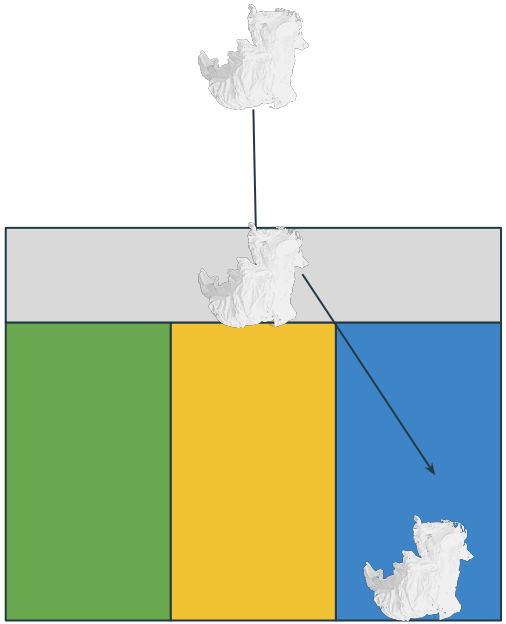
Recyclotron

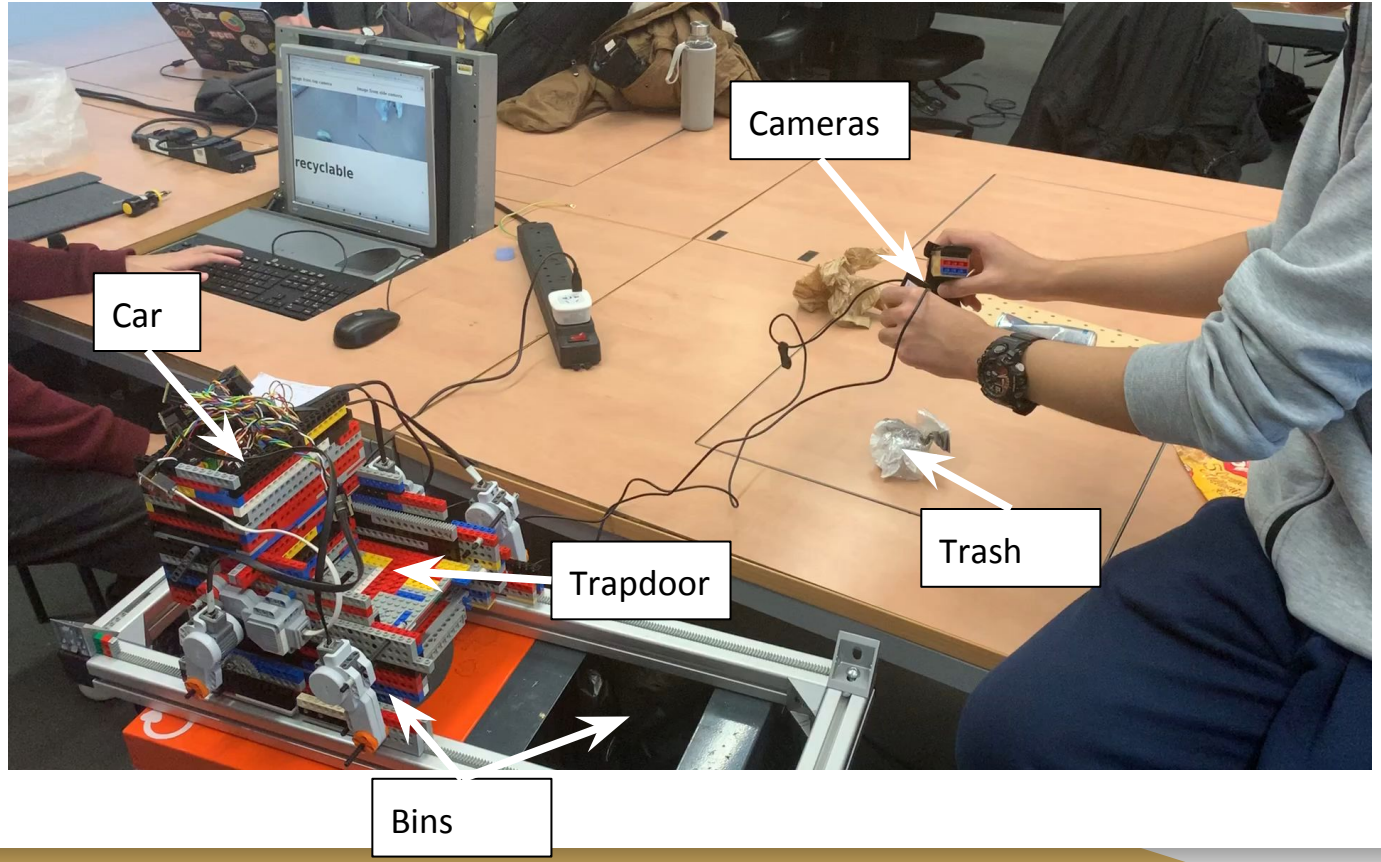
brainfart

What is Recyclotron?

Recyclotron is a smart-bin that detects, identifies and sorts rubbish, reducing user interaction to one bin.

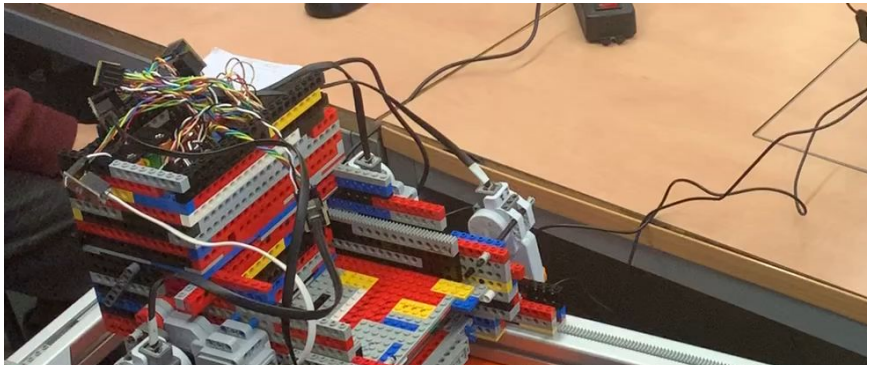


What we made for Demo 1



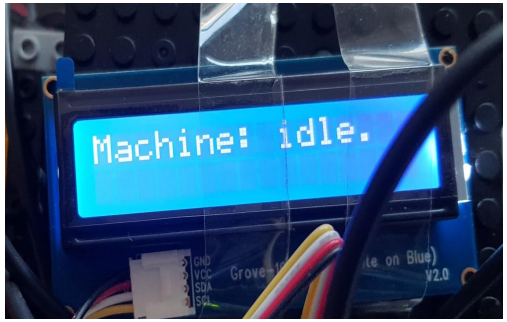
Problems with Demo 1

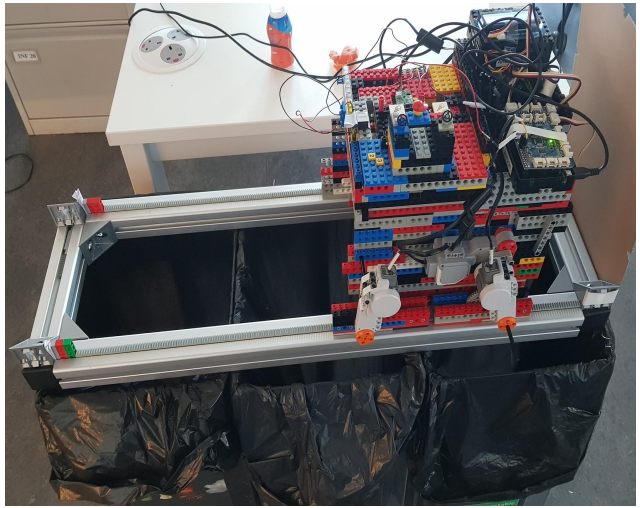
- Cameras had to be held up by a team member
- Detection had to be manually started by us, wasn't automatic
- Wires and Raspberry Pi were loose (sometimes getting in the way)
- Feedback wasn't clear enough to the user
- The chamber was unaware of its location and how much it needed to move - movement was hardcoded

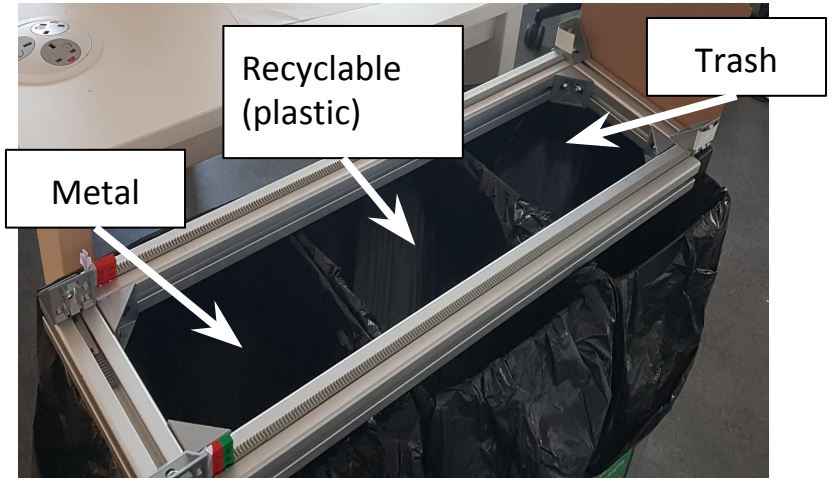


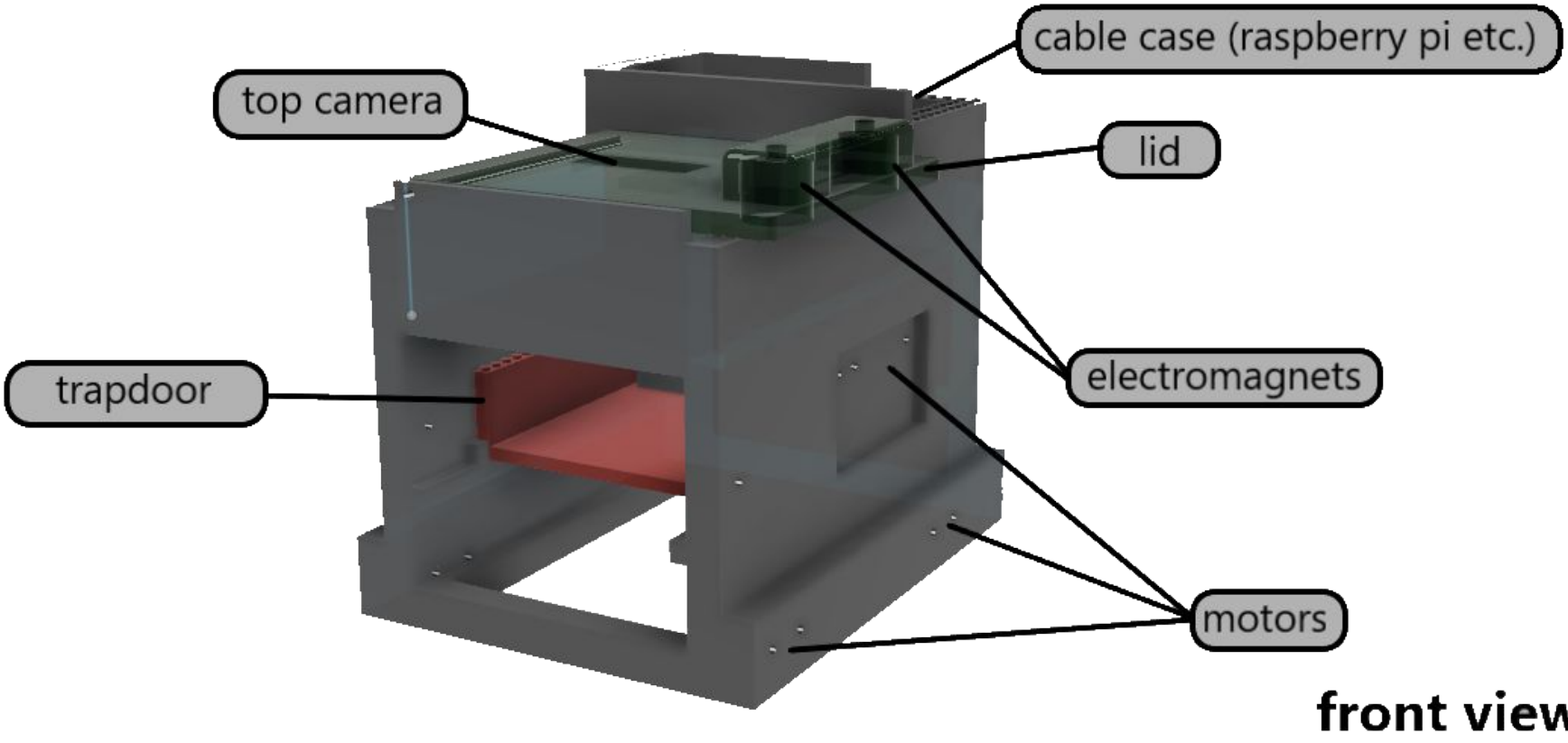
Goals for Demo 2

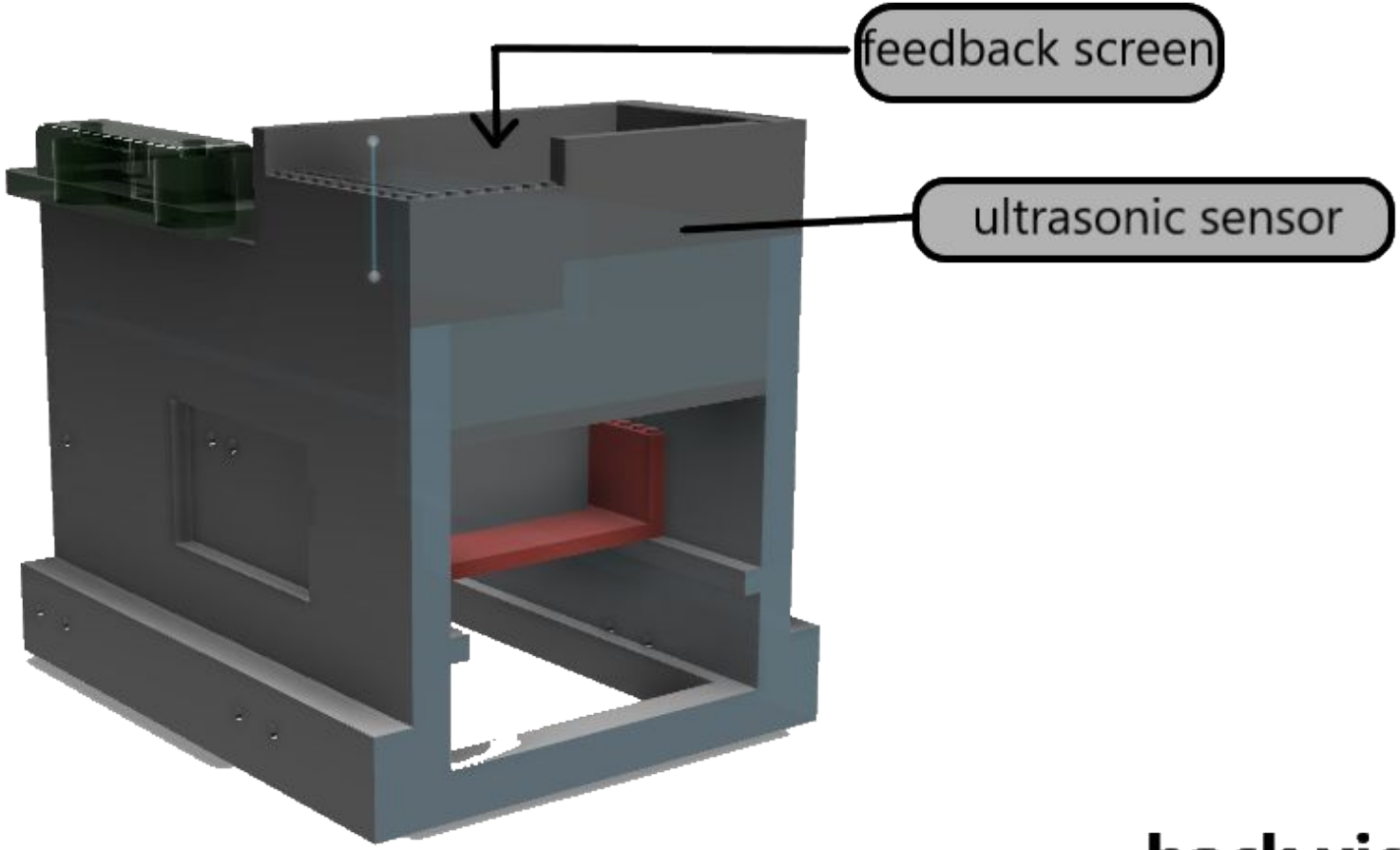
- Add a chamber to hold rubbish, cameras and space for wires
- Increase structural stability and scale by 3D printing parts
- Add a trigger to detect rubbish
- Show clear feedback of what category the rubbish is
- Improve the ML Model to have low false positives
- Allow the ML model to work with 3 and 4 bins



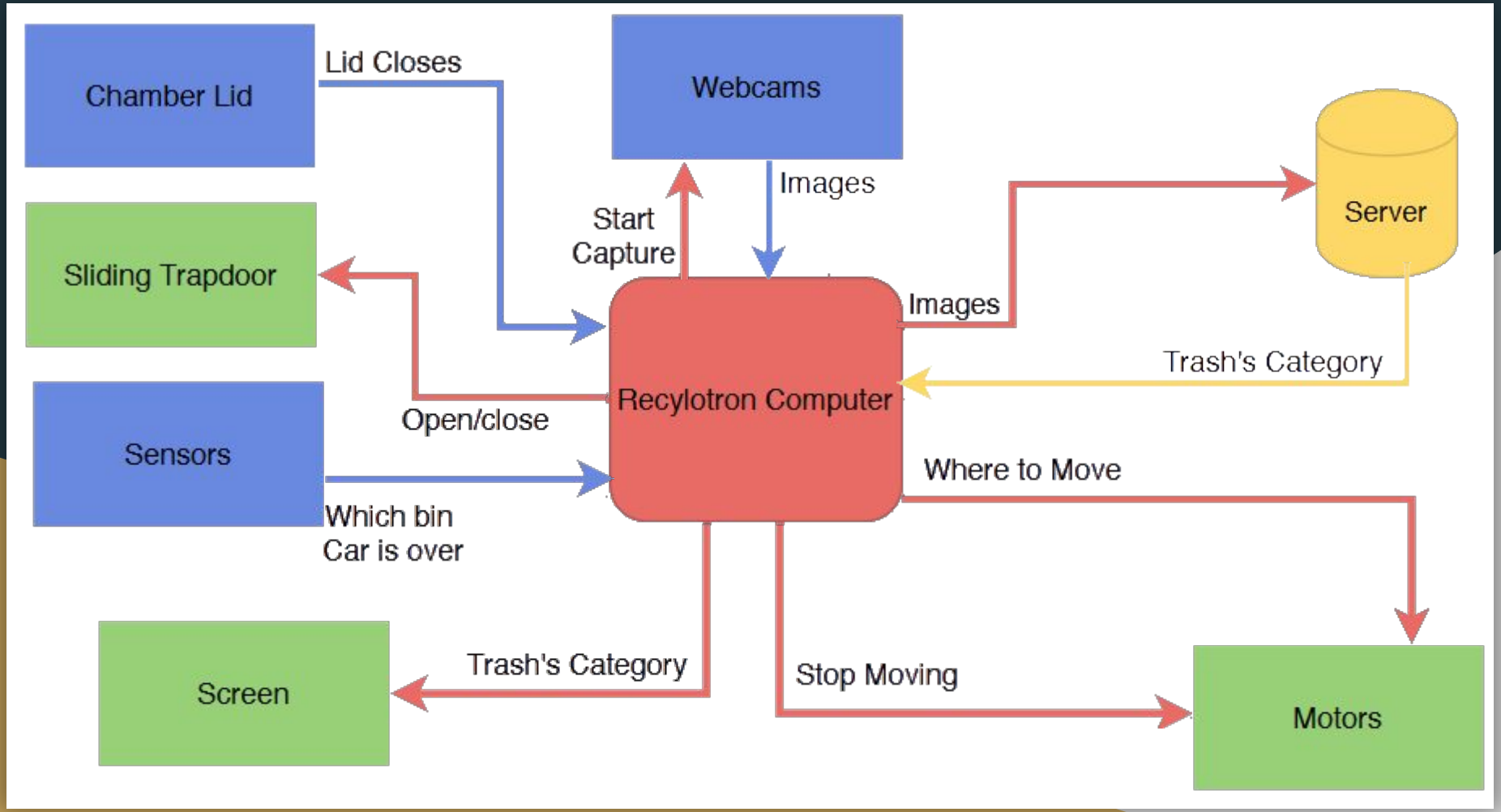





cable case (raspberry pi etc.)
top camera
lid
trapdoor
electromagnets
motors
front view

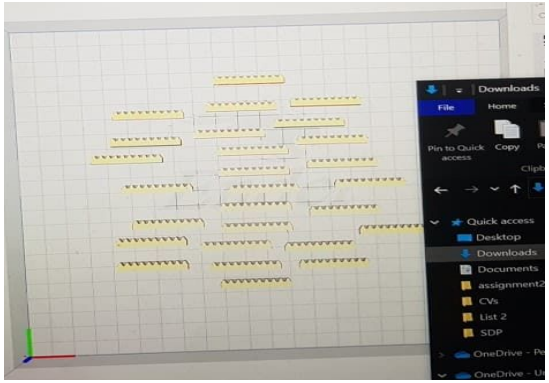


back view


Chamber Lid
Lid Closes
Webcams
Images
Start
Capture
Server
Sliding Trapdoor
Images
Trash's Category
Recylotron Computer
Open/close
Sensors
Where to Move
Which bin
Car is over
Trash's Category
Stop Moving
Screen
Motors

Problems with Hardware

- SD Card Crashed
- 3D Prints Failed Multiple Times
- Modeling Turn Around (body took 5 days to print)
- Sizing Errors
- Lack of Lego Pieces (e.g. gear racks)

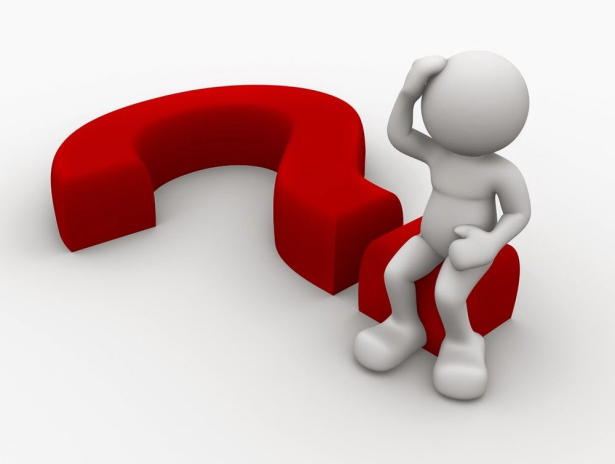


Test Name	Number of Trials	Success Rate
Lid Trigger	50	96%
Motor Function	20	100%
Electromagnet (Locking)	10	100%
3D Printing	7	43%
Ultrasonic (Location Detection)	10	90%

Problems with Datasets

- Initial size of *training* dataset was too small (2K images)
- Too small for large models like deep neural networks
- Very few trash items (only about 100)
- Constructed artificially by taking multiple photos of clean items

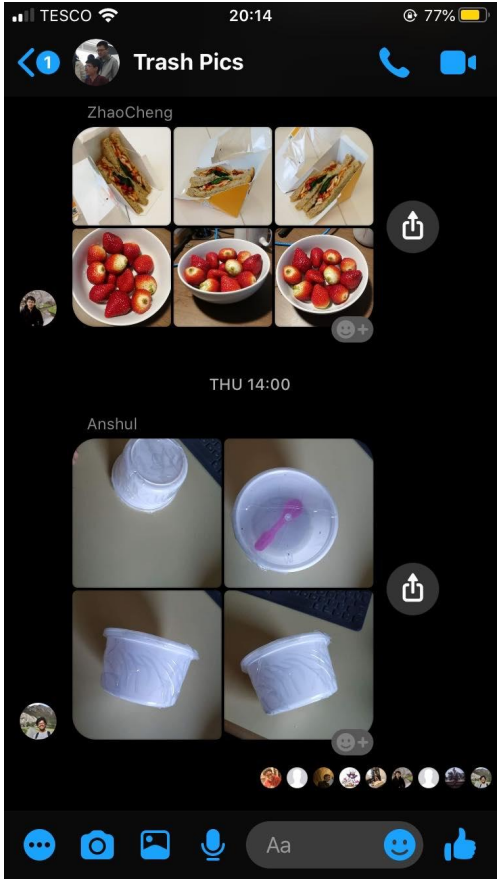
- *Testing* set was a random split from the training set, so there are some overlap of items between the two sets.
- Tests are too easy for classifiers, fails to estimate real world performance.



New Datasets

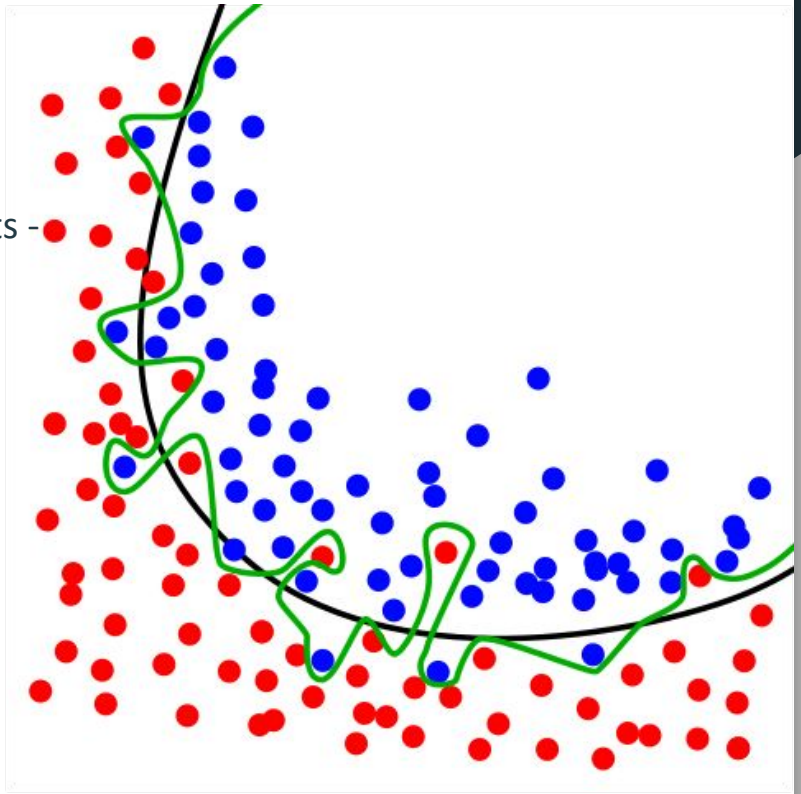
- Created our own dataset for *testing* (only using 111 useful photos for 57 objects)
- Found KNN Model performed poorly on new *test* dataset (~40% accuracy)

- So we updated *training* dataset with images from Litterati's global map
- Now have 1.5 million images to *train* Recyclotron on!



Problems with KNN Model

- Poor at generalization - same bottle may be un-recognised at different angles because of KNN's precision!
- KNN is expensive computationally for large training sets - our dataset is too large for KNN to store and process efficiently



The New Model

Image fed into network

Each block outputs a feature vector

Feature vectors are concatenated

Classification layer outputs a category

ResNet block 1

ResNet block 2

ResNet block 3

ResNet block 4

ResNet block 5

1 0 1

0 1 1

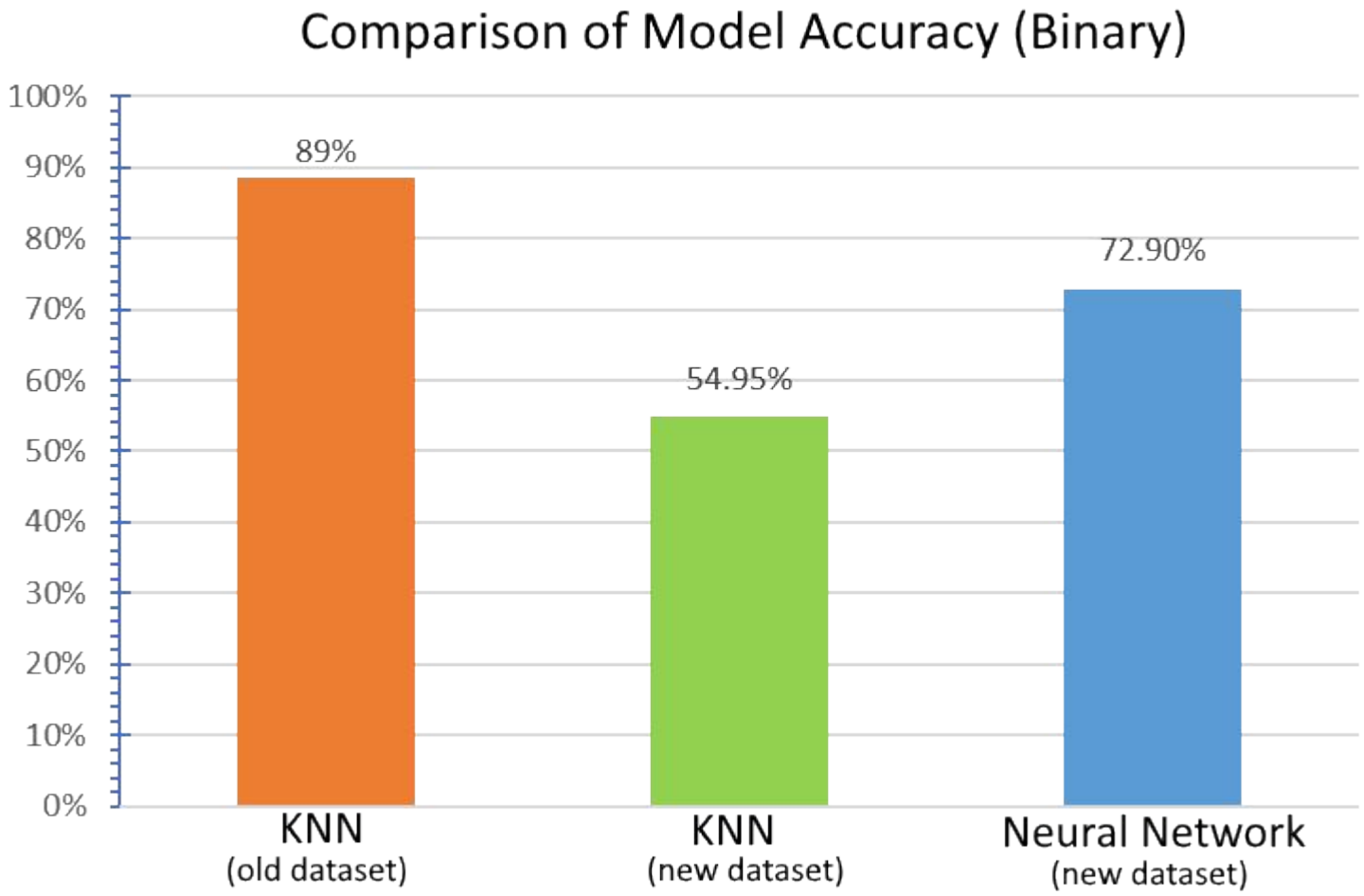
1 1 1

0 0 1

+

Neural Network Classifier

“METAL”


Comparison of Model Accuracy (Binary)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
89%
54.95%
72.90%
KNN
(old dataset)
KNN
(new dataset)
Neural Network
(new dataset)

Why are we punishing false positives?

If a recyclable object is categorised as “trash”,

Recyclable object goes into bin

Taken to landfill

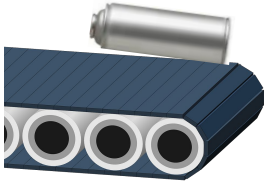
Dumped into landfill

Why are we punishing false positives?

If a “trash” object is categorised as recyclable,

Trash goes into recyclable bin

Taken to Recycling Facility



Trash is sorted by machines and people

Machines break which costs time and money

Confusion Matrix (Contingency Table)

	Glass	*Metal*	*Paper*	*Plastic*	*Trash*	*Precision*
Glass	0	0	1	0	0	0
Metal	0	2	0	0	1	0.67
Paper	0	0	20	1	10	0.65
Plastic	0	0	0	12	2	0.86
Trash	0	0	5	11	42	0.72
Recall	0	1	0.8	0.48	0.76	

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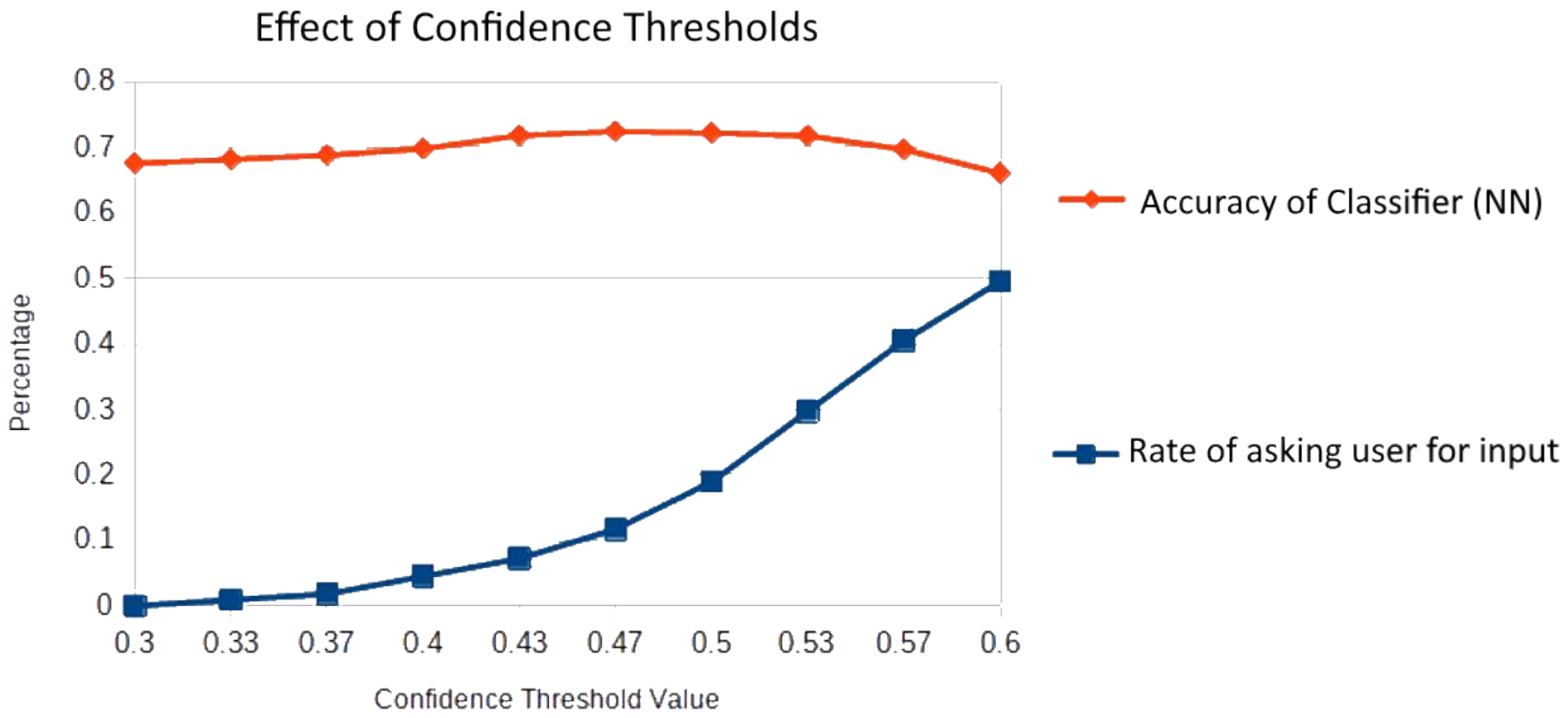
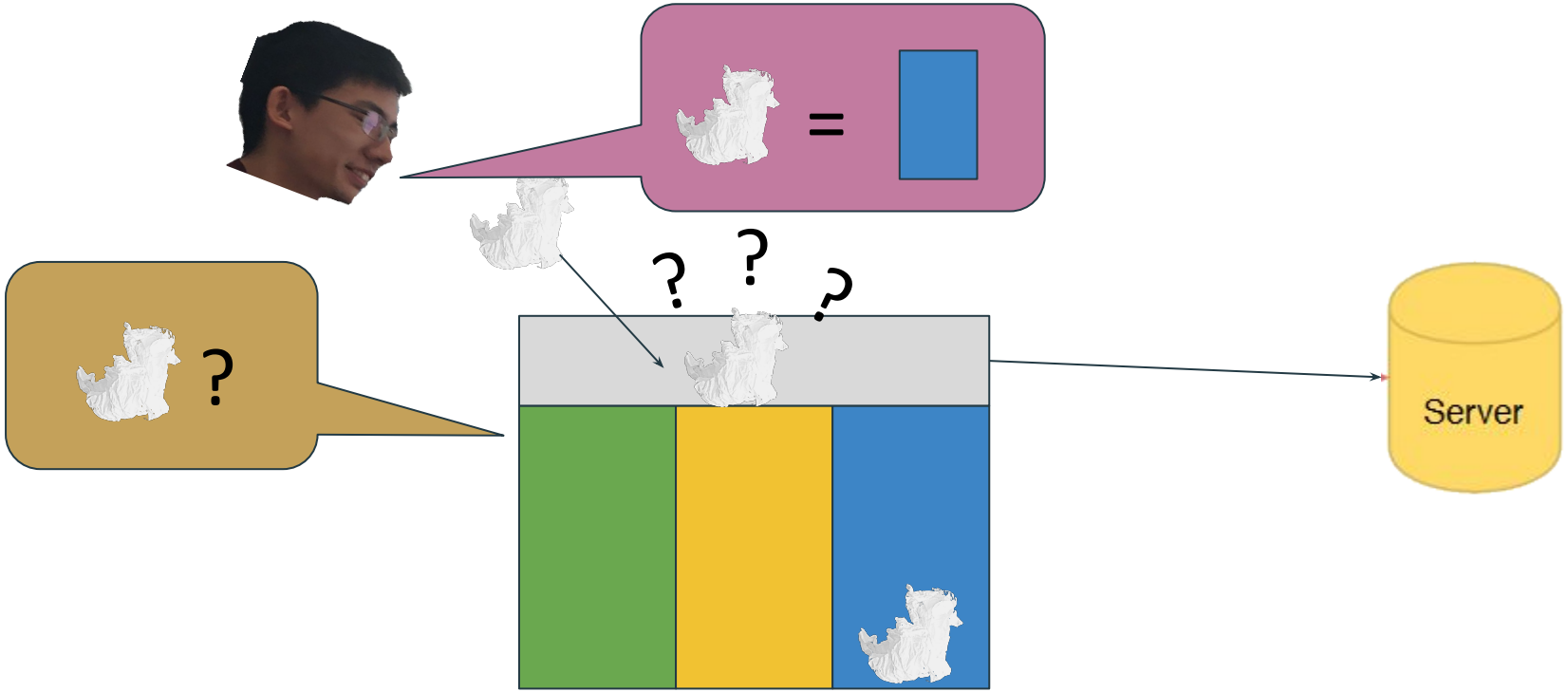
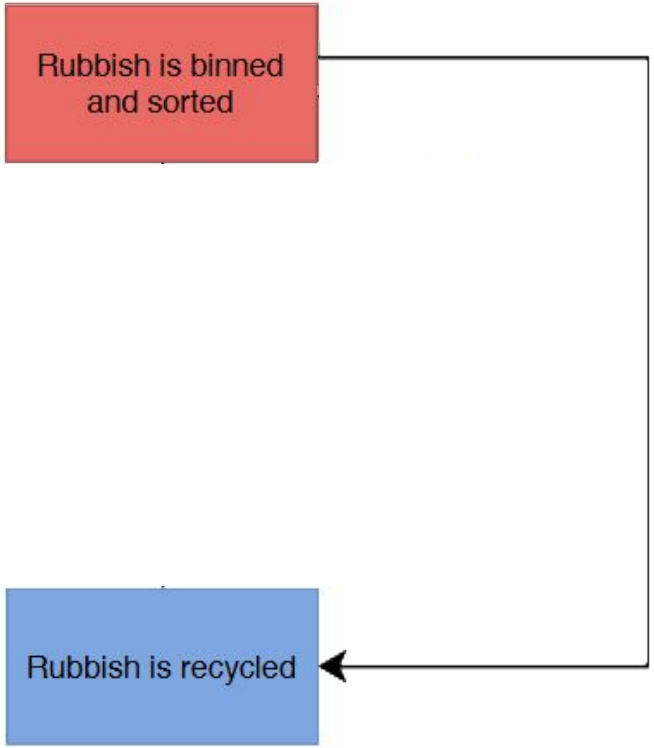
False positive rate of 24%!


Effect of Confidence Thresholds
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Percentage
0.3
0.33
0.37
0.4
0.43
0.47
0.5
0.53
0.57
0.6
Confidence Threshold Value
Accuracy of Classifier (NN)
Rate of asking user for input

Future Milestone: User Training

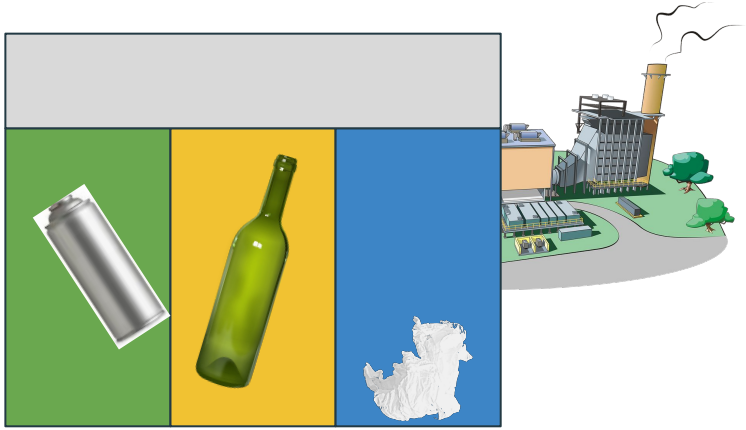


Future Milestone: Highly Extendable



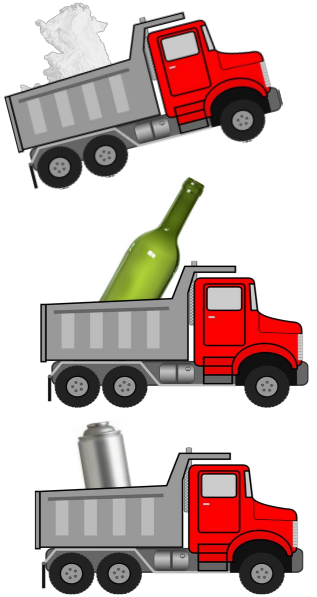
Future Milestone: Highly Extendable

Trash all goes into one bin



Trash taken to Mixed Recycling sorting Facility

Trash is pre-sorted by Recylotron



Trash taken to respective recycling plants

Budget

RED indicates items that were purchased this demo

COMPONENT	***COST***
3D Printed Body & Lid	£65
3 Electromagnets	£4
2 Ultrasonic Sensors and LCD Screen (GrovePI Kit)	£10
2 LEDs	£3
2 Webcams	£15
5 EV3 Motors	£130
2 Steel Railings	£10
Higher End Raspberry PI	£50
Total Cost	*£287*
Total Spent	*£97*

Questions?