UE17CS490B – Capstone Project Phase – 2

SEMESTER - VIII

END SEMESTER ASSESSMENT

Project Title : Smart Waste Segregation
Project ID : PW21CBR02
Project Guide : Charanraj B R
Project Team : Guruprasad Hadimani
Nagesh K J
Laxman
Sanathkumar G

Outline

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Abstract

- An increase in population, modernization, and industrialization has led to the generation of humongous amount of waste.
- According to an estimate, 2.01 billion tonnes of solid waste is generated annually.
- This proves to be a major concern in many countries today.
- The inefficiency of existing techniques adopted for the disposal of the waste further uplifts the problem by adversely impacting the ecosystem.
- The major contributors to solid waste are metals, glasses, and plastics. Segregating them into different categories ease the problem of disposal of waste.
- Therefore we aim to propose an affordable and easy-to-use solution for the aforementioned problem into four categories which are wet, metal, glass, and plastic.
- The proposed system uses various sensors along with the power of image recognition to achieve the purpose.

Team Roles and Responsibilities

SRN & Name	Literature Survey	HLD	LLD	Implement ation	Testing	Report	IEEE paper
PES1201700980 Guruprasad Hadimani		✓	✓	✓	✓	✓	✓
PES1201701528 Nagesh K J	✓	✓	✓	✓	✓	✓	✓
PES1201701632 Laxman	✓		✓	✓	✓	✓	
PES1201701771 Sanathkumar G	✓	✓	✓	✓		✓	✓

Summary of Requirements and Design

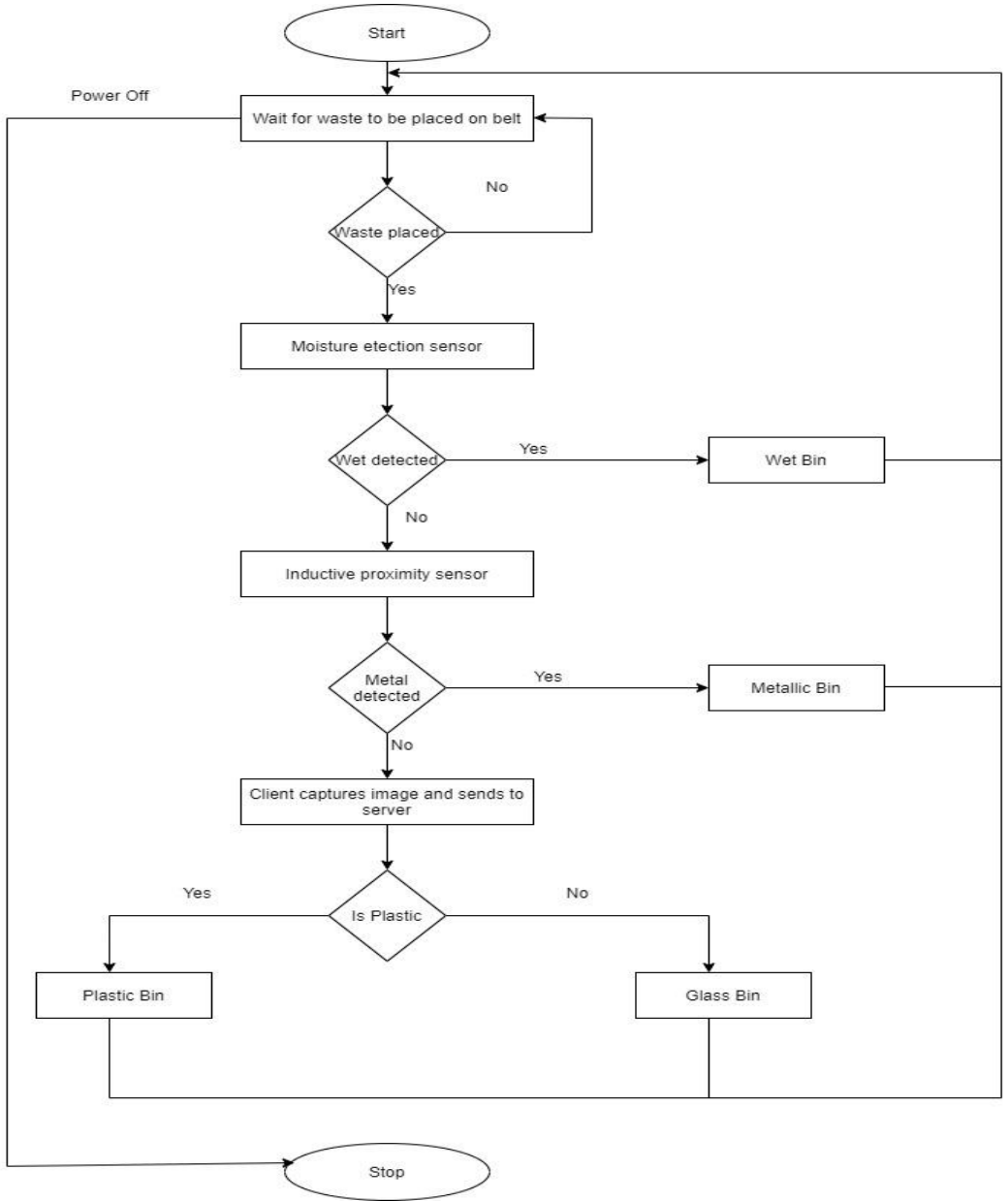
- Low power consumption: The system should start working once the waste is placed on the conveyor belt else it should remain in an idle state.
- The system should segregate the waste into wet, metal, glass, and plastic categories correctly when they are placed one after the other on the belt.
- The system should be easy to use. This is achieved by automating the entire system where the user will just place the garbage and all other things are taken care of by the system itself.

Summary of Requirements and Design

- During the background research, some of the existing systems were studied.
- Some of them aimed to segregate the waste into dry, wet, and metal categories. Some others segregated waste into glass and plastics.
- Our system combines the methodologies adopted in the existing systems to categorize the waste in a more robust way using industrial-grade sensors and image processing.
- Some systems used a blower for segregating dry from wet waste which can potentially blow off the light-weight wet waste.
- Electromagnets were used for the metal waste segregation in some existing systems which is difficult to maintain.

Summary of Requirements and Design

Design Approach



Summary of Requirements and Design

Constraints: Garbage mixed and given for separation may not be classified into the correct category.

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.

Risks: This system works only when one waste at a time is given to it rather than dumping the mixed waste all at once. There could be some unforeseen failures in the hardware that could pose a problem during its final delivery.

Summary of Methodology / Approach

Technologies used:

- Arduino IDE : Provides an interface to write the programs and feed the same into the Arduino microcontroller.
- C programming: Used to program the Arduino microcontroller.
- Python programming: Used for image processing.
- Google colaboratory: Used to run the image classifier model.
- Ngrok: Used for making the REST API publicly available.

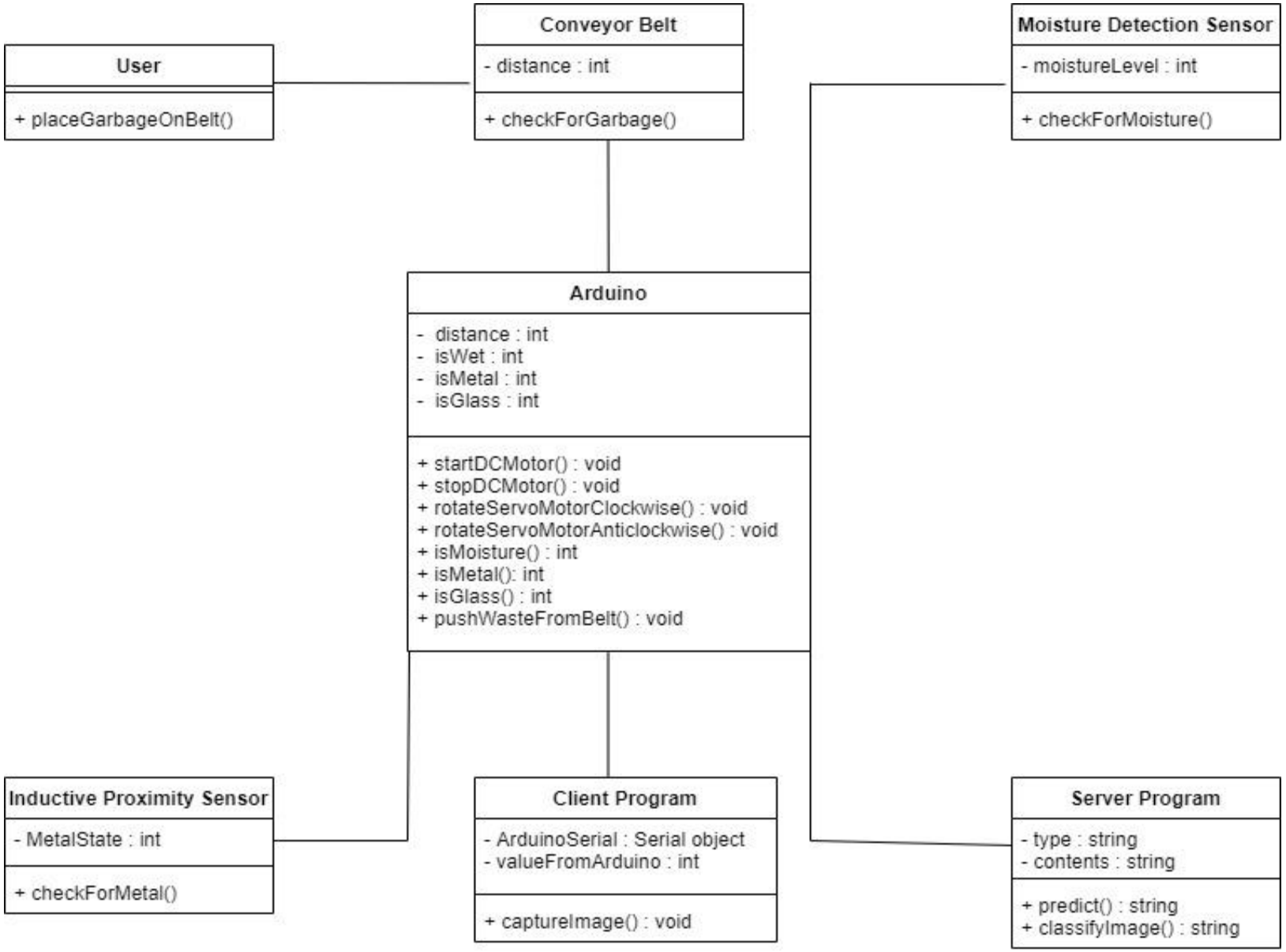
Summary of Methodology / Approach

Alternative approach chosen after phase-1

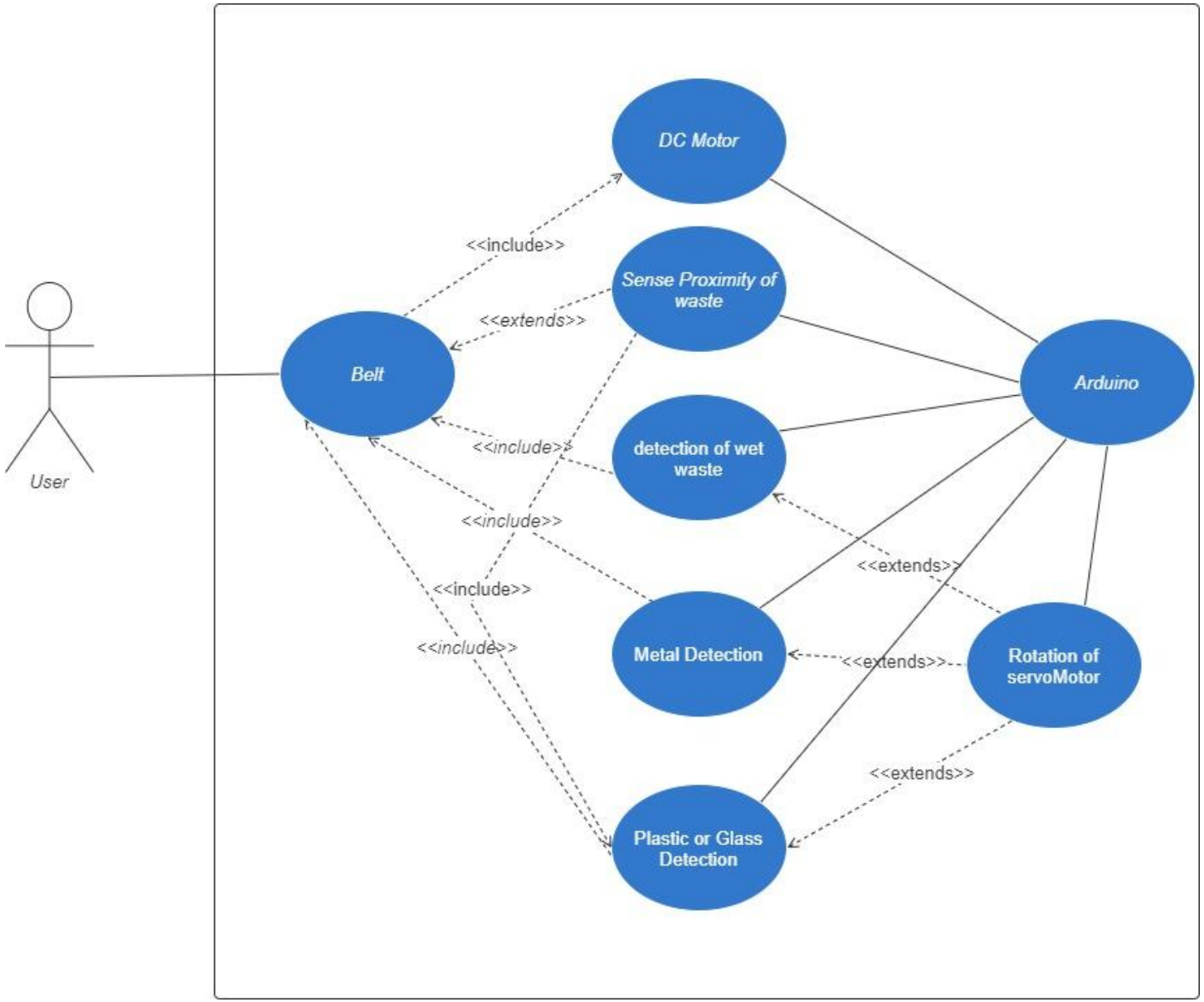
- Initially it was decided to use capacitive proximity sensor for the glass and plastic waste detection but later an image classifier model using resnet34 was implemented.

- The above mentioned change is due to the fact that the output of the capacitive proximity sensor was varying drastically whenever the materials were brought near to it. Because of this behavior, it was difficult to find out the ranges which could differentiate between glass and plastic.

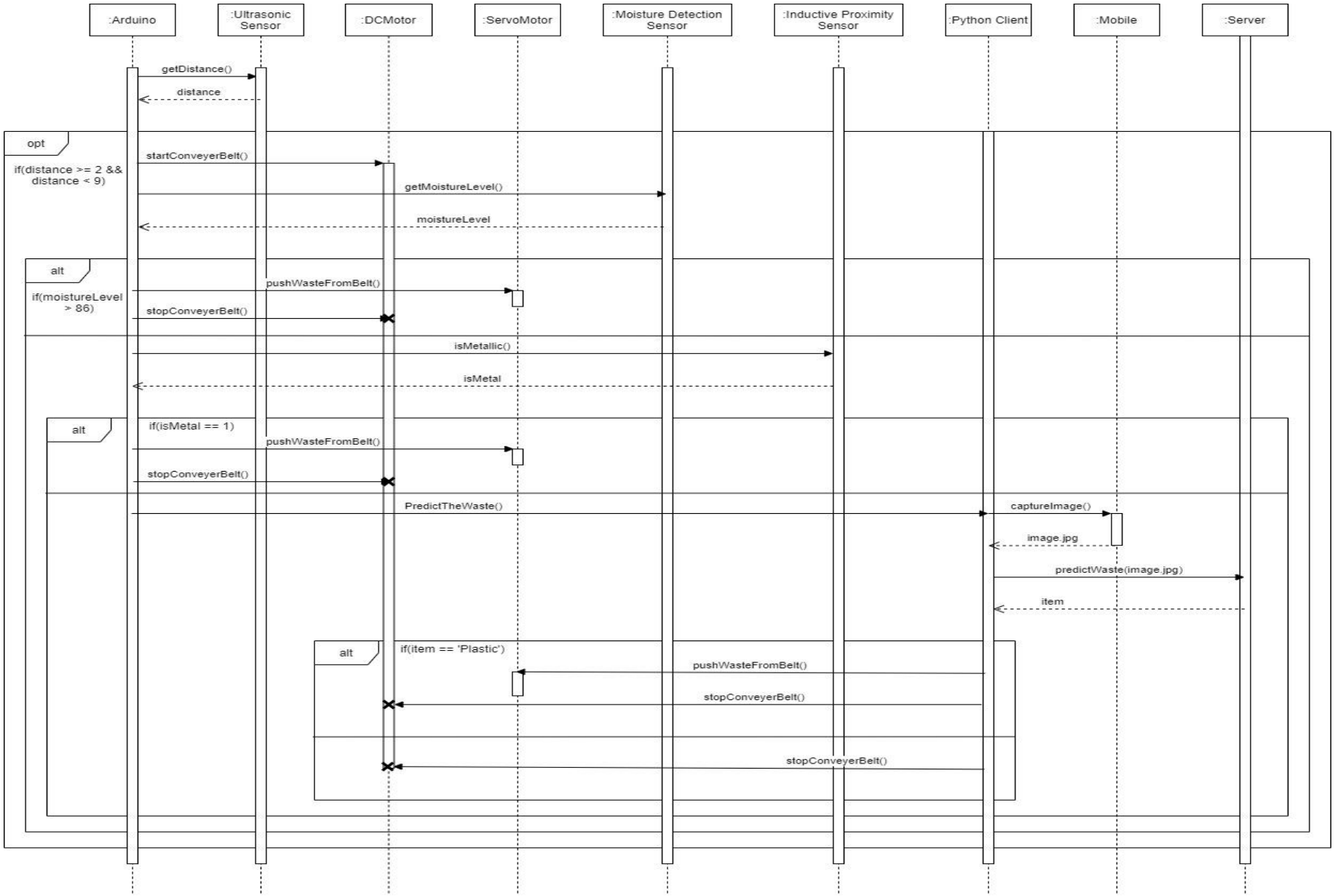
Design Description – Master class diagram



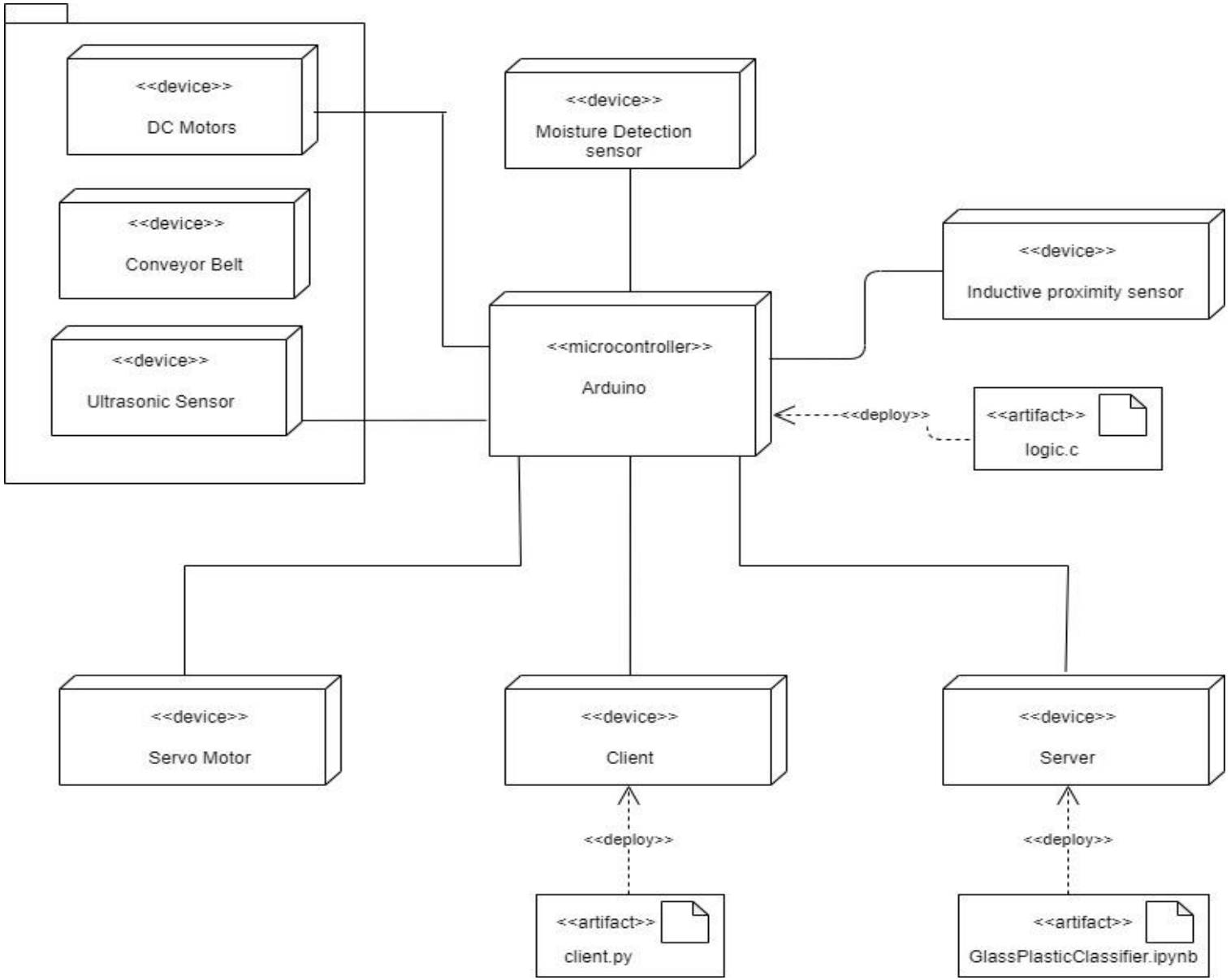
Design Description – Use case diagram



Design Description – Sequence diagram



Design Description – Deployment diagram



Modules and Implementation Details

- **Conveyor belt module** - It is used as a medium to carry waste from source to destination bins. It also helps to move the waste from one sensing module to another.

- **Moisture detection module** - It is used to segregate wet waste from dry. The wet waste is segregated to a separate bin dry waste is further processed.

- **Metal detection module -** It is used to segregate metallic waste from non-metallic. The metallic waste is segregated to a separate bin non-metallic waste is further processed.

- **Glass or plastic detection module –** It is used to segregate glass and plastic wastes, both are collected in separate bins.

Modules and Implementation Details

Conveyor belt module

Components : Conveyor belt, DC motors, Ultrasonic sensor.

The module entails the functions.

- To start the rotation of the conveyor belt.
- To stop the rotation of the conveyor belt.
- A function to check when to start and stop the conveyor belt.

The system is designed to work in low power consumption mode by using an ultrasonic sensor to detect the presence of waste on the belt.

Modules and Implementation Details

- This is done by checking if the waste is within certain distance from the sensor. If found so, the belt is rotated and the process of segregation begins.

- If there is no waste placed on the belt, the belt remains in the stationary state thereby saving the power needed to rotate the conveyor belt.

Modules and Implementation Details

Moisture detection module

Components : Soil moisture detection sensor, Servo motor.

This module consists of following

- A function to detect if the waste is wet or dry using the output of soil moisture detection sensor by fixing a threshold value.
- A function to push the waste from the belt using a servo motor with the flap-like mechanism. This function is activated once the waste is detected as wet.

Modules and Implementation Details

Metal detection module

Components : NPN type Inductive proximity sensor, Servo motor.

This module consists of following

- A function to detect if the waste is metallic or non-metallic using the output of inductive proximity sensor. If the output is 1, the waste is metallic. If it is 0 the waste is non-metallic.

- A function to push the waste from the belt using a servo motor with the flap-like mechanism. This function is activated once the waste is detected as metallic.

Modules and Implementation Details

Glass or plastic detection module

Components : Ultrasonic sensor, Python client, Python server, and Servo motor.

This module consists of following

- A function to detect if the waste has entered this module using ultrasonic sensor which detects the proximity of object.
- A python client which captures the image of waste that has entered this module. This also continuously monitors the state of ultrasonic sensor to check if the image can be captured.

Modules and Implementation Details

- A python server that has trained model to classify image sent from client as glass or plastic and send the response back to the client using REST API. The API is made publicly available using ngrok.

- The model is trained using resnet34 which is a Convolutional Neural Network. This is trained on images containing glass and plastics.

- A function to push the waste from the belt using a servo motor with the flap-like mechanism. This function is activated once the waste is detected as plastic.

Project Demonstration

- Link to the dataset consisting of images of glass and plastic.

  https://drive.google.com/file/d/1mkMhTdFVIUKBW6HW3wIcSdDiVmd9BExQ/view?usp=sharing

- Dataset is a zipped folder containing two internal folders glass and plastic which have their respective images in them.

- To the existing folders we added images of glasses and plastics kept on the conveyor belt.

- The data is split into train, test, and validate sets in the ratio 2:1:1.

- The data is randomly sampled and then separated into the three aforementioned sets.

Walkthrough

Link to the project demonstration video

https://drive.google.com/file/d/1HPuQjC_nr4C5jIlfpIgbuPJ5rgcS4QL9/view

Test Plan and Strategy

Unit testing - Each component was tested individually for proper functioning before any module was built.

- DC motors were tested for the direction and speed of rotation.
- Servo motors were tested for rotation by varying the degree of rotation.
- Moisture detection sensor was tested to check if it was able to differentiate between dry and wet waste.
- Inductive proximity sensor was tested to check if it was able to differentiate between metals and non-metals.
- Ultrasonic sensors were tested to verify if they could measure the proximity of the object.

Test Plan and Strategy

Integration testing – This test was conducted to ensure if all the components are working when combined into modules.

- Integration of ultrasonic sensor with DC motors and conveyor belt to ensure If the requirements for power consumption mode is satisfied.

- Testing for integration of soil moisture detection sensor along with the servo motor and Arduino to check if the moisture detection module works as intended.

- Testing for integration of inductive proximity sensor along with the servo motor and Arduino to check if the metal detection module works as intended.

Test Plan and Strategy

- Testing for integration of ultrasonic sensor along with the servo motor and Arduino's serial connection to laptop running python client connected to image classifier.

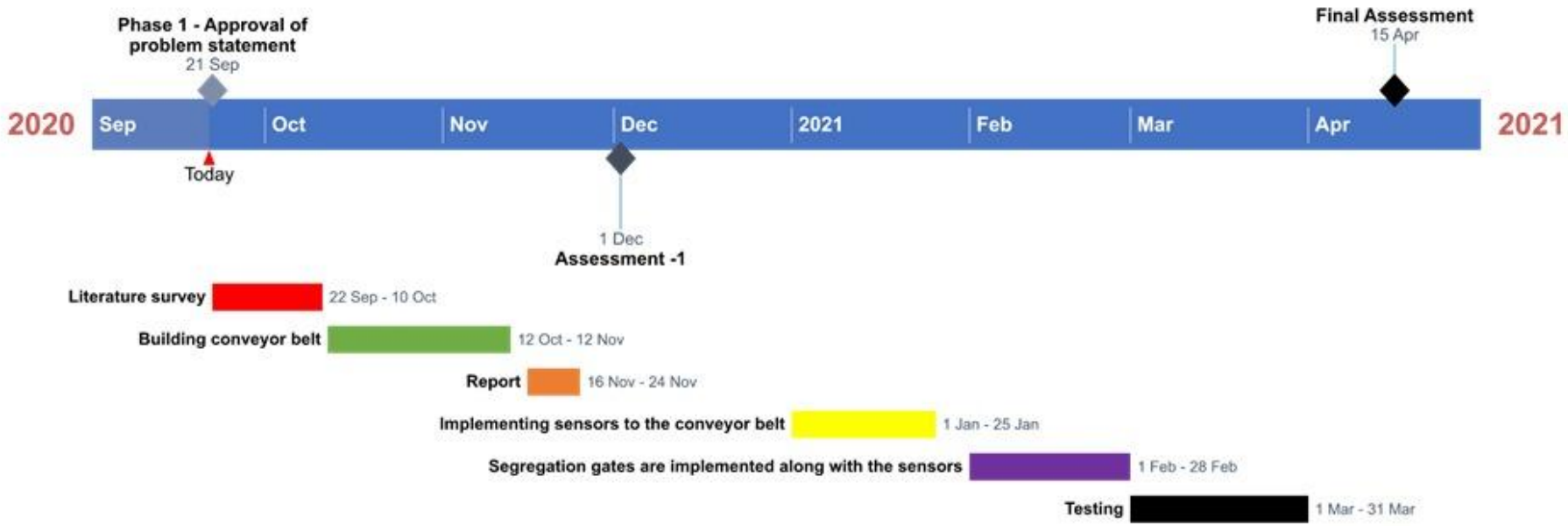
System testing – An end-to-end test was carried out to ensure if the system was classifying the waste into its respective category correctly.

Results and Discussion

Sl.No	Material Used	Expected Outcome	Actual Outcome
1	Dry paper	Dry	Dry
2	Wet cloth	Wet	Wet
3	Power bank	Metallic	Metallic
4	Silver ring	Metallic	Metallic
5	Vicks bottle	Non-metallic	Non-metallic
6	Bisleri water bottle	Plastic	Plastic
7	Glass tumbler	Glass	Glass
8	Steel tumbler	Metal	Metal

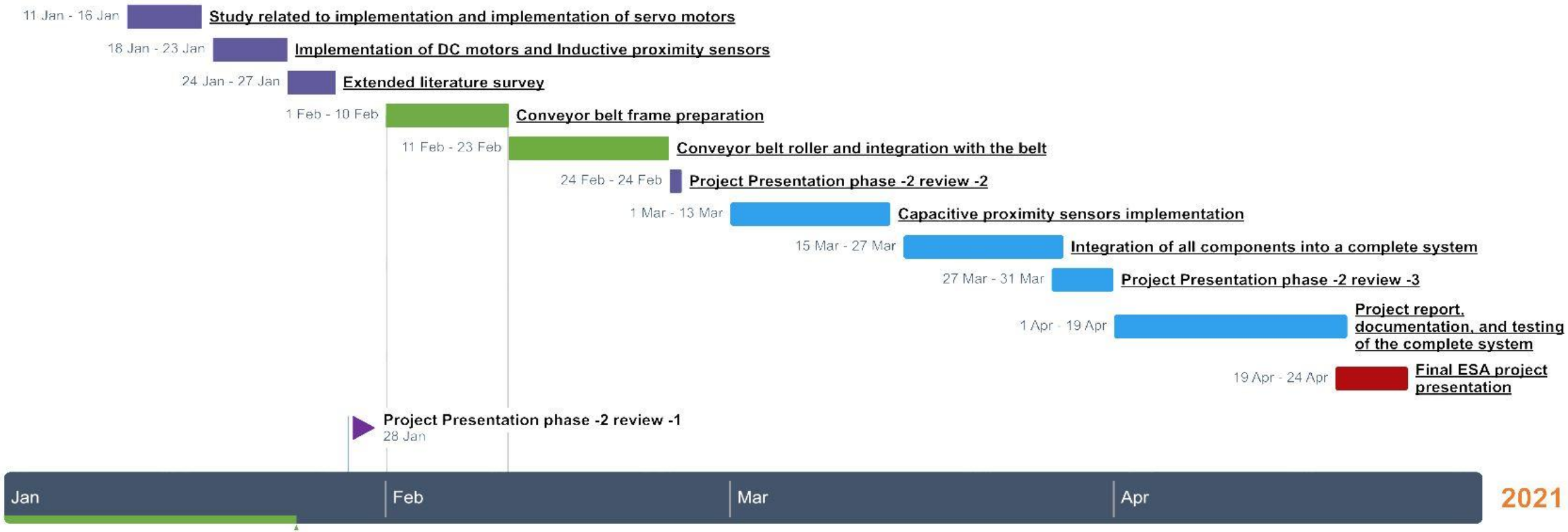
Schedule - Time plan for capstone phase – 1

Planned schedule of this phase was met as expected.



Schedule - Time plan for the capstone phase – 2

This phase had some difficulties in differentiating between glass and plastics. Initially capacitive proximity sensor was planned to use for the purpose. Eventually it was found that capacitive proximity sensor could not be used for the purpose. Hence an image classifier is incorporated. There were some difficulties faced while using this model. Hence there was slight deviation in the actual time plan of this phase.



Documentation

- Project report finalized by Guide? – Yes.
- IEEE (similar) Format of Paper ready for submission or current status? Which Conferences are you targeting? – Ready with plagiarism score 8% and applied for the IEEE conference at https://ieee-conecct.org/.
- Video (2-3 minutes) of your project? Please Play.
- Add the Github repository link – Documents yet to be uploaded to this link.

https://github.com/Ramanujan1999/CapstoneProject

- A3 size Poster of your project to be shown – Ready.
- All artifacts of your project uploaded in the CSE Project repository? – Yet to be uploaded.

Lessons Learnt

- We have learnt how to carry out a project in all aspects starting from background research followed by system design, implementation, and testing along with the documentation.

- We have learnt to work collaboratively in teams.

- We got an exposure of working with various hardware devices like Arduino microcontroller and different sensors.

- We got a chance to apply the concepts learnt in various courses in the project such as using REST APIs, machine learning model.

Conclusion and Future work

- The proposed system segregates the waste into different categories such as wet, metal, glass, and plastic.
- The wet and metal waste detection modules were built using sensors whereas an image classifier model was built to differentiate between glass and plastics.
- The system is an easy to use and a cost effective system both in terms of development time and operating cost.
- The operating cost of the system is low since it is designed to work in low power consumption mode.

Conclusion and Future work

- The system can incorporate a chemical sensor to detect any harmful substances in the mixed waste and take necessary actions such as alert the municipal corporation or segregate them into a separate bin.
- Our system is incapable of handling mixed waste, this drawback can be fixed by segregating the dumped waste using multiple conveyor belts and screening mechanism before it reaches the main conveyor belt for segregation.
- IoT can be incorporated to collect the amount of waste segregated for each type and this can be used to perform analytics and visualizations.
- The fill level of each bin can be measured using IR/Ultrasonic sensors which can be used as an indication for emptying the bin.

References

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

online drawing tool was used to design the flowchart of the system. https://app.diagrams.net/

Thank You