Automatic Waste Segregator for Efficient Recycling

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Abstract— **Rapid increase in volume and types of solid and hazardous waste due to continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments to ensure effective and sustainable management of waste. It is estimated that in 2006 the total amount of municipal solid waste generated globally reached 2.02 billion tones, representing a 7% annual increase since 2003 (Global Waste Management Market Report 2007). The segregation, handling, transport, and disposal of waste needs to be properly managed to minimize the risk to the health and safety of patients, the public, and the environment. The economic value of waste is best realized when it is segregated. Currently, there is no such system of segregation of dry, wet and metallic wastes at the household level. This paper proposes an Automated Waste Segregator (AWS) which is a cheap, easy to use solution for a segregation system for household use, so that it can be sent directly for processing. It is designed to sort the refuse into metallic waste, wet waste and dry waste. The AWS employs parallel resonant impedance sensing mechanism to identify metallic items, and capacitive sensors to distinguish between wet and dry waste. Experimental results show that the segregation of waste into metallic, wet and dry waste has been successfully implemented using the AWS.**

Index Terms— **Automation, waste segregation, metal detection, capacitive sensing, inductive sensing**

I. INTRODUCTION

Waste disposal is a huge cause for concern in the present world. The disposal method of a voluminous amount of generated waste has had an adverse effect on the environment. Unplanned open dumping at landfill sites made by municipal is a common method of disposal of waste. Human health, plant and animal life are affected due to this method. The harmful method used for waste disposal generates harmful chemicals which contaminate surface and groundwater. It can give rise to disease vectors which spread harmful diseases. In India, rag pickers play an important role in the recycling of urban solid waste. Rag pickers and conservancy staff have higher morbidity due to infections of the skin, respiratory, and multisystem allergic disorders. Dependency on the rag-pickers can be diminished if segregation takes place at the source of municipal waste generation. The economic value of the waste generated is not realized unless it is recycled completely. Several advancements in technology have also allowed the refuse to be processed into useful entities such as Waste to Energy, where the waste can be used to generate synthetic gas (syngas) made up of carbon monoxide and hydrogen. The gas is then burnt to produce electricity and steam; Waste to Fuel, where the waste can be utilized to generate biofuels. When the waste is segregated into basic streams such as wet, dry and metallic, the waste has a higher potential of recovery and consequently recycled and reused. The wet waste fraction is often converted either into compost or methane-gas or both. Compost can replace demand for chemical fertilizers, and biogas can be used as a source of energy. The metallic waste could be reused or recycled. The purpose of this project is the realization of a compact, low cost, and user-friendly segregation system for urban households to streamline the waste management process. The mixed waste is sorted based on the following methods at the industrial level. Larger items are removed by manual sorting. Then the refuse is sorted based on its size by using large rotating drums which are perforated with holes of a certain size. Materials smaller than the diameter of the holes will be able to drop through, but larger particles will remain in the drum. For metallic objects electromagnets or eddy, current based separators can be used.

II. LITERATURE SURVEY

[1] Amrutha Chandramohan: states there is no such system for segregation of wastes into categories such

as dry, wet and metallic wastes at the household level. An Automated Waste Segregator (AWS) can be used at the household level so that the waste can be sent directly for processing. The AWS employs inductive sensors to identify metallic items, and capacitive sensors to distinguish between wet and dry waste depending upon the threshold values set. By increasing accuracy and overall efficiency, we can eliminate noise.

[2] Nishigandha Kothari: used Ultrasonic Sensors are used to monitor the garbage collection. When the garbage reaches the sensor level an interrupt is sent to the microcontroller. Advanced processing techniques can be incorporated once the waste has been segregated, methods for individual material feeding for local use so that the segregation can be performed continuously once the waste is dumped, image sensing can be used to segregate materials through Image processing technology.

[3] Rashmi M. Kittali says that even PLC can be used for AWS. It has an advantage of reduced manpower, improved accuracy, and speed of management of waste. It also avoids the risk of working in hazardous places. The bins can be unloaded by placing limit sensors at the top of each bin.

III. PROBLEM DISCRIPTION

- Industrialization, modernization, rapid advancements and increase in population have led to large generation of waste. Segregation makes it possible to reuse and recycle the waste effectively.
- Waste Management is the important aspect that should be kept in mind. There is a need of segregation at the base level so that waste can be dumped properly at the dumping sites.
- When waste is collected from different places, it is mixed and then sorted manually. This consumes more time. To manage the waste, sorting is very important at base level.

IV.SCOPE OF THE PROJECT

- The proposed system tries to automate the task of manual segregation.
- Sorting can happen right at the source of garbage disposal provided the garbage is not a mixed garbage. It could be a plastic bottle that can be detected using a inductive sensor or a organic waste which can be detected using a capacitive sensor.
- The proposed system segregates based on the mechanical processes such as trommel screening, density separator, air separator.
- The proposed system works on separating wet waste and dry waste.

V. OBJECTIVES OF THE PROJECT

- The objective of the project is to segregate mixed waste into wet and dry waste by simple mechanical process automated through sensors and microcontrollers.
- This Project deals with waste segregation as a step of managing and effectively disposing huge waste and minimization of blue-collar method.
- An automation of this style not only saves the manual segregators from numerous health issues, but also proves to be economical to the nation. When installed in apartments or small colonies, it proves to be beneficial in sorting the waste at the site of disposal itself.
- To design a product for waste segregation in economical way.
- To avoid manual sorting of waste and can easily be sorted out.

VI. BLOCK DIAGRAM
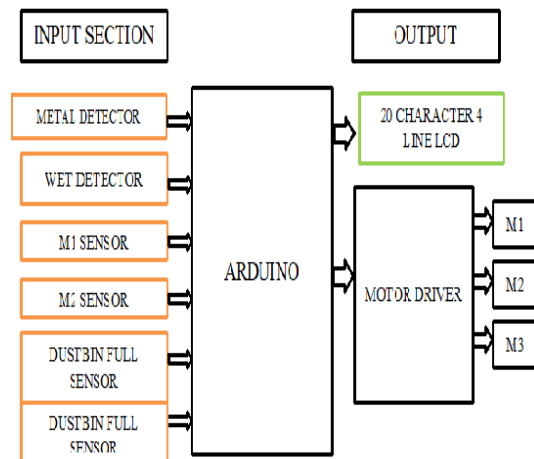
Block diagram of automated waste segregator
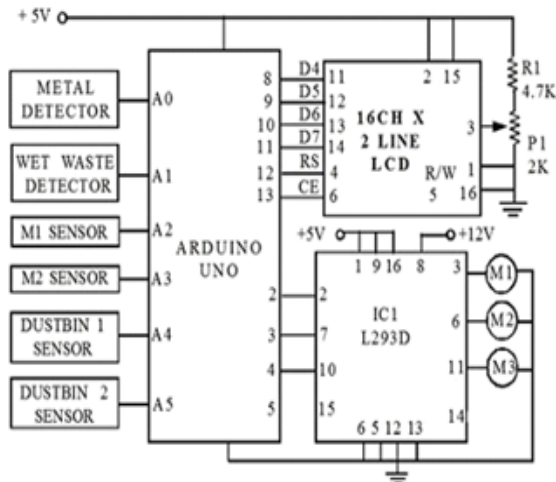
Circuit diagram of automated waste segregator

The Arduino Uno is a popularly used open-source micro-controller board that runs on ATmega 328P micro-controller. This board contains a set of digital and analog I/O data pins that are used to interface this board with other electronic components. Arduino Uno consists of 14 digital pins and 6 analog pins. An external battery of 9V can also be used to power Arduino board.

IR sensor is one of the most commonly used sensors in the field of electronics. IR module is a sensor module that consists of both IR transmitter and a receiver. Operating voltage of this module is 5 volts. An IR sensor can detect the heat of an object as well any motion in the surrounding. As the module contains both transmitter and receiver. When powered, IR transmitter starts to transmit continuous IR waves, if an obstacle is placed in the path of the waves, they get reflected back from the obstacle and are received by the receiver.

An Inductive Proximity Sensor is a non-contact electronic proximity sensor used for the detection of metals. Sensing range of this sensor completely depends upon the metal being detected.

Moisture sensor is used to measure the moisture content in a given material. These sensors use the volumetric water content indirectly by making use of some other properties like electrical resistance, dielectric constant. In general cases, the sensor generates a voltage proportional to the dielectric permittivity and therefore measures the moisture content of a material.

Now the output of the microcontroller is fed to the DC motors. The DC motors are always preferred over stepper motors. There are many thing which you can do with your DC motor when interfaced with a microcontroller.

L293D is a motor driver circuit that is connected with a motor when the required current for a motor is more than what is specified. Hence, motor drivers act as a current amplifier. L293D is a 16-pin IC which can control two DC motors simultaneously. It works on the principle of H-bridge. H-bridge is a circuit which allows the voltage to be applied in either direction.

VII. METHODOLOGY

The methodology includes a set of process used to segregate mixed waste. This is designed keeping in mind the domestic waste. Normally the unsegregated waste is usually packed inside a plastic polythene cover tied tightly. This goes to the landfill directly which creates problem of waste getting piled up. Hence the project is developed to segregate mixed domestic waste which is usually received at public dustbins.

The methodology includes the following –

- Design aspect
- System requirements
- Implementation

Design
The design part mainly includes the mechanical design part and the measurements related to it. It also includes the controlling aspects of electrical motors and drive directions. The software part automates these tasks and makes sure the operation gets carried out smoothly.

System Requirements
The system requirement part includes two parts –

- Hardware requirements
- Software requirements

Implementation
This part includes the implementation of the project from design to integrating all the hardware and software part. The circuit connection diagrams and the flow charts with explanation of the working are considered in this section.
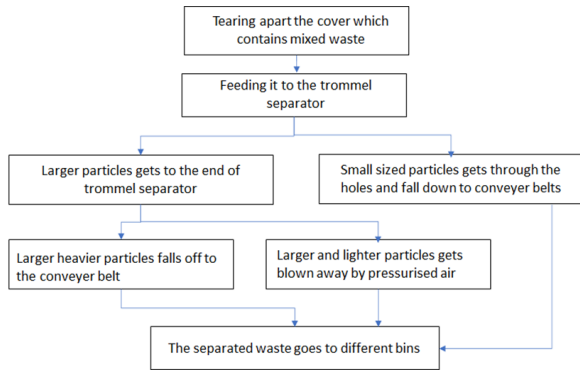
Process flow chart of the Segregation of waste

The speed of the trommel should be such that its rotating speed is less and does not give a centrifugal effect rather separates the smaller waste particles from the larger ones. Since these are inclined a slightly at the feeder end the larger sized particles just flow through it and get to the other end of the trommel.

- These when reach at the end of trommel are again separated to the heavier ones and lightweight ones.
- A strong blow of air is angled at the end of the trommel separator which blows the light weighted particles and heavier parts just fall vertically down.
- There are two conveyer belts which carry these heavier particles and lightweight particles to a separate bin.

The size of the mechanical design plays a very important role in efficient segregation of the waste. As the process involve segregation of waste depending on the physical factors of the waste such as wetness, dryness, mass, size and texture.

The whole setup is 1m x 1m x 1m cubical enclosure that will contain

- Opening rods
- Trommel separator
- Air separator
- Conveyer belts
- Separate bins for collection

## VIII. HARDWARE REQUIREMENTS

1.Arduino Board – ATMega 328P
The Arduino Uno is a popularly used open-source micro-controller board that runs on ATmega 328P micro-controller. This board contains a set of digital and analog I/O data pins that are used to interface this board with other electronic components. Arduino Uno consists of 14 digital pins and 6 analog pins. An external battery of 9V can also be used to power Arduino board
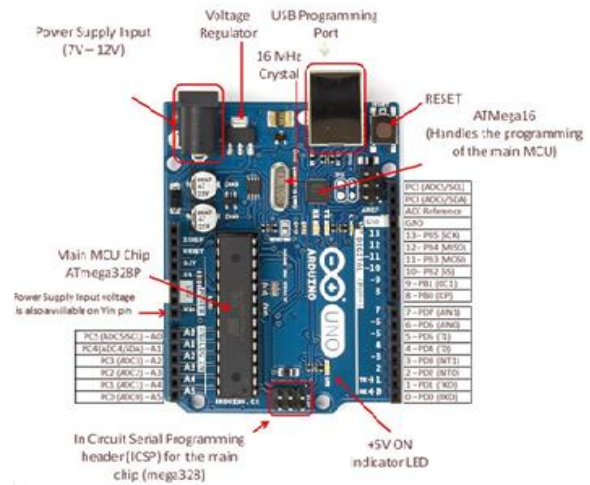
2.IR Sensor
IR sensor is one of the most commonly used sensors in the field of electronics. IR module is a sensor module that consists of both IR transmitter and a receiver. Operating voltage of this module is 5 volts. An IR sensor can detect the heat of an object as well any motion in the surrounding. As the module contains both transmitter and receiver. When powered, IR transmitter starts to transmit continuous IR waves, if an obstacle is placed in the path of the waves, they get reflected back from the obstacle and are received by the receive
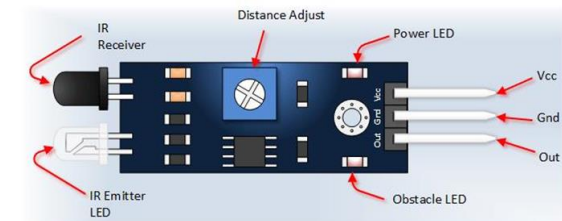
Technical Specifications:
IR Sensor have four pins:
1. VCC +5V
2. GND
3. D connects with any digital pin of Arduino when IR pair use as Digital Sensor.
4. A connects with analog input pin of Arduino when IR pair use as Analog Sensor
5. Operating Voltage: 5V
6. Minimum Distance: 2-5 cms
7. Maximum Distance: 10-15 cms

3.Motors

It stands for the direct current motor. It is an electrical machine that converts direct current electrical energy into mechanical energy. Mostly all types of DC motors have an internal mechanism to reverse the direction of current flow in part of the motor. Smaller versions of this motors are exercised in toys and also many home appliances. Larger DC motors are used in the propulsion of electric vehicles, elevator, and hoists, or in drives for steel rolling mills. DC motors are of two types viz. Brushed and Brushless DC motors.

Brushed DC Motors: The brushed DC motor is known to be one of the earliest and simplest motors as it implements the laws described above in the simplest manner. The construction of a brushed DC motor comprises of a fixed stator made of a permanent magnet and a moving armature (Rotor) on which components like the commutator, brushes, and split ring all of which is placed around the motor shaft.

The motors that we will be using are
- High torque motors for trommel application
- High speed motors for air separator.

IX.SOFTWARE REQUIEMENTS

The tool required to code the microcontroller is Arduino IDE. It has libraries written in C language and since its open source it will help us fetch in more information from the open source.

Highlights of Arduino IDE:

- Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module.
- It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.

X. IMPLEMENTATION

The implementation happens in three ways
The design fabrication of each of the following parts :
1. The opening rods
2. The trommel separator
3. Air separator
4. Conveyor belt

Opening rods

The opening rods pierce into the covered plastic which has mixed waste. Once it completely pierces, the sharp-edged cutters open up and the rods while going back to the original position tears the plastic and thereby scattering the waste that was inside, into the conveyor belt. This happens only when the IR sensor detects a plastic bag moving across it.
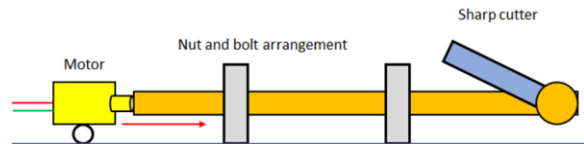

The mechanism works on a nut and bolt arrangement where the nut is placed permanently on a surface and a long bolt is connected to the motor that is kept on a rolling bench track. As the motor turns, the stationary nuts pull the bolt and pushes the sharp cutter forward. The motor is controlled by the microcontroller.

Trommel separator

The trommel separator rotates at a constant speed which separates the larger particles from smaller ones. It is slightly inclined at the feeder end so that the lighter particles do come rolling to the end of the separator. The aperture of the trommel separator plays an important role as to how efficiently the separation

happens. The size of the mesh keeps on increasing from the feeder end to the outlet end thereby separating the waste based on the size.
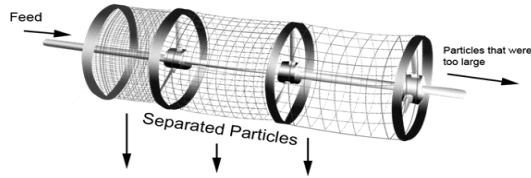
Air separator

The air separator contains a fan which blows the lighter particles of the waste that comes to the outlet end. This is angled slightly greater than 90 degree so that the lighter particles falls away from the place where heavier particles fall.
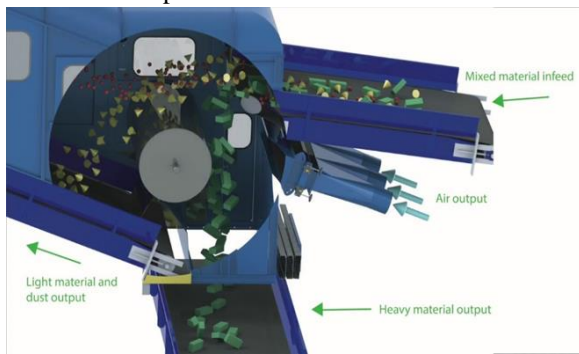

Conveyor belt

The conveyor belt plays a major role in transporting material from one end to another end without much complicated working designs. A rotating cylinder combined with a belt provides a movement which is horizontal and can be slightly given an angle.

After the mixed waste goes through all these separators it finally gets segregated into three separate bins which will be later collected and emptied. The materials that will be separated will be wet waste and dry waste. The dry waste will also contain the hard materials like coconut shells etc.

XI. FLOW CHART

The code part includes checking for IR sensor input which actually indicates whether a waste bag has been put inside or not. Once the IR sensor detects the motors M1 and M2 of opening rod mechanism starts running that will move forward for a certain amount of time and then moves back completing one full cycle. Then the conveyor belt motor M3 switches ON with a delay of 5 seconds as all the waste particles gets into the trommel. After this delay of 5 seconds the trommel motor M3, the fan motor M4 and the conveyor belt motor M5 starts simultaneously and after a delay of 15 seconds all the three motors stops.
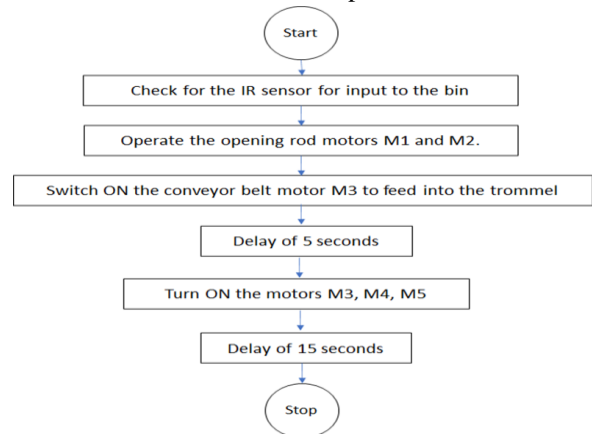
XII. CONCLUSION

The project was designed and developed to meet the objectives at the first place. The design was divided into mechanical, electrical and software part. In the course of developing the project there were many changes that were made as this was a project that worked on a non-linear set of data and had huge discrepancies with respect to what the input to a system was and what the output was supposed to be. The mixed waste being the non-linear set of data it was difficult to put together one set of separation method to get the segregated part separately. Hence it was a challenging project to work on and we have successfully received a good separation efficiency. The time duration of one cycle of mixed waste separation depends on the size of the waste bag that is given as input. The system is not compact and future designs would include sorting that happens on the basis of computer vision and robotics. This will help us separate materials such as glass, electronic gadgets etc which gets unnoticed in this system. The overall working of the project has been good and has

achieved the desired result and also fulfilled the objectives of the project.

ACKNOWLEDGMENT

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