponent used the sweep method with the certain angle suited for the coin dispenser design.

The code for receiving and sending messages with the GSM module is pre-defined and can be easily configured. With the Android App, the code is a bit complicated because the proponenthas to hide the number of the recipient. Thus, the proponent used variables that would temporarily hold the contact number until it is modified. The integration of the two systems is correlated through the GSM module.

CONCLUSION AND RECOMMENDATION

Upon thorough research, a Solar Powered Reverse Trash Vendo Machine is developed to help lessen the improper waste disposal practices of Filipino citizens, to promote recycling, and to implement the idea of green engineering.

The device is capable of detecting either the scanned material is a plastic bottle or an aluminium can, each with a respective monetary value of compensation. The entire process is controlled by the Gizduino X ATMega 1281, and the Gizduino 644. From determining the input, to the outputs of the LCD display, to the crushing of the input, to the dispensing of equivalent monetary value of the inputs, and up to the communication between the device and the owner through the GSM shield and the Android messaging application.

Summing up, the proponent has successfully integrated the concept of trash can and reverse vending machines into a device that is economic and environmental friendly.

The proponent recommends to the future researchers with the similar project to improve and enhance the following features of the Solar Powered Reverse Trash Vendo Machine. Additional feature of accepting papers as inputs by getting its weight as a basis for the monetary value of the input papers, segregation of the plastic bottles from the aluminium cans for easier disposal, reduced processing time of one input to avoid flooding and spamming of inputs, enhanced coin dispenser that can dispense up to 5 peso coins, and reduce the size of the device to conserve space and enhance its mobility.

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