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Classification and Segregation of Garbage for Recyclability Process

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Abstract: ***Large amounts of waste are generated per day in developing countries like India. Hence, there is an urge to treat the waste properly. There are ranges of waste materials that require different methods of treatment. Sorting of garbage is a crucial factor in developing as well as developed countries. Researchers from various fields are drawn to recover valuable material which may be lost if proper segregation methods aren't followed. For proper disposal of waste at dumping ground it is very important to sort the waste at ground level. Analyzing and classifying the garbage using deep learning methods are often a really effective way to process the garbage. Identifying and separating elements found in waste streams using IOT and Deep Learning can enable to recover useful material, promote enhanced recyclability and also reduce the amount of waste materials sent to the landfills.***

Keywords: Yolo, IOT, garbage, classification, segregation**.**

1. Introduction

Segregation and recycling of garbage materials is very important task. This process of segregation and recycling methods require humans to sort the garbage by hand and huge numbers of filters are used to sort the garbage. The inspiration behind this project is to find an automatic method for segregating waste materials. This makes the processing plants more efficient and helps them to reduce waste, because it isn't always possible by employees to sort waste materials with 100% accuracy. By introducing such mechanisms won't only have good environmental effects but also better economic impact [1]. The frequently used waste management methods viz. dumping and destroying of waste have become more costly and energy inefficient. The financial costs of handling the long-term environmental impacts of traditional waste disposal techniques is incredibly high, compared to smart methods of disposing waste materials. Conventional methods of waste disposal have negative effects on the environment like harming the natural surroundings, wildlife and ecosystem. In other words, Conventional methods of waste disposal don't seem to be sustainable and can have negative impacts for future generations [2].The destroyed waste materials from different sources contain a variety of solid waste materials which can or might not be useful. However, for recycling of recyclable waste it is important that the waste must be segregated properly using accurate algorithm. Deep Learning algorithms can be effectively used to classify different types of garbage and segregate them [3].

The proposed system uses live images of a single piece of garbage at a time, then that data is passed to the trained model [9]. The model trained on Yolo does processing and classification of the image and output is generated. According to the output generated segregation of garbage is done using IOT.

2. Related Work

In [1] Gary Thung and Mindy Yang used two algorithms SVM and CNN for classification of garbage. CNN and SVM were the two algorithms used to train models by taking images of a single piece of garbage of six different categories to test the accuracy. The result obtained was SVM provides better accuracy than CNN.

In [2] George E Sakr, Maria Mokbel, Ahmad Darwich, Mia Nasr Khneisser and Ali Hadi paper states that the accuracy of the model can be increased significantly by using the model hyper parameters appropriately. The object can be classified more precisely with the help of more images in the dataset.

In [3] J. Donovan paper has used an automatic sorting dustbin which uses Raspberry Pi module and camera for dividing organic and recyclable waste. Tensor Flow is used for this purpose. Their project also contains hardware components to segregate waste. Important thing about their project is to classify between compost and recyclable waste, instead of having five or six classes.

In [4] G .Mittal, K. B. Yagnik, M. Garg, and N.C Krishnan have used recycling based classification problems which use physical properties of an object. They had used chemical and mechanical methods such as probing to identify the chemical contents and can be separated or not. This paper's approach provides interesting advanced methods.

In [5] C. Liu, L. Sharan, E.H. Adelson, and R. Rosenholtz had used image based classification of material performed on the Flickr Materials Database means colored images of surfaces of garbage. The features used such as SIFT, color, micro texture and outline shape. This project is similar to our project in that it attempts to classify images based on classes.

3. Data Preparation

3.1 Data Collection

There are no publicly available datasets available for garbage materials. So our project uses an image dataset collected from a variety of sources. We have used datasets of Gary Thung and collected additional data from different sources. Our dataset consists of four classes: glass, paper, metal, plastic consisting of a total of 4000 images. Each category consists of around 1000 images.

3.2 Data Cleaning

The collected garbage dataset is cleaned by discarding replicas, noisy images. Images of garbage which are redundant in nature are discarded. Also, garbage data with no use is eliminated. After cleaning the dataset is done, now the dataset is ready for labeling.

3.3 Data Labeling

After cleaning of data is done, then in the next step labeling of data is done. Labeling of dataset is done to make images more informative. By labeling the dataset accuracy of classification of garbage becomes easy for machines. In our project we had used Labelimg software to label images. After labeling the image is done and an xml file is generated for the labeled image.

4. Proposed System

In fig no.1 the proposed system uses YOLO (You Only Look Once) for image classification. Using Yolo, the labeled dataset is trained. Once the model is trained by training the dataset successfully Json file or weight file is extracted, so that there is no need to train the model again and again. The workflow of our system is basically a map in the website will display the location of garbage by seeing this map, the garbage collector goes to the site and collect the garbage and bring the garbage at the sorting site. Then after a live image of single garbage is taken through a camera and the captured frame is given to trained Yolo model for processing. The frame captured is then compared with the trained model to detect whether what type of garbage it is i.e. plastic, paper, and metal and glass.

After detecting the type of garbage the next step is to segregate the garbage. Segregation of garbage is done using IOT Device based on the type of the garbage detected. Segregation of waste material makes the recyclability process easier [7].

The IOT device comprises arduino, servo motors and infrared sensors to effectively segregate garbage based on the type of garbage detected. The Serial communication between trained models and IOT devices is assisted by using the Pyserial library. A website is created to assist garbage collectors to collect the garbage from different locations. The website will also keep a record of the garbage collected per day.

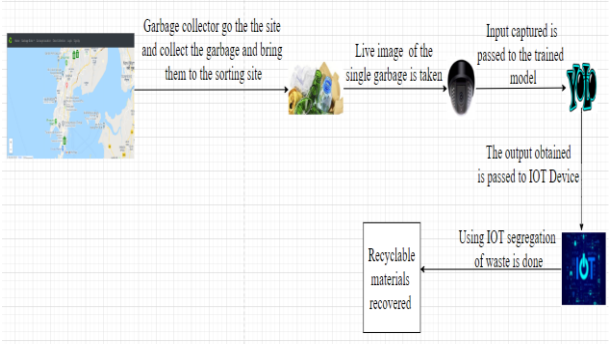

Figure 1: Workflow Model

5. Implementation Details

5.1 Implementation Details

a) Yolo only Look Once V3(Yolov3)

Figure 2 shows YOLO v3 architecture is an object detection model that uses a variant of Dark net, within which it's 53 layers of network trained on Image Net. For the task of detection, 53 more layers are stacked onto it, providing convolution architecture with 106 layers for YOLO v3. This is often the rationale why Yolov3 is slower than Yolov2.

This is often a previous detection system adapted for use in numerous purpose classifiers or localizers to perform detection. A single neural network is applied to a full image. It takes the high scoring areas of the image. This network divides so that the probability of each images can be obtained by obtaining bounding boxes around images. These bounding boxes are weighted by the predicting probabilities of the model. Here is how the architecture of YOLOv3 seems like.

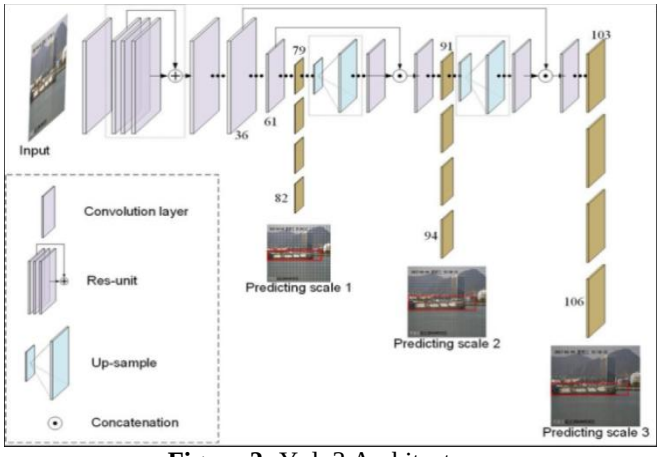

Figure 2: Yolo3 Architecture

b) Convolution Neural Network (CNN)

A Convolution Neural Network (CNN) is an Deep Learning algorithm which might take an input image, assign importance to varied aspects [features] within the image and be ready to differentiate one from the other objects. The pre-processing required during a ConvNet is way lower as compared to other classification algorithms. While in primitive methods filters are hand-engineered, with enough training, ConvNets have the flexibility to find out these filters/characteristics. CNN consists of three layers

Convolution Layer, Max pooling Layer and also the fully connected layer.

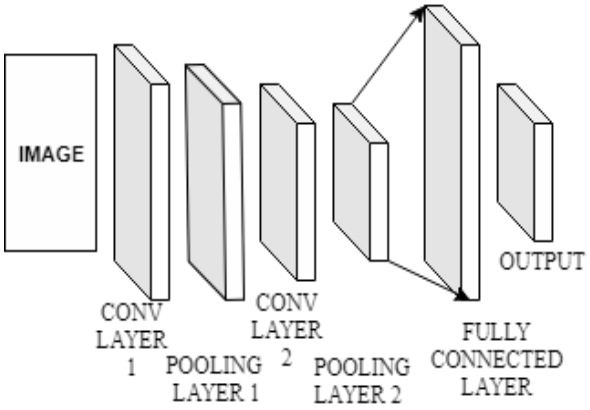

Figure 3: CNN Architecture

c) IOT

The Internet of things (IOT) is establishing communication between computing devices, objects, animals or people that are provided with unique IDs which has the ability to transfer data over a network without any need of human interaction.

d) Tensor Flow

It is an open source library for high-performance for numerical computation. Its flexible architecture allows easy deployment of computation across a variety of platforms (CPUs, GPUs, TPUs), and from desktops to clusters of servers to mobile and edge devices. Tensor flow library comes with strong support for machine learning and deep learning and also the flexible numerical computation core is used across many other domains. A Model generated using Yolo for image classification will be generated using Tensor flow. This model will be trained with input images. Class of the input image is already known. A model will perform calculations on its own and it will update itself accordingly to the aim of the project. The trained model will then be used for classification of objects.

e) Labelimg

It's a picture annotation tool. It labels the object by bounding boxes in images which makes easy reading of objects by machines. Graphical interface is provided with the help of Python is used along with Qt. VOC is the format in which the annotations are saved. Besides, it also supports YOLO format. This is used to label images.

f) ImageAI

This is a library for object detection which provides an API to detect, locate and identify 80 most typical objects in daily life in a picture using pre-trained models that were trained on the COCO Dataset. The model implementations provided include Retina Net, YOLOv3 and TinyYOLOv3.

ImageAI for video detection and analysis provides an extended API to detect, locate and identify 80 objects in videos and retrieve full analytical data on every frame, second and minute. This feature is supported for video files, device camera and IP camera live feed.

g) Website

A website is created using html, css, java script, mysql for database. It contains a map which will display garbage location. And also it will display the count of the garbage sorted per day.

5.2 Results

As shown in fig.3.1the model is trained by a training dataset. The test accuracy obtained was around 98% and test accuracy was around 85%.

```
Model File:  /content/drive/My Drive/LabelledData.zip (Unzipped Files)/LabelledData/models/detection_model-ex-027--loss-0003.162.h5

Using IoU :  0.5
Using Object Threshold :  0.3
Using Non-Maximum Suppression :  0.5
cardboard: 0.9909
glass: 0.9636
metal: 0.9345
mAP: 0.9657
==============================
Model File:  /content/drive/My Drive/LabelledData.zip (Unzipped Files)/LabelledData/models/detection_model-ex-028--loss-0003.040.h5

Using IoU :  0.5
Using Object Threshold :  0.3
Using Non-Maximum Suppression :  0.5
cardboard: 0.9923
glass: 0.9626
metal: 0.9387
mAP: 0.9645
==============================
```

Figure 3.1: Training Dataset in Yolo.

After detection, the model was tested on a number of images to test its accuracy. It was tested on noisy and cluttered images for accuracy. It obtained positive results in most of the cases with a satisfactory accuracy every time.

(a)

(b).

Figure 4.1: Before Detection

In the above image, it shows the labelled images before the detection of garbage.

(a)

(b)

(c)

Figure 4.2: After Detection

As shown in figure 4.2 after detection the accuracy is around 90%.The model was successfully able to detect metal cans with a testing accuracy of 98 % and 72% respectively.

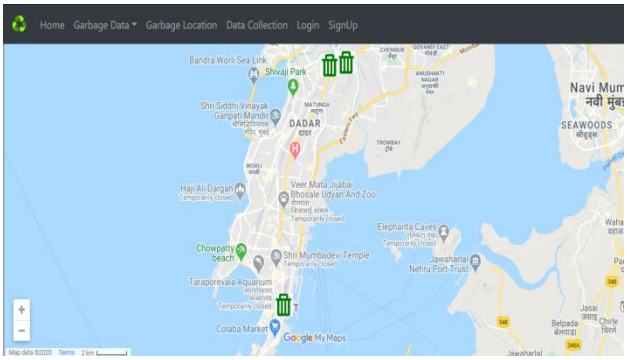

Figure 4.3: Garbage Location

The figure 4.3 shows the location of garbage, so that the garbage collector can easily collect the garbage by going onto the location and bringing the collected garbage to the site where the segregation process has to be done.

6. Conclusion

We studied various Online Datasets for garbage of different categories and selected the most optimal dataset for classification. The Data was pre-processed, labeled and classified into testing and training sets. A model using Yolo was successfully trained with the given dataset and training accuracy of 98% was achieved during the same.

7. Future Scope

Currently, this project work with a single image of garbage, in future complex images with different type of garbage in the single frame and many more images can be detected using alternative or new algorithms. We intend to increase the number of classes and segregate the waste as per the class label by using IOT Device.

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