Smart Trashcan

A Deep Learning Approach to Sustainable Waste Management

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What is the problem: According to the Environmental Protection Agency's (EPA) report, USA generated 254.1 million tons of trash in 2013, with only a 34.3% recycling rate [1]. Compared to 1960 when USA generated only 88.1 million tons, the municipal solid waste generation has increased by a staggering 188.4%.

What we propose: Here, we propose to increase the efficiency of recycling by building an inexpensive smart trash can that takes trash images, processes them and then automatically segregates it into Compost, Recyclable & Landfill bins.

How we do it: We do this by implementing Convolutional Neural Networks (CNNs) and Computer Vision algorithms on a Raspberry Pi 3 to correctly identify the images of trash. Our current model is able to classify Glass, Plastic, Cardboard & Paper objects with an accuracy of 83.2%. With an increasing set of data acquired by the trashcan, further improvement in accuracy is attainable.

What is our vision: Our goal is increase the recycling efficiency by 20% by using AI-driven, smart recycling. This project paves the way for intelligent, inexpensive and sustainable waste management across a wide spectrum of commercial and residential facilities.

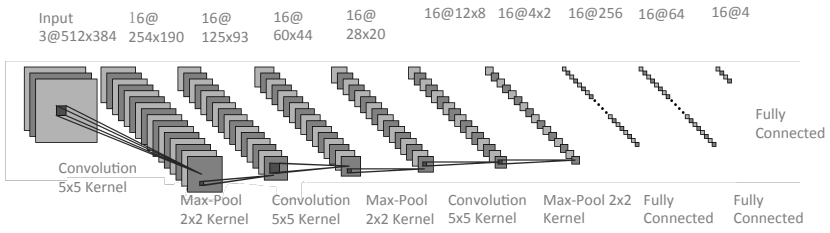
Data

Our dataset includes 1980 labeled Trashnet[2] images that are divided into four categories: glass (501 images), paper (594 images), cardboard (403 images), and plastic (482images).

Method Overview

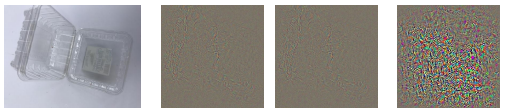
Algorithm: We used ten folds cross validation to divide training and testing data. After we resized and normalized data, we sent the training data to the CNN model and utilized the gradient descent to train the data. The batch size is 16 and the learning rate is 0.0001. we sent the testing data to the tuned model and got the testing result.

CNN Model



Approach

Image Visualization:



Original Image | Layer 1 First CNN Layer | Layer 4 Second CNN Layer | Layer7 Third CNN Layer

- The model learns **more features** (shape and texture) as it **trains deeper**.

Filter Visualization:

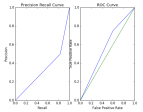
Layer1 Filter | Layer4 Filter | Layer7 Filter

Layer7 Filter Iteration5 | Layer7 Filter Iteration50 | Layer7 Filter Iteration100

- The texture becomes **more similar** to the original image as the model **learns deeper**.
- With **more iterations**, features are **more obvious** shown in the images.

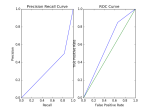
Result

Glass



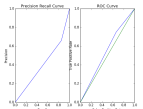
We achieved a **0.34 AUC**, **0.53 ROC AUC**, and **0.73 accuracy** on our test dataset (200 images).

Cardboard



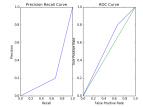
We achieved a **0.31 AUC**, **0.57 ROC AUC**, and **0.92 accuracy** on our test dataset (200 images).

Paper



We achieved a **0.42 AUC**, **0.52 ROC AUC**, and **0.88 accuracy** on our test dataset (200 images).

Plastic



We achieved a **0.28 AUC**, **0.52 ROC AUC**, and **0.80 accuracy** on our test dataset (200 images).

Summary: Our current model reports an **accuracy of 83.2%** for recyclable trash. Over the course of time, with an increasing set of data, our model should be able to achieve a higher accuracy among a wider class of objects. This project can also be used as a **data collection mechanism** to gain insight about patterns of waste generation.

Reference: [1] https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/
[2] https://github.com/garythung/trashnet