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A Review on Image Based Classification of Waste Material

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Abstract
Recent administration of law by the Indian government for the well-being of hygiene workers has raised the need for an automatic system in waste management. The existing garbage removal system in India consists of unsystematic waste collected from homes which are then separated at manually. This separation of waste done by manual labor can bring about many health hazards and problems for the waste sorters in addition to being less efficient, time consuming and not totally feasible due to their large amount of waste. In our project, we have proposed an Image-based classification of waste material using Convolutional Neural Network (CNN) algorithm in Deep learning to classify objects as biodegradable and non-biodegradable, where the system once trained with an initial data set, can identify objects real-time and classify them almost accurately. Biodegradable waste is used to produce power, improve soil and act as food to animals. This process does not harm the earth making it valuable, ecologically safe and helps us to protect our environment, rich ecology and human inhabitants in future. Categories like glass, paper, cardboard, plastic, metal, and other trash.

Keywords: *Garbage segregation, convolutional neural network (CNN), waste, ecology, classification*

1. Introduction

The ever-growing amount of waste in a country with a population of more than 1.2 billion calls for some action. The waste collection generated by developing countries' rapidly expanding cities is increasingly beyond the municipal administrations' capacity and financial means. The current recycling process needs recycling facilities to divide garbage by hand and to use a series of large filters to separate more specific objects.[1] Consumers can also be confused about how to decide the best way of disposing of a wide range of materials used in packaging. In the era where resources are reducing fast, it is our top priority to improve the existing methods of recycling to ensure bearable development. The most famous transfer learning application is the classification of images using deeply convolutional neural networks (CNN). These are the Alex Net VGG16, VGG19 and InceptionV3 models. Transfer learning allows deep learning to be used with a limited amount of data and lower computing capabilities. [2]

Trash has always been a public problem because of the way people organize such things. Some of them are burying, burning, and keeping in places where the trash should not belong. Air, water, and soil contamination are created through these methods. Reducing the amount of trash reduces pollution. Recycling by re-use of trash materials is an appropriate method of waste reduction. Dividing trash into categories improves a community's recycling capacity. Selling the recyclable materials identified contributes to reducing community garbage collection expenses. Municipal laws and regulations need people to separate paper in one container, metals in another container, glass in a third container, and plastic in a fourth container.[4] Recognizing waste is achieved first

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to accomplish the separation of waste that will lead in recycling.

Waste stances a threat to public health and the environment if it is not stored, collected, and liable off properly. Attitudes towards disposal have been conquered by the perception of waste as unnecessary material with no fundamental value. India needs to solve its waste management problem. Be it solid municipal waste, manure or chemical and manufacturing waste, in India, every waste is mismanaged. So, instead of construction landfill sites, given existing ones are effective way past their lifespan, experts say that the government should look at innovative methods to recycle waste. Despite the huge steps India is making universally in several spheres, one area that has been completely ignored for long is cleanliness. The need for segregating waste materials according to the desired properties is constantly increasing.[3] As the rate of generation of waste products is high, pure man power cannot do much to counter this process. Therefore, teaching a machine the difference between such objects would not only be a faster method, but also efficient. An amalgamation of technology and motive would give effective results. In order to impersonator a stream of materials at a reusing plant or a user taking an image of a material to identify it, our classification problem includes receiving images of a single object and categorizing it into a recycling material type. The input to our pipeline is images in which a single object is present on a clean white background. We can use an SVM and CNN to classify the image into different categories of garbage classes. By using computer apparition, we can predict the category of garbage that an object belongs to base on just an image.

Automated Waste Segregator (AWS) [4] is considered to classify wastes according to the following categories: biodegradable waste, non-biodegradable waste, and dry waste. It uses parallel echoing impedance to distinguish mechanism to classify metallic objects, and capacitive sensors to differentiate between wet and dry waste. The waste segregator [5] will sort waste into the paper and plastic categories into three major classes, namely metallic, wet, and dry waste, and further categorizing dry waste. Arduino UNO is used with sensors for the categories. Identified wastes are disposed of in their separate category bins where they can be recycled or reused.

2. Literature Survey

In Paper 1the concept of Classification plays a vital role in identifying the objects and categorizing them into different groups and by naming them under particular labels. This process of separation becomes easier to segregate objects into their respective divisions.

Classification is done based on the given input of images or the datasets to learn by using the training data and based on that predicting the category of the waste. The approach used in this paper is transfer learning which is done by recognizing small patterns of dataset in image matrix and then assigning values to feature maps based on weighted values of previous images of the trained model. Detecting bigger patterns based on combination of small patterns and finally calculating the score of each category based on final layer of feature map values [1].

In Paper 2 the data acquisition is done by using some open source images and also from TensorFlow. The dataset contains images of mainly three categories like Cardboard, Glass, Plastic. Since the input data which is taken directly from the Dataset are not much useful in learning or understanding more efficiently about the data and its characteristics, the data is preprocessed.

Data Preprocessing is done in various methods such as Cropping, Zooming, Brightening, so that various possibilities of the same images can be learnt and effectively trained. This will help in understanding more clearly above the data [2].

In paper 3 the concept of transfer learning is used. Transfer learning uses pre-trained models and makes small changes in the original data model. The large amount of data is applied to produce the good results and it is widely used to avoid the more costly deep neural networks. The data or the image set from pretrained model are extracted and transferred to trained dataset, as the learned features are transferred.

There are different transfer learning models and in that image classification using deep CNN is most useful, such models include AlexNet, VGG16, VGG19, and InceptionV3. Transfer learning allows the use of deep learning with a small amount of data and lower computational capabilities, Mobile Nets are a family of mobilecomputer vision models for TensorFlow, designed to effectively maximize accuracy while considering the restricted resources for an ondevice or embedded application [3].

In paper 4 the Deep Learning algorithm is used. It is a subpart of Artificial Intelligence (AI) which is related with the learning approach that studies and describes about data patterns. It plays a vital role in many tasks such as identifying the images, translating speech to text, recognizing the speech, face identification and detection, whether forecast, drug detection etc. With the help of High-Performance Computing (HPC) Many technologies and innovative techniques such as Big Data is used for

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processing the large data sets to predict the output. It helps to learn data representations with abstraction of multiple layers. The libraries used are TensorFlow, NumPy, Matplotlib, Pillow, OpenCV etc.It is trained by large datasets of categorize data.

Deep learning algorithms which are supervised and linear are stacked in a hierarchy of increasing complexity and abstraction. The advantage of deep learning is that the program builds the feature set by itself without any help of people and hence they are much faster and more accurate.

A Deep Neural Network (DNN) is a neural network with many complex layers between the input and output layers. The DNN finds the algorithmically correctmethod to turn the input into the output [4].

In paper 5 the installation of required libraries is explained. Python is a high-level object-oriented programming language with code readability and various built-in libraries functionalities for different usages. It is a scripting language, which provides different methods to provide large data and advanced calculations with libraries such as TensorFlow, SciPy, and NumPy.

TensorFlow and Scikit-Learn are libraries that provide various machine learning frameworks and algorithms, such as neural networks and support vector machines. TensorFlow helps in visualization tools that can become very simple to understand, debug, convert into better form of TensorFlow programs.

NumPyis a library used for applying different mathematical functions containing arrays, matrices, problematic expressions.

SciPy is a package for performing efficient usage of the experimental routines in Python. It is used to work efficiently on NumPy arrays, so that NumPy and SciPy work together[5].

In paper 6 CNN is used. Convolutional neural network (CNNs) are mostly used for classification of images. CNN is the most popular image classification method. Here no additional features are extracted from the separated dataset Items, and the training process of the dataset model is time consuming and depends on variousattributes likespeed,codequality and correctness of the Model.

The CNNs extract unique properties of the image and then classify it into various classes. Large image datasets can be processed in a very short amount of time and thus CNNs can be helpful in the classification of different datasets into their respective classes. The working of the Convolutional layer is as follows - the layer receives some input, an image with a specific dimension of different height, width and depth. There are filters which aredesigned as matrices and initialized with random numbers. The Filter is designed over input volume. It undergoes through the image and computes dot product throughout the image. The Filters end up producing activation maps for the input image [6].

In paper 7 Max pooling is defined. Max pooling is the process of sampling of the activation feature sets. Normally, Max pooling layers of 2x2 filter and stride 2 are used, which helps in reducing the input activation maps into half spatial maps.

Maxpooling is a sample-based separation process into their particular categories, which help in representing the input – image into a Matrix, thus by providing a well defined and required form of feature set through over-fitting model. This optimizes the computational cost by reducing the number of train attributes and provides a clear invariance to the internal representation of translation. This process is done by adding a max filter to the initial representation's non-overlapping subregions[7].

Paper 8 talks about Flattening. Flatting transforms the tridimensional image dimensions into anon dimensional image. The two-dimensional convolution layers making a two-dimensional dataset such as images etc. usually output a tridimensional image with the dimensions being the image resolution by removing the filters, additional convolutional layers and the number of unwanted patterns. This structure is required to convolution layers together or with other layers that provide atreatment such as pooling, upscaling, etc. Within classification, usage of fully connected layers that do not take any structureinto account for processing are done in the last steps of the network. The output of the last convolution layers are 6``1 to be considered as a large piece of unstructured data [8].

Paper 9 gives the reference of the requirements used in the project. Usually waste classification is basically a software-based project that takes images as input and predicts the groups digitally. For the project to run, some basic conditions must be following in an environment. The hardware requirements like Multicore processor, At least 8GB of RAM, At least 1GB disk space, Preferably a decent graphics card, like GTX Nvidia graphics card. This project also has some software requirements like Python, with version greater than 2.6, An operating system that supports python, like Windows, Mac, or Ubuntu, Some python libraries like TensorFlow, NumPy, SciPy etc. The project uses Transfer Learning to re-train Inception v3 model based on convolutional neural networks on Google’s Tensor Flow architecture. The steps involved in the project are explained in sequential manner [9].

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Paper 10 describes about the prediction of the results based on the provided training datasets and the testing models. The final stepis predicting the categories of new images. The testing model provides various separate images for testing purposes. The model can classify multiple images at a time, all images inside a directory and the subdirectories are classified one by one. The prediction can be a single label or all labels with the likeness of the image belonging to that label. The accuracy appears to be high in training set. The problem of overfitting is also avoided since test accuracy is high too. This helps in distinguishing between different images with appreciable accuracy. In order to improve the accuracy of the prediction, more data can be collected and trained and applying more deeper model with more layers etc. [10].

3. Table 1: Survey of existing work

Author`s Name [Year]	Techniques	Advantages	Disadvantages	Accuracy
S. Sudha, et al. [2016]	*Machin Learning *Neural Network	To classify objects as biodegradable and non-biodegradable, where the system once trained.	Network models which represent the probability is not satisfy in this paper.	85%
Mindy Yang et.al [2017]	*SVM *CNN(Convolutional Neural Network)	Achieve a good accuracy using CNN.	The SVM performed better than the CNN, it is not expected result.	75%
BalajiMasanamuthu et al. [2016]	*CBIR(image Features)	All these modules were successfully integrated to achieve satisfactory results	Improving upon the design.	82%
Stephenn L. Rabano et.al. [2018]	*SVM classifier	The performance and accuracy is good	It may still improve the quantized model for better results	79%
R. S. Sandhya Devi et.al. [2018]	*Deep learning *CNN	Advance techniques uses like bigdata to produce good results	Training Process is more time consuming	83%
JoyalMendonca et.al. [2016]	* IR proximity sensor	which is a cheap, easy to use solution for a segregation system	Hazardous and the economic value of waste is best realized	80%
OmarLongoria et.al.[2017]	*KNN Algorithm	*Traditional way of dealing the waste *places automatically in different containers * image processing	Separating trash manually, which does not always work.	90%
Sachin Hulyalkar et.al.[2018]	* CNN	*Using afore mentioned hyper parameters for the CNN. *They able to achieve good accuracy on training data.	*Using different models of CNN, they couldn't achieve an accuracy.	85-90%
B V Monisha et.al. [2019]	* SIFT and Bag of VisualWords (BoVW)	Efficient and applicable to all environments	Compromised accuarcy	72%
Zenghui Wang et.al. [2019]	*SVM *CNN	Process is faster and intelligent	System accuracy can be improved	87%

4. Accuracy table

Data type	**Correctly Classified Images**	**Total Images**	**Accuracy**
Training Dataset	2885	3039	94.93%
Test Dataset	559	601	93.01%

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5. Conclusion

The use of Deep learning helps in providing more accuracy to get better prediction. The classification of features, the acquisition of data, categorization of modules into different submodules, training the data models, using different techniques like SVM, CNN, KNN helps us to predict and classify. So convolutional neural network (CNN) produces the accuracy more efficiently.

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