Garbage Classification Using Convolutional Neural Network (CNN)

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Abstract:

Image segmentation and classification is more and more being of interest for computer vision and machine learning researchers. Many systems on the rise need accurate and efficient segmentation and recognition mechanisms. This demand coincides with the increase of computational capabilities of modern computer architectures and more effective algorithms for image recognition. The use of convolutional neural networks for the image classification and recognition allows building systems that enable automation in many industries. In this I proposes a system for classifying waste. The obtained results show that automatic waste classification, using Convolutional Neural Network, allows building effective systems that operate in the real world.

Problem Statement:

India has finished at the bottom of the Environment Performance Index-2022 released by the World Bank. This means India is among those countries in the world that have the worst environmental health. Out of 180 countries that have been ranked, India is in the bottom five with a score of 18.9.

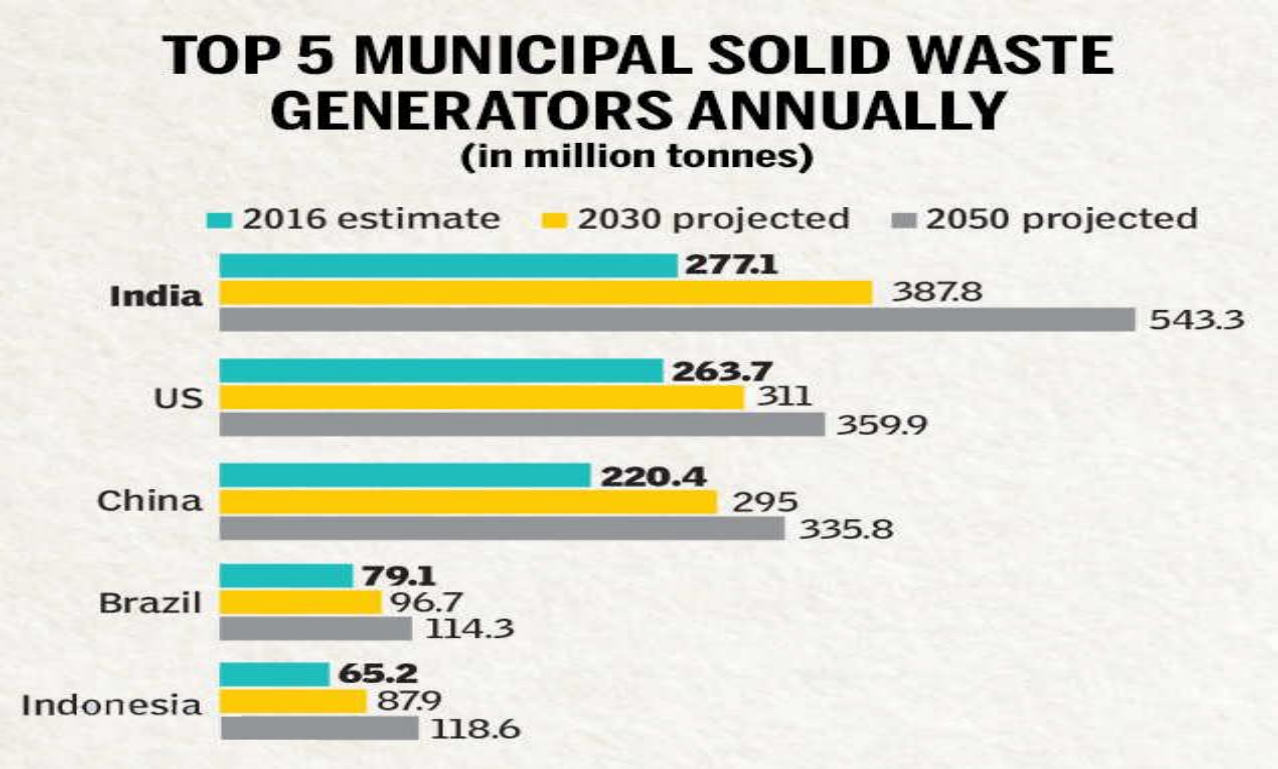
According to the report, the total annual municipal solid waste generation increased by 77% since 1980 to 292.4 million tons per year. This means that one person generates 4.9 pounds of waste per day.

At present, most of the garbage disposal methods are still in the traditional landfilling method, occupying tens of thousands of acres of land; and the flies fly, the sewage overflows, and the smelly air smokes, seriously polluting the environment.

Market/Customer/Business need Assessment:

The accumulation of non-recyclable waste on landfills all around the world and the huge amount of time that most of its materials take to biodegrade can affect in a significant manner our lifestyle in the near future if we, as a society, don't take action to prevent this from happening. Moreover, among the most notorious risks for humans, waste accumulation can enhance the disease spread via vectors such as flies, mosquitoes, and many more insects. Also, in addition to the ruin of the beauty of natural habitats, deforestation, and terrain occupation to provide enough space to landfills, soil and water can be susceptible to be polluted due to the toxic chemicals located in improperly treated materials. At the same time, that pollution can alter the food chain, which inevitably leads to more diseases and health issues for humans and the natural ecosystems worldwide.

Garbage classification and collection can reduce the amount of garbage disposal and treatment equipment, reduce the treatment cost, reduce the consumption of land resources, and have social, economic, and ecological benefits.



From the above chart we can easily see the need of waste management in the country and waste or garbage classification is the starting step for it.

Target Specification and Characterization:

. To create a CNN model which classify garbage in different categories for proper waste management.

. Reducing Solid Waste with the help of proper classification.

The above target can be achieved by:

(1.) Analyzing what kind of wastes are present in the locality, on the basis of which we will set our classification parameters.

(2.) After successful classification we can manage the waste i.e., **Reuse**-**Reduce**-**Recycle** or dump them at their proper place.

External Search:

The sources I have used as a reference for this project are:

https://www.wikipedia.org/

https://www.kaggle.com/

https://towardsdatascience.com/a-comprehensive-guide-to-convolutional-neural-networks-the- eli5-way-3bd2b1164a53

https://www.turing.com/kb/transfer-learning-using-cnn-vgg16

Related Work:

Over the most recent couple of decades, specialists and researchers have been dealing with precisely grouping the pictures into their separate classes. By custom, because of the need for computational force and restricted picture datasets, picture arrangement was difficult. However, today, because of regularly expanding handling intensity of the GPUs and the accessibility of enormous datasets, it has become attainable to utilize PC vision procedures effectively. In the field of grouping of pictures, notable and profoundly skilled CNN design is Alex Net [1], and ImageNet Large Scale Visual Recognition Challenge (ILSVRC) was won by it in 2012. The engineering is nearly straightforward and not very profound, and is, obviously, known to perform well. Alex Net was compelling on the grounds that it began a pattern of CNN approaches being exceptionally famous in the ImageNet go up against and turning into the best in class in picture arrangement.

The isolation of waste incorporates two fundamental advances – ID and partition. The standard waste isolation procedures incorporate weight-based isolation, Trommel separators which relies upon the molecule size, Eddy current separators which is utilized for metal isolation,

X-Ray innovation can be utilized to separate waste material dependent on their densities.

Recognizable proof of the waste is a significant advance before detachment and it very well may be done effectively with the assistance of various AI and picture preparing calculations. Convolutional neural systems (CNNs) are most picked for grouping of pictures. The CNNs permits to remove interesting characteristics from the picture and afterward order it into foreordained classes. Some of the researches that have been done and related to our review are listed below: - In paper [1], The tests were carried out on proven CNN models in this study. The results obtained from this research; Adam received better accuracies in the test than Ad delta. In addition, the data augmentation procedure was implemented to improve classification accuracy due to small Trash net dataset samples. The best results were obtained from DenseNet121 with 95% fine-tuning.

The success rate of InceptionResNetV2 model was 94% for test accuracy using fine-tuning. It was found that deep learning models were incorporated in the classification of recyclable waste. They have carried out some experiments on known deep learning models for this purpose; the performance rate in real-time systems was poor because of the lack of sufficient data and the images having white color background.

In paper [2], This paper makes use of Faster R-CNN to get proposals for regions and identify objects. Some of the areas where they were lacking where training of the model was not done scratch and instead of that use of the pre-trained model was done. They have only used ZF

Net that has 5 convolutional layers and 3 fully-connected layers because of which the architecture was not good. Test was done on the given dataset but on the real Images.

In paper [3], This narrative literature review evaluated global issues due to different fractions of waste showing how several pollution sources affect the environment, population health and sustainable development. The findings and case studies presented that serve as a guide for scholars and stakeholders to measure comprehensive impacts and to plan integrated solid waste collection and treatment systems to enhance global sustainability.

In paper [4], The proposed framework has been determined for successful programmed isolation of waste at the source itself, along these lines diminishing the physical endeavors. The framework depends on ideas of Machine Learning, Image preparation. The goal of this undertaking is to catch pictures of a solitary waste material and successfully recognize and isolate it into four classes viz. Metal, glass, paper and plastic. The model utilized for this task is Convolutional Neural Network (CNN), a Machine Learning calculation.

This framework will guarantee compelling robotized squander the board and will accelerate the procedure of isolation with no human intervention [7].

A novel application was proposed in this paper [5] for measuring the cleanliness of a place, with the use of a deep learning framework.

The application helps in localizing and classifying waste from three meters of height in RGB images taken by a camera facing ground. Due to the unavailability of a waste dataset, they used their proposed acquisition to get photos. We have also developed an annotation method to mark items for 25 different forms of waste in our dataset. In order to increase the accuracy of the existing system we can attach more images other than the butt of cigarette leaflet to their dataset.

Applicable Patent:

WO2017129325A1 - A convolutional neural network

CCHANG. (2018). Garbage Classification [Data set]. Kaggle. https://doi.org/10.34740/KAGGLE/DS/81794

These two will be significantly considered while developing and implementing the CNN model.

Applicable Constraints:

Data collection from Kaggle dataset.

Continuous data maintenance.

Lack of technical knowledge for the users.

A collection system needs to find suitable treatment options and markets for the sorted waste.

Convincing people to implement the system at various places for garbage classification.

Applicable Regulations:

Data protection and privacy regulations.

Govt Regulations.

Household Hazardous Waste (HHW)

Guide for Industrial Waste Management

Protection of the Environment Operations Act 1997 (POEO Act).

Business Opportunity:

Classification of materials is part of the municipal waste management necessary in the recycling process. The manual sorting process is tedious and expensive, which is why we need to create automated sorting techniques to improve recycling efficiency. An important element of the whole process is the preliminary division of waste into various groups of materials.

We can do it with the help of powerful CNN model which classify wastes for us and we can do further processing.

It should be installed at all shops and homes to classify wastes, so that we can easily manage the wastes according to their types.

Concept Generation:

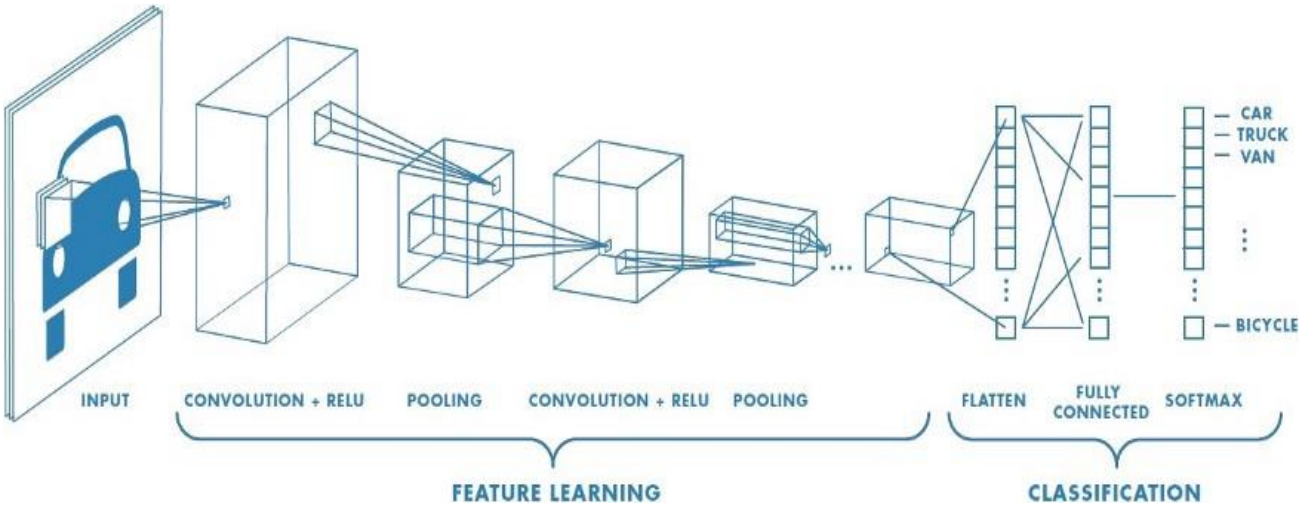
''Every garbage is not a total garbage'', we can classify them and even use them for different purpose because we know that some wastes are reusable and we can recycle some of them.

But doing this classification manually by using hand is not healthy at all.

So, by using deep learning model and with the help of CNN we can make it automatic and one doesn't have to touch the wastes manually.

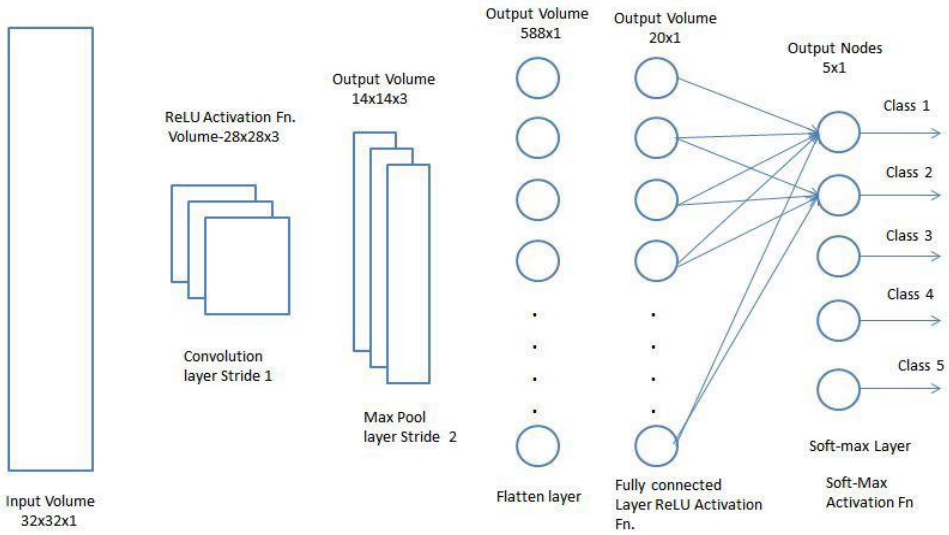
Final Product Prototype:

Convolutional Neural Network:



A **Convolutional Neural Network (ConvNet/CNN)** is a Deep Learning algorithm which can take in an input image, assign importance (learnable weights and biases) to various aspects/objects in the image and be able to differentiate one from the other. The pre-processing required in a ConvNet is much lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, ConvNets have the ability to learn these filters/characteristics

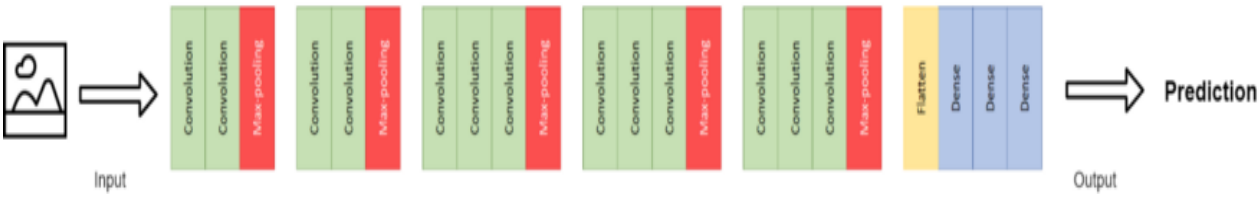
How CNN help in Classification of Images:

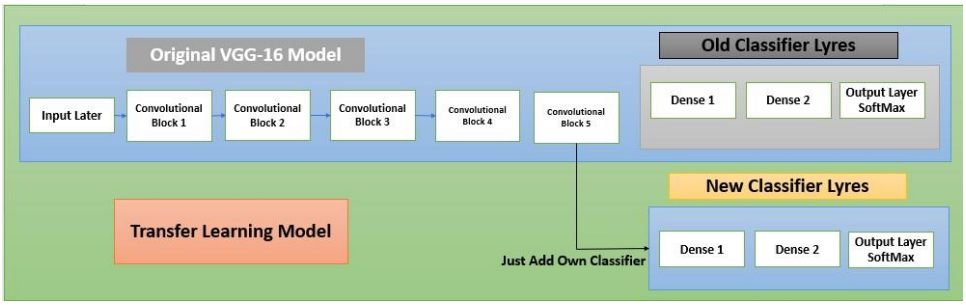


Transfer Learning:

It is utilizing the feature learning layers of a trained CNN to classify a different problem than the one it was created for.

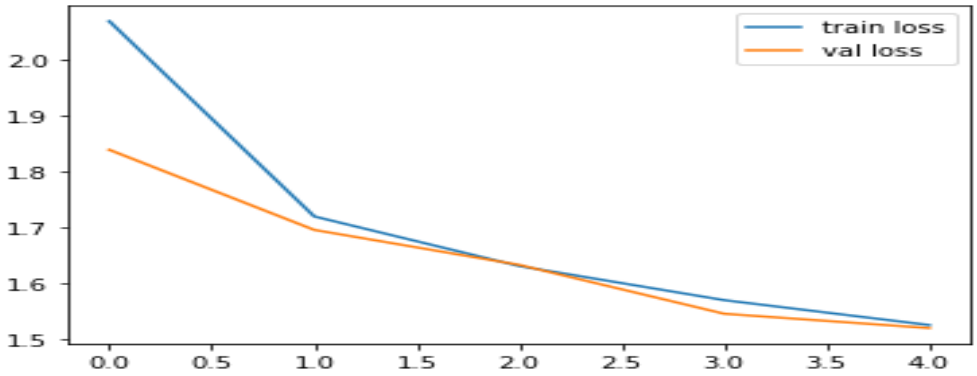
Here we will use VGG16.



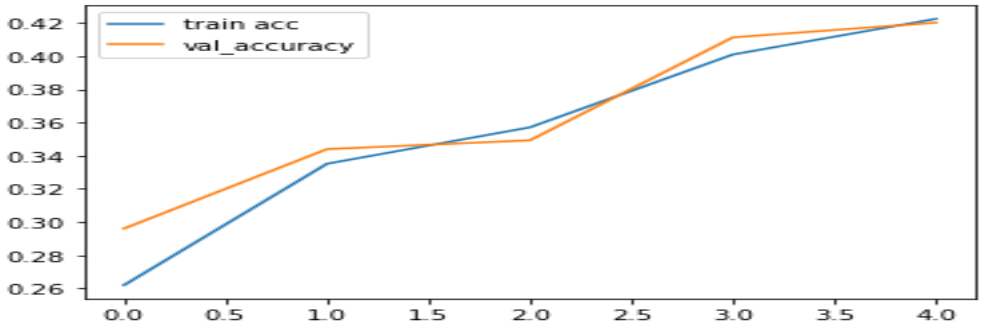


After proper implementation we will get the graphs as below:

LOSS PLOT OF VGG16:



ACCURACY PLOT OF VGG16:



Conclusion:

To limit the impact caused by incorrect disposal of trash, this project introduced an automated waste detection framework using deep learning algorithms and image processing techniques. Thus, for implementation, the framework worked with a large dataset of images, training algorithms, and predictive patterns for object detection and classification.

The main issue of this project was the dataset which includes images that are slightly different from local waste materials. This is the reason for which the model predicted wrongly on a few local waste images. The future work that should be taken for consideration is a similar method however an improvement in the datasets by including pictures of locally taken waste materials. There is a need of attaching images of the waste materials in the training dataset which are not clean and looks dirty. This will help the model predicting actual local waste materials which include mostly dirty household items. This can assist in getting some improved classification with a higher accuracy rate. The dataset should also include many images that contain pictures of multiple waste materials so that the framework can easily be trained to predict multiple objects in a single image without giving any error in the detection process. Further research of this project should also consider including different types of other bulky waste categories in the dataset. **By intensifying the list of categories this framework will get more developed and would surely help in the improvement of the proper waste management process.**