Abstract:

Waste management is one of the biggest challenges of our times.This paper aims to solve one of the major steps in waste management and that is waste segregation.Waste segregation aids waste management process as the wastes are segregated at source itself so that organic wastes could be separated from recyclable ones.Failing to do so results in poor management and unhygienic manual work.With this project my aim is to provide an application which could be either installed inside modern bins or in mobile phones and help individuals decide whether they are disposing trash in the respective bins(that is organic or recyclable).This application may be integrated to another application that takes picture of the trash being deposited(outside scope of this project) and then provide this picture as an input to the machine learning module which in turn tends to predict the correct classification and sends a message to user if they are not disposing trash to their respective bins.

Introduction:

Waste segregation is an important concept in waste management.This essentially means dividing waste into 1)Dry waste(recyclable) 2)Wet waste (organic).
Unfortunately, in many parts of the world due to lack of awareness, individuals tend to ignore the segregation and the process is still done manually by sanitation workers.
With this project my main aim is to provide a simple application that would assist every individual to properly dispose the trash into respective trash bin and failing to do so may prompt a message or warning or so.

There are many ongoing research for this particular topic.some of them are:

Intelligent Waste Classification System Using Deep Learning Convolutional Neural Network by Olugboja Adedeji, Zenghui Wang
This paper proposes an Intelligent waste classification system that completely eliminates manual picking and segregation of solid waste which may cause different kind of diseases in human beings.The proposed system makes use of convolutional neural network and SVM to separate the accumulated waste.As the trash dataset used is very small they make use of pre-trained ResNet-50 model which is a type of Convolutional Neural Network architecture.With increase in depth of convolutional neural network(CNN),there is always the issue of vanishing gradient and ResNet-50 is able to go around this problem by introducing modules called residual models.The proposed system when tested against trash dataset yielded an accuracy of 87%

Waste Segregation using Deep Learning Algorithm by R.S.Sandhya Devi, Vijaykumar VR , M.Muthumeena
This paper also proposes a low cost, compact and fully automated method of waste segregation to promote the segregation at source and without human intervention.The proposed system makes use of convolutional neural networks.The python libraries like Numpy, matplotlib, os,tensorflow,etc are used for model preparation and classification/ identification of images.Also the dataset used here is SSD mobilenet COCO dataset.
Multilayer Hybrid Deep-Learning Method for Waste Classification and Recycling by Yinghao

Chu,Chen Huang, Xiaodan Xie,Bohai Tan,Shyam Kamal ,and Xiaogang Xiong
As discussed in previous papers, this also emphasises on the importance of having an automated waste segregation system to achieve the recycling target.The system proposed makes use of MHS(multi layer hybrid system) that gives an accuracy of higher than 90%.Also the system proposes an innovative architecture to simulate the sensory and intellectual process of human inspections. While most of current waste classification methods take images as the sole input, the proposed method makes use of an AlexNet CNN to act as “human eyes” to visualise and extract key image features from its last dense layer. The system also utilises sensors to act as “ears” and “nose” to detect other numerical feature information. Ultimately, multilayer perceptrons (MLP) act as a response centre (the “human brain”) to classify the waste object by consolidating information collected from diverse channels.

Artificial Intelligence in Automated Sorting in Trash Recycling by ernardo S. Costa, Aiko C. S. Bernardes, Julia V. A. Pereira, Vitoria H. Zampa, Vitoria A. Pereira, Guilherme F. Matos3 Eduardo A. Soares, Claiton L. Soares, Alexandre F. Silva
As discussed in previous three papers, this also proposes an automated system of waste classification and segregation.The models used in the experiments were VGG-16 model (VGG16), AlexNet, Support Vector Machine (SVM), K-Nearest Neighbour (KNN) and, Random Forest (RF).The VGG16 is a pre-trained Convolutional Neural Network (CNN) that has been trained on approximately 1.2 million images from the ImageNet Dataset by K. Simonyan et al.The model has 16 layers and can classify images into 1000 object categories. Also, VGG16 came up with significantly more accurate ConvNet architectures, which not only achieved the state-of-the-art accuracy on ImageNet Large-Scale Visual Recognition Challenge (ILSVRC) classification and localisation tasks, but are also applicable to other image recognition datasets, where they achieve excellent performance even when used as a part of a relatively simple pipelines (e.g. deep features classified by a linear SVM without fine-tuning).To estimate the performance of each neural network,Pearson correlation coefficient (PCC) and the Spearman Rank Order Correlation Coefficient (SCC) is calculated.

Almost all the research works are focussed on classifying the images into either organic or recyclable but for the images containing both organic and recyclable trash there is not much work.

This paper has four main sections:
1)Method- This will list down machine learning models used for training with the metrics used for measuring the performance of a given model
2)Results: The model performance based on the provided metrics and with different loss functions and optimizers.
3)Discussion:How results obtained address this waste segregation issue
4)References

Methods:
I am using two different models to classify my datasets into organic and recyclable or both in cases where the image contains both organic and recyclable items.
Model1: using dense Artificial Neural Network
Model2 using Convolutional neural network along with Artificial neural network

ANN
ANN is my baseline model
Library: Tensorflow(keras)
Layers:
1)Input layer
2)Hidden layer with activation function as **relu** and 20 neurons
3)Output layer with activation function as **softmax**
Optimizers:
Tried optimisers from keras like-SGD,adam,adadelta,RMSprop,adagrad,nadam,etc.
SGD has best performance so far.
Loss:
Used **sparse_categorical_crossentropy** for the loss function
Metric:Accuracy

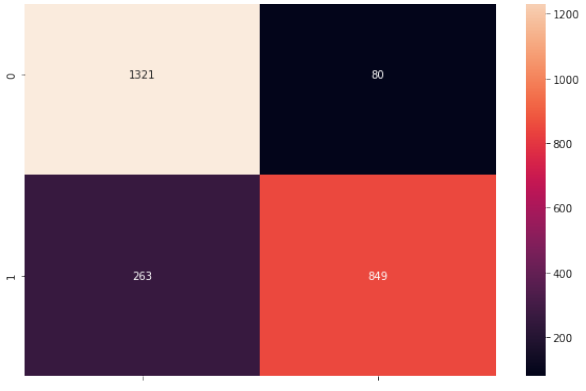
CNN
Library :Tensorflow(keras)
Layers:
1)Convolution Layer with 30 filters,kernel size as (3 by 3) and activation function as **relu**
2)Maximum pooling layer
3)First layer ANN
4)Hidden layer with activation function as **relu** and 20 neurons
5)Output layer with activation function as **softmax**
Optimizers:

Tried optimisers from keras like-SGD,adam,adadelta,RMSprop,adagrad,nadam,etc.
SGD has best performance so far.
Loss:
Used **sparse_categorical_crossentropy** for the loss function
Metric:Accuracy

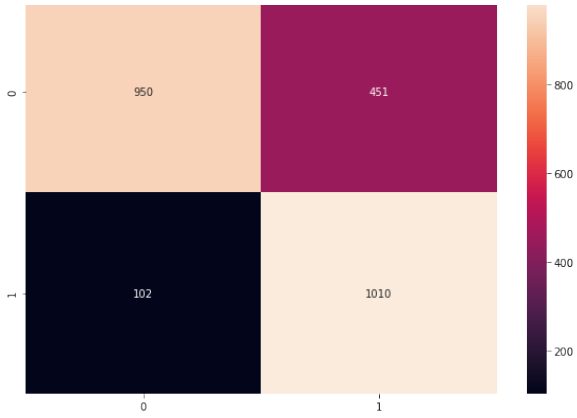
Results:

Model	Optimizers	Metrics=Accuracy(in percentage
ANN with Relu and softmax	Adam	60-70
ANN with Relu and softmax	Adadelta	50-60
ANN with Relu and softmax	Adagrad	50-60
ANN with Relu and softmax	RMSprop	50-60
ANN with Relu and softmax	Nadam	50-60
ANN with Relu and softmax	Ftrl	50-60
ANN with Relu and softmax	Adamax	50-60
ANN with Relu and softmax	SGD	80-85
CNN with ANN	SGD	90-95

Confusion Matrix:



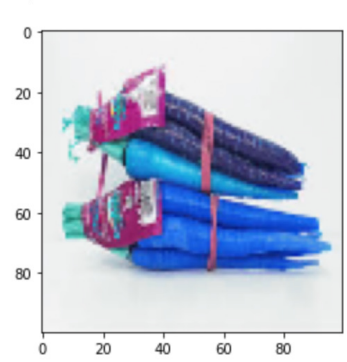
Confusion_Matrix_CNN



Confusion_Matrix_ANN

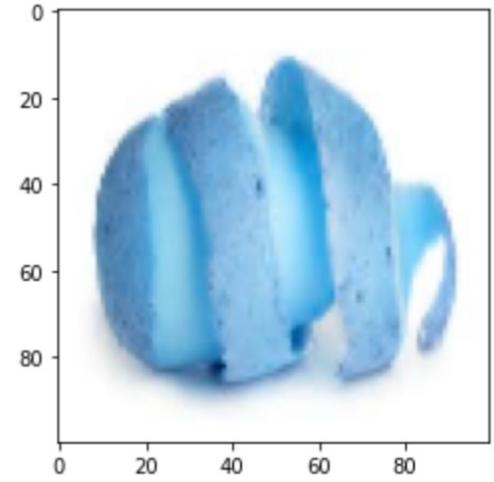
Discussion:

The result obtained from above will be:
“Organic”,”Recyclable” or "Both Organic and Recyclable”.



```
Recyclable
done!
```

Result_Recyclable



```
Organic
done!
```

Result_organic

b) As we see the results obtained can be further sent over to any other integrated application which could prompt user with warning if he/she is disposing wrong trash in wrong bin.This type of system could be installed in bins present in public area.

c)This could be extended to future research where in we can use more advanced technique like RNN to identify if there are both organic and recyclable trash in the image.

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