Image Based Recycling Recognition Device To Increase Household Sustainability Efforts

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01. Background

The concept of recycling is simple, it's the process of taking one item that would otherwise end up in the landfill and turning into a new material or object. However, many are misinformed of the many nuances there are when it comes to recycling properly. Every year tons of recyclable waste gets thrown in the trash. In addition the items that do make it to the recycling bin can often can be incorrect or incorrectly disposed of contaminating the rest of the items in the bin. People often forget that recyclables need to be both clean and dry to be recycled, forgetting to clean something out properly can result in all the items just being thrown in the landfill. Contamination causes entire bins to longer be eligible for recycling however some items can sneak past sorting causing issues to the machinery in many cases leading to the closure of entire recycling plants. The most significant issue is the confusing and inconsistent information that exists about recycling. This has been a persistent issue with recycling for years that only becomes more and more difficult every year as companies release new forms of packaging.

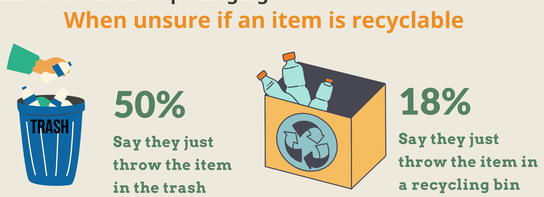

Figure 1. Survey results from The Recycle Chronicles showing that most people are unsure of what is recycle and do not take actions to find out

02. Abstract

To increase recycling efforts in a household standpoint, we created a device that informs the user of the proper recycling for their specific item. The device is simple to use and can be stationed by a trash can for easy accessibility. By identifying the correct way to recycle an item we decrease contamination at recycling plants and the amount of recyclable items that end up in landfills. The camera module on the Raspberry Pi takes an item in it's view and compares the image to a recycling database we created through TensorFlow's Model Maker. After it identifies the object correctly, information about how to properly recycle the object is sent to a webpage that can be accessed through any device on the same wireless network as the Raspberry Pi.

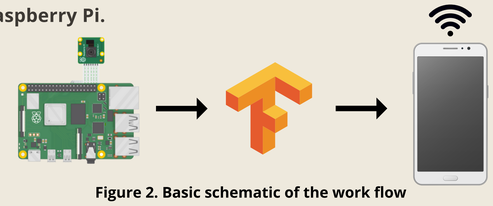

Figure 2. Basic schematic of the work flow

03. Creating a Database

In order to create our custom datasets we took a plethora of pictures and used the software Label.img to create a bounding box around the object. The images were taken in different backgrounds and angles to better train the object detection software. We created two datasets for each item, one that assists in training the software to identify the object and another dataset in a new environment used to validate software.

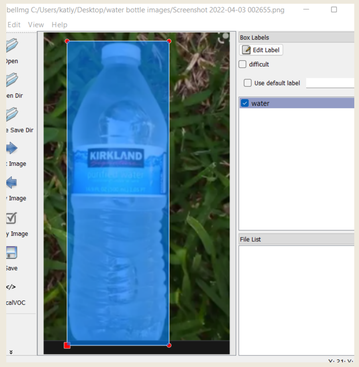

Figure4 . Label.Img software used in creating custom datasets

Figure 3. Camera input from the object detection program

04. User interface

Users can easily learn the best recycling practices from any device in the comfort of their own home. After holding the item in front of the camera, our program identifies the image and a webpage matching the item can be found at the URL "sustech.sustechproject.xyz" On the webpage instructions on how to properly recycle will be presented along with helpful hyperlinks for that item. Links include resources to company sponsored recycling services or to find local drop-off centers.

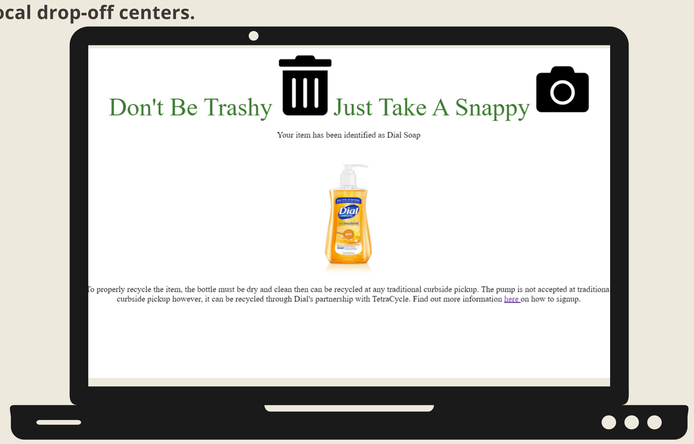

Figure 4. Image of the webpage that displays for the user after an object is identified

05. Code Schematic

On start-up, the raspberry pi will start the server. Apache, a cross-platform web server software that acts as a link between the server and a directory will take any requests made to the specific port on the server and will point the request to the right directory to look for the html file in. Upon starting the program, the camera will turn on and start detecting. Our python script utilizes TensorFlows libraries and custom datasets we created using TensorFlow's model maker to identify the object. Once the object is detected and matches an item in our database, the python script will delete the html file that is currently being displayed to replace it with a html file matching the item. The user can now navigate to sustech.sustechproject.xyz in any web browser to view instructions on how to properly recycle the item.

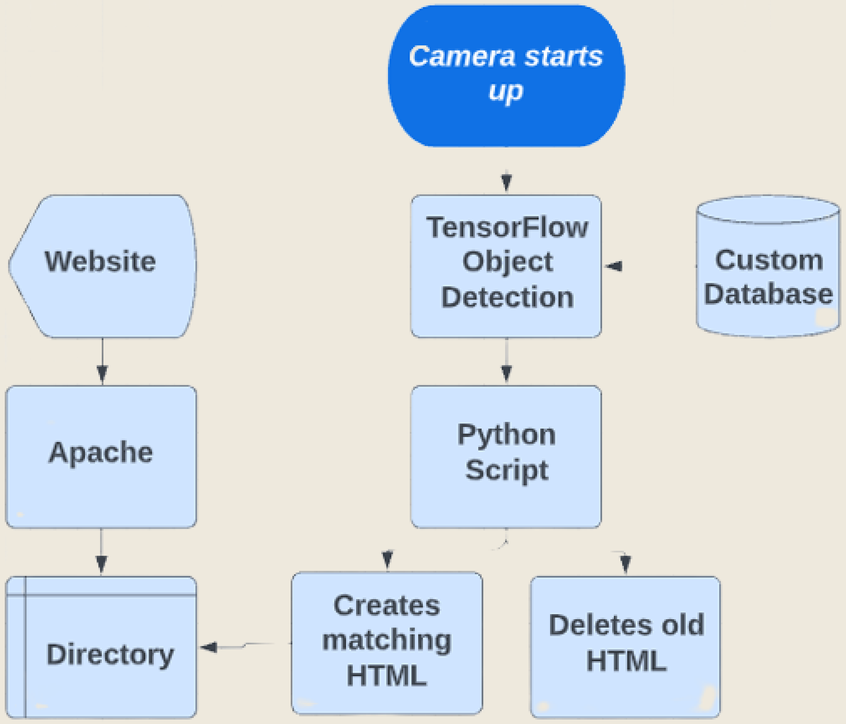

Figure 5. Schematic of the process from start up.

06 Future Works

Continuing this project, we would like to first improve the average precision of our detection model which is currently at .67 by introducing more images of the same items to our current model. Following that we can begin to expand our model by introducing new items as well. Additionally, we hope to install LED indicators to let the user know when the item has been identified successfully as well as build a case for the device and camera to fit in properly. These additions would make the device easier to use for people of all ages.

07. Survey Results

To understand the feasibility of this device and and the impact it would have on recycling efforts we conducted an anonymous survey asking individuals about their recycling habits. Based on the survey results we discovered that a majority of participants do not recycle as much as they hope to, many noting issues with not understanding where to recycle them with many drop off locations only taking the generic plastic bottles, glass, and aluminum cans. Additionally we found that 72% of participants would implement the use of this device.

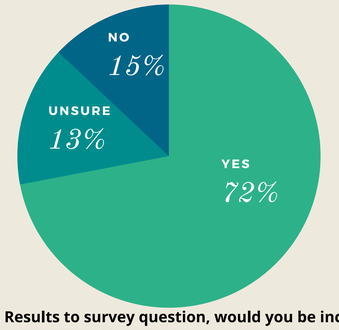

Figure 6. Results to survey question, would you be inclined to recycle more if you had access to our device

08. References

[1] Tensor Flow, 2021. Introduction to object detection on Raspberry Pi. [video] Available at: <https://www.youtube.com/watch?v=mNjXEybFn98&list=PLQY2H8rRoyvz_anznBg6y3VhuSMcpN9oe> [Accessed 8 April 2022].

[2] Tensor Flow, 2021. Train a custom object detection model using your data. [video] Available at: <https://www.youtube.com/watch?v=-ZyFYniGUsw> [Accessed 8 April 2022].