Garbage Classification

A Neural Network Approach

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Abstract

According to World Bank report global waste to grow by 70 percent by 2050 unless urgent action is taken. Countries around the world are struggling to find solutions. Smart cities that have smart traffic, smart grids, smart energy also has to include smart waste management facility. There are many types of waste. It can home-based like papers, plastic. It can be hazardous like medicine, battery. These all kinds of waste need proper solution for recycling and all waste cannot be recycled using same technique. Beyond this garbage and littering cause degradation of area and also impact quality of life of people living in that area. The main idea of this study is to is take an image as input and classify it. The dataset used for the garbage is available on Kaggle. Dataset contains about 17,000 images with 34 different classes. Convolutional Neural Network (CNN) is used to train the model. Results show that CNN alone is very less accurate.

Keywords Kaggle, CNN, World Bank, Tensor flow, Colab, VGG16, ResNet, ImageNet, InceptionV3

1. Problem statement

Waste in urban areas has become complex problem to solve. All over the city's garbage production is higher than recycling. It is hard to separate different type of waste. Proper is recycling is very important for every type. For example, a glass cannot be recycled as plastic. To solve this problem, we need to classify each item. This waste not only effect environment it is also cause of many types of diseases.

2. Introduction

A lot of development in science and technology has solved many difficult problems and people's lives have greatly improved. Developed countries are struggling to the problem of waste increase. With education people's can be solved. But it will increase the need of man power and resources for sorting things. The resource classification and recycling treatment mechanism of urban domestic garbage is an effective solution[9]. With a lot of storage and computation power we are able to do complex task and store a lot data. Deep learning is playing pivotal role in the advancement and helping mankind in daily life. CNN is also a deep learning model that can be used to extract feature of images and also in image recognition. We don't need to do more complex image processing tasks.

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Figure 1. Waste Classification.

Figure 1. showing six types of classes that are separated and put in to different bins. In this way we can classify the images and manage better.

3. Related work

A lot of work is done already experts around globe have tried to solve problems by many algorithms but because the garbage image can have multiple types of waste. The accuracy to split and classify is still very low because there is a lot of noise and density in images. Also, the images for such tasks need to be clearer. There are transfer learning models such as AlexNet, VGG16, VGG19 and InceptionV3[9]. By using these models, we will need a lot less images. Their experiments showed that the SVM performed better than the CNN. Support Vector Machine: The SVM-based approach achieves test accuracy around 47.25% using the same training and test sets with other models[7]. In many of researches the study has found that SVM outperforms CNN in term of accuracy. When Sigmoid or Tahh functions are used as training activation functions, because these activation functions belong to the saturated non-linear function category, the model converges very slowly during training, and the efficiency will also decrease[9]. It is impossible for human labour to classify and sort the recyclable waste separately hence this classifier technique helps to segregate the solid waste safely and quickly in a large-scale process if it's been automated[8]. As deep neural networks are able to describe more complexity, they theoretically perform better than shallow networks on training data. However, in a practical application like ours, deep neural networks tend to perform worse than shallow ones[10]. Another technique

has also been studied which is YOLOv3 a Convolutional Neural Network, composed of 106 layers. The first 53 layers refer to the Darknet-53 network used as Feature Extractor and it is pre-trained on Imagenet, allowing Deep-Transfer Learning[2].

4. Proposed Approach

In this study i have used neural network approach and the model is Convolutional Neural Network (CNN). Motivation behind selecting the model is deep learning models perform well as because of their ability to extract features and recognize the images. The model is used for training two times. First before augmenting the images and after augmenting the images. After training model with best training result is evaluated by feeding the picture to check the accuracy of model.

4.1 Dataset Classification

The dataset i used is avaiable on Kaggle but no one contributed in that dataset there are thirty-four classes in that dataset.

Figure 2. Dateset Images With Lables.

There are twenty-three thousand images from which fourteen thousand images were used for training and five thousand images are used for validation. The data is labelled and is divided in to each type of waste classes. Data pre-processing is also done as the dataset contains corrupted images.

4.2 Data Augmentation

As because neural nets need a lot data so i augmented the data and generated five more variants of each image.

- Cleaning corrupted images
- Flipping horizontally
- Image rotation
- Image zooming

The augmented data is used to convolve and results are drawn. Figure 3. show that how images are zoomed and rotated. Now we will have at least seventy thousand images for training and validating.

Figure 3. Augmented Images.

5. Evaluation and Experiments

For this study I have used CNN on Google Colab that is online Python tool using Tensorflow very famous machine learning and deep learning library provided by Google. At first iteration that data is split into 80% training set and 20% validation set then the images are normalized and CNN model is built with three layers with 16, 32, 64-bit filters and activation function of Rectified Linear Unit (Relu) is used. There are three hidden layers used for convolving. At the end the layer is flattened and densed with 128-bit input size with an activation function of Relu.

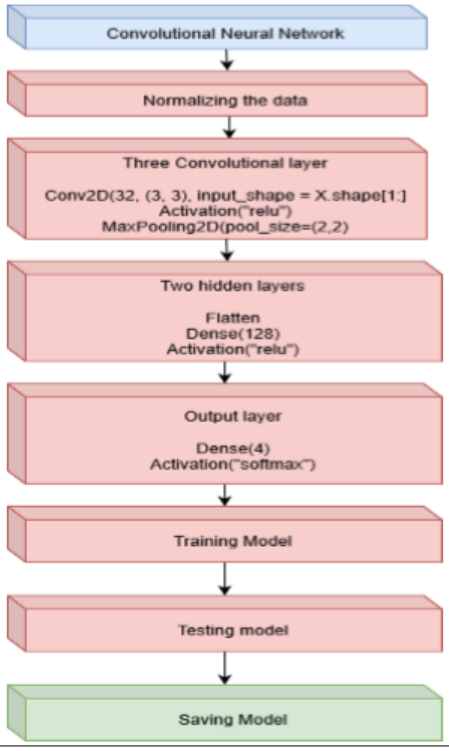

Figure 4. Convnet Model[8].

5.1 Convolutional Neural Network (CNN)

The CNN is a very classical deep learning algorithm. CNN model takes resized 2D image as input and then applies filter on it. It extracts properties of images by using convolving window and pass on to the next layer after that all inputs are flattened and densed to get the single output.

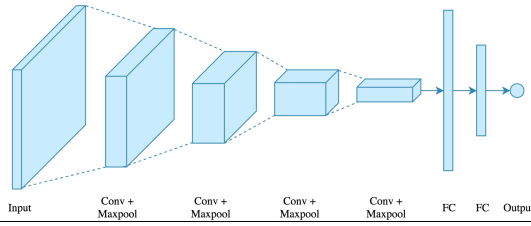

Figure 5. Convolutional Neural Network.

5.2 Training Without Augmentation

First model is trained with image size of 180x180 epochs=10, steps per epoch is set to 445. Images used for training are fourteen thousand.

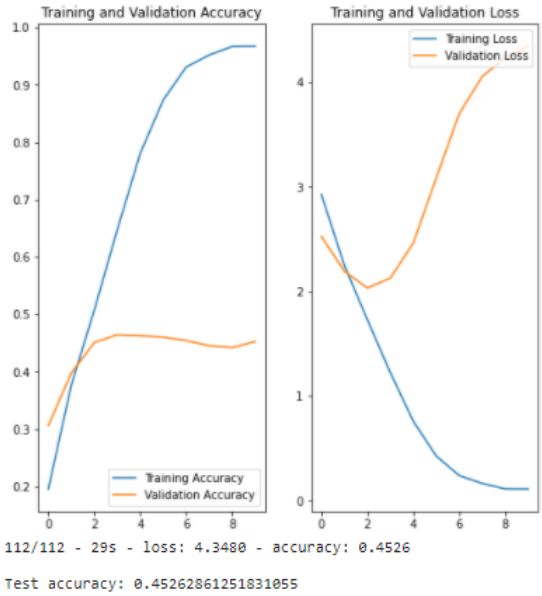

Figure 6. Training Results Without Dataset Augmentation.

From Figure 6. we can see that the results the model is very overfitting with training accuracy 95% and validation accuracy with only 45%.

5.3 Training With Augmentation

As the model was overfitting to solve this problem, we need some method otherwise model will not give good results. There can be many methods like data augmentation that increases size of dataset for training therefore more information is provided to model. Another technique that can be used is fine tuning hyperparameters. I used augmentation and training and validation set will be enlarged or almost five times. Now this model is modified I added 20% dropout. Training is done using epochs=15, image size is 180x180 and steps per epochs is 445. Model is improved if there is not much big difference between training and validation accuracy. We may need to increase the epoch size these both are improving with time.

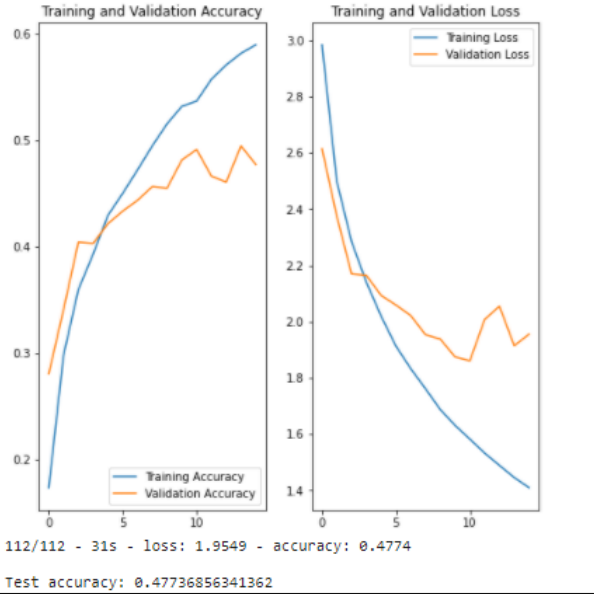

Figure 7. Training Results With Dataset Augmentation.

Figure 7. shows that after training with augmented data training accuracy is around 60% and validation accuracy is around 47% percent.

5.4 Checking Model Predictions

For predicting image class i used an image of glass bottle and fed the model with that image. Model generates probabilities and compares it with provided image.

Figure 8. Training Results With Dataset Augmentation.

The model gave about 66% accuracy and predicted class is plastic bottle which is somehow a good result. Dataset is very small therefore if we train the model more and more images it will improve accuracy and more accurate predictions. Many techniques can be used to improve accuracy ImageNet also helps in improving accuracy because it has more layers. Time for training and getting these results is approx. five hours.

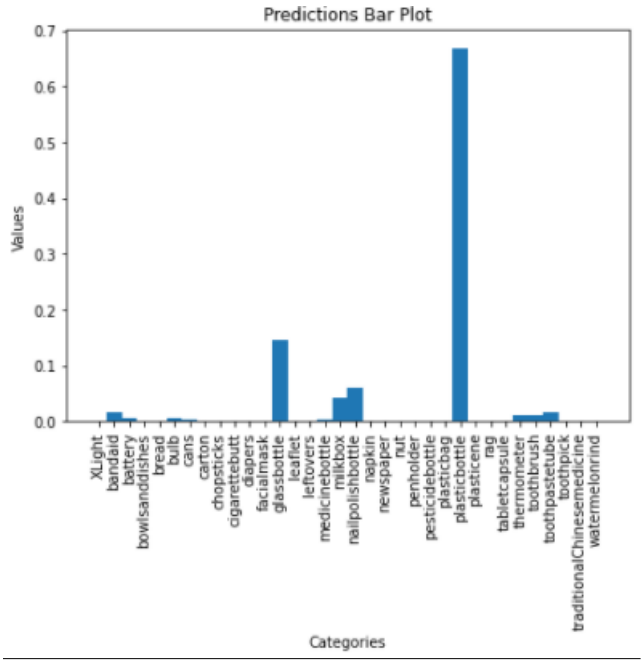

Figure 9. Training Results With Dataset Augmentation.

Figure 9. shows a bar chart made with probabilities of each of class and it clearly shows that image provided is highly likely a plastic bottle.

Acknowledgments

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