NPS2001A Milestone 1

Caitlin Seet Wing (A0259081B), Denice Yeo Si Yu (A0254913A), Luu Gia Dinh (A0265153H)

1. Low recycling rates in Singapore

Low recycling rates is a problem of significant environmental concern in Singapore, and this issue is also evident within NUS, where the habit of recycling correctly and effectively is uncommon (National University of Singapore, Waste Management and Recycling Taskforce, 2020).

According to the Straits Times, around 40% of the contents in recycling bins are contaminated mainly by food and liquid waste, as well as e-waste and styrofoam (Begum, 2022). From a survey conducted in NUS, 1 in 5 students did not know that contaminated items should be washed before being put in recycling bins (National University of Singapore, 2022).

2. Why is it an important problem?

Singapore’s only landfill is expected to run out of room by 2035 at the current rate of waste generation and disposal (Khor, 2019). With rising waste disposal rates, a low recycling figure, and limited landfill capacity, it is crucial for us to improve local recycling rates in order to reduce the amount of stress on Semakau landfill.

Low recycling rates lead to an increased demand for the production of materials such as plastic and metal. This has various implications:

- Economic Impact: With low recycling rates, businesses and governments may need to invest more in producing raw materials instead of relying on recycled resources.
- Environmental Impact: The increased production of materials contributes to global warming due to the energy and resources required for manufacturing, leading to higher carbon emissions.
- Increased Workload: Low recycling rates also mean more work for recycling centres and waste management facilities as they must handle larger volumes of our recycled waste, necessitating additional resources and labour.

3. Our proposed solution

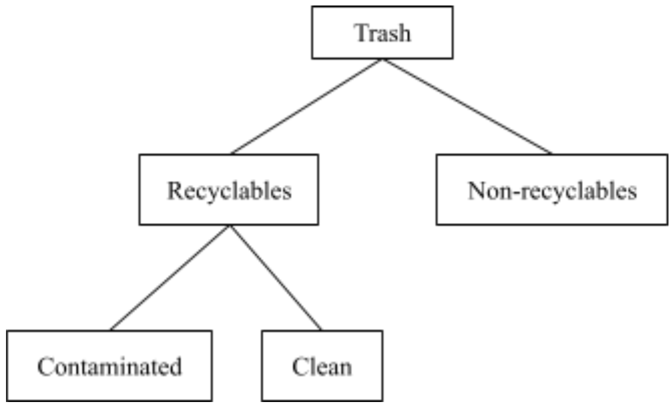
Our solution is a recycling machine that sorts out recyclables from non-recyclables and further sorts the recyclables into whether it's contaminated or not. The machine utilises a camera and an image classification algorithm to do so. The non-recyclables end up in the general trash compartment while recyclables travel to another chute and undergo another scanning process for the machine to differentiate between a contaminated and uncontaminated recyclable. Uncontaminated recyclables travel down the clean recyclables compartment. Contaminated recyclables end up in the contaminated recyclables compartment where they undergo a washing process. Afterwhich, the machine assesses their cleanliness (whether food or liquid content is present). After the cleaning process, the now clean recyclables would travel to the newly clean recyclables compartment. Recyclables not assessed to be clean would undergo the same cleaning process again until the machine deems it to be clean.

This machine could make the recycling process easier for the users and reduce the chances of recyclables getting contaminated. We foresee that with this recycling machine, people may feel more encouraged to recycle as we’ve simplified the process for them. They can throw their trash immediately into the bin which makes the recycling process more convenient for users. Moreover, these bins can reduce the chances of recyclables getting contaminated due to food or liquid leakages from other recyclables. The screening process helps us sort the contaminated recyclables from the uncontaminated recyclables. As a result, the recycling rates may increase with the implementation of this recycling machine.

Our group plans to focus on the software behind the recycling machine for this project. We will work on the sorting algorithm for the machine to sort between recyclables and non-recyclables, and also to sort between contaminated and non-contaminated recyclables.

4. The algorithm behind our solution

Our bin will use an image classification algorithm as depicted below:



It will be trained using data sets consisting of pictures of contaminated and clean recyclables, as well as non-recyclables, and will likely follow a supervised learning model where we predetermine the 3 classes as mentioned in the previous sentence.

Image classification models such as YOLOv7 and Mask R-CNN have been developed and are in use; thus it is feasible to implement a similar one in our solution. There are a myriad of different image classification algorithms that exist on the market. Some resources we have found explaining the algorithm are:

1. A Levity Article Explaining Image Classification
2. A Guide to Image Classification and Types of Neural Networks
3. A Medium Article on the Types of Image Classification Techniques

These resources are relatively easy to understand. Though the inner workings of the code for image classification algorithms require a lot more time and knowledge to grasp, we do not necessarily have to know how to code them since tools such as Teachable Machine make the process of designing an image classification model simple and accessible to us.

5. Target users

Our target demographic is NUS students and staff members who will likely use the bin on the go when they have trash or recyclables on their hand that they want to dispose of.

The issues users may run into include:

1. People throwing rubbish into the bin that may dirty the main chute: This may contaminate the subsequent trash items (especially the clean recyclables) that users throw in. If we don't design around this issue, it may negate the purpose of separating the trash into the 3 categories shown above in the first place, and may thus not lower the proportion of contaminated trash.
2. Long waiting times that users may run into while the bin is sorting trash: the amount of trash that users can throw into the bin at one go depends on how efficiently it's designed; it may be that it can only effectively sort trash items one by one. This translates to longer waiting times for users who want to dispose of multiple items.

References

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