Development of a Solar Powered Charging Station via Recyclable Plastic Bottles

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Abstract –*This project proposes an alternative way of disposing garbage using a microcontroller operated charging station that provides incentives to users that properly disposed of their plastic bottle scraps with a power supply to charge their electronic gadgets. The authors believed the potential of the system to lessen the gap of environmental technologies within the country by engineering a unique machine that applies technology and its current trend to solid waste management. Solar panel and rechargeable battery will be the core energy source of the machine to have sustainability, made of low-cost but durable material as its frame for support and stability to the system. The system will be generally in stand-by mode until a waste material is deposited inside the opening hatch of the system, and then the chamber will close. The bottle count indicator will increment in value material deposited was accepted; the user can then pick a chamber to use as the charging ports of their mobile device. Another set of indicators displays the remaining time for each charging chamber; generally, each bottle that has been deposited and categorized accordingly using the system will provide a five minute charging interval for the user. Based on the testing for the accuracy and power conservation and dissipation, the system has accurately classified a number of materials that has been disposed within the chamber of the system, it can be also able to sustain its core energy source without the need of using an external power source as long as the proper solar source is available.*

Keywords –*Solar Powered, Charging Station, Recycling, Green Engineering, Gizduino-Based*

INTRODUCTION

Plastic is a superb and low-cost material used in production and packaging but durable and slow to degrade ultimately becoming solid wastes [1], [2], also one of the most important material for sustaining society and our current way of living [3], a measly portion of plastic bottle scraps are being recycled, while a high percentage of energy is saved when producing new plastic products from recycled materials instead of raw materials [4], [5].

Solid waste generation is greatly affected by a country's development [6] and waste generation is indicative of the degree of urbanization [7], and in the Philippines, one-by-one cities are becoming more and more urbanized making waste generally a problem of the cities, and in the country solid waste management is governed by the Solid Waste Management Act - The law propagated "Zero Waste Management" as a national program [8], but still the country's solid waste management is still inefficient and cannot be solved alone by the government [9], Local Government Units (LGU's), Non-governmental Organizations (NGO's) and communities must work together to be able to minimize and try to solve the solid waste problem in the country [10], [11].

Strategies in solid waste management are moving from waste disposal to recycling and recovery, while also considering that solid waste can be used as another valuable resource [12] and in economic terms recycling is proven to be less expensive than its counterparts in solid waste management. It requires less capital and operating expenses. Additionally, it gives way to development of businesses in the recycling industry [13].

In applying environmental technology to be able to also lessen the negative impacts of human involvement in solid waste generation, the proponents proposed the development of a solar-powered charging station via recyclable plastic bottles that will be able to apply current trend in technologies and green engineering to engineer a unique solid waste management system. The proposed project aims to develop a microcontroller-based charging station that is powered by solar energy and activated through recycling, which urges citizens to dispose their garbage properly and responsibly and by doing so rewarding them with a power source to be used in charging their mobile devices. With the development of this project, a way to lessen environmental problem such

as flooding in public areas and other environment disaster caused by improper waste disposal can be achieved.

RELATED WORK

Different literatures and studies gave the foundation and background in the development of the proposed system, the developed Solar Powered charging Station via Recyclable Plastic Bottles, used a solar panel as one of the sources of energy, Garg and Prakash [14] discusses how solar panel convert sunlight into electricity by implementing photovoltaic effect. Photovoltaic system is a category of power system intended to supply usable solar power by means of photovoltaic effect. It consists of a solar panel to absorb and convert sunlight into electricity and solar inverter to change the electric current from DC to AC. In the discussion of Sharman and Monga [15] showed the difference of FPGA-based machine and microcontroller-based machine. Wherein, FPGA machine are more flexible and microcontroller based machine needs to change the whole architecture when being modified.

The system of Pudegon [16] is a similar reward-based system that uses plastic bottles as a means of enabling the system and providing animal feeds to stray animals in the country. The system shows the helpful effects in the environment like reducing trash that is not being disposed properly and its benefits when technology is properly interfaced with. The system of Coxworth [17] is another similar reward-based system that provides cash incentives to the users of the system; this provided the proponent the proper guideline of execution of the system from the inputs to the final output. The system of Batchelor [18] helped in determining what will be the possible materials to be used in developing the project and also provided the idea about the input, process and output of similar based systems. In the system of Rubio [19] discusses that develop system must not just be systematically functional but also aesthetically functional. Overall, the literatures and studies have been valuable and beneficial to the proponent in assisting to develop and create the overall system.

MATERIALS AND METHODS

Project Design

Figure 1 shows how the components of the entire system are integrated with each other and how the components interact with one another. The solar powered charging station is composed of a Gizduino Mega ADK, Solar Panel, Charge Controller, and Lead Acid battery, Voltage Regulator, Light Dependent Resistor, Sensor Amplifier, Load Cell, Sonar Sensor, Light Emitting Diode, Servo Motor, SMS Module and Charging Ports. Solar panel will charge the lead acid battery, then passes to the voltage regulator to decrease the voltage entering in the Gizduino.

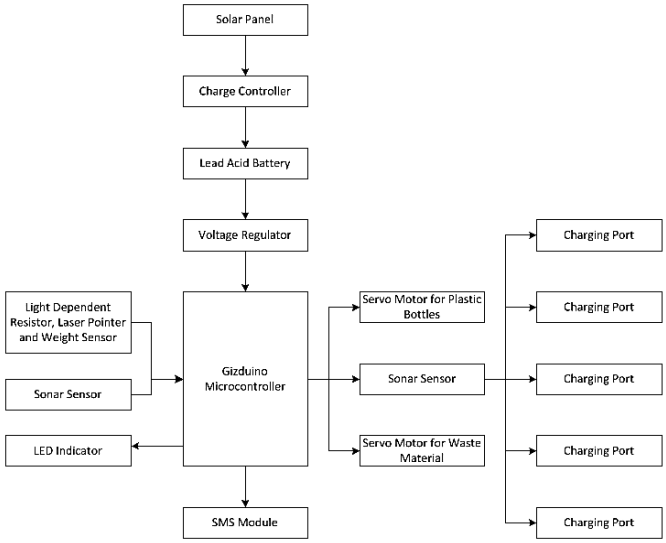

Fig. 1.Block Diagram of the system

Light dependent resistor, sensor amplifier, load cell, sonar sensor and LED indicator is controlled by the microcontroller to classify the trash deposited in the chamber with the help of servo motors, the trash disposed inside the chamber will fall in the bin depending on the classification of the trash, there is a 3-5 second delay before the hatch will open again. If bottle is successfully accepted by the system, it will increment the display in the system. Then system will let the user choose in which charging chamber to use. After the user successfully picked a chamber, the time will start to decrement. If the user put a bottle that is not plastic, the sonar sensor still accepts the deposited material but there will be no equivalent reward and if one of the trash bins inside the machine is full, a message will be sent to the administrator to notify them.

Project Operation

Figure 2 shows the final design and structure of the system, three different compartments with different types of charging cables are provided in each compartment. The button above each compartment is to initialize the use of the compartment and the seven-segment display shows the time remaining for the compartment being used. Bottles are deposited through the bottle hatch in the centre of the system; a larger seven-segment display shows the number of bottles that has been currently deposited.

Fig. 2. Final Output Design of the System

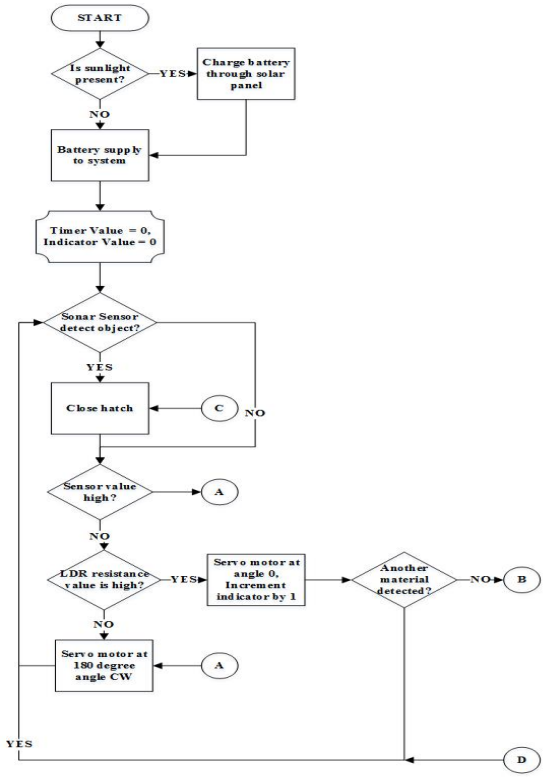

Fig. 3.System Flowchart of the system

Figure 3 and Figure 4 shows the system flowchart operation of the system, initially the system is in stand-by mode until the user deposit a garbage inside the chamber, the chamber will close then the system will categorize whether a plastic bottle or other waste material is deposited in the bin. If the sensor recognizes a plastic bottle, the large seven-segment display will increment and the user can choose whether to charge in the available chambers or repeat again the process of depositing materials. The user will be rewarded with five minutes of charging for every plastic bottle they have deposited.

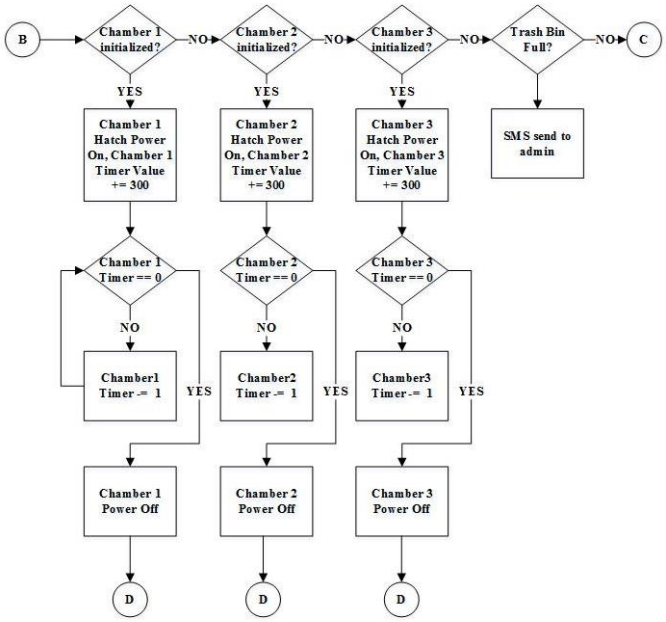

Fig. 4.System Flowchart of the system (cont.)

SMS module has been incorporated with the system to support the administrator in checking if the trash bins are full. The system has two sonar sensors placed to the upper part of the trash bin. If the sonar sensor satisfies the condition in the microcontroller, it will trigger the SMS module and will send a text message to the administrator that one of the trash bins is full or both then the chamber will close.

The system has 5-7 seconds interval before the next input has been made. It takes 2-3 seconds for the sensor to detect that the chamber has an object then the chamber will close, and a 3-4 second interval for LDR and sensor amplifier to recognize if the object inside is an empty plastic bottle then the seven segment display will increment. It takes 3 seconds upon clicking the charging button to open the charging port.

The project was designed and developed to lessen plastic bottle disposed inappropriately and to encourage citizens to dispose of their waste properly and additionally lessen the gap of environmental technologies within the country.

RESULTS AND DISCUSSION

Numerous sensors are used within the development of the system to be able to distinguish and categorize materials that are deposited within the system, sonar

sensors are used to detect whether a material is deposited, multiple light dependent resistors are used by the system to identify whether the deposited material is an empty plastic bottle or not along with the use of an sensor amplifier the system can be able to detect the weight of the deposited material and decide whether the material is a plastic bottle or not. The regulated electricity of the system is supplied using a retrofitted solar panel that can swivel to adjust its angle to the position of the sunlight, charge controllers manage to keep the battery of the system from overcharging and over discharging. Also, it can monitor the batteries health using an indicator.

The system provides five minutes of charging time for every plastic bottle that has been deposited and correctly recognized by the system. The user can either add the five minutes time to the same charging chamber which will increment or the user will choose another charging port. The maximum devices that can be charge simultaneously is up to three devices. The table below shows the circuit loading variation of the system.

Table 1. System load per added devices

Description	Circuit Load
System in stand-by mode	35 – 40 mV
System with one device being charge	40 – 45 mV
System with two devices being charge	45 – 50 mV
System with three devices being charge	50 – 55 mV

Table 1 shows the different voltage load of the system depending on the devices being charged. As shown in the table above, the system load proportionally increases with a range of 5 – 10 mV per devices added.

The following table shows the accuracy of the system on the different constraints of inputs that user may provide.

Table 2. System's sensor accuracy of common plastic material

Material	Classified Properly
Sprite (1.5 L)	Yes
Royal (250ml)	Yes
C2 (230ml)	Yes
Mineral Bottle	Yes
Mountain Dew (400 ml)	No
Sprite (500ml)	Yes
Mountain Dew (1.25L)	Yes
Nestea (500ml)	No
Mogu Mogu (350ml)	Yes
Aqua Flow (300ml)	Yes

Table 2 shows that 8 out 10 commonly thrown plastic bottle was identified properly, the accuracy of the LDR with the laser beam pointer are 80%. Based on the values acquired, laser pointer cannot accurately read by the LDR if the plastic bottles thrown are not translucent and clear or plastic bottle wrap making it hard for the laser pointer to reach the LDR and LDR causing inconsistencies in reading the resistance.

Table 3. System's sensor accuracy of common school solid waste material

Material	Classified Properly
Paper	Yes
Can	Yes
Paper Cup	Yes
Crumpled Paper	Yes
Scotch tape	Yes
Glass Bottle	Yes
Junk food wrappers	Yes
Metal	Yes
Plastic Bottle with water	Yes

Table 3 shows that 9 out of 9 different kinds of common solid waste material was identified properly, the accuracy of the LDR in the laser pointer is 100% as well as the accuracy of the sensor amplifier for the weight of the object being scanned. Nevertheless, the sonar sensors cannot detect flat objects 3mm and below.

Table 4. Voltage change when idle and charging through solar panel

Time Interval	Voltage
Initial State: 10:00 am	12.18V
10:30 am	12.34V
11:00 am	12.48V
11:30 am	12.56V
12:00 pm	13.01V
12:30 pm	13V
1:00 pm	13.01V
1:30 pm	12.98V
2:00 pm	12.88V
2:30 pm	12.94V
3:00 pm	13.00V
3:30 pm	13.11V
4:00 pm	13.06V

Table 4 shows that when the system is idle and charging through the solar panel is approximately 1%.

Table 5. Voltage change when in-operation and charging through solar panel

Time Interval	Voltage
Initial State: 12:24 pm	12.70V
12:54pm	12.46V
1:24pm	12.14V
1:54pm	11.95V
2:24pm	11.69V
2:54pm	11.45V
3:24pm	11.20V
3:54pm	11V

Table 5 shows that for every 30 minutes of operation, the voltage loss of the system is approximately 3%.

CONCLUSION AND RECOMMENDATION

Upon thorough research, the proponent developed a Solar Powered Charging Station via Recyclable Plastic Bottle that encourages citizens to dispose of solid waste appropriately using the charging station and helps the immediate vicinity by minimizing its solid waste generation.

Solar Powered Charging Station via Recyclable Plastic Bottle is capable of detecting plastic bottle and can still accept other type of material except that other solid waste material cannot give them free charge. The proponent used light dependent resistor to detect if the object inside the chamber is clear and sensor amplifier is use to detect if the object is heavy. The regulated electricity is supplied through batteries that are charged through solar panels that precisely positioned within the system to collect solar power from sunlight. The system provides five minutes of charging time for every bottle that has been properly recognized by the system and can charge up to three devices simultaneously, with no minimum limit of credit time. SMS module is combined with the sonar sensor to detect if the trash bin is within the range of being full, the SMS module will send a text message to the administrator and the chamber will be closed and no additional solid waste can be disposed within the system, the system has a 5-7 seconds interval from input of the user up to the recognition of the object whether the inputted object is an empty plastic bottle or not.

The proponent would like to recommend to future researchers with the similar theme to improve and enhance the following features of the Solar Powered Charging Station via Recyclable Plastic Bottles. First is to develop or implement another method of categorizing solid waste being disposed with the use of different sensors. Secondly, crushing / crumpling the solid waste to accommodate more solid waste to the available bins. Lastly, a better capacity of batteries and solar panels for better sustainability of the system. The developed system can be maximized to its fullest extent by installing the device in areas in which solid waste is generated in bulk over the whole day such as school canteens which the device will also double as training tool for students to dispose of their solid waste properly.

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