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Garbage Classification Using Convolutional Neural Network

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Abstract— For any developing country like India, the major problem is about the waste management. The important aspect in waste management is garbage classification which helps in proper recycling and disposal of the garbage. Our objective is to provide an application for classifying the garbage in an efficient and cost-effective manner for the department. The application identifies and segregates the waste into different groups. In this paper, the application is built upon the ResNet model which is one of the widely used convolutional neural network (CNN) model for image classifications, and a dataset is given which contains images of the garbage. The procured outcome was given a remarkable result as the application obtained an efficiency of 95% accuracy.

Keywords— Waste Management, Garbage Classification, Residual Network (ResNet), Convolutional Neural Network (CNN).

I. INTRODUCTION

Waste Management is one of the major issues that is torturing the societies for many years. And the issue is drastically increasing in the modern world. The improper disposal of these garbage waste causes severe health problems, damages the environment and ecosystems. At present, the world generates garbage of 2.01 billion tons and by the year 2050, the garbage generated by the world is expected to increase drastically to a whooping 3.4 billion tons [1]. The Garbage Classification is an important step in reducing the amounts of garbage ending up in dump yards and helps in recycling the waste properly. But this garbage classification is a very complicated process as it consists of various categories of wastes which need to be segregated in order to recycle it. And the manual method of garbage classification is a very time consuming, expensive, inefficient process. So, the automated methods and techniques are used to reduce the time and cost and significantly improves the efficiency of classification.

Several studies and ground works have been done on garbage classification using various artificial intelligence techniques. Recently studies revealed that, the deep learning algorithms shown a high efficiency and high accuracy in these image classifications. There are various types of deep learning models out of which the convolutional neural network (CNN) showed a great potential and led to a sequence of developments in the image classification processes [2]. In the CNN, there are various architecture of which Residual Network (ResNet) is one of the best and extensively used architecture for image classification. Therefore, in this manifesto, we would create an application built upon the ResNet architecture for the garbage classification. The scope of this manifesto is limited to the developing and testing of the application built on ResNet architecture. We gone use a dataset

which consists of various categories of wastes to train, test and assess the application. However, this thesis does not address any other waste management points like garbage reduction, recycling process, and disposal methods.

II.DATASET

The dataset which was used in the application for Garbage Classification is downloaded from Kaggle website. The dataset named "Garbage Classification" [3] is taken from Kaggle which consists of 2467 images in which each image consists of a single item of garbage with a clean and neat background. The amount of light and position of the item is different in different images in the dataset. The resolution of these images is 512 × 384 pixels where the height of image is 384 pixels and the width of the image is 512 pixels with a bit depth of 24. All the images in the dataset are be in one of these six groups are: cardboard, metal, plastic, glass, paper, trash [3].

This entire dataset is being used to train and test the application, how it was performing in identifying the garbage items in the images present in the dataset. Based on which it can tell the which item belongs to which group, out of the six group given in the dataset. The Fig. 1. shows some sample images present in the dataset.

Fig. 1. The sample images of the Garbage Classification dataset

III.METHODOLOGY

Developing the applications and system facilities which are automated in many industries by the execution of CNN based on a pre-trained models to recognize & classify the given set of pictures. In the project, we will initiate a garbage classification technique using the advanced deep neural networks.

A.Deep Learning

The Deep Learning (DL) [4] is a subset of machine learning. Deep Learning involved in use of neural networks with multiple layers. In the normal machine learning techniques, the feature extraction of various types of data like images, text, audio etc, is done manually by experts and given to the machine learning models to train. But in the deep learning, the models does feature extraction by themselves as neural network automatically understand and extract the applicable features from the input data. This is the reason why deep learning is widely used in image classifications, image recognitions, natural language processing, speech recognition etc,. One of the main advantages of deep learning is that, they can be trained on large datasets and with more data, the model gets improved.

B.Transfer Learning

Transfer Learning (TL) [5] is a technique in machine learning. In this technique, a model which is trained on a particular task is being used or adapted for another task which is different, but related to the previous task. Transfer learning is like the transfer of experience and knowledge in one task is being used for solving another tasks. This helps in reduction of required data and training time in solving that task. The models which are trained on a

particular task and solves another related task are called as pre-trained models. Researchers done a deep analysis and provided an efficient usage of the pre-trained models on various applications like computer vision [6].

Industries often use these transfer learning models as training a model on a very massive sets of data takes many months. But by simply using these pre-trained models with some factors, the industries saves a lot of time in training and solves the given task faster than previous methods. Similarly, we use this transfer learning in developing our application for garbage classification which helps to save a lot of training time and reduce the data usage without compromising on the accuracy of the application.

C.Pre-trained models

In transfer learning, a model which is trained on one dataset is being reused or adapted to solve another dataset which is different, but related to the previous dataset. Here, that model is called as pre-trained model. These pre-trained models are used on larger data which normally takes more than a month to train. By using these pre-trained model, we can save the training time and reduce the data to be required to solve the task without being compromising on the accuracy of the model. In this paper, we use the pre-trained model to built the application for garbage classification as we didn't have any large data to train and didn't have any enough resources to train the model from scratch.

D.Convolutional Neural Network (CNN)

Convolutional Neural Network (CNN) is a specific class of deep learning technique. This technique is best suited for recognition like text, image, video etc., image analysis & classification, media recognition. CNN mainly consist of convolutional layer [7] along with connected layers, which helps in learning features from raw data. The CNN architecture possesses different layers like input layer and the count of these layers varies for different models. These layers are responsible for learning, analysing, and identifying set of features in various formats like images, text, etc, are called convolutional layers. In the CNN, the input layer takes the images and passes it to the convolutional layers. The convolutional layers posses set of masks which helps in extracting the features. The filters are nothing but small matrices in size of 3 x 3. Now by matrix multiplying the input image and filter based on the given stride, we get an output value which is used to create a feature map and passed to next convolutional layer.

After each and every convolutional layer, there is a layer which helps in reducing the spatial dimensions of feature in the map. It is called pooling layer. This also helps in reduction of computational process. The pooling layer performs a statistics on the feature map, as the maximum value or average value. When pooling is done based on maximum value is called maximum pooling. If it is done based on average value, then it is called average pooling. After completion of the feature maps, the output is get flattened and it will be going through another layer. This is called fully connected layer. These are a sort of neural networks which are intended to perform classification and regression. The fully connected layers are feed forward network of which the back propagation is applied to get the output layer over a series of epochs. The output layer is a SoftMax layer which gives about the probability distribution of classes.

E.Residual Network

Based on the set of empirical experiment [8], Researches found out that deep neural network are hard to be trained. As the accuracy might be over saturated and sudden degradation takes place. In order to solve this problem, the Residual Network (ResNet) is introduced.

Residual Networks (ResNet) are deep neural network architecture. It is mainly designed for resolving the problem of vanishing gradient, which usually occur when gradient of loss function become very small. In ResNet, the residual blocks are mainly used in learning and retaining the residual part of return. This is being done by making a shortcut path to the mapping section that allows gradient to directly back propagated to the earlier layers. These shortcuts do not cause or add any extra parameters or complexity to the layers. There are many different types of Residual Networks based on their layer architecture and deep layers.

Let us discuss about the one specific type of Residual Network called ResNet50. ResNet50 belongs to the ResNet family with 50 layers. It incorporates several convolutional layers, with pooling layers, and finally a

sequence of residual blocks. The final layer present in this model is the fully connected layer which gives us the required output. ResNet50 uses the bottleneck architecture in residual block. The ResNet50 starts with a convolutional layer which takes the input image and apply filters to get a feature map and this particular feature map is passed on to set of residual blocks. Each of these residual blocks consists of several number of convolutional layers, and ends with a connection. This is called skip connection. This helps in adding the user given input in the derived output of the residual block and allows the network to be learning the residual mappings.

After a normal convolutional block, the ResNet50 model uses some residual blocks like 16. This is done with the increase dimensions of a set of features. In this model, the final residual block always connects the average pooling layer. This is being a down sample of the feature matrix. The flatten layer is being used in classifying the features of image. The dropout is being a way of regularization, it is used to add noise to hidden units and averaging the derived errors particularly overfitting errors and helps in reducing the adaptors. Residual blocks probably use ReLU function for most of its advantage. ResNet50 also being tend to use SoftMax function in the final or output layer.

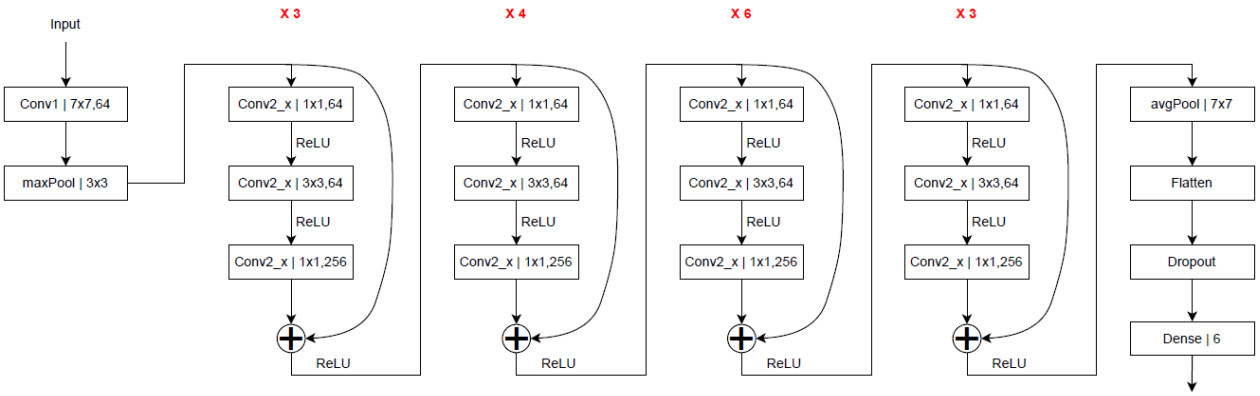

Fig. 2. Structure of the ResNet50

IV. Results and Discussion:

In this segment, let us find the outcome of the application using ResNet50 developed to classify the garbage. The ResNet50 model achieves a testing or validation accuracy of 95-96%, but it attains training accuracy of 98%. So, there is difference between the training loss and test loss. The Fig. 3. shows the test accuracy based on the number of epochs. It gives the evolution of the test accuracy with increase of epochs in graphical form. The Fig. 4. shows the training and validation/test losses along the number of epochs. It gives the evolution of training loss and test loss with increase of epochs in the graphical form.

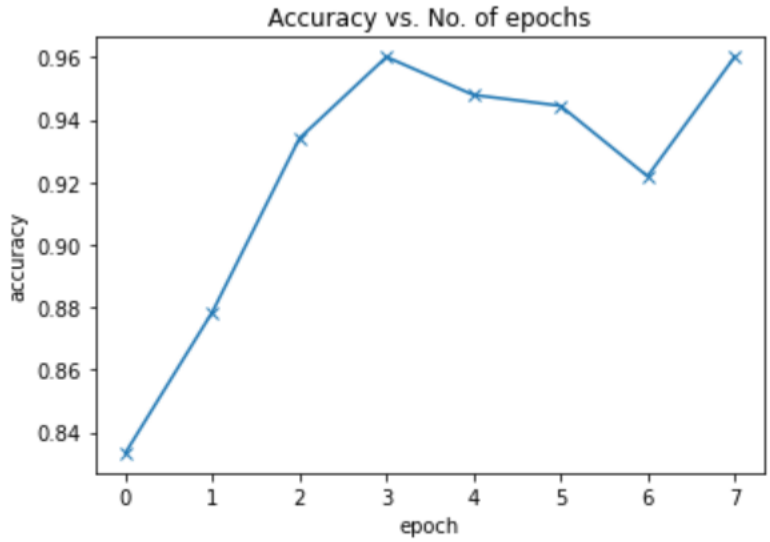

Fig. 3. Evolution of the test accuracy of the ResNet50 model.

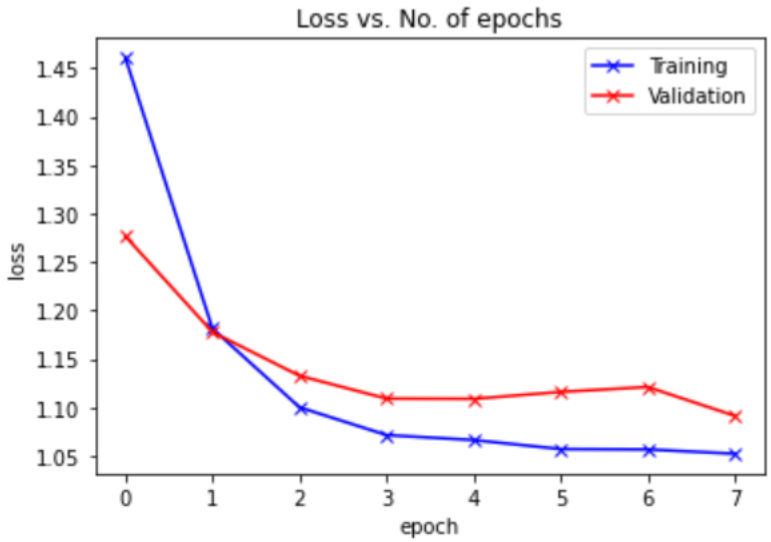

Fig. 4. Evolution of the Training and Test/Validation losses of ResNet50 model.

V.Conclusion

The above segment gives us that the ResNet models are one of the best in classifying and differentiating the waste. The deep learning model helps us to attain the accuracies in the classifications. The application developed based on ResNet is an automated method for classifying the garbage. However, there are various limitations in this method. It is very difficult to take the image of the item in the clean and plain background for each and every time for classification. Due to a small dataset used in this application, we cannot simply use this in the daily life, since there exist a lot more varieties of garbage need to be separated, disposed, and treated properly. So, we need a much larger and much complex dataset of various garbage types and used to train the application in order to make it useful in a day-to-day basis for various corporations.

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