HIGH LEVEL DESIGN DOCUMENT

Smart Waste Segregation

UE17CS490A – Capstone Project Phase – 1

Submitted by:

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1. Introduction

One of the major concerns today is waste disposal. The improper disposal of waste can lead to various disastrous effects on the health of humans and other living organisms. The first step towards the disposal of waste is segregation. This document discusses the high-level design of our intended solution according to the requirements stated in the project requirement specification.

Our solution to the problem of segregation is building a smart waste segregator that can segregate the waste into different categories such as wet, metallic, glass, and plastic.

This is achieved by the usage of various sensors and a conveyor belt which is used as a medium for transporting the waste from the source (segregation point) to its destination that is their respective bins. We will be using a moisture detection sensor to segregate the wet waste first, and then segregate the remaining waste into metallic waste, glass, and plastics using a metal detection sensor (inductive proximity sensor) and capacitive proximity sensors respectively. The coordination among all the sensors and working of the system is governed by an Arduino board which has the program written in C language to be followed. This is an overview of the design of our smart waste segregator.

2. Current System

All the existing systems try to segregate the waste into either dry, metallic, and wet waste or segregating them into glass and plastics. This is achieved by using various sensors such as metallic sensors, electromagnetic induction coils for the segregation of metals. For detection of wet and dry waste some architectures have used moisture detection sensors, some use capacitive sensors, and others have used a blower for segregation the wet and dry waste. Some existing systems use a series of conveyor belts as a medium for transportation and some of the others use a bin set up which successfully separates the waste according to its category.

After all the above considerations, we are trying to build a system that can integrate uses of existing systems into one so that the product is more useful and robust.

3. Design Considerations

3.1.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.

3.2.Architecture Choices

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.

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.

3.3.Constraints, Assumptions and Dependencies

Assumptions:

We need to place the garbage one by one for separation rather than dumping it all at once. This is because of the limitations and accuracies of the hardware used.

Constraint:

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 sensors used.

Risks:

There can be some unforeseen failures in the hardware which could pose a problem during the final delivery of the project.

Limitations :

- The system developed in this method will need to be continuously monitored since the hardware used are prone to failures and they need to be replaced once failed for the system to work properly.
- The accuracy of the classification of mixed waste cannot be predetermined because the system works differently for different materials.

4. High-Level System Design

The system mainly consists of 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.

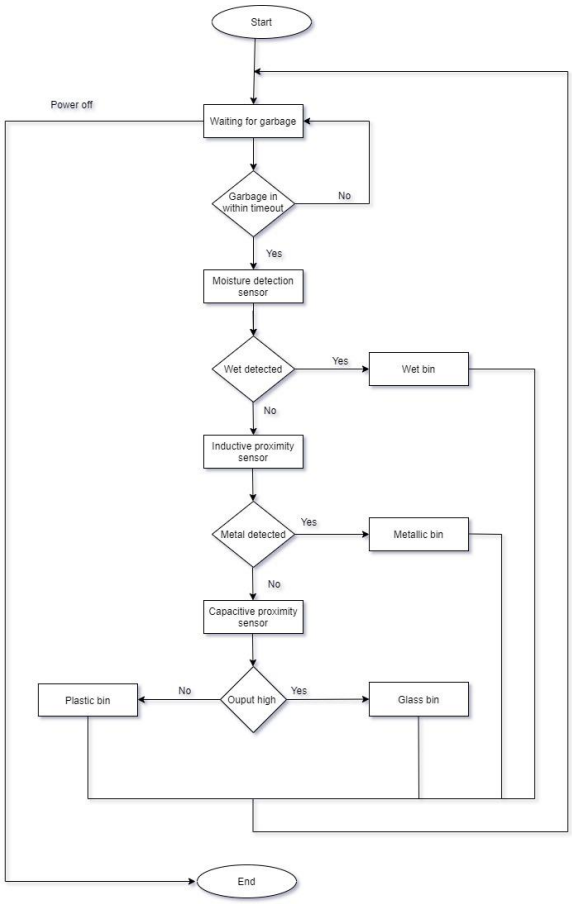
The conveyor belt module is responsible for moving the waste placed on the belt to the detection sensor modules. This module is driven by DC motors which are powered by a microcontroller. This module initiates the movement of the conveyor belt only if the proximity sensor of this module detects the waste 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.

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.



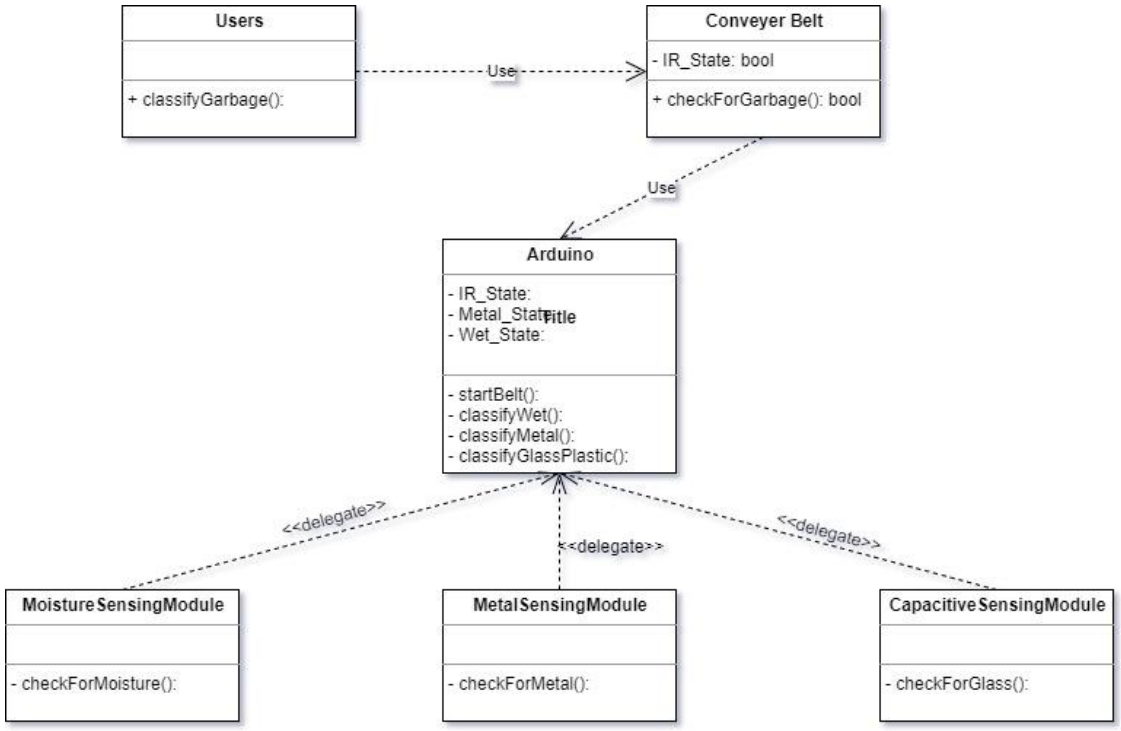
Flowchart depicting how the system works

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.

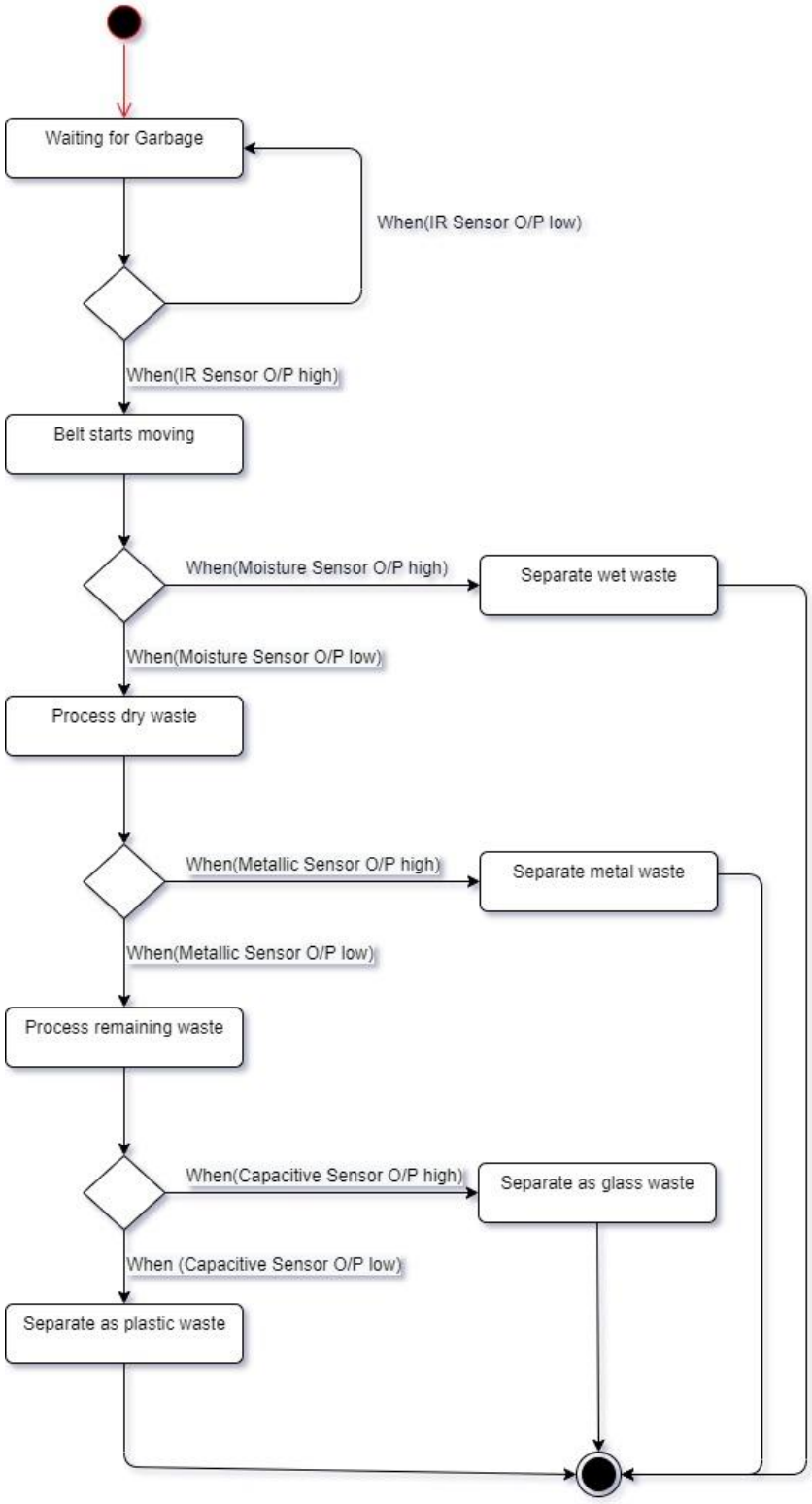
5. Design Description

5.1. Master class diagram

The class diagram for the system is as follows. This shows how each module interacts with other modules to enable the working of the system as intended. This diagram also shows the dependencies between various components of the system.



6. State Diagram:



7. 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.

8. 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.

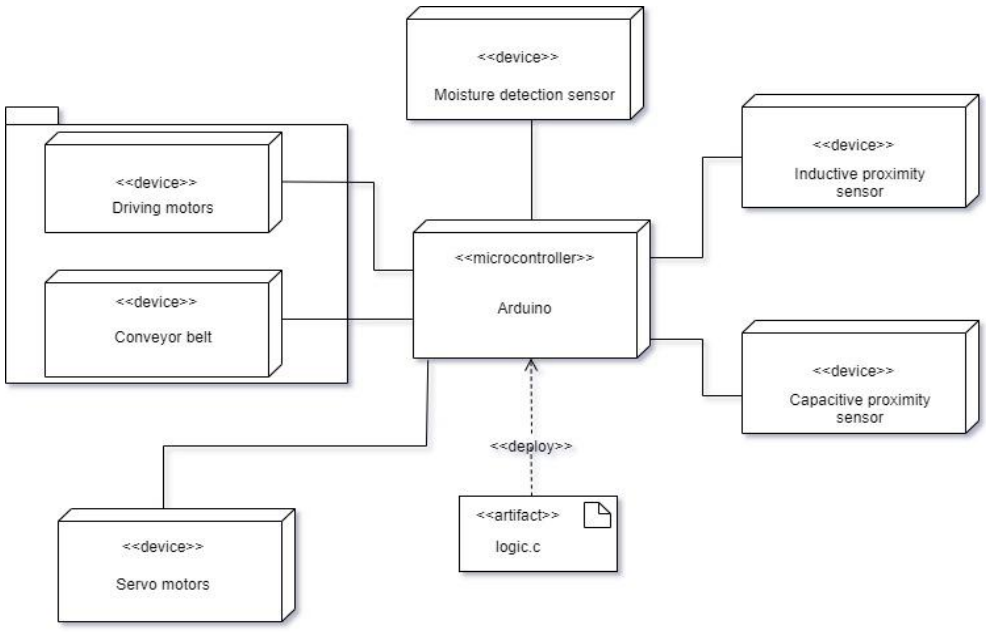
9. External Interfaces

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.

10. Packaging and Deployment Diagram



Deployment diagram for the proposed system

11. Help

https://www.arduino.cc/en/software

This is the main source for all the references for Arduino which has many tutorials regarding the usage of various devices with Arduino.

https://www.cprogramming.com/

This is the source of reference that can be used for C programming.

12. Design Details

12.0. 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.

12.1. 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.

12.2. Maintainability

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

12.3. 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.

Appendix A: Definitions, Acronyms, and Abbreviations

PWM pins: Pulse Width Modulation pins. It is used for analog results with digital means.

Conveyor belt module: This module consists of a conveyor belt, DC motors for driving the belt, proximity sensor for switching on and off the belt.

Moisture detection module: This module consists of a moisture detection sensor along with a mechanism that uses a servo motor to push off the garbage to the respective bin if the garbage is detected as wet.

Metal detection module: This module consists of an inductive proximity sensor along with a mechanism that uses a servo motor to push off the garbage to the respective bin if the garbage is detected as metal.

Capacitive detection module: This module consists of a capacitive proximity sensor along with a mechanism that uses a servo motor to push off the garbage to the glass or plastic bins respectively based on the dielectric value read by the sensor.

Logic module: This module consists of an Arduino microcontroller which enables the working of all other modules as intended.

Appendix B: References

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/

For design ideas papers reviewed in literature survey.

Appendix C: Record of Change History

#	Date	Document Version No.	Change Description	Reason for Change

Appendix D: Traceability Matrix

Project Requirement Specification Reference Section No. and Name.	DESIGN / HLD Reference Section No. and Name.
3.Functional requirements	6.State diagram
3.Functional requirements	5.Design Description
4.2.Hardware requirements	10.Deployment diagram