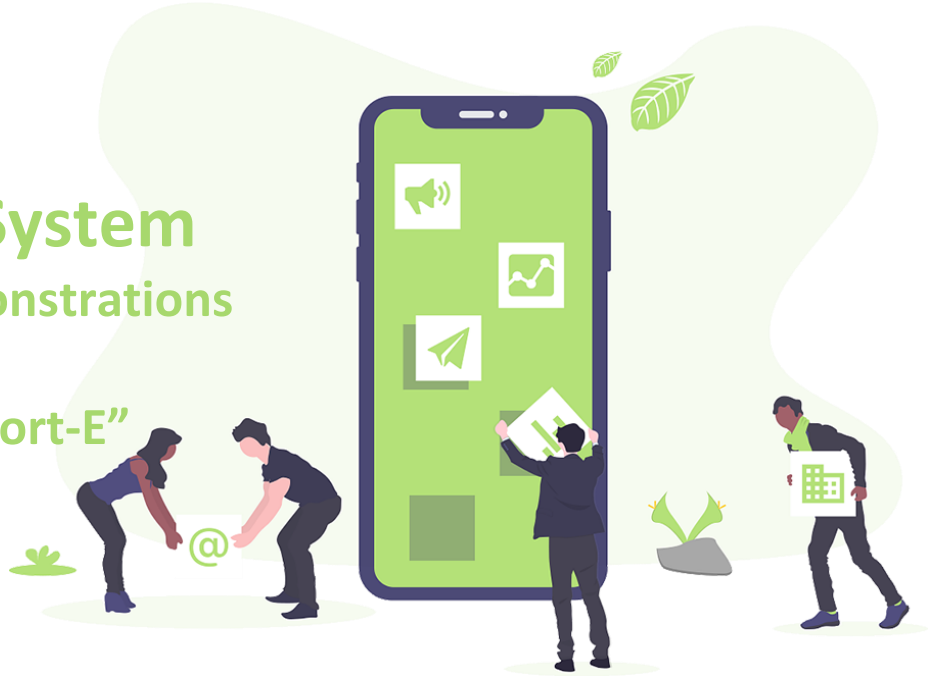
BGreen

Sort-E

Smart Waste Sorting System

Team 8 – Proof of Concept Demonstrations

"Everything is Simple with Sort-E"



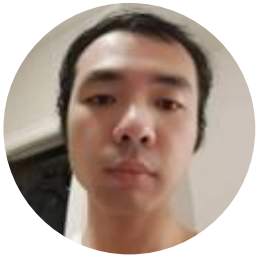
SFU

BGreen

Our Team

ChinHo Wan (Justin)
CEO

DongYue Shi (Stone)
CCO



ChenXi Wang (Charlie)
CTO

TianXiao Liu (Michael)
COO

31,000,000 t

Canadians produce more garbage per capita than any other country on earth [1], Canadians generate approximately 31 million tones of garbage a year (and only recycle about 30 per cent of that material).

30%

Only recycle about 30 per cent of waste material [1]

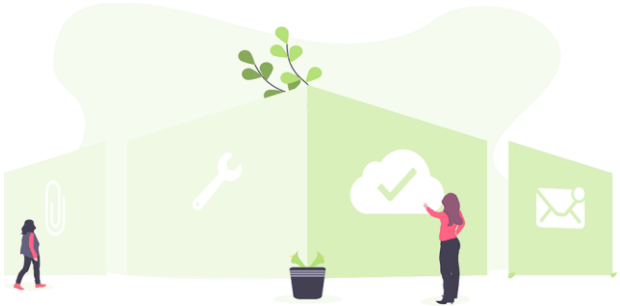
Introduction

Purpose

- Sort-E – Smart Waste Sorting System
- Reduce the negative impact of waste pollution on the global environment
- Bring a more convenient life for Canadian residents
- Provide information related to waste sorting

Target Market

- Schools
- Airports
- Offices



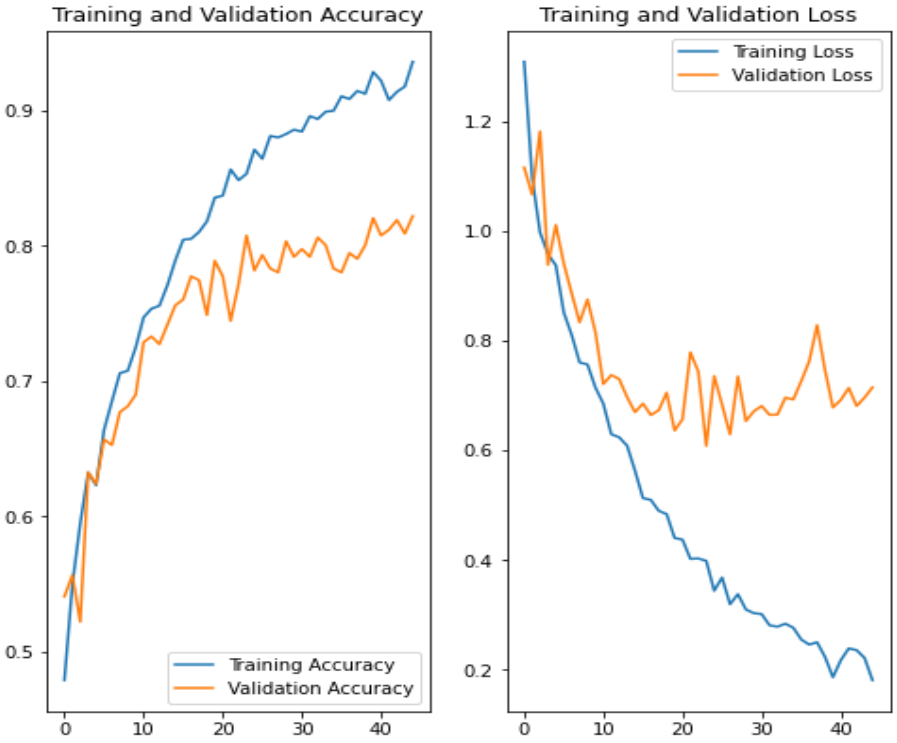
Technical Case (Software)

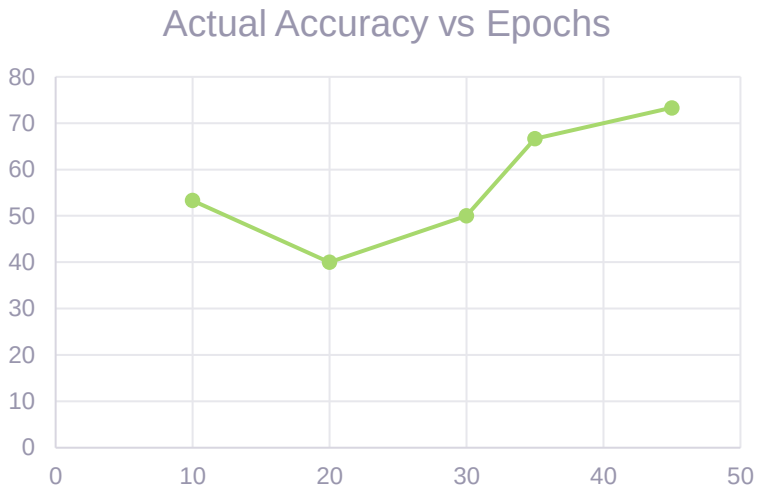
Accuracy (Data Argumentation)

Data Argumentation generates additional training data from existing examples by augmenting them with a random rotational transformation

- Training Accuracy
  - 80% of dataset used to train
- Validation Accuracy
  - 20% of the dataset used to test
- Actual Accuracy
  - 30 photos taken manually (Not including in dataset)

Accuracy Comparison





Classes And Catogories

Classes

- Compost
- Landfill
- Plastic
- Metal
- Glass

Categories

Compost | Plastic/Metal/ Glass | Landfill

Software Demo (AI) - Compost

Software Demo (AI) - Landfill

Software Demo (AI) - Plastic

Software Demo (AI) - Metal

Software Demo (AI) - Glass

Software Demo (AI) - Explanation

Accurate

- Compost
- Landfill

Imprecise

- Plastic
- Metal
- Glass

Reasons

- Small dataset of plastic, metal and glass
- Color confliction
  - Transparent color
  - Deep color

Solutions

- Increase the dataset of the plastic, metal and glass
- Plastic, metal and glass will be placed into the same recycle bin

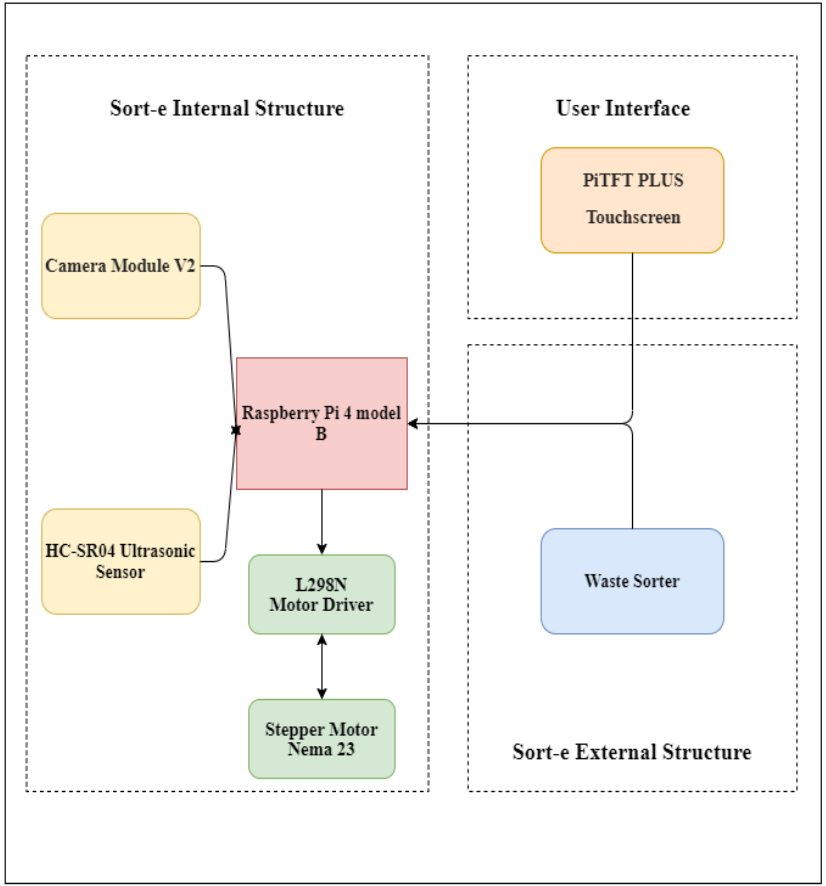
Technical Case (System)

Main Functions

- Provide users with fully automated waste sorting, minimizing the contamination of recycle materials
- The motor controlled by the motor drive will be able to control the opening and closing of various gates
- Flexible installation on waste bin of different sizes and categories

Project Modules

- Drive System
  - Stepper Motors
  - Motor Drivers
  - Drawer Slide
  - Joint Bearing
- Camera Module
- Raspberry Pi 4 Model B
- Ultrasonic Sensors



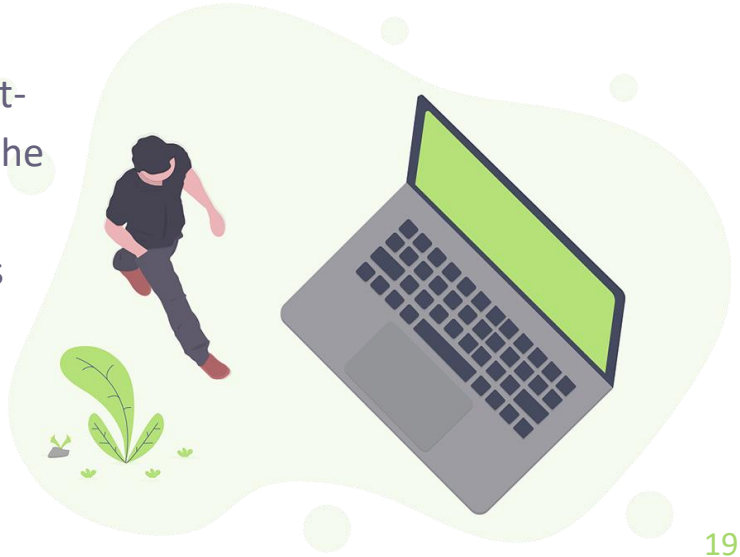
Materials

Materials

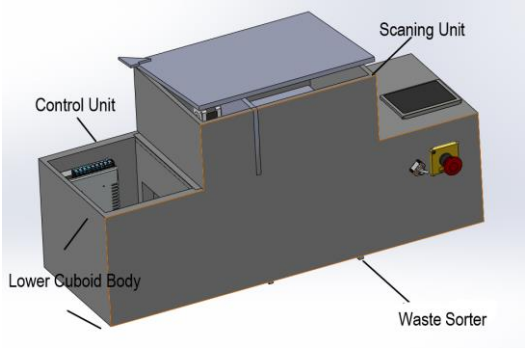
- Woods
  - Device structure
- Plastics
  - Device exterior & interior
- Metals
  - Microcontroller
  - Motors
  - Motor Drivers
  - Wires

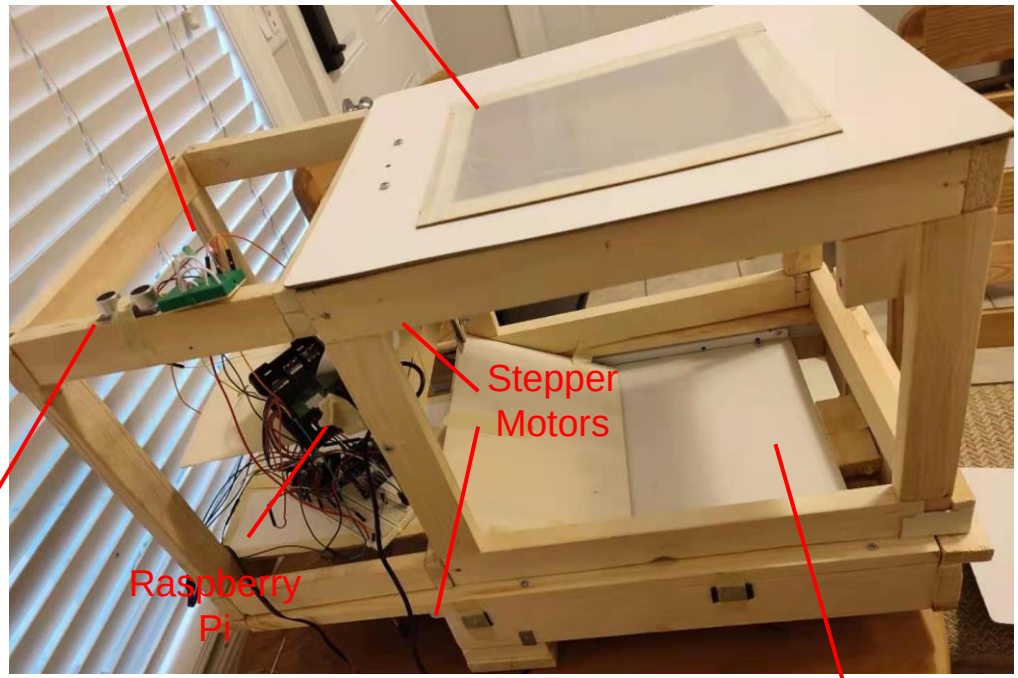
Cradle to Cradle Design

- All designs use the most environmentally friendly materials
  - Woods
  - PETG Plastic
- Purchasing the most cost-effective parts through the required functions
  - Purchase materials from China

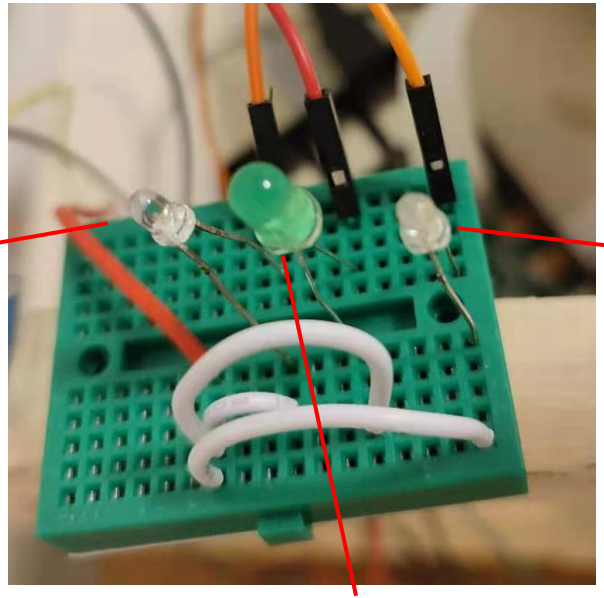


Appearance


Scaning Unit
Control Unit
Lower Cuboid Body
Waste Sorter

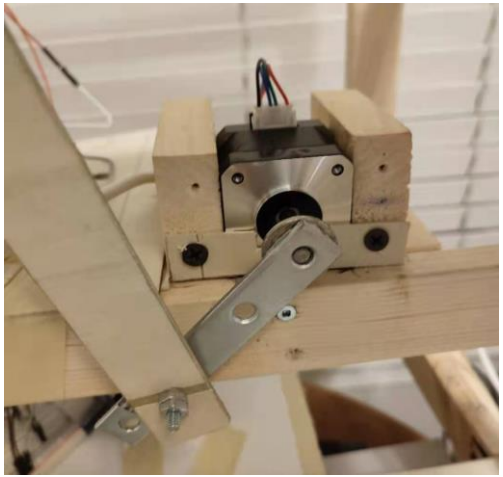

Cover
(Scanning Area)
LED
Indicators
Stepper
Motors
Ultrasonic
Sensor
Raspberry
Pi
Bottom Gate

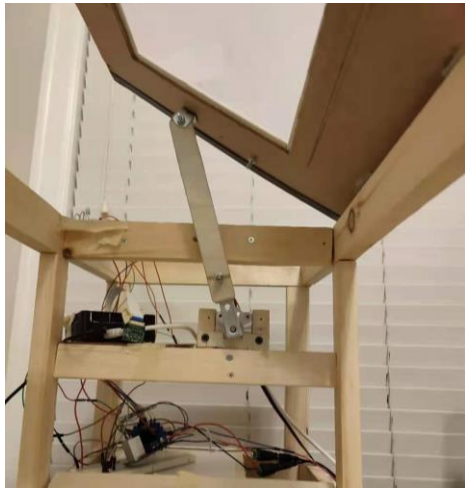
Display Result via LED (Demo)



Mechanical design

Stepper motor is a good way to control the cover opener since stepper motor offers excellent speed control, pieces positioning and repeatable movement.





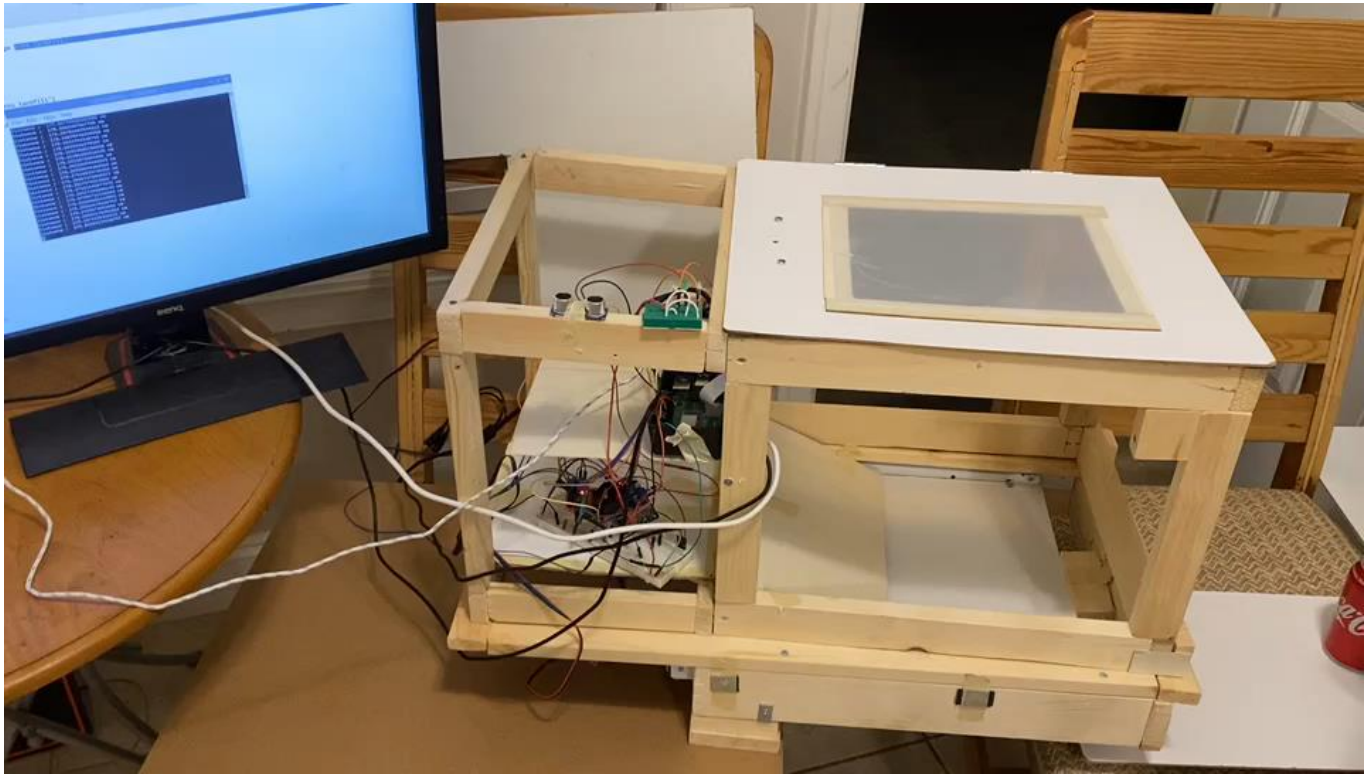
- Difficulty
  - Torque of the motor might not enough for fully open the cover
- Solution
  - Using the gear sets to increase the torque

Mechanical design

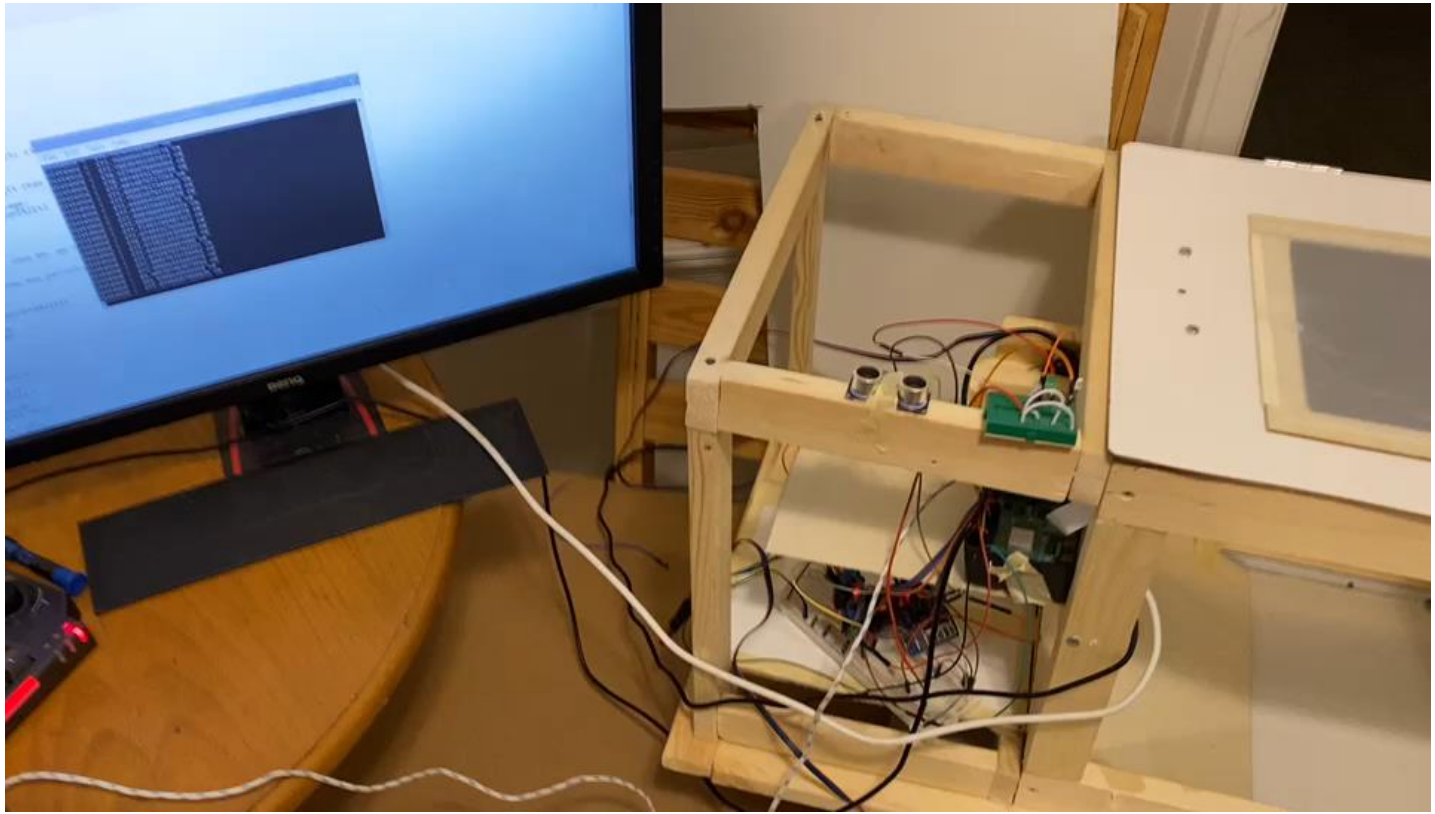
Using friction to drive the bottom gate (Rubber strips)

- Difficulty
  - Sliding occurs between rubber
- Solution
  - Using gear rack and pinion instead

System Demo 1 (Metal)



System Demo 2 (Landfill)



Testable and Tested

Test: Ultrasonic Sensors

Test procedure: The ultrasonic senor outside of the device will detect the user approaching the device, and the stepper motor will open the cover

Expected outcome: The ultrasonic senor outside of the device will detect the user approaching the device, and the stepper motor will open the cover. The ultrasonic sensor inside of the scanning box will begin to scan if waste is present in the scanning area after the cover is closed.

Observed outcome: Ultrasonic sensor able to detect user's hand and the device able to open the cover

Test: Release waste
Test Procedure: Once the system has completed image processing, the waste will be released from the scanning area.
Expected Outcome: Once the system has identified the category of the waste, the gate under the scanning area will open (driven by the stepper motor) which releases the waste material.
Observed outcome: The waste is able to drop when the during the bottom gate operation

Test: Power on the system
Test Procedure: The motor driver and the Raspberry Pi will be powered by a power supply, and the LCD display shall be on.
Expected Outcome: Once the system has identified the category of the waste, the gate under the scanning area will open (driven by the stepper motor) which releases the waste material.
Observed outcome: Once the system is powered on the LED light (indicating power on) will turn on.

Test: Image classification result accuracy test
Test Procedure: Twenty pre-labelled test images (not used for AI training) will be used to test the model's accuracy.
Expected Outcome: To meet the requirement of an 80% accuracy, at least 16 correct predictions are required.
Observed outcome: The best model >70% accuracy with 30+ testing images (close to 80%)

Test: Image classification processing speed test
Test Procedure: Input 5 random waste images for image classification. Start timer when the program starts to run. Stop timer when all predictions are complete. Record the processing time
Expected Outcome: To meet the requirement, the average process time for each input image must be less than 1 second; a total time of 5 seconds.
Observed outcome: Used <1 sec to process the image

Problems and Solutions

Description	Difficuity	Solution
Software (AI model)	Inaccuracy result: Plastic/ Metal/ Glass	Increase the dataset of the plastic, metal and glass
Software (AI model)	Color conflictions including transparent color and deep color	Plastic, metal and glass will be placed into the same recycle bin
Cover opener	Torque of the motor might not enough for fully opening the cover	Using the gearsets/ strong motor to increase the torque
Bottom Gate	Sliding occurs between rubber at the bottom gate	Using gear rack and pinion instead

Concept Proven

AI

- Recognize 5 classes
- Output the prediction and the most likely result
- Use the data argumentation for more accurate result

Detection

- Ultrasonic sensor detect user’ approaching
- Camera able to capture image for image classification

Movement

- Step motor used to drive the gate and the cover

Technical Design, Exploration, Research

Description	Approch	Alternative
Power source for driving cover and bottom gate	Stepper motor: it provides excellent speed control and positioning	DC motor: it has high starting torque, but hard to stop at desired position.
Detecting user approch	Ultrasonic secsor: it is able to detect the distance between user and sensor which is more flexable.	Infrared ray sensor: It is cheaper but hard to use in sunlight or dark environment [4]
Method for opening bottom gate	Drawer slides: It saves the vertical space. After gate opening, drawer slides will hide below the body structure	Trap door: It is useful, however, it needs extra height for body structure
Library for training AI	TensorFlow : Provide functions and classes to train the AI model. Adaptable for microcontrollers.	PyTorch - It can be used to train the AI model, but it can only be used on the script.
Main control unit for prototype	Raspberry Pi: it has more powerful processor for complex processing such as image classification	Arduino: can’t perform complex processing.

Live Demo

Business Case

Technology and Sustainability Market

“ $48.36 billion

24.3%

By 2027, the global green technology and sustainability market is expected to reach $48.36 billion[2]

With a compound annual growth rate (CAGR) of 24.3%

Global Smart Waste Management Market

“ $8.03 billion

26%

In 2019, the global smart waste management was valued at US $1.5 billion, and expected to reach US $9.53 billion by 2027[2]

CAGR increased from 2020 to 2027

Ideal Customers

- **School**
  - Inspire awareness and discussions for a sustainable future
- **Government**
  - Aligns with the government of Canada’s values - reduce pollution and waste
- **General Public**
  - Allow effortless sorting experience for all users

- **Considerations for ideal customers**
  - Correct detection
  - Accuracy of image classification
  - Power consumption
  - Indoor/outdoor capabilities
  - Installation
  - Maintenance

Cost, Price and Financing

Approximate cost of Proof of Concept: ~ $400

- Raspberry Pi
- Motor Drivers
- Stepper Motor
- Camera Module
- Power supply
- Others (materials)

Approximate cost of Prototype: ~ $400

- Gear rack
- 3D Printing
- LCD monitor
- Others (materials)

Cost, Price and Financing

Manufacture Cost: ~$300

- Reduce cost by using microcontroller and microprocessor
- Reduce electronic components
- Mass Produce

Retail price: $500-$600

- With at least 40% profit margin

Funding & Financing:

- ESSEF
- Wighton Development Funds

Competition

Competitor: Intuitive AI - Oscar Sort[3]

Advantage: The Oscar sort provide first class UI.

Disadvantage: High cost, required users to dispose the waste manually

Schedule & Brief plan for 440

NAME	Start Date	Due Date
Project Management IV		
Implementation (Phase II)		
Improve existing AI model	Sep 7	Oct 16
Build waste disposal mechanism	Sep 27	Oct 16
Implement emergency system	Oct 12	Oct 22
Cable management and circuit ...	Oct 23	Nov 4
Implement GUI for LCD display	Oct 23	Nov 9
Build attachment piece	Oct 23	Nov 13
Final Testing	Oct 30	Nov 13
Final Integration	Nov 9	Nov 30
Finalize device's appearance	Nov 22	Dec 4

Team and Self-reflection

Things we learned as a team:

- Proper market research for project idea
- Proper research for technical design
- System Integration (with different components)

Things we learned as individuals:

- AI training (TensorFlow)
- Working with Raspberry Pi

Changes to development Process:

- Meet weekly meetings
- More Status/ progress updates

Reference

[1] CBC News. (2014). http://www.cbc.ca/news/business/canadians-produce-more-garbage-than-anyone-else-1.1394020

[2] "Market Research Company offers Syndicate & Custom Market Research Reports with Consulting Services - Allied Market Research", Alliedmarketresearch.com, 2021. [Online]. Available: https://www.alliedmarketresearch.com/green-technology-and-sustainability-market-A06033, Dec. 2020

[3] Intuitive AI. Accessed on: Aug. 10,2021 [Online] https://intuitiveai.ca/oscar-sort

[4] https://www.maxbotix.com/articles/ultrasonic-or-infrared-sensors.htm

Thanks!

Any questions?