GreenLens: An AI-Powered Waste Classification Application

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Abstract—Have you ever finished a meal but were unsure which recycling container to throw away your trash in? You might not know where to throw away your napkins, plates, utensils, leftovers, etc. Not recycling correctly can have devastating environmental damage. Plastic pollution from neglecting to recycle is one of the main causes of ocean pollution, destroying much marine life. This AI-powered waste classification app called GreenLens is able to recognize dozens of common daily wastes that people have little knowledge of how to dispose of properly. GreenLens, using people's phone cameras, is easily accessible to the majority, has the ability to scan and recognize the type of waste in a matter of seconds, and gives detailed instructions on how to dispose of the waste. It is lightweight, yet powerful, allowing it to achieve recognition accuracies of up to 95%. With the help of GreenLens, people will be able to identify common daily wastes easily and dispose of them correctly, thus helping to reduce pollution caused by inappropriate recycling. In this paper, I will talk about how I came up with the idea of developing this application, as well as the technologies that were applied to build GreenLens. In many experiments, GreenLens is able to recognize all wastes trained for the model while also achieving high accuracies.

1. Introduction

Reports have shown that 62% of Americans do not recycle correctly [1]. A high percentage of responders were also not able to recognize which materials are recyclable [1]. Other researchers report that 94% of Americans support recycling, but only 35% of people consistently recycle [2]. There are many harmful effects of not recycling. First, not recycling causes many unwanted plastics and trash to end up in landfills or the ocean, creating pollution for humans and destroying animals' natural habitats [3]. In addition, the continuing problem of wasting resources by not recycling also causes a lot of air pollution, which is detrimental to everyone's health. Finally, the most harmful consequence is the huge increase in greenhouse gasses such as methane and carbon dioxide being present in the atmosphere, resulting in climate change and health problems [4]. In addition, not recycling could result in fossil fuels being used up. Plastic manufacturers and many other factories use fossil fuels, so not recycling would eventually burn up this fuel reserve. It is estimated that by 2050, the fossil fuel reserve would be all used up [4]. A 2014 report describes that 136 million tons of trash went to landfills, and if it was not for recycling, 258 million tons of trash would pile up in landfills [4]. Recycling can save a lot of resources and help the world be more sustainable. However, reports show that low percentages of people recycle even though the majority of people say recycling is a good thing. Some of the top reasons people do not recycle are an inconvenience, lack of time, lack of knowledge on how to recycle, and laziness [1]. To address this issue, I decided to build a mobile application for IOS designed to facilitate the recycling process for the average person. GreenLens can help resolve this disastrous issue since it is easily accessible and takes a short amount of time. What makes it unique is that in addition to classifying wastes, it also gives proper instructions on how to dispose of the waste to people who may not know.

2. Methodology

The first step was to find a place to code the project. Since this is an IOS app, my mentor and I chose to use Xcode, a software specialized in IOS development. However, I have a windows computer. At first, I tried to use a virtual machine to have a macOS environment on my windows computer, but it was not working. The first step in approaching the project was to find and collect my data. I used folders from the internet with images of common wastes to train in Azure, a cloud computing software that can be used to perform highly computational tasks. The goal here was to use Azure to train an AI model to detect images and recognize each type of waste. The dataset used to train the model was acquired on Kaggle [5] and had 18 labels of different wastes, and each label contains over 100 waste images. The 18 wastes include diapers, bowls, plastic bags, towels, toothpicks, bandaids, thermometers, batteries, bulbs, newspaper, boxes, cans, plastic bottles, glass bottles, napkins, toothpaste tubes, toothbrushes, and leftover food. After training, the model had an accuracy of around 85% to 95% on the training and validation data. The training and validation accuracy were similar, so we can be sure we found a good balance between overfitting and model complexity. After training the model and tuning model hyperparameters, I exported the model as a .ml file to be implemented into the program. I then used Xcode to develop GreenLens for using data from the model and the camera configuration on an iPhone. The camera captures many constant images, then processes each image frame into the model to calculate what type of waste it is. Then GreenLens will return what type of waste it has detected (residual, hazardous, recyclable, or food waste) and detailed instructions on how to dispose of it

3. Experiments & Results

Table 1: TRAINING ACCURACY - GreenLens

Class	Precision	Recall	A.P.	
Newspaper	100.0%	100.0%	100.0%	
Diapers	100.0%	100.0%	100.0%	
Thermometer	95.2%	100.0%	99.2%	
Leftover Food	95.2%	100.0%	99.8%	
Battery	95.2%	90.9%	98.7%	108
Cartons/Boxes	95.0%	95.0%	99.2%	
Bowls/Dishes	95.0%	95.0%	96.9%	
Towels/Rag	94.1%	80.0%	96.1%	
Cans	93.8%	68.2%	93.0%	
Plastic Bag	92.9%	65.0%	80.7%	
Plastic Bottle	90.5%	90.5%	98.0%	
Glass Bottle	90.0%	90.0%	97.6%	
Bulbs	84.2%	80.0%	94.5%	100
Toothpicks	83.3%	78.9%	82.8%	
Toothpaste Tube	83.3%	52.6%	76.2%	
Toothbrush	83.3%	78.9%	85.7%	
Band-aid	81.0%	85.0%	93.6%	
Towels/Rags	70.0%	70.0%	83.%	

The results from the tests were very successful. It was able to recognize all labels with at least 85% accuracy. It only takes a few seconds to detect what waste it is after pointing the camera at something. GreenLens is extremely efficient since it is portable and helps users effectively identify wastes and provides instructions for disposing of them.

4. Conclusion and Future Work

Recycling properly is important because plastic pollution destroys the environment. In addition, most Americans are unsure how to recycle properly, causing further damage. By training images in Azure and developing an IOS app called GreenLens in Xcode, we have shown that we can solve this problem with this app that can scan different wastes and classify them along with providing disposal instructions. Our solution was shown to be 85% effective at solving the problem. In the future, I might consider making the model more accurate by training more images under each waste label to do a better job.

5. Appendix

5.1. Neural Network Architecture

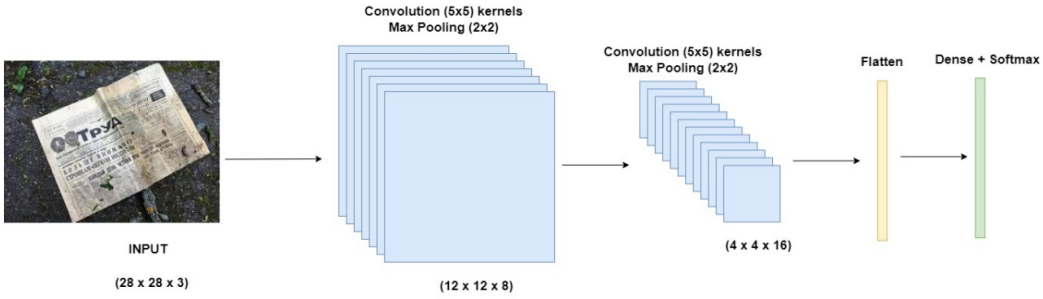

Figure 1: Diagram of neural network architecture

References

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