PES UNIVERSITY

UE17CS490A – Capstone Project Phase – 1

End Semester Assessment

Project Title	:	Smart Waste Segregation
Project ID	:	PW21CBR02
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Agenda

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Problem Statement

We aim to build a smart waste segregator that is capable of segregating the waste into different categories.

The main categories into which the waste will be segregated are wet waste that contains moisture in it, metallic waste, glass waste, and plastic waste.

This is aimed to be achieved by using the intrinsic properties of different materials which they exhibit under different conditions.

These properties are as follows:

The ability of a metal to be attracted to a magnet or its property of induced eddy currents can be used for the identification of metal. The system uses an inductive proximity sensor for the purpose.

The property of dielectric constant, which varies across different materials can be used to distinguish between glass and plastic. This is because glass has a higher dielectric value as compared with plastic. This can be detected by the capacitive proximity sensor which is planned to be used in the system.

Abstract and Scope

With the rapid growth in population, urbanization, and economic development the amount of waste that is being generated is increasing. According to an estimate, the world generates 2.01 billion tonnes of solid waste annually. By 2050 the expected growth in the amount of waste generated will be increased to 3.04 billion. Many countries, today are facing lots of issues regarding the proper collection, segregation, and disposal of the solid waste generated. Improper methods adopted for the same can lead to various environmental hazards and can impact the health of the citizens of the country. The economic value of waste is realized only after its segregation. As the slogan states “Recycle today, for a better tomorrow”, the step involved in recycling waste is the proper segregation of waste. This is better utilized if the segregation is at the source itself. In the present scenario, there is no such system that is capable of segregating solid waste into different categories such as glasses, plastics, metallic waste, and wet waste at the source of generation of waste.

Abstract and Scope

Most of the solid waste such as glass and plastics are recyclable, therefore we aim to segregate the wastes into the above-mentioned categories with the help of various sensors available and automate the process of segregation thereby reducing the manpower required for segregation which in turn reduces the occupational hazards of the manual workers.

Purpose: One of the major problems faced today is the improper and inefficient disposal of waste produced, which has adverse effects on the environment. The segregation of waste helps in determining the economic value of the waste. The consequences of traditional practice cause health hazards, environmental pollution, and the loss of precious resources that can be recycled.

Therefore, we aim to build a cost-effective and easy-to-use solution that can handle the entire segregation process automatically.

Abstract and Scope

Benefits: Automating the process of waste segregation is helpful in many ways such as:

- It reduces environmental pollution caused by the improper disposal ofmixed waste.

- It reduces the amount of manpower required since the waste segregation happens automatically, which was traditionally done manually by laborers.

- It reduces the hazards on the health of workers who manually segregate the waste by automating it.

- Since the waste is segregated into different categories at the source, we can directly send the segregated waste into a recycling plant rather than first sending it to a segregation plant, which in turn reduces the overall time.

Literature Survey

Automatic Waste Segregation [1]

Nimisha S Gupta et. Al 3.1.1

Introduction

This paper discusses an interesting fact that the segregation of waste helps in realizing the importance and value of the waste. This paper proposes a system which helps in separating metal, dry, and wet waste automatically. This helps in the reduction of the occupational hazards of the people who manually sort the waste. In this way, sorting waste automatically reduces the threat to the environment. The system developed here consists of various small sub conveyor belts that protrude to a major conveyor belt. The major conveyor belt is responsible for the segregation of waste. At the end of each conveyor, there is a dustbin that has IR sensors incorporated into it. This is done to detect any waste in the bins. If found, the waste falls on the small sub conveyor belt. This is achieved by rotating the bin and then, the waste is moved to the major conveyor belt. At this point, the segregation begins.

Literature Survey

A non-contact type metal sensor is used for the detection of metallic waste. A capacitive proximity sensor is used to separate dry and wet waste. There are different bins at the end of the conveyor, that are rotated using servo motors so that the waste falls into their respective bins correctly. IoT is also incorporated to count the number of wastes of different categories that are collected and then this information is available through a mobile app.

Working of the metallic waste detection module

The metallic waste detection module uses a non-contact type sensor which is used to detect the metallic objects that are close to it. Only metallic objects are identified and non-metallic ones are ignored. This uses the principle of eddy currents and a parallel resonance impedance system. The sensor uses an electromagnetic coil to detect conductive metals by creating a magnetic field, which in turn induces eddy currents on the metallic surface. This eddy current developed on the surface generate a magnetic field that opposes the actual magnetic field which reduces parallel impedance resonance. As the metallic object gets closer to the system, it reduces the amplitude for which a threshold is fixed, and then corresponding action is taken.

Working of the dry and wet waste detection module

A capacitive sensor is used for this purpose. The dielectric constant of wet objects is greater than that of the dry objects. Therefore, if the change in capacitance value is more than a fixed threshold value, the waste is classified as wet else classified as dry.

Results and conclusions

Some materials that were detected as dry waste include paper, plastic, and dry cloth. Some materials that were classified as wet waste includes a banana peel, lemon, and wet cloth. Materials that were detected as metallic waste includes keys, and Aluminum sheet

Future scope

Using more sensors, the capabilities of segregation of waste into different categories can be increased. For example, waste can be categorized into biodegradable and non-biodegradable which is a useful classification.

Automation of Plastic, Metal, and Glass Waste Materials Segregation using Arduino in Scrap Industry [2]
Mohammed Rafeeq et. Al

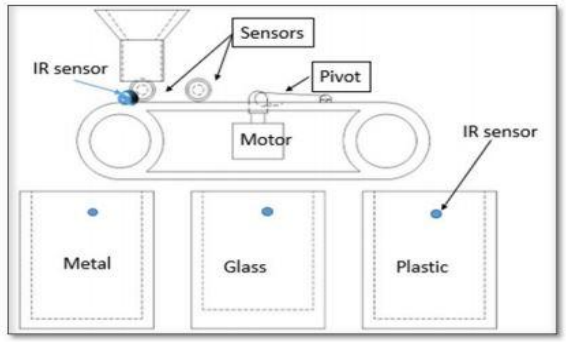
Introduction / Abstract

This paper elucidates the fact that one of the major concerns today is disposing of the waste collected. It also reports that2.02 billion tonnes of waste are generated worldwide. The paper also tells that, for proper management of waste it has to be segregated and transported efficiently. It also quotes that the segregation of waste helps in determining its economic value. Therefore, it aims to segregate the solid waste materials collected into three categories metals, glass, and plastic.

This paper also tells that it is better if the waste is segregated at the source, rather than first sending the waste collected to a segregation plant and later to the recycling plant. This, therefore, reduces the time for recycling. It also gives an insight into how waste is converted into energy using the syngas produced from waste.

This automated system will also reduce the hazards caused to manual waste segregator. It also tells that metal, glass, and plastic form the major part of waste materials.

Working of the system



This system effectively uses three types of sensors:
IR sensor
Inductive sensor
Capacitive sensor

The functionality of each of these are:

- An infrared sensor is used for detection of the fill level of the bins and also to detect any object that is placed on the conveyor belt.
- The metallic waste is detected by an inductive sensor.
- The capacitive sensor is used to classify waste into glass and plastic categories.
- First, the presence of an object(waste) on the conveyor is detected using an IR sensor later when the inductive senor also gives a high output, the belt moves in the clockwise direction to collect the metallic waste. If the above condition is not true, then the belt moves in the anticlockwise direction until it reaches the capacitive sensor. After this, based on the output generated by the capacitive sensor, the material is classified as glass or plastic.
- If the output of the capacitive sensor is high, then the material is glass and if the output is low, the material is plastic and hence, they are collected in their respective bins.

Conclusions and future work

This paper states that there can be several other features that can be incorporated into the system such as segregating dry and wet waste.

The Capacitive sensors available only uses digital values therefore there is a need for a sensor that can read analog values which has many uses. This can reduce the overall cost of the system.

It also states that image processing can also be incorporated for segregation.

AN IoT Based Waste Segregator for Recycling Biodegradable and Non-Biodegradable Waste [3]

Jeberson Retna Raj et. Al

Introduction

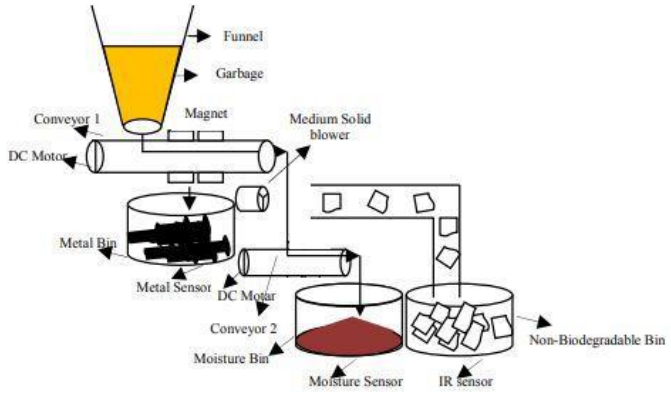
This paper suggests that the segregation and disposal of garbage in cities is a key challenge. Usually, the waste is collected and dumped in a dump yard which is later either burnt or used as land to dump wastes exclusively. This will lead to the emission of harmful gases that affect the environment. Therefore, the solution suggested here, aims to build an autonomous system which can separate waste into metallic, non-biodegradable, and biodegradable (dry and wet).

The system here is built using:

- IR sensor
- Moisture detection sensor
- Medium speed blower
- Magnet
- Two conveyor belts

Working of the system

All the garbage is dumped into a funnel, then the waste is taken to the first conveyor belt. It consists of a magnet, which is used to separate metallic waste. All the metallic waste is first attracted by the magnet and it moves along with the conveyor. Later, there is a bin equipped with a metal detection sensor to detect the metallic waste.



The leftover garbage after extracting metallic waste is passed through a medium speed blower, using which lightweight materials such as papers, plastics are put into a duct which leads to a bin equipped with an IR sensor to detect the waste which is non-biodegradable in a separate bin. Further, the leftover waste that is of higher weight than the plastics and papers fall over the second conveyor belt which leads to the moisture bin which has a moisture detection sensor below to sense all the wet waste coming into the bin.

IoT module is also integrated within the system to upload all the data from the sensors to a cloud which can be later used for processing and visualization.

Results

The metal waste accuracy is 95 percent. Paper waste was detected with an accuracy of 85 percent. The left out waste is dumped into the moisture bin, so the accuracy is 82 percent.

A unique technique for solid waste segregation [4]
Mahesh Kumar et. Al

Introduction
The authors started a survey of solid waste segregation.They found out that it is difficult to segregate different varieties of mixed waste in a single platform. Therefore they suggested implementation for the same. This system consists of a conveyor belt mechanism that is used for segregation. It also makes use of a blower for separating dry and wet waste. Electromagnets are used for separating metallic waste. The working of this system is explained below.

Working of the system
When the mixed waste is deposited on the belt for segregation, the infrared sensor detects the waste present on the conveyor belt. It signals to the microcontroller that waste has been placed on the belt, microcontroller starts the motors, which in turn powers the conveyor belt. Thebelt starts moving.
Once the waste enters the blower section, the belt stops, and the blower is switched on thereby allowing the dry waste to be blown off to the dry bin.

Once the dry waste is segregated, the conveyor belt moves towards the metallic waste segregation section. The belt again stops and the power is given to the electromagnet to attract the metallic objects from the waste. Once metallic wastes are removed from the electromagnet, it is de-magnetized. Hence, the metallic objects fall into the bin. Then the belt starts to move again, to dump the remaining waste (wet waste) into the bin which is placed at the end of the belt.

Conclusion

The waste is segregated into three different categories, namely metal, dry and wet waste, which means a division of waste into biodegradable and non-biodegradable.

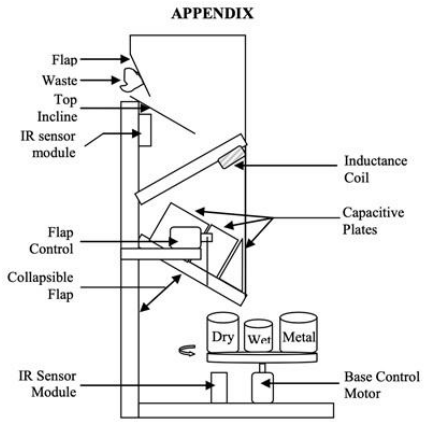
Automated Waste Segregation [5]

Amrutha Chandramohan et. Al

Introduction

The idea in this paper is that waste segregation at the source is always better than doing it in the segregation plant. The benefit of doing so is, it leaves us with higher quality materials from the waste for recycling. Also, the segregated materials are sent directly to the recycling plant for reuse.

The number of workers needed will also be reduced.



Working of the system

On dumping the waste into the system, the infrared proximity sensor senses the waste near it and gets activated which is responsible to bring the microcontroller to working mode(power on mode). The object slides over the inclined surface and falls on the inductance coil which is used to detect any metallic waste that is present in the waste.

The coil generates a magnetic field around it when an alternating current is passed through it. Once the metallic objects are introduced, eddy currents are induced on the surface of the metals. The newly generated magnetic fields oppose the existing field generated by the coil. This decreases the parallel resonant impedance of the circuit which can be observed as an increase in the proximity value. This shows that the object is metallic.

The waste moves down towards the second inclined surface. If the garbage is non-metallic, then the capacitive sensing module starts sensing the object. The property of the relative dielectric constant is used for the classification of waste. Dry waste has a lower dielectric constant than wet waste since it has various fluids contained in it. If the output of the capacitive sensor is higher than a threshold, it is classified as wet waste else it is a dry waste.

Three bins are placed on a circular base, that can rotate and bring the correct container under the flap after the waste is identified.

Later the flap is lowered once the correct bin is under the flap so that the waste goes into the correct bin.

Limitations of the system

The system is capable of segregating one type of waste at once.
Some materials with a higher relative dielectric constant cannot be segregated into dry waste.

Conclusions and future work

This system has been implemented for segregating waste into metal waste, dry waste, and wet waste. Since it segregates only one type of waste at once,it can be improved to segregate mixed wastes by using buffer spaces.

Suggestions from Review - 3

- Implement some sensors and integrate with the Arduino.
- Make a video showcasing the implementation along with the explanations.
- Send the report for plagiarism check.

Design Approach

Design Goals

The main design goal of our system is that we should efficiently segregate the waste into different categories such as wet, metallic, glass, and plastic. Some of the existing systems classify waste into dry, wet, and metallic. Some other system classifies them into glass and plastics. Since solid waste is one of the major categories of waste generated, our system integrates both the features so that a single system has multiple features and is more robust and useful.

Our system will segregate wastes that of not mixed with higher accuracy and it may not very accurately classify the waste if they are mixed such as plastic dipped in water since we are first checking for the presence of water and later checking if it is plastic or not. The system is also designed in such a way to reduce the amount of power consumed by making the conveyor belt move only when there is some waste placed on the belt.

Design Approach

The alternate choices for metal detection were the usage of electromagnets for attracting metal pieces and some systems also used the concept of eddy currents for detection of metallic waste. We planned to use the inductive proximity sensors so that the design complexity of the system remains simple and also to reduce the overall cost of the system.

The other alternatives that were available for segregating wet and dry waste were the use of blowers. These systems used blowers to blow off the dry waste which is usually lighter when compared to wet waste. This system has the disadvantage of blowing away some of the wet waste also.

Therefore, we have designed our system using a moisture detection sensor, which is more accurate than blowers.

Design Approach

Pros :

- The system is simple and easy to use and also cost-effective.
- The entire system is automated where the user needs to place the waste material on the belt and the segregation is all automated.
- The system also uses less power by remaining in an ideal state unless the garbage is placed on it.

Cons:

- The system would not segregate waste accurately if it is mixed due to the limitations of the hardware used, which can sense only one property at a time.
- Any unforeseen hardware failures can prevent the entire system from working as intended

Design Constraints, Assumptions & Dependencies

Constraints: Garbage mixed and given for separation may not be classified into the correct category. For example, a plastic material dipped in water may not be classified as plastics due to the limitations of the hardware such as sensors used.

Assumptions: We need to place the garbage one by one for separation rather than dumping it all at once.

Dependencies: The dependency type of this system is Finish-to -Start that is the first task has to be completed before the second task can start. In our system, the separation of dry waste from wet waste needs to be completed first before further classification of dry waste into different categories. Likewise, the non-metallic waste needs to be segregated first from metallic waste before further classification of non-metals into plastic or glass.

Design Details

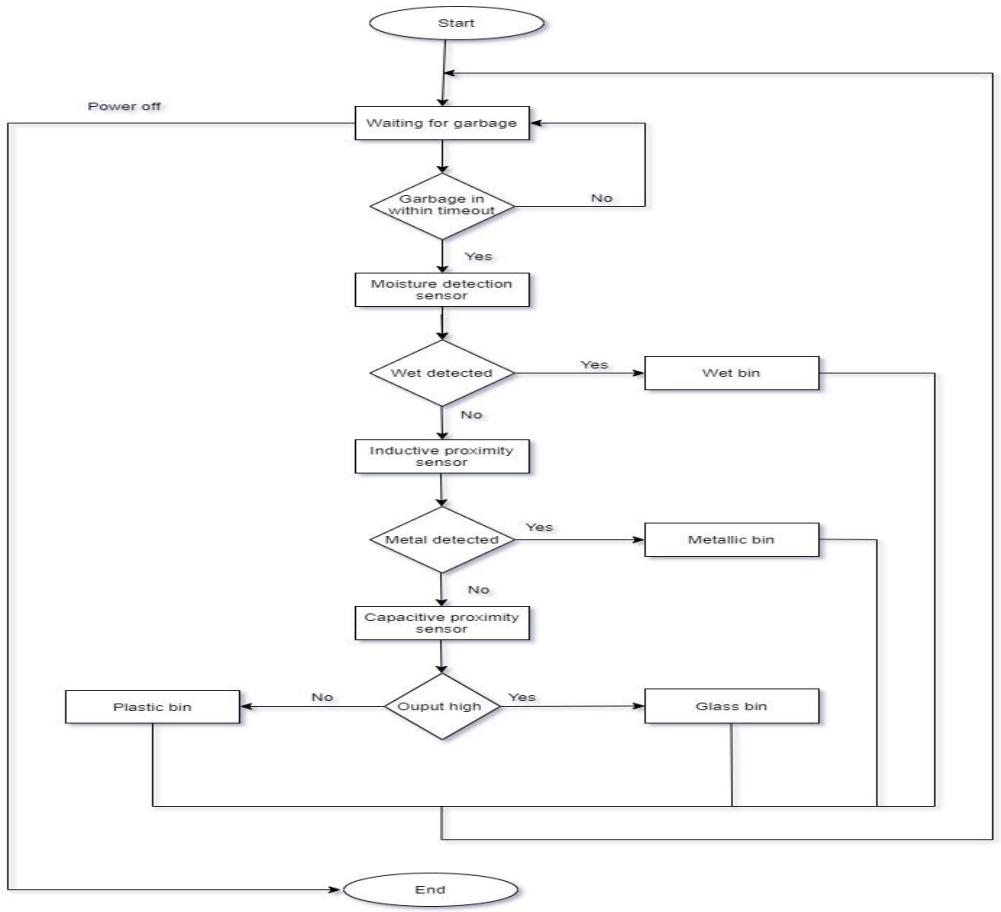
Novelty
This system tries to integrate many types of systems available, to make the system more usable and robust for use. This solution suggested is also a cost-effective solution.

Performance
The best performance of the system is when waste is placed individually on the belt for segregation. It can be measured as the number of materials classified per unit amount of time.

Maintainability
The system suggested here will require continuous examinations and regular maintenance since the hardwares used are prone to errors and failures.

Application compatibility
Since the Arduino used is compatible with almost all commercially available operating systems, it can be used with any of them which provides flexibility for use.

Proposed Methodology / Approach



Flowchart depicting how the system works

Architecture

•The system mainly consists 5 number of modules, which are, conveyor belt module, a moisture detection module, a metal detection module, a capacitive detection module, and a logic module which consists of the Arduino microcontroller.

•The conveyor belt module is responsible for moving the waste placed on the belt to the detection sensor modules. This module is driven by DC motors which are powered by a microcontroller. This module initiates the movement of the conveyor belt only if the proximity sensor of this module detects the waste on the belt or else it continues to stay in a stationary state.

•The moisture detection module which is connected to the logic module gets the waste from the conveyor belt module and is responsible for detecting the wet waste using the moisture detection sensor of this module and sweeps the waste using the servo motor of the module into the corresponding bin if the wet waste is detected.

Architecture

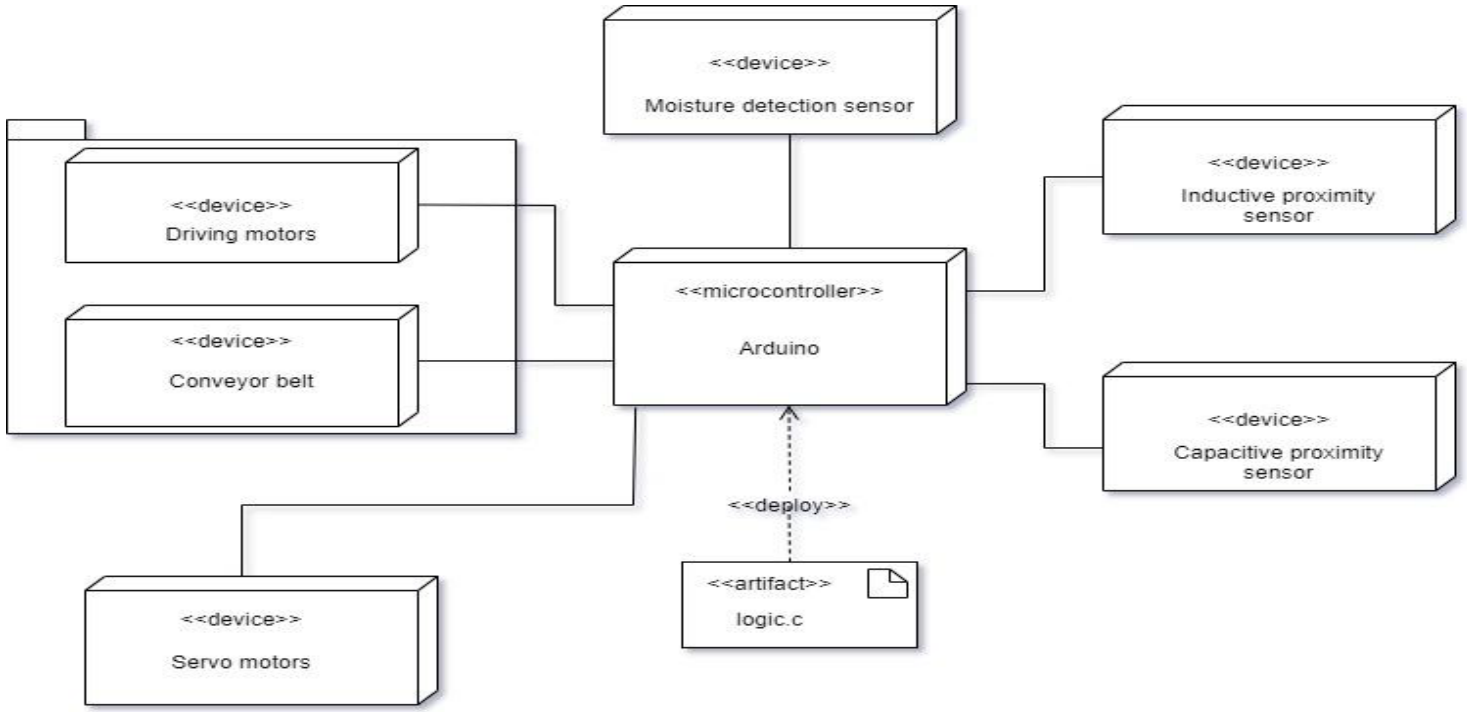
•The waste that is not detected by the moisture detection module is then checked by the metal detection module which is also connected to the logic module. This module gets the waste from the conveyor belt module, and is responsible for detecting the metallic waste using the inductive proximity sensor and sweeps the waste using the servo motor into the corresponding bin if the metallic waste is detected.

•Further, the waste that is not detected by the metal detection module is then checked by capacitive detection module which is connected to the logic module. This module gets the waste from the conveyor belt module, and is responsible for detecting the plastic/glass waste using the capacitive proximity sensor. If the dielectric value read by the capacitive proximity sensor is high then the waste is classified as glass and if the value is low then it is classified as plastic and these wastes would be swept into their respective bins by the servo motors.

•The working of the conveyor belt system depends on the logic module which reacts based on the output of the proximity sensor. The segregation process is also dependent on the logic module which activates the respective servo motors for segregation depending on the output of all the other modules mentioned above. All the above modules are interconnected using physical wires, connected to various pins of the Arduino board.

Architecture

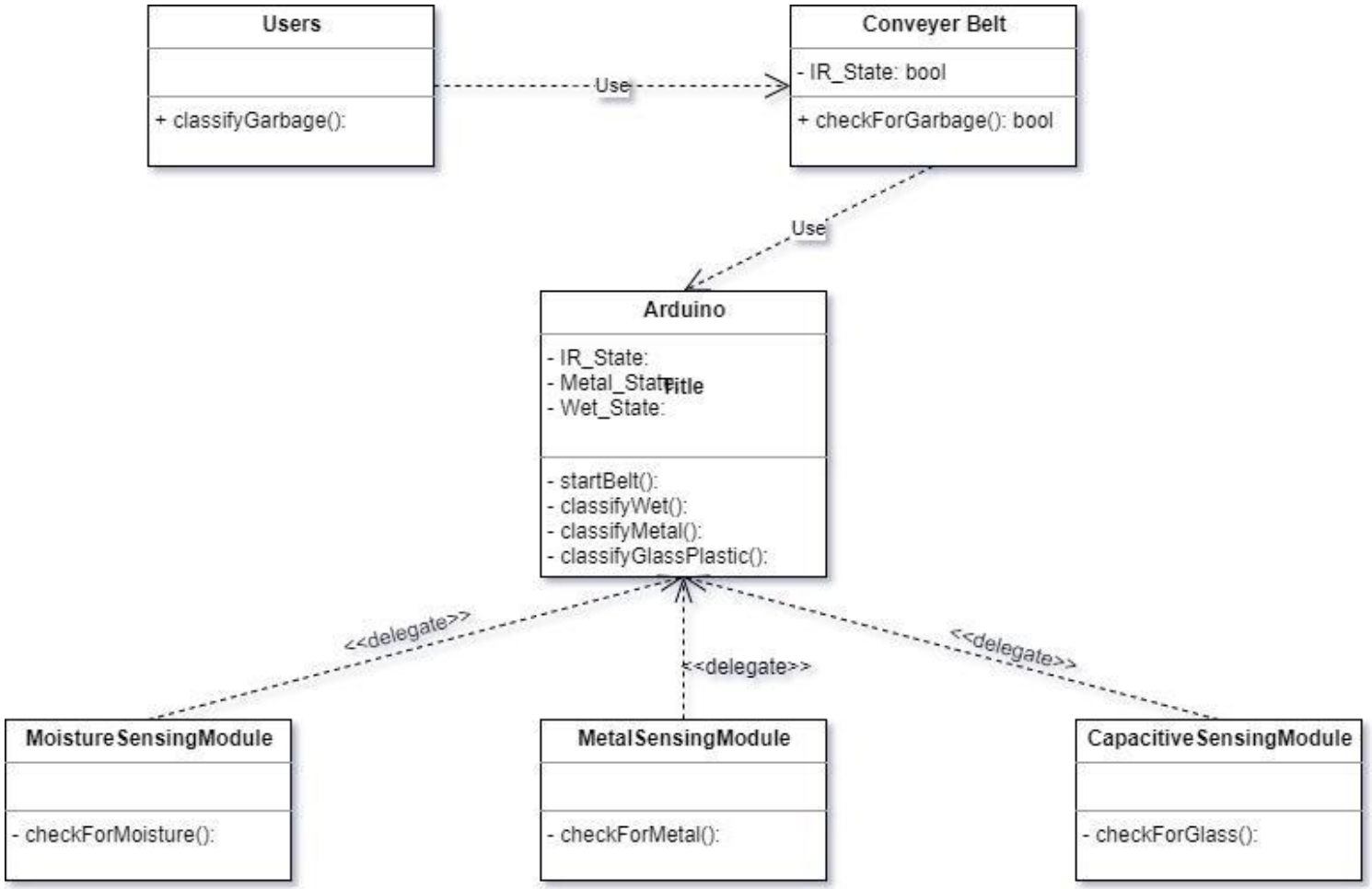
Deployment Diagram



Deployment diagram for the proposed system

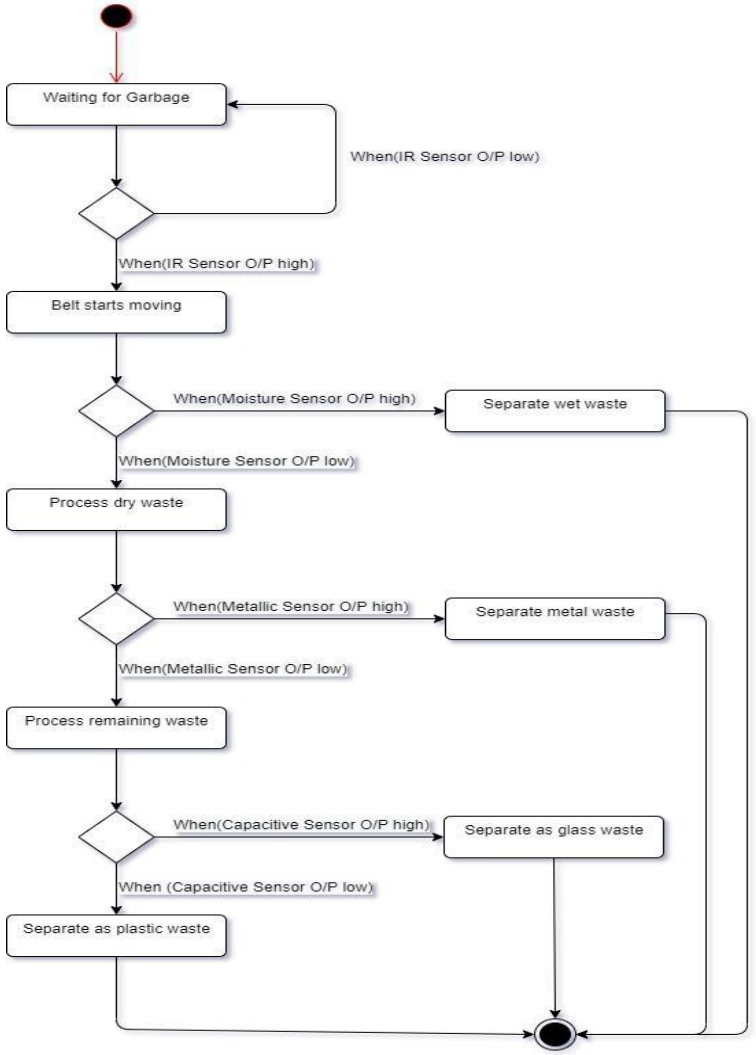
Design Description

Master Class Diagram



Design Description

State Diagram



Design Description

User Interface Diagrams

Our system does not contain any screen as such. It just has the conveyor belt on which the garbage is placed for segregation. This is the only interface with which the user will interact. The other part of the system with which the user interacts is the dustbins, which need to be emptied as and when the bins are full.

Report Layouts

The report for the verification and validation of the project contains the following:

1) Sl. No.
2) The material used for testing
3) Class of the material output by the system
4) Actual class of the material

Lastly, some metrics such as accuracy can be calculated based on the observations made during the testing.

Design Description

External Interfaces

Various devices are connected to the Arduino board using the various types of pins available such as:
1) Power pins: Used to supply power to the microcontroller.
2) Analog pins: Used to provide analog inputs to the microcontroller.
3) PWM pins: Used to provide PWM output can be used for dc motor driving.
4) Digital pins: Used to provide the inputs in the digital form to the microcontroller.

Other pins are also available for use.

Technologies Used

Arduino Integrated Development Environment:

- This is an open-source software tool that facilitates the easy writing of the code which helps in faster development. This software tool also allows us to upload the written code into the Arduino board.

C programming language:

- This is a general-purpose, procedural programming knowledge that can be used for various purposes. We use this to write code that controls the whole system

Project Progress

•We have started the implementation of the project.

•We have completed the implementation of ultrasonic sensor and moisture detection sensor and integrated both with the arduino using a breadboard.

•25% of our project is complete and we will have to work on inductive proximity sensor, capacitive sensor and we should also build the conveyor belt.

•The link to our video explanation of the implementation : https://drive.google.com/drive/folders/1lFBP7b31BagYy2FH-UpDXNSc-GmhmQzp?usp=sharing

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For component diagram:
https://www.visual-paradigm.com/guide/uml-unified-modeling-language/what-is-component-diagram/

For deployment diagram:
https://www.visual-paradigm.com/guide/uml-unified-modeling-language/what-is-deployment-diagram/

For state diagram:
https://www.guru99.com/state-machine-transition-diagram.html

https://www.smartdraw.com/state-diagram/

Thank You