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"GARBAGE CLASSIFICATION USING DEEP LEARNING"

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Abstract - The process of segregating waste prompts the generation of energy out of waste, diminishing landfills, recycling, and reduction of waste. Erroneous disposal of waste leads to recycling contamination. Contamination is a tremendous issue to the recycling industry that can be alleviated with automatic computerized waste sorting. The presence of models or strategies which help people to sort trash has become extremely important in the right discard of that garbage. Even though there are various sorts of recycling categories, many people remain confused or cannot appropriately recognize how to decide the right trash bin to dispose of every trash. Waste management and systematic sorting of them are considered to be a significant role in ecological development around the world. Society needs to lessen waste by recycling and reusing discarded materials that result in reducing environmental problems. This project aims to create an automated waste detection system using a deep learning algorithm that will gather the waste images or videos from a camera with object recognition, detection & prediction, and categorize the waste materials like cardboard, glass, metal, paper, plastic, and trash so that the waste can be properly dumped in the recyclable and non-recyclable bin.

Keywords- Deep Learning, Object Detection, TensorFlow, Faster R-CNN, Waste Classification, etc.

1. INTRODUCTION

Waste Management in the present time is known to everyone but unfortunately, it is neglected by numerous people that are utilized to portray exercises for waste segregation to take care of issuesbrought about by wrong garbage disposal [1]. An examination shows that 74% of the plastics spilling into the ocean from the Philippines originate from the garbage [2]. To automatize the process of recycling, it is essential to propose smart frameworks that can see waste classification effectively. By making the use of object detection software in waste segregation is a worthwhile methodology when contrasted with the traditional recycling strategies, because of the huge numbers of objects that are recognized in a limited timeframe. The conventional approach depends on the goodwill of the human work which inclines to fail on waste sorting for recycling [3]. Thus, this paper is aimed at planning and developing up a framework with a deep learning approach that can be effectively used for waste segregation. The image will be recognized by utilizing the concept of a convolutional neural network and with the help of an image processing method that identifies wastes from their shape, color, dimension, and size [5]. This technique automatically will help the system to learn the pertinent features from the sample images of the trash

and consequently recognize those features in new images. By this, garbage will be classified into different classes. The strategy utilized for this characterization is with the assistance of TensorFlow's Object Detection API and Faster R-CNN technique. The main objective of this study is to develop software to detect types of recyclable materials in trash bins and check for possible contamination (non-recyclable materials), which would ultimately reduce human effort in waste segregation and expedite the entire process.

2. LITERATURE SURVEY

Throughout the previous years, various works have been executed with the point of limiting the effect of the incorrect disposal of waste. Many neural network and support vector machine based image classification projects are being done previously[6].

A comparison study was performed by Mindy Yang et al. to classify garbage between SVMs with scale-invariant feature transform (SIFT) and an eleven-layer CNN design like AlexNet. The result shows that the SVM beats CNN. The accuracy level was 63%[7].

This paper aimed at comparing the study of deep learning convolution neural network and machine learning algorithm SVM for classification of garbage for powerful waste sorting . The rate of accuracy of SVM was nearly greater than CNN. Nonetheless, with increment in data and GPU utilization, the CNN algorithm gave out more accuracy and lessen the impact of overfitting. For the final execution of hardware, the SVM model was executed for classification purposes. It utilizes a raspberry pi 3 associated with a superior quality HD camera. The camera takes a preview of the waste and the picture is saved in a PNG record. The captured picture is shipped off to the preloaded classification for grouping whereas per its category diverse LED shading illuminates[8].

They proposes the method of gray level co-occurrence matrix (GLCM) for waste classification and detection, joining advanced communication mechanizations with GLCM to reinforce the waste gathering activity. The proposed framework utilizes a few technologies of communication which includes geographical information system (GIS), radio frequency identification (RFID), and general packet radio system (GPRS) with a camera integration and streaming out the monitoring of the solid waste. The highlights are acquired from the GLCM and afterward utilized as inputs to a multilayer perceptron (MLP) and a K-nearest neighbor (KNN) strategy for waste segregation. The obtained outcome showed that the KNN classifier outperforms the MLP[9].

The creators of Recycle Net experimented on the architectures of the broadly recognized deep convolutional neural network. The training is being done without pre-trained weights, and with 90% test accuracy Inception-v4 outperformed all others. The creators at that point performed transfer learning and fine-tuning of weight parameters by utilizing the weights of ImageNet, and DenseNet121 acquired the best outcome with 95% test exactness. This last arrangement has a slower prediction time[10].

They propose a computerized framework dependent on an approach of deep learning and conventional strategies to effectively isolate waste into four distinctive recycling classes (Paper, metal, glass, and plastic). Results demonstrated that VGG-16 techniques are a productive methodology for this issue, reaching the accuracy rate of 93% in its best situation.

At the TechCrunch Disrupt Hackathon, "Auto Trash" has been made by a group which is an automatic garbage bin that sorts trash dependent on the features of recycling and composting. Their framework uses a raspberry pi camera and has a pivoting top. The group utilized the engine of Google's TensorFlow AI and constructed their layer on top of it for object detection.

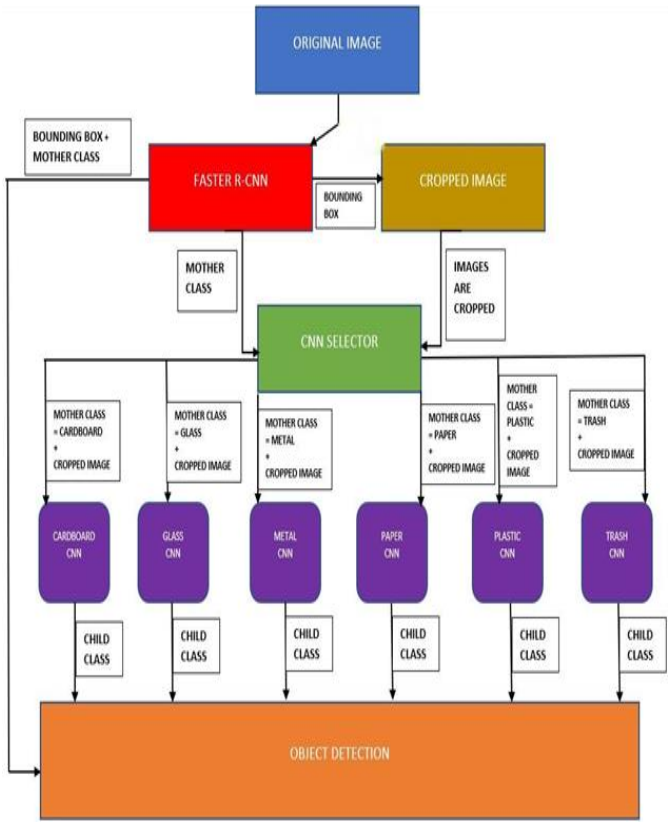
Basically, in the most recent years, computer vision has been considered as an apparatus to help waste classification, and deep learning strategies have reached sensible outcomes in controlled situations. Object identification, addressed in waste management, was considered in Oluwasanya Awe et al with the help of the Faster R-CNN model, demonstrated reasonable outcomes. In the same work, the author proposes a strategy utilizing Faster Region-based Convolutional Neural Networks (Faster R-CNN) procedure to get the proposal of regions and for object classification at a mean Average Precision of 68.3%[11].

3. CHALLENGES IN GARBAGE CLASSIFICATION

The presence of models or strategies which help people to sort trash has become extremely important in the right discard of that garbage. Even though there are various sorts of recycling categories, many people

remain confused or cannot appropriately recognize how to decide the right trash bin to dispose of every trash. Waste management and systematic sorting of them are considered to be a significant role in ecological development around the world. Society needs to lessen waste by recycling and reusing discarded materials that result in reducing environmental problems. This project aims to create an automated waste detection system using a deep learning algorithm that will gather the waste images or videos from a camera with object recognition, detection & prediction, and categorize the waste materials like cardboard, glass, metal, paper, plastic, and trash so that the waste can be properly dumped in the recyclable and non-recyclable bin.

4. BLOCK DIAGRAM OF SYSTEM



Architecture of Faster R-CNN Model for Waste Classification

5. METHODOLOGY

This segment of the paper gives a short outline of the methodology utilized in this paper. Here the developed approach mainly covers four significant stages. The primary stage is mainly related to the collection of the data(images) and labeling them, the second stage includes model development, the third stage consists of model training, and in the last stage testing of the model is done. Apart from this approach, a short portrayal of the various libraries and tools utilized in this paper has also been explained. The most important necessary libraries used in this project are NumPy, Matplotlib, OS, TensorFlow, Utils, and OpenCV.

5.1 Libraries Used

5.1.1 NumPy

An array of the multidimensional matrix which supports high-level mathematical calculations. Operations on array included in mathematics such as algebraic, statistical, and trigonometric patterns can be performed with the assistance of NumPy. The Image gets converted to matrix form.The Matrix form of the image is used for interpretation and analysis by using the Convolutional Neural Network [12].

5.1.2 Matplotlib

Plotting functions for python programming languages are supported by Matplotlib. In this project,it will be used to draw the bounding boxes to display the image name and score range. The bounding box is utilized to show the object detection name with a score range of an image. The Matplotlib comes up with an object-oriented application programming interface. The Numpy is one of the mathematical numerical expansion of Matplotlib [4].

5.1.3 OS

OS is one of the import libraries of python. It is utilized to provide a path of operating system dependent functionality and it is also used for the manipulation of a path. To represent a large amount of data by reading and writing **Tarfile** is used. The import file contained in this reduces the size of the code which is used in writing and reading operation [4].

5.1.4 TensorFlow

The TensorFlow is utilized to make a quick mathematical computation which is developed by Google. TensorFlow aids in Data augmentation. It isadditionally used to make

the efficiency of the algorithm perfect, and after

that, it downloads the pre-trained weights of the image net.Here in this project, TensorFlow is helpful to detect, classify types of waste in real-time videos (webcam), and supports graphical representations of data. It is additionally applicable in a mobilephone camera as well.

5.1.5 Utils

One of the parts of the python library is used for the collection of functions and classes. Themain function of the Utils is to support the implementation of the Convolutional Neural Network. In this project, Utils will be installed from the library of TensorFlow.

5.1.6 OpenCV

OpenCV is utilized for the analysis of a wide range of images and videos. Image processing is done through OpenCV. It focuses on real-time computer vision. Here in this model by utilizing the OpenCV python library, python scripts will be written to test the newly trained waste detection classifier on any webcam feed, images, or videos

5.2 Data Collection

In the online GitHub Repository, the training data was obtainable which was mainly used in the classification of garbage for recyclability status. There were around 2527 pictures with 403 imagesof cardboard, 501 images of glass, 410 images of metal, 594 images of paper, 482 images of plastics, and 137 images of trash [11]. These divisions were made depending on the pictures contained in the separate respective folder. But the annotations of these images were specifically needed for training the data in a Faster R-CNN model. To get the annotations that are for the labeling of the images, a tool has been used which is known as the LabelIMG tool.

Figure : Dataset Image of Cardboard, Plastic, Glass, Paper, Metal, and Trash

5.3 Model Development

Here in this model, Faster R-CNN is prepared for 6 mother-classes dependent on cardboard, glass, metal, paper, plastic, and trash. Six convolutional neural networks are prepared, one for each mother class, which will also prevent the recognition of a class that doesn't exist. For instance, if the mother class is cardboard, at that point we realize that the child class can't be a bottle. At first,this model gets the image as input, at that point, the Faster RCNN creates the bounding box and the mother-class as an output. With that data, the real image is being cropped, which is one of CNN's input identified with the mother-class.

5.4 Model Training

The Training Data is generated by generating TFrecords [14] and converting the XML files (annotations of the images labeled by LabelIMG tool) to CSV files which contain all the data for the train and test images. After the training data is generated, a label map is created which notified the system about what each object is by characterizing a mapping of class ID numbers to class names.Once the training pipeline is successfully built up and configured, TensorFlow started initializing the model training.

A lot of computational power is required for training an enormous network in Faster R-CNN. Extra requirements of the software that were included were the CUDA® deep neural network library CUDNN SDK installed for the windows 10 machine and compute unified device architecture (CUDA) Toolkit were used. Along with Python version 3.5, TensorFlow GPU version 1.4.0 open-source software is used for high-performance mathematical calculations. Its adaptable architecture allows easy deployment of calculations over a variety of stages.

5.5 Model Testing

Testing the trained model is the last part of the process. After the training gets completed, the frozen inference graph is exported. This is used for identifying and classifying the objects in a real-time feed utilizing webcam, images, and videos. In this project protobuf is used to predict a specific object detection from a video or image orwebcam feed. In this stage, the created model is tested utilizing the test dataset. The framework processes the test dataset like the training dataset. Finally, the framework classifies waste materials into 6 categories (Cardboard, Plastic, Metal, Paper, Glass, and Trash).

6. CONCLUSION AND FUTURE SCOPE

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, andpredictive patterns for object detection and classification. In this paper, we have demonstrated that how the classification of waste materials in 6 categories (Cardboard, Metal, Glass, Paper, Plastic,Trash) is done on multiple objects in a single image with the help of utilizing the method of FasterR-CNN algorithmThe detection of waste materials is done correctly maintaining a higher accuracy level. The detection of the waste materials is not only confined to images, but it can also detect and classify the waste materials from any video feed or real-time webcam feed. The methodologyused in this paper will help in lessening the contamination levels and in the long run, it will focuson the advancement of the universal waste management system. Hence, it can be concluded that this project is a significant asset to society.

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.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. Analysis and comparison of variousmodels such as Faster R-CNN, SSD Mobile Net, YOLO, etc. can also be done in the future. This analysis can be done by applying the various classification algorithm of each model on this framework separately and lastly conclude the best-suited model which will be utilized to get moreaccurate object detection and prediction in a short time. The future work also aims to implement this technology in a mobile platform so that it becomes very easy for the user to classify waste materials and dumping the waste materials in the correct disposal bin to protect the environment and reduce pollution.

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