USING IMAGE CLASSIFICATION TO INCENTIVIZE RECYCLING

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ABSTRACT - *Recently the topic of recycling and climate change is a debating point and many Non-Governmental Organizations are campaigning for change in governmental policies in many countries around the world. One of the factors of climate change is the improper disposal of trash. In India only 5% of household waste is recycled, 77% is disposed into open dumps and 18% is compostable. Most Indian household waste can be recycled as materials that can be recycled are glass, plastic, paper, wood, and metal. The goal of this project is to solve the problem of creating a web application/website to promote recycling. With the help of a website and the use of object identification, this is possible. Object identification refers to a machine learning-based algorithm and networks to identify objects and labels them without any user interaction or approval. There are many methods for object identification, for example, Convolutional Neural Networks (CNN). This method is much more complex and computationally intensive however using Image processing for object detection. Image processing is less computationally intensive and relatively easier to implement for a website/web application. Image processing is a method of processing images into a digital format and performing operations to get an enhanced version of the image or extract information.*

***Key Words*: Recycling, Object Detection, Image Processing, CNN, Image Classification**

1. INTRODUCTION

Climate change is an immense topic of debate worldwide and solving problems that contribute to climate change is an area of growing interest. Several attempts from the governments around the world are being made but the progress is slow as there are inconsistencies in the process such as a lack of transparency between civil bodies and the general population. To give more emphasis on the environment governments do spend on marketing the effort via social media and billboards and banners. To solve and make the general population more aware and in control of a website/web application using Image processing and enhanced user experience. The user can upload a picture of a recyclable piece of material and get a quotation based on the number of Recycle points. Image processing is used to extract information from images. Through image processing, it is possible to identify objects. This identification of objects is technically called Objection. This technique is used for Unmanned Aerial Vehicles [3]. CNN is a deep learning technique used for object detection and many algorithms use CNN as a base in their architecture.

2. LITERATURE SURVEY

A. Single Shot Multibox Detector (SSD): It is one of the most efficient detectors on the market, and it is also one of the fastest and most precise. Detect objects comprises two basic steps: feature map extraction and convolution filter applications [4]. The SSD design is based on the VGG16 architecture, which is a very accurate classification and detection model that scores 92.7 percent accuracy in ImageNet's [5] 5 tests.

B. YOLO (You only look once): A cutting-edge object identification method designed for real-time applications. It is not a classifier as an object detector. It functions in a manner where the input is split into an SxS cell grid, each of which is accountable for confidence ratings, bounding boxes, and probability maps. It classifies and creates them. The forecasts are formed by combining the outcomes of the preceding procedures.

C. Faster region CNN: A cutting-edge CNN deep learning object detector approach. The network here receives the input image into a convolution network that provides a map of its features. Rather using a selective search algorithm to identify the region made in the previous iterations. A different and separate network is used to learn and predict these regions [4]

D. Image Processing using Haar Classifier: An object recognition program that identifies objects in an image and/or video. It is a machine learning approach that uses positive and negative images to train the classifier.

E. Image Processing in conjunction with CNN: Uses a similar process as the Haar classifier algorithm but uses the image's negative masks to get the coordinates that are not black in contrast. The coordinates are then recorded and classified.

2.1 SUMMARY OF RELATED WORK

The summary of the literature is presented in Table 1.

Table 1 Summary of literature survey

Literature	Advantages	Disadvantages
Viola, Paul & Jones, Michael, [6]	In object detection, pioneers paved the path for more recent and more advanced techniques. Still relevant today. Guaranteed output and technically sound.	It is dated and more new methods are available which can be implemented easier.
Magalhães, Rafael & Peixoto, Helton. [4]	**SSD:** Accurate and faster and improves the detection at a different scale. **YOLO:** Fast as it can process 45 frames per second **Faster R-CNN:** Improves the training and detection time from R-CNN	**SSD:** Difficult to predict and classify small objects. **YOLO:** Struggles to detect small objects and close objects **Faster R-CNN:** The search algorithm is slow and time-consuming.
Jalled, Fares & Voronkov, Ilia. [7]	Follows Viola and Jones's concept and seems to be an implementation for object detection	Dataset of images has to have less noise and all images should have correct density and contrast.

3. PROPOSED WORK

The existing system is manual and it seems to be unfair as it relies on weight scales owned by scrap dealers and instead of reward points it is a small monetary reward depending on the price of the material by the kilo. To incentivize users to recycle and to have a greater reach and accessibility to everyone, a web application, where the user can upload images of their recyclable material and using image classification algorithms the material is identified and a certain number of points is given. Once a certain amount is given the user is then committed to taking the material to a nearby drop point. Once the exchange is done the committed points are credited to the user's account. In the future, once the user has a substantial number of points, they can change it for vouchers and gift cards. In more simple words it is a rewards program for recycling. Controlling the computer mouse using the eyes movement

3.1 SYSTEM ARCHITECTURE

The architecture of the system is shown in Figure 1. Each block is also described in this section.

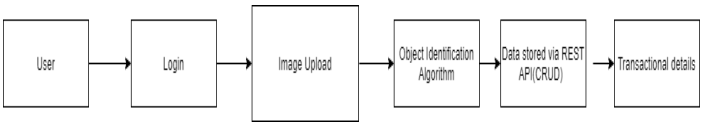

Fig 1: Proposed Architecture of the System

A. User and Login block - Using industry-standard authentication methods the user has their credentials when logging into a website. All credentials are to be encrypted and protected in the database with the DBA being a single person and the password being encrypted.

B. Image Upload - Here the image which is taken by the user is uploaded to the website. The image is saved in the database and goes through the object identification algorithm.

C. Image Classification/Object - Here the image is analyzed using an object identification algorithm. The image is broken down into negative and positive images. Its mask is used to plot the points of the highest contrast points and later using the trained prediction algorithm it is then classified. The output of this stage can only be one of these options: paper, plastic, wood, and metal. All the data is saved in a NoSQL database and details of the type of material are saved in an array containing the user's details.

D. Data Storage - Using REST APIs, simple CRUD (Create, Read, Update and Delete) operations are used to correspond the input details with the user. This will allow the website to be more dynamic and use fewer resources in terms of running this backend process on its own. Using REST APIs allows websites to be more responsive as well as adds an extra layer of security as the data is being stored in pseudo cloud storage.

E. Transactional Details - This part refers to the point and rewards the user is promised after recycling the materials and fulfilling the commitment of recycling once the materials are dropped off at the nearest recycling station.

3.2 DATASET AND PARAMETERS

To train the image classification model, Image datasets are readily available through open-source datasets and paid datasets. An example of an open-source data set would be Open Images and a paid one would be ImageNet.

3.3 METHODOLOGY

To create an image classification model to identify what type of object is headed for recycling, two main technologies were used; a pre-trained model called ResNet was used, and a very popular and easy-to-use python library called FastAI.

ResNet- ResNet stands for Residual Neural Network which is a Convolutional Neural Network consisting of a series of layers. Specifically, ResNet34 is a 34-layer CNN already trained dataset on the ImageNet. An already trained Convolutional Neural Network model will perform a new image classification task since it has previously learned visual features and can pass on the knowledge.

This is mainly because their ability to outline Deep Neural Networks should perform comparatively better than other insubstantial networks on paper.

ResNet was created to bypass and solve this problem using a method called Random-access connections. It is very much possible to adjust the bias and weights if the nodes in a certain layer have sub-optimal values. The optimal node is to be used in the question. Changes are made to nodes only as needed (when there are no remainders).

The direct access links employ the function of identity to give critical information to subsequent layers. This method diminishes the Neural Network to a certain extent. Also allows ResNets to possess deep architectures and behave more like flat neural networks.

Random access bindings apply the identity function to pass information to subsequent layers when customizations are needed. This makes the neural network short wherever possible, allowing ResNets to have deep architectures and behave more like flat neural networks. The 34 in resnet34 refers to the number of layers present.

FastAI - FastA1 is a python library that is open source and based upon PyTorch, which is one of the modern and flexible deep learning frameworks.

3.3.1 PERFORMANCE METRICS OF IMAGE CLASSIFICATION MODEL

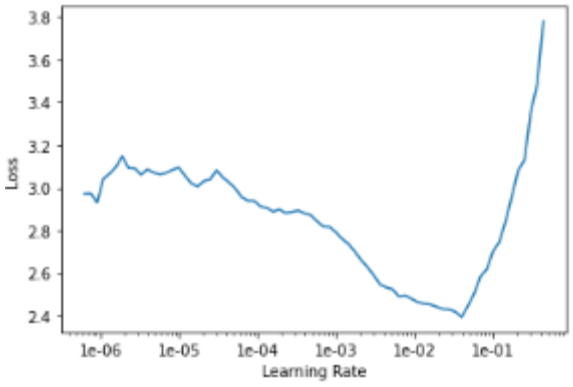

Fig 3.3.1.1 Learning Rate Graph

The model was performed for 20 epochs. The fitting method's speed of learning decreases with each epoch, bringing it even closer to the perfect fit. The model accuracy was the highest in epoch 18 but decreased in epoch 20 and later.

epoch	train_loss	valid_loss	error_rate	accuracy	time
0	2.456650	1.573735	0.614286	0.385714	20:09
1	1.825725	0.950618	0.349206	0.650794	20:06
2	1.439973	0.639108	0.223810	0.776190	19:39
3	1.094977	0.487017	0.166667	0.833333	19:33
4	0.857936	0.427129	0.142857	0.857143	19:36
5	0.805142	0.404819	0.131746	0.868254	19:33
6	0.666509	0.395299	0.119048	0.880952	19:43
7	0.575401	0.388733	0.109524	0.890476	19:33
8	0.493833	0.392756	0.111111	0.888889	19:29
9	0.435394	0.366890	0.111111	0.888889	19:31
10	0.412142	0.350794	0.106349	0.893651	19:20
11	0.418416	0.369038	0.100000	0.900000	19:40
12	0.393125	0.336083	0.100000	0.900000	19:22
13	0.346573	0.300294	0.088889	0.911111	19:22
14	0.325712	0.315092	0.088889	0.911111	19:31
15	0.290400	0.302783	0.084127	0.915873	19:10
16	0.344900	0.327405	0.092063	0.907937	19:12
17	0.319683	0.312191	0.090476	0.909524	19:17
18	0.314346	0.304619	0.084127	0.915873	19:09
19	0.280173	0.318963	0.090476	0.909524	19:09

Table 3.3.1.2 Epoch Table

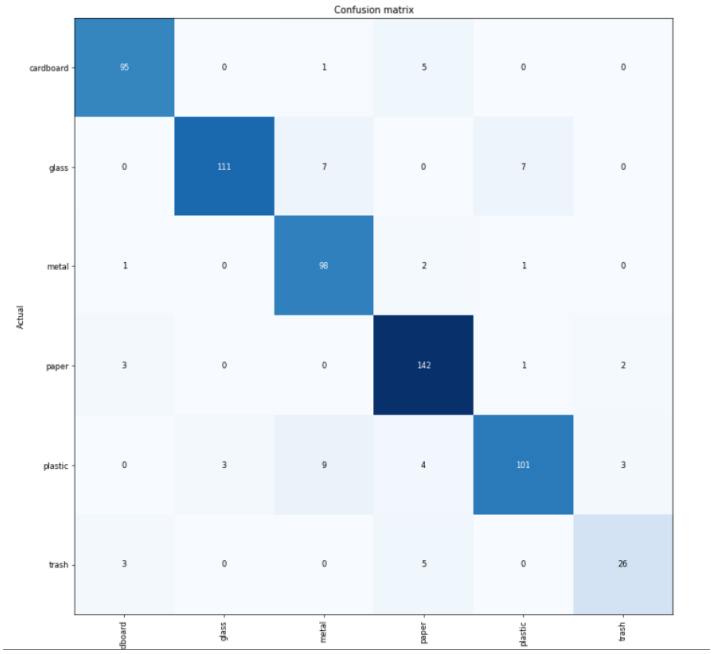

Fig 3.3.1.3 - Confusion matrix for training, here the plastic is being confused for metal most of the time, and glass is being confused for plastic, another confusion is where trash is being confused with paper and the last significant cardboard is confused with paper.

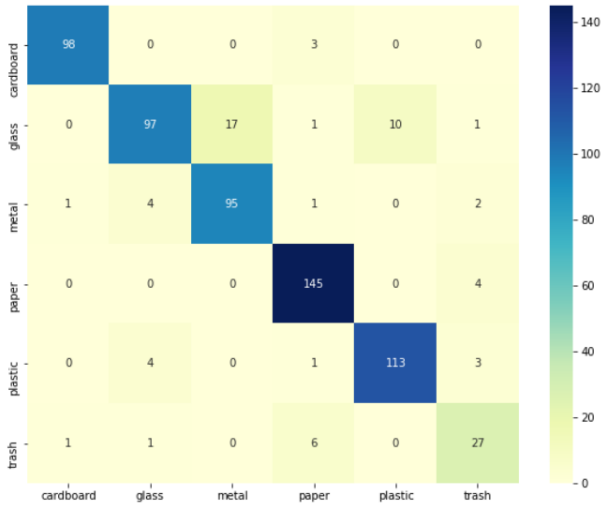

Fig 3.3.1.4 Test confusion matrix: Again, the model seems to have confused glass for metal and glass for plastic. In conclusion, the machine learning model using transfer-based learning is highly accurate and can classify the images appropriately however there is still confusion when images containing objects have similar contrasts and features like reflections from plastic objects can mimic metal reflections.

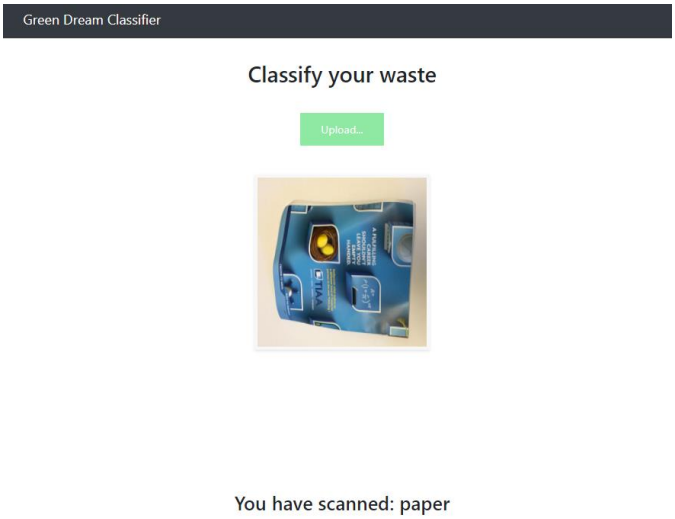

Fig 3.4.1.5 Working of the application

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