WASTE CLASSIFICATION USING IMAGE PROCESSING WITH CNN'S

CIS 731

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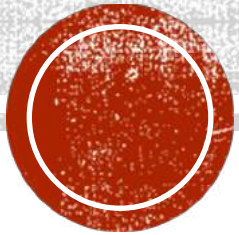


INTRODUCTION

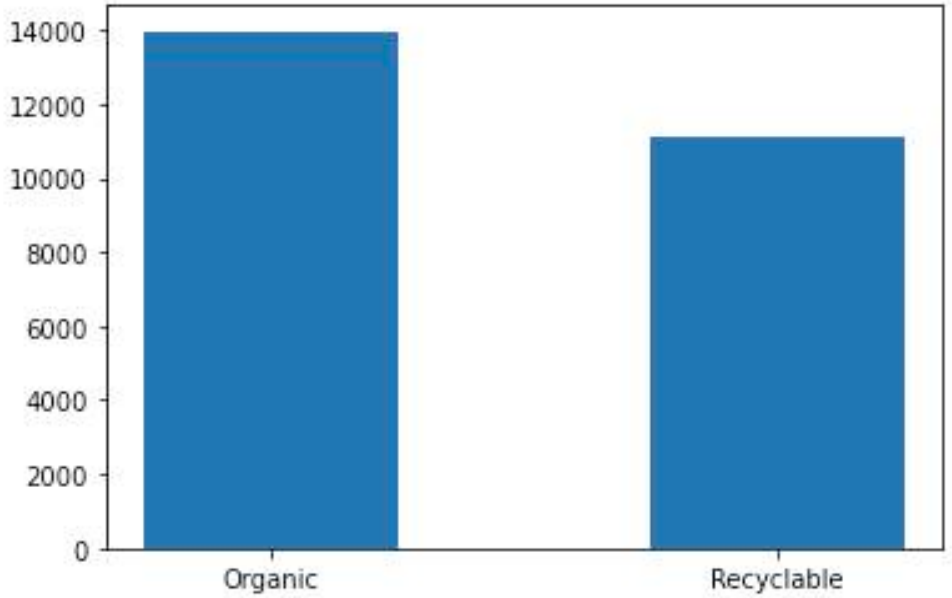
- Disposing off waste in an effective and environmentally friendly manner is one of the primary concerns in the modern world.
- According to the EPA, of the 267.8 million tons of municipal solid waste generated by Americans in 2017, only 94.2 million tons were recycled or composted.
- A large amount of workforce as well as time is needed to segregate waste, but even with all the time and work force human error can often come into play and lead to misclassification of trash.

PROBLEM STATEMENT

- The goal of this project is to develop a system that can at first classify the trash as recyclable or organic.
- After the trash has been classified as recyclable then another model will be developed which will classify the trash into one of the 5 subcategories of recyclable trash namely cardboard, glass, metal, paper and plastic.
- Experiment with various types of CNN architectures like VGG and DenseNet to see which yield the best results.

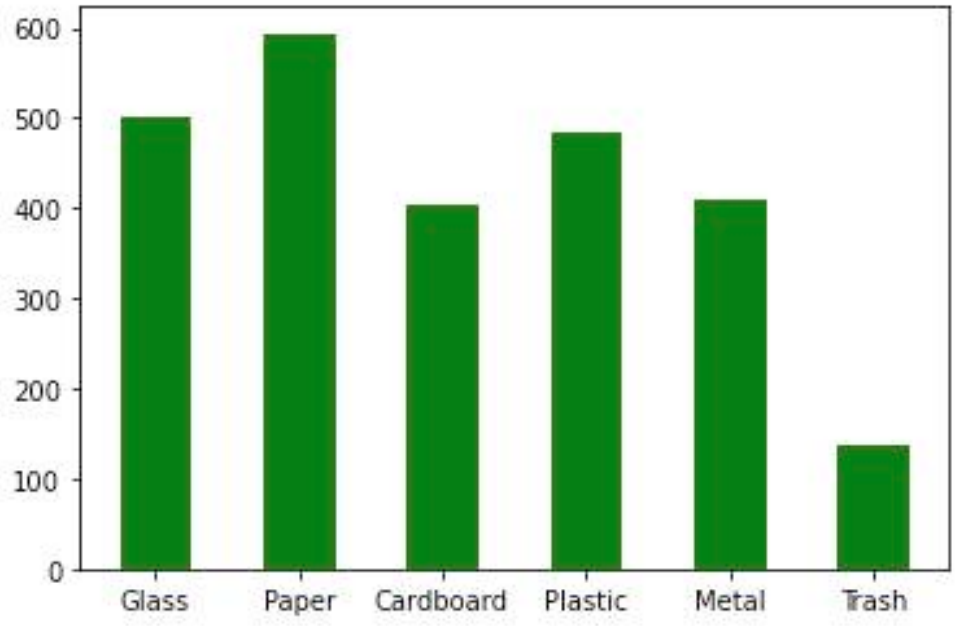
ALL ABOUT THE DATA

- Two separate datasets were used for this purpose.
- The first dataset was comprised of about 25,000 images split into organic and recyclable.
- The images were all of mixed sizes with the largest being 500 X 500.



ALL ABOUT THE DATA

- The second dataset used contained about 2500 images spread across 6 categories.
- The image sizes were 512 X 384. The distribution of the images among the classes as well as some samples are shown below



DATA PREPROCESSING

- The images were resized using the open cv library which is a powerhouse for image processing applications.
- In addition to providing the algorithm with a fixed size image it also greatly reduces the computational complexity which enables the training process to be faster.
- The Image array was then normalized to get the values in between 0 and 1.
- After resizing and normalizing the images, Image augmentation was applied in order to increase the size of the data which gives the model a larger number and a greater variety of images to learn from.

MODELS USED

- During the course of this paper multiple Convolutional Neural Network architectures were tried out and tuned in order to perform the best.
- Each neuron in a Convolution Layer responds to only a certain portion of the image.
- Convolutional layers in a convolutional neural network systematically apply learned filters to input images in order to create feature maps that summarize the presence of those features in the input.
- The MaxPooling layer helps perform dimensionality reduction while still retaining all of the original information.

SIMPLE CNN

- As a starting point and baseline at first a simple CNN was developed in order to classify images.
- To start off with the network just consisted of a couple of convolutional layers followed by maxpooling layers.
- From there on more convolutional and maxpool layers were added in succession gauging the performance benefits as well as the extra computational effort needed for a total of 10 epochs.

DENSENET ARCHITECTURE

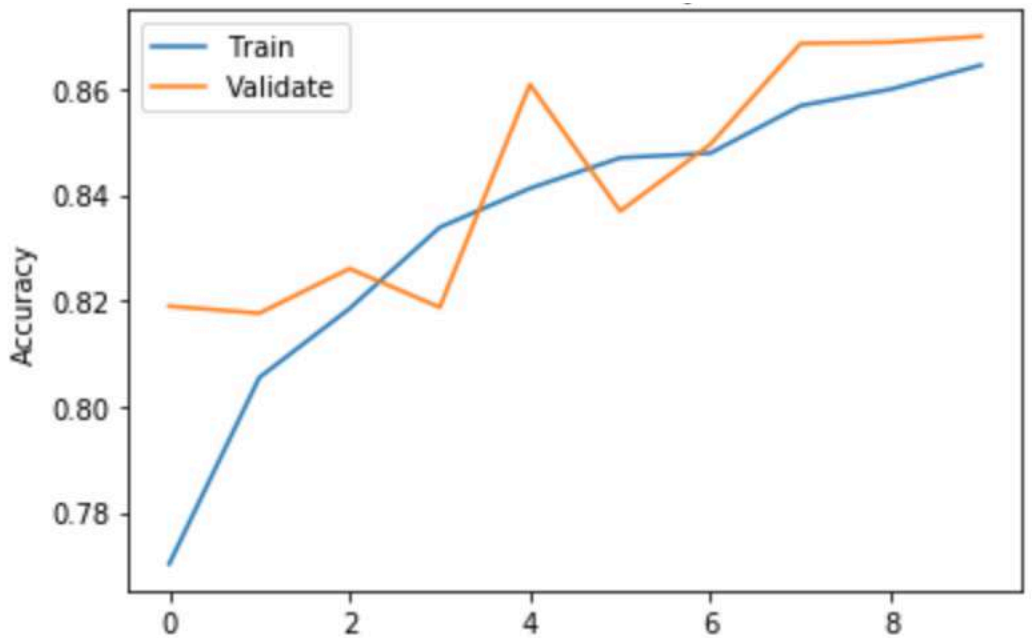
- DenseNet121 is a pre-trained model which leverages the concept of Transfer learning.
- With torchvision.models these pre-trained networks can be downloaded and used in applications
- Transfer learning is the improvement of learning in a new task through the transfer of knowledge from a related task that has already been learned.
- This is efficient due to the inherent computational costs involved with training a neural network.
- Also, because readily available datasets are generally not sufficient for optimal results.

VGG INSPIRED CNN

- This model was developed to further classify the recyclable waste into its subcategories.
- VGG is a complex model which is known to perform well for image processing applications.
- It supports upto 16 layers, but initially the idea of VGG was used in a smaller network consisting of 4 convolutional layers.
- This model did not perform exceptionally well getting an accuracy of about 75%.
- As a scope for further improvement a full fledged VGG network was developed and trained but, it did not perform too well. This can be attributed to the lack of a big dataset, with only about 500 images per class it is difficult to get a high accuracy.

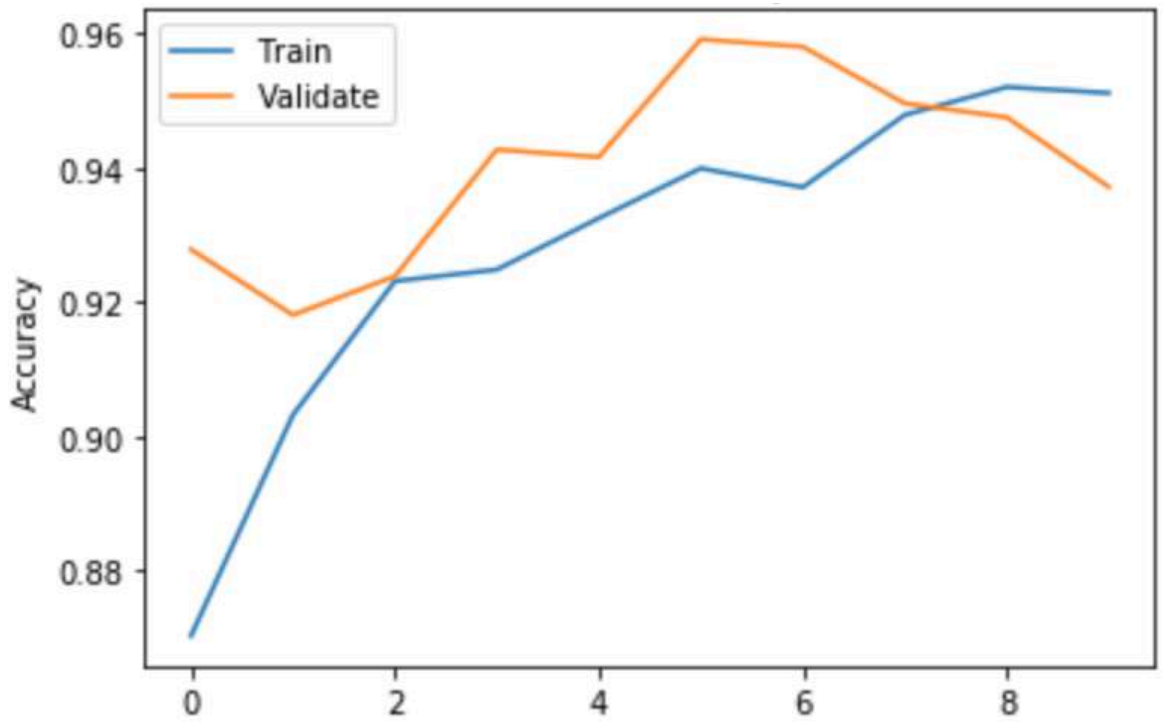
RESULTS

- The simple CNN model performed reasonably well for the size of the model but was not able to go above the 85% mark.
- The loss value which was minimized was categorical_crossentropy.
- The results for the Accuracy per epoch can be seen below



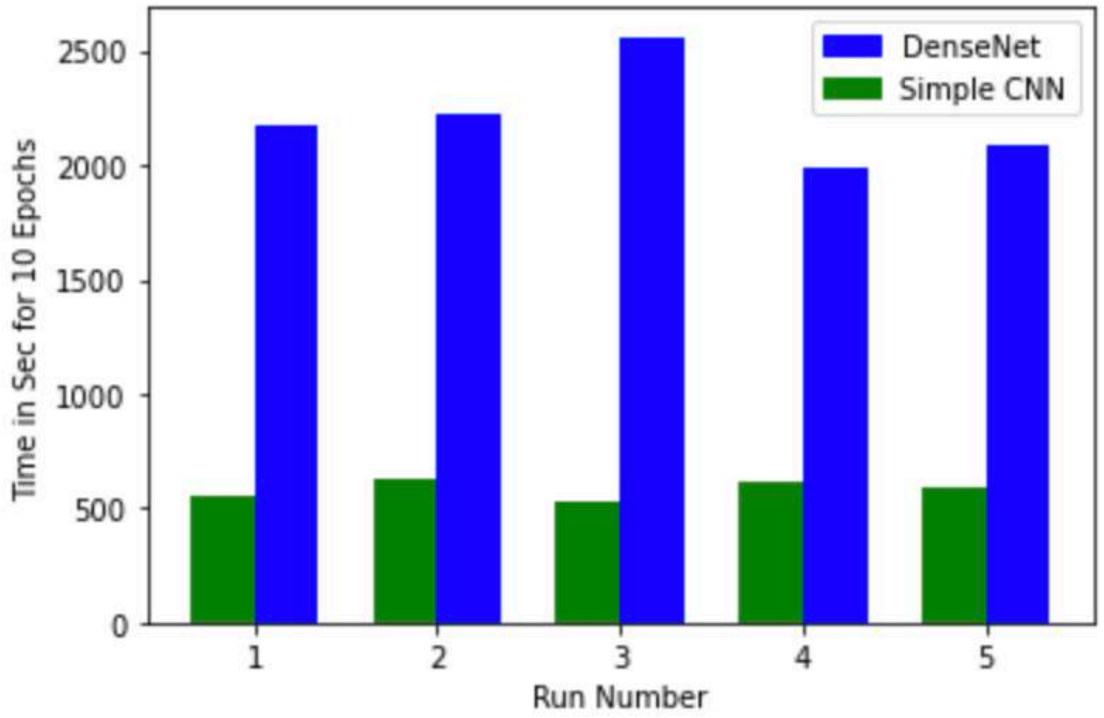
RESULTS

- The DenseNet model though took a long time to train was able to yield impressive results getting an accuracy of almost 95% with 98% predicted correctly for the organic class.



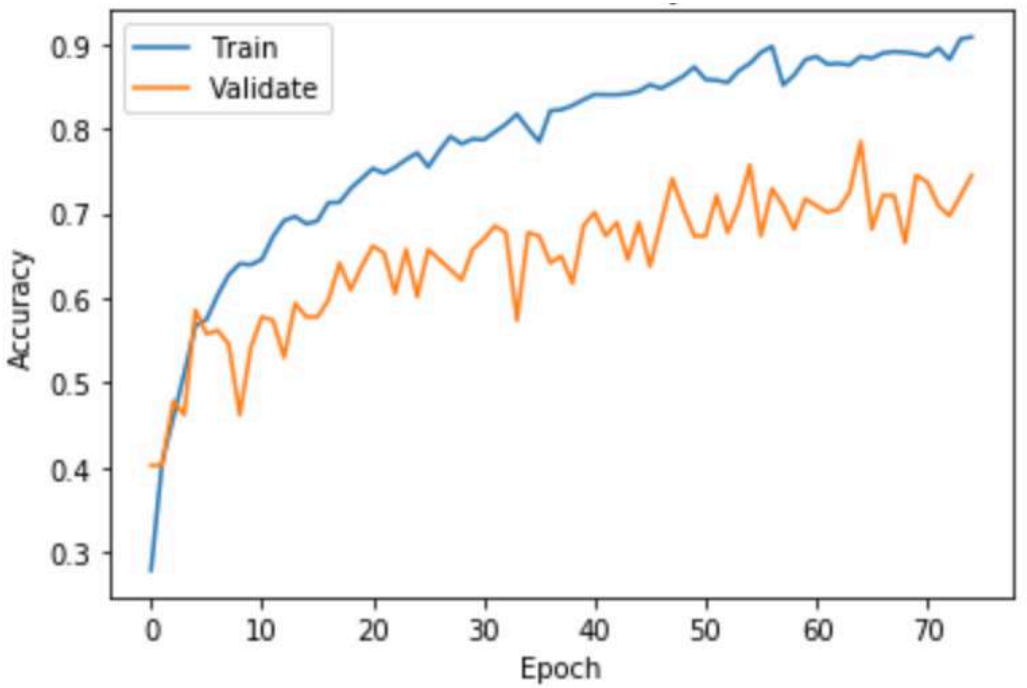
RESULTS

- Apart from the accuracy and loss another critical aspect is the computational complexity of the algorithm. Below we can see the time taken by the forementioned models across 5 different runs.



RESULTS

- The model developed for the classification of recyclable waste into subclasses was a modification of VGG 16, a very popular model for image classification problems.
- The lack of many labelled samples made it hard to get good results. Even though the model obtained a high accuracy on the training data, on the validation set it was able to get only about 75%.



CONCLUSION

- The DenseNet model which is a recent breakthrough development in the field of image processing greatly outperformed a traditional convolutional model.
- Using DenseNet waste was able to be segregated as organic or recyclable with up to 95% accuracy.
- Due to the lack of a large number of training data for the subclasses of recyclable waste the VGG inspired CNN model was able to achieve an accuracy of about 77% which can act as a baseline for further studies and developments.

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THANK YOU !!