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AUTOMATED WASTE SORTER WITH MOBILE ROBOT DELIVERY WASTE SYSTEM

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ABSTRACT

Waste segregation and recycling are simple yet effective ways of reducing the amount of waste dumped into our landfills. But there are people who are unaware or even choose to ignore the fact that waste segregation and recycling are environment friendly solutions to the problem of wastes management and disposal. In the Philippines, there are recycling centers but the process is tedious and done manually. There are guidelines implemented by the government with regards to recycling but these efforts have yet to touch the mindset of the people. Escalating amounts of recyclables that are not maximized and indifference in proper waste segregation has led to the group in developing a solution to this. The Automated Waste Sorter (AWS) and Mobile Robot Waste Deliver System (MRWDS) are intended to automate the sorting process of steel cans, aluminum cans, glass bottles and plastic bottles. Along with the integration of the Mobile Robot Delivery System the process of collecting the waste that is to be sorted by the AWS human interference is minimized. This paper describes the approach to implementing a sensor array, for each corresponding material to be sorted, along with a conveyor belt as the Automated Waste Sorter. The Mobile Robot Delivery System is composed of a line following robot that is able to mechanically pick up an appointed trash bin and collect the waste in the said bin and through the designed line path proceed to the receiving end of the AWS and dump the collected waste. Through the use of the implemented systems the group was successful in collecting and delivering the waste and sorting to an accuracy of above 80%.

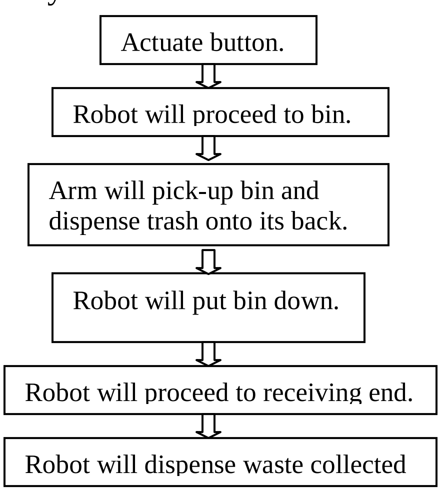
Key Words – Automated Waste Sorter, Mobile Robot Waste Delivery System, Recyclables, Cost-Benefit Analysis

1. INTRODUCTION

Waste segregation and recycling are effective ways of reducing dumped trash. Unfortunately, these practices are not widely implemented in the country. People have been negligent when it comes to proper waste disposal, ignoring labels and throwing recyclables that can still be reused. Most are unaware or choose to ignore the fact the waste segregation and recycling can reduce cost, reduce drain in our resources, and lessen the waste being produced. Typical composition of garbage people throw in Manila are 5.8% metals, 3.5% glass, 1.6% plastic, 12.9% papers, 1.8% textiles and 53.7% biodegradables which means only the remaining 20.7% of the wastes should really be going to our landfills (Mair et al, 2011). In our country, recycling centers do manual process of sorting wastes leading to a high risk of acquiring sickness. This study aims to automate waste segregation and implement a waste delivery system that would minimize human interference in the waste collecting and segregation process. Materials such as tin cans, aluminum cans, glass bottles and PET bottles are the wastes that need to be segregated in this project.

2. METHODOLOGY

A mobile garbage collector robot is designed to gather wastes from three bins. The MRWDS is a line following robot. The MRWDS is actuated by a button that sends radio frequency signal which corresponds to the location where the robot should go and pick up the waste. The robot is able to track the bins through following a line that leads to the said positioned bins. The group designed a left path, right path and a center path. It would pick up the bins and transfer the wastes through pouring the collected wastes on the bigger bin that is placed on its back. Once the robot has completely gathered the wastes, it proceeds to the receiving end of the sorter and will pour the collected wastes onto the receiving end of the AWS. Wastes are to be fed onto the conveyor belt and will continuously run at a speed that prevent any waste from falling sideways and going astray its path. Wastes are singulated before going on the conveyor belt and pass through sensor array. When a waste triggers a sensor that corresponds to it, it is dispensed to its proper bin. The flow of operation of MRWDS and AWS is shown in Figure 1 and Figure 2 respectively.



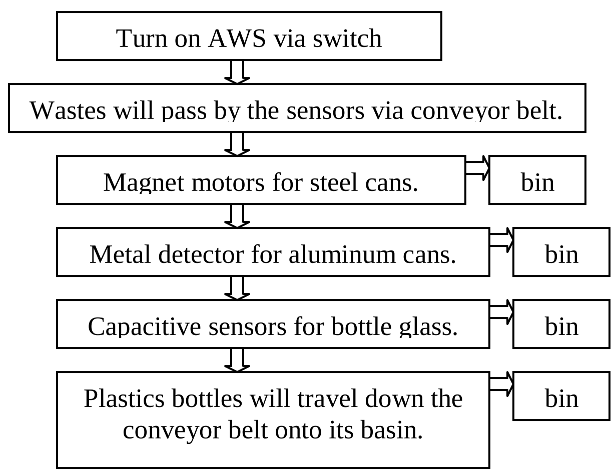


Fig. 1. Flow of Operation of MRWDS

Fig. 2. Flow of Operation of the AWS

3. DESIGN CONSIDERATIONS

The sensor array the AWS composes of magnet motor, neodymium magnets attached onto the shaft of a rotating motor that would be able to sort out the steel cans. A metal TDA0161 detector circuit that would be able to sort out the aluminum cans. A tunable capacitive sensor E2K-C25ME (OMRON, 2011), which would be able to sort out the glass bottles and by process of elimination all the plastic bottles would be dispensed at the end of the conveyor belt. All of the sensors for the recyclables are connected to the microcontroller (MCU) specifically a Microchip PIC16F877A microcontroller. When specific sensors sense the presence of a recyclable, it actuates the servomotor connected to a door that will open and the material is dispensed onto its proper bin. The conveyor belt of the AWS is powered by an AC motor. Please refer to Figure 3 for the System Block Diagram of the AWS.

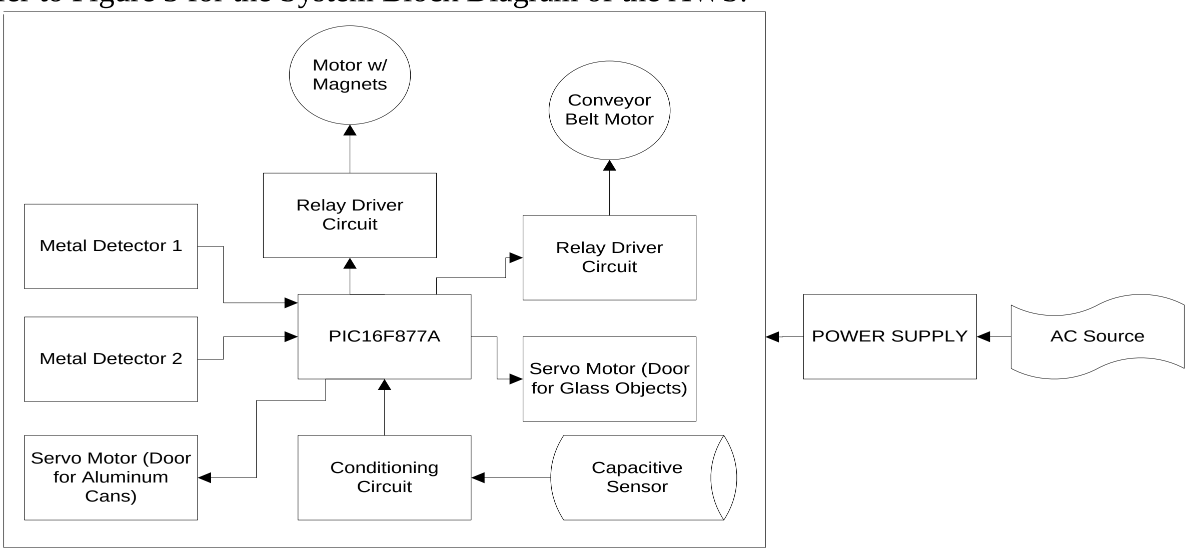


Fig. 3. System Block Diagram of AWS

The Mobile Robot Waste Delivery System is actuated by a radio frequency signal triggered by a button. The robot is able to follow the lined path via a line following sensor and two H-bridge controlled DC wiper motors. The arm of the robot consists also of a DC wiper motor with two limit switches, one at the top and one at the bottom, as a guide for the arm mechanism. The limit switch at the top would signal the arm to stop rising while the limit switch at the bottom would signify that the trash bin is already placed back on the ground and the mobile robot can reverse and go back to its original position. Shown in Figure 4 is the actual MRWDS while Figure 5 shows the AWS.


Fig. 4. Mobile Robot Waste Delivery System


Fig. 5. Automated Waste Sorter

When the robot goes to the receiving end of the AWS to dispense the collected waste, the door of the MRWDS is opened so the waste flows down. The robot has an internal hopper; this is where the trash from the trash bins is stored while it is traveling to its lined path. The hopper is inclined in order to make sure that all of the trash is dumped to the receiving end of the sorter. The mobile robot would again wait for a signal from one of the buttons and the same procedures would be performed with the exception of the master button. The master button commands the mobile robot to collect all three trash bins before dumping all of the trash into the receiving end of the AWS. The controller of the whole system is a Microchip PIC16F877A microcontroller and a Lithium-Ion battery powers the robot. Shown in Figure 6. is the block diagram of the MRWDS.

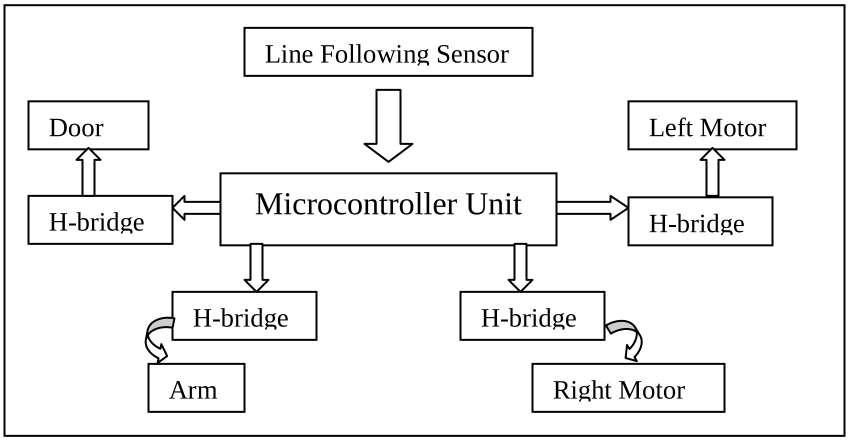


Fig. 6. Block Diagram of MWRDS

4. DATA AND RESULTS

The group was able to conduct multiple testing on the AWS to gather data. Test after test the group optimized the tuning of the circuits and modify the program of the microcontroller to set the proper timing when it comes to the flow of the AWS. Refer to Table 1 and 2 for the data and results gathered on the AWS while Table 3 shows robot timing in collecting wastes.

Table 1. List of unsorted materials and result after sorting

Product	Result	Classification
San Miguel Light	Sorted	Glass
Coke Bottle	Sorted	Plastic
Coke in Can	Sorted	Aluminum
Mountain Dew Bottle	Sorted	Plastic
Mogu Mogu	Sorted	Plastic
Nescafe Expresso Roast	Sorted	Tin
Nescafe Mocha	Sorted	Aluminum
Mountain Dew in Can	Sorted	Plastic
C2 Green Tea	Sorted	Plastic
Vitamilk	Sorted	Glass
Summit Drinking Water	Sorted	Plastic
Nescafe Expresso Roast	Sorted	Tin
Nescafe Latte	Door Jam	Aluminum
Magnolia Pure Water	Sorted	Plastic
Pepsi in Can	Sorted	Aluminum
Nescafe Expresso Roast	Sorted	Tin

Table 2. Summary of the Data and Results

Total no. of Inputs	16
No. of Items Sorted	15
No. of Items Not Sorted	1
Sorting Percentage	93.75%
Time	1 minutes, 54 seconds

Table 3. Times it took for the robot to collect and deliver

Direction	Time
Straight	1 min. 7 secs.
Right	1 min. 21 secs.
Left	1 min. 24 secs.
Master Button	4 mins. 36 secs.

Based from the results, the AWS was able to fulfill its objectives and was able to comply with the scopes and delimitations declared. Due to the proper tuning and proper setting up of the flow of the program of the microcontroller the AWS was optimized.

The Mobile Robot Waste Delivery System was also able to collect and deliver the wastes corresponding to the button pressed. The initial testing of the MRWDS included running multiple tests on each of the direction specified. Through the tests the group was able to identify the proper alignment of the lined path that would be able to guide the MRWDS to its destination, specifically when it will turn right or left. In line with the tests done the mechanical parts and structure of the MRWDS was also modified for better performance. Through the tests the group was also able to gather data regarding the time it takes for the robot to collect and deliver the wastes to the receiving end of the AWS. In Table 3, the times listed are longest times, out of the 5 initial tests done, it took for the robot to collect and deliver successfully.

From the collected data it can be noted that the MRWDS was able to perform its objectives within the required time frame.

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5. CONCLUSION

The automated waste sorter was able to sort out the 4 different materials specified in the objectives. The steel cans were sorted out via a magnet motor, consisting of neodymium magnets installed on to the shaft of a motor. Aluminum cans and glass bottles were sorter out via a TDA0161 metal detector circuit (STMicro, 2011) and E2K C25ME1 tunable capacitive sensor (OMRON, 2011) respectively. When these sensors are triggered the servomotor-powered door is actuated and the materials are dispensed onto its proper bins. By process of elimination only the plastic bottles are left to be sorted out so they proceed to the end of the conveyor belt where they dropped onto the corresponding bin for plastic bottles. This study concludes that with the sensor array methodology of sorting, the spacing and position of the items in the conveyor belt play an important part in determining its accuracy. It was determined in the tests done that a distance of 8 inches between the two consecutive items to be sorter is advisable for proper sorting. In relation to this singulation of the item plays an important part in controlling the flow of the wastes to the sensor array.

The robot was able to receive and react to the RF signals sent via remote control. The mobile robot was then directed to one of the line paths and was able to follow the paths with the use of a line-tracking sensor array. A horizontal line would signify the end of the path taken, here the trash bin is collected with the use of an arm that would lift the bin and dump all of the contents to the space designated for the waste in the robot. After which the robot would then reverse and return to its base station and wait for another command. The commands are differentiated via buttons, each button has its own specific function i.e. (button A for collecting the bin at position A, button B for collecting the bin at position B). From the testing done the useful battery capacity was determined to be an hour of continuous operation.

Based from the tests and results, it can be concluded that the design of the line path is important to the operation of the mobile robot. Sudden sharp turns are not advisable. Also, computing the battery capacity, the application of operation, time of operation and the power consumption of the system must be taken into consideration. In addition to this, since the mobile robot is following a lined path and using changes in the path to detect if it is to pick up a trash bin, the proper placement of bins in line with the change in the path must be given attention. Proper placing of the marker and the trash bin are needed for the robot to lift the trash bins properly. It is also important to take in consideration the stability of the body of the robot since it is relatively large. But the group was able to optimize the positioning the line following sensors and modify the robot to prevent any error in line with its size.

6. RECOMMENDATIONS

With the current design of the sorter, modifications and recommendations for a better prototype can be applied. Other sorting methodologies such as image processing, X-ray imaging or infrared scanning can be used in differentiating the materials to be sorted out (Jiu and Zhengfu, 2010). Multiple conveyor belts and sensors would also make the sorting process a lot faster. Modifying the way of dispensing the wastes can also improve the sorting process because the waste has a chance to get stuck in current design. Proximity sensors can be added for the mobile robot to avoid the obstructions and collisions. In the integration between the mobile robot and the automated waste sorter the group recommends improving the in-feed conveyor for better timing and better singulation of the waste materials in entering the belt of the automated waste sorter. In improving the in-feed conveyor a vibrator can be used to better singulate the materials. Building a more inclined in-feed conveyor also helps in minimizing the number of material in each of the teeth of the in-feed conveyor due to the effect of gravity. In applying the automated waste sorter in wide-scale sorting a way of singulation and feeding from delivery to the sorter is the Gator Singulator from Ensalco. The Gator Singulator utilizes the concept of having two sets of skewed rollers that move the inputs to the belt toward the center, which results, to the materials forming a single line.

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