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A Design of Novel Method for Classification of Waste Materials with its location using Deep Learning and Computer Vision for Smart Cities

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.**ABSTRACT-** Waste management is the one of the main problems in all over the globe, presently waste materials are collected and sorted by hand, it is very time consuming and it also requires so much man power. Improper management of waste materials leads to hazards including environmental deterioration, soil contamination, water pollution, and air pollution. To solve this problem, there may be a requirement for an automatic method to aid to recognize the type of waste substances and it's Position. Today's technology is so sophisticated due of Artificial Intelligence and Machine Learning. These technologies may be utilized to address various real time issues, this article handles the fundamental challenge of detecting and separating the waste items like plastic, paper and metal with their location. In this article above stated issue is addressed using the Faster RCNN (Region Based Convolutional Neural Networks) model which is very much accurate compared to other algorithms like YOLO (You Look Only Once) and other similar algorithms. The model is trained on a custom dataset gathered on a mobile camera and pre-processed using Label-Img Tool. Data collected with different light conditions and in unique angles. The model is trained using Faster R-CNN identify objects and to obtain locations. This may assist individuals to keep their surroundings tidy and to become conscious of the garbage substances and to identify them. This paper has been precisely recognizing kind of items and places with higher accuracy.

KEYWORDS- Artificial Intelligence, Convolution Neural Network, Faster R-CNN, Machine Learning, Waste Management.

I. INTRODUCTION

Waste management is one of the major problems all over the globe. India is the second largest populous nation within the globe, strong waste management is of the important issue that wants attention [1-4]. Contemporaneous methods find it hard to control the amount of strong garbage generated with the assistance of the growing urban populace. Currently trashes were sorted manually by hand[5-8]. This technique can't survive with the bulks of trash generated by utilizing the growing city population and impacts on the environment and community fitness. The main difficulties to manage waste management are,

- Unscientific Treatment.
- Improper Collection of the Waste.

The process of manual suppuration of waste materials can be mechanized and waste categorization and suppuration can be done utilizing Deep learning and Computer vision methods. The computer should also be able to identify the kind of waste items with its position in the picture or video utilizing object detection methods [9]. This will assist the community to manage contamination of the environment caused by these waste items. And it will save a lot of time and human efforts [10-14]. This article also addresses the issue of unscientific treatments and inappropriate collecting of trash. Many issues are happening with existing trash collection techniques they are:

- Currently suppuration was done by manual patrolling, this method was very time consuming and it requires so much human work.
- Current trash collection technique is not precise due of sloth and bulkily gathered
- This produces so much pollution in the environment, this may create dangers like water pollution, soil pollution, air pollution and environmental degradation. And it is extremely damaging to all living creatures.
- Currently, there is no Software or Model to recognize the item with its position to suppurate the waste materials.

This article focuses on waste material categorization and also with its location in the picture. Using Deep learning and Computer vision methods. This study can be applied in Robots, it would address some of the issues of waste management, by decreasing man power, by lowering time Consumption and also avoids pollutants effectively [3][15,16].

II. LITERATURE REVIEW

This chapter intends to give comprehensive information on the CNN and Object detection method assessment, which acts as a reference for future research. This chapter covers the different works and studies to assist directly or indirectly aids to carry out the current research effort. Lenet became one of the notable works in convolutional neural networks developed by Lecun, w. Hubbard, d. Henderson, j. S. Denker, r. E. Howard and l. D. Jackel, handwritten digit popularity with a backpropagation network, in nips. Citeseer, 1990 (17)

In this work, the authors suggested a main popular CNN structure makes use of the average pooling layer, to output the average values of 2×2 feature maps. Proper now, several LeNet implementations employ max-pooling that simply the maximum value from 2×2 characteristic maps are produced, and it appears that it may help with speeding up the training. Because the strongest feature is selected, the larger gradient may be obtained at some point in returned-propagation. They obtained an accuracy of 80 percent on the MNIST dataset. However, it changed into restricted to hand digit recognition duties and didn't scale well to all kinds of images (18). Alex krizhevsky, "Alexnet". Nips'12 proceedings of the twenty-fifth worldwide conference on neural facts processing systems – September. 2012, volume 1, pp 1097-1105 (19). The system (network) evolved into five fully linked levels. The method they designed became used for grouping with one thousand feasible classes. That's the winner of the ilsvrc Competition conducted in the year 2012.

In this study, convolutional neural networks (CNN) are used to recognize objects. The Model provided by the author includes Single Shot Multibox Detector (SSD) utilized with the mobilenet v1, and a faster region based convolutional neural network (quicker CNN) with initiation v2. The end result demonstrates that one form is ideal for genuine time usefulness on account of quickness and the opposite could be used for more precise item identification. Here, Convolutional neural network (CNN) is utilized as foundation for classification, artificial neural systems that have been used to produce an accurate generally speaking execution in computer vision undertakings, which includes image kind and detection. CNN'S imitate usual neural networks, however with extra deep layers. It has biases, loads, and yields by way of a nonlinear activation. The hidden units of the Convolutional neural network are arranged in a volumetric way encompassing stature, breadth, and profundity. The authors utilized a faster-RCNN method to teach the version. It is a single, tied together system for object identification. It uses a Region proposal network (RPN) Technique that fills in as the ocular component. It encourages the linked together system to concentrate on particular context. On the other hand, initiation is built out of an effective inception module with 22 levels and with none of the fully linked layers. The key improvement of this version is the accelerated use of the processing resources in the network (20).

In this work, traditional methods in machine learning for detecting traffic lights and categorization were modified with regard to current advances in deep learning object recognition strategies. This article offers a method for robust identification of traffic light using deep learning, mild by comparing two-item detection styles and with the help of assessing the ability of the TensorFlow object detection framework to tackle real-time issues (21). They include single shot multibox detectors (ssd), faster-rcnn and mobilenet v2. They have trained the model on their own data-set. Their experimental evaluation shows that the Faster-RCNN guarantees 97.015 percent, which is superior to SSD through 38. 806 percent for a version and this model is trained utilizing 441 pictures. They have been educated using windows 10 working gadget, TensorFlow framework model 1. 13, python, and Nvidia GeForce GTX 1080 GPU and acquired an accuracy of 97 percent.

Selective search and NMS (Network Management System) are used to extract the area and the size of rubbish territories reliant on the waste subdivision map. The trial results show that the intended calculation has an acceptable presentation on garbage placement in huge areas. With that the MSCNN (Multi-scale convolutional neural network for crowd counting) has achieved better presentation in comparison with other HSI (Hyperspectral Image) characterisation methods in the open HSI datasets Indian Pines and Pavia College. Here, the writers have meant to grasp the difficulties of inspecting garbage in huge areas and obtained a decent accuracy with the picture size 27×27.

A. Required Hardware and Software Tools

This chapter deals with various steps adopted during the period of A Design of Novel Method to Detect the Waste Materials using Deep Learning and their analysis [22].

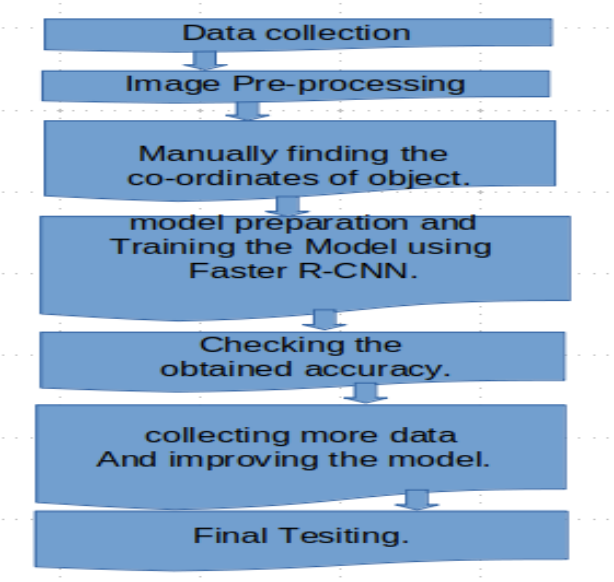

Figure 1: Flow Diagram of Steps Carried Out

Fig 1 illustrates the flow diagram of steps carried out in this study and additional details of each phase are given in the following sections.

Faster R-CNN needs a dataset that must include a large number of pictures for effective training. We've accumulated 1700 pictures of each three kinds of plastic, metallic, and paper. First, we have captured video of each item, utilizing that we have gathered frames. Sample of the gathered pictures has been presented in Figure 2.

Figure 2: Sample from The Dataset Showing the Waste Items

Since pictures are selected from video, some images appear so noisy, blurred and in some frames undesirable elements are present. So, selecting the required pictures and eliminating irrelevant images are the one of the crucial stages. We have gone over each picture and chosen the best one as our requirement.

We identified the locations of items in the pictures using a label-IMG tool. Using that, we have built a bounding box around an item in the picture. After that, we organized the changed pictures based on the criteria we had been viewing, which have been paper, plastic, and metal. We at then point may use a 600 × 1024 apparent white verified past and union 1-3 bits of trash onto this historical past aimlessly puts. Subsequently, we produced fresh images with linked titles and the locations of each garbage's bouncing box within the white verifiable past.

For model preparation we have chosen python as my programming language because it offers broad library support for an AI development. To build the model, we have utilized a Faster-RCNN. For training we have utilized Google collaborator. Because training the model in CPU (central processing unit) would take weeks but, it will be quicker in GPU (graphics processing unit) (graphics processing unit). And Collab is giving a 14GB free GPU. Therefore, we have trained models on Collab [23].

After training the model we have tested the accuracy on unseen data. And we obtained accuracy of 70 percent on Plastic, 80 percent on Metal and 80 percent on paper items. At this point we achieved good accuracy. But still the model was not that much better and we can increase its accuracy. To accomplish so, we have gathered additional data and pre-processed and retrained the model using old plus new data. Since deep learning has a thirst of data, we may add additional data to make the model more resilient. We produced 5100 photos of garbage. We split up the entire date into train, test (4080, 1020) pictures.

After training, we once again evaluated the model and obtained higher accuracy of 80 percent on Plastic, 0.95 percent on Metal and 90 percent on paper items. That was considerably better than the prior model. But still, we can utilize additional data to make it far more robust.

- Programming language - Python 3: Official website Link. https://python.org
- Operating system: Ubuntu 18.04
- Tensor Flow:

Tensor Flow is a free and open-source framework to enable data streaming and differentiable programming. It was primarily based on pure mathematics and it was especially developed for machine learning issues. Using this programmer may build efficient programs without coding needless and repetitive codes. Since it was open sourced many researchers utilize this tool in their models. Tensor Flow is developed by the members in the team of google brains. It was released beneath the apache permission 2.0 on November 9, 2015. Tensor Flow framework is the 2nd invention of that team. Tensor Flow can utilize multiple CPU'S, GPU'S and TPU'S for execution and it can be used across different operating systems like Linux, mac, Windows etc. Tensor Flow is designed in such a manner that utilizing it programmers may conduct better deployment across different settings. It may also be utilized for edge computing [24]. It supports additional libraries like NumPy which makes it extremely fast. Tensor Flow offers several API's, (application programming interface) one among them is Tensorbord. I have built a loss epochs graph using this Tensor board API.

1) NumPy

NumPy stands for numerical python. It is an open-source library, it was developed in C language and its capacity extended to different programming languages like python, java, Scala and C++. NumPy is designed to make multidimensional matrix multiplication simpler and quicker and it can run on different clusters. This was created by Jim Hugunin with pledges in 2005. Large community working on this library to make it more powerful and quicker. So, it was continuously growing better and better over time.

2) OpenCV

OpenCV stands for Open-sourced computer vision library. It is developed especially for computer vision related applications. It comprises of huge algorithms, for example for edge detection it utilizes a canny edge detection method. It is based atop NumPy, because NumPy enables multi-dimensional computing with extremely fast speed of execution. It included the capacity of willow storage, then

it seez and it is a cross platform library. This library is open-sourced under BSD license.

3) *Google Collab for Training the Detector*

Google Collab is an open sourced and free cloud service API, it comes with 14GB of free powerful GPU and it offers a fully managed runtime for Machine learning and deep learning related applications. The UI of collab is comparable to Jupiter Notebooks which offers an interactive platform for programmers and Collab has 25GB RAM, thus we are able to put extremely large datasets into memory. The speedup was estimated to be approximately 2.5x, using the same data preparation procedures!!! (May be quicker than this when we load our dataset from google drive. which is a free cold storage offered by google.) To utilize this API, we must have a google account. It also offers different functions like making a new notebook, storing the notebook in google drive, downloading the notebooks etc.

III. DISCUSSION

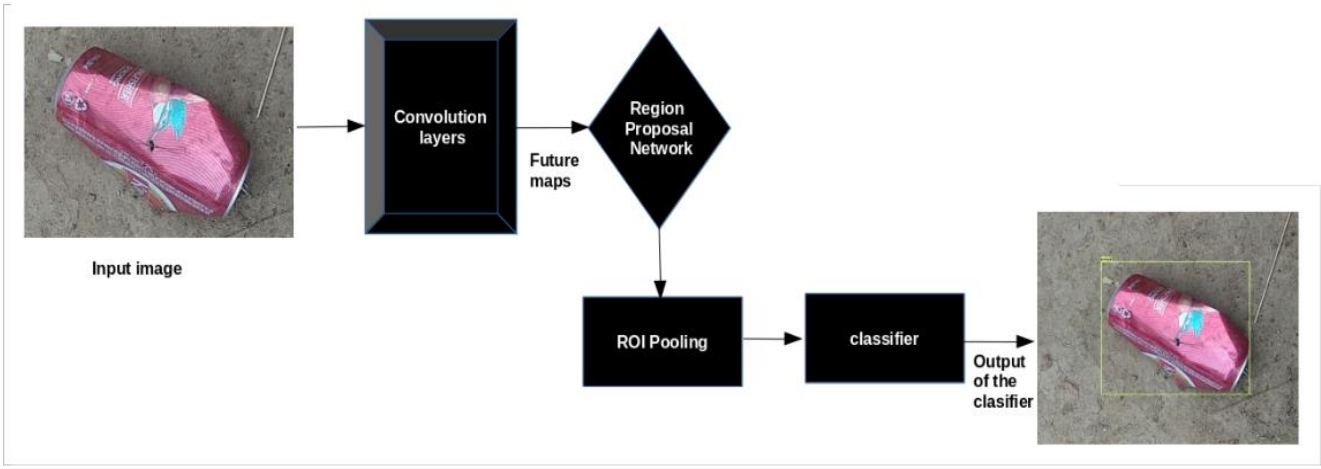

Figure 3: System Architecture Based on Faster RCNN

In this Implementation an input picture is feed to the convolutional layer to create a feature map. This is done by Making use of an array of weights to all the input sections from the picture and generating the output feature map. The resulting feature maps are subsequently sent to the area proposal network (RPN) (RPN). That stocks complete full convolutional functions with the discovery of the network, in order to enable virtually price-unfastened area suggestions as shown in Figure 3. The model can detect the position of the suggestions and distort them into the squares and by utilizing a ROI (Region of interest) pooling layer. Finally, we categorize the kind of item. Each operation and its functioning process are described briefly in the following sections.

The objective of this operation is to obtain the high-stage features consisting of edges from the input picture. For that aim, we shall utilize Convolution layers. Traditionally, the main conv layer is accountable for shooting the low-degree capabilities such as edges, colouring, gradient orientation, and so on. With added layers, the structure takes the excessive-stage characteristics as well, this unravels the facts existing in the pictures of the dataset, just like how people could.

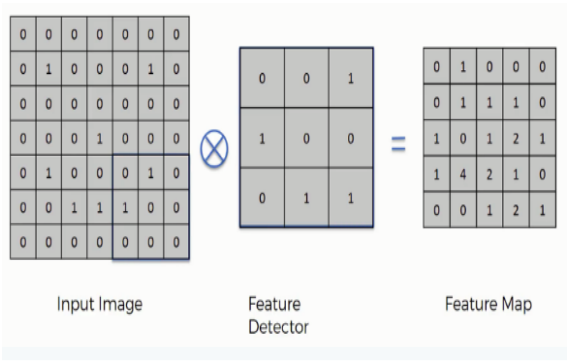

Figure 4: Illustrating the Convolution operation

An RPN is a fully convolutional network that simultaneously predicts the object confines and objectiveness scores at every role. The RPN is competent to produce exceptional region suggestions that can be utilized by the quicker RCNN for the detection. The important point here is the detection network and the RPN have common convolutional layers {Figure 4}.

4) Selective search

Selective search technique provides a limited collection of the outstanding item locations. The main concept is to use the bottom-up collection on the picture regions to create a structure of tiny to large areas. We may utilize this underlying picture structure to create object positions. This produces a completely class-unbiased collection of places.

Here we need to create suitable places, to make the issue considerably easier. And primarily, it requires less computing resources. So, this may be utilized in the stronger deep learning methods and larger effective models. We may remark that selective search is the gradual and time-taking procedure that impacts the overall performance of the model.

After reshaping the projected region into the constant size, it is fed into a fully linked layer. And using the acquired ROI feature map, we will utilize a SoftMax layer to anticipate the elegance of a suggested region and furthermore the offset values to the boundary regression. It may be used to categorize an image in the given area and are expecting the box coordinate values to create the bounding boxes. The feature maps produced by the ROI pooling are then transmitted through two fully connected layers, those layers flatten the feature maps and then deliver the output to the totally linked layers with the specific assignment provided to them, and the first layer consists of a SoftMax layer. The second layer consists of a bounding box regression layer.

The SoftMax layer helps the neural network to create a multi-class classification. In summary, the neural network is now able to detect the likelihood that an item is present in the picture, as well as the probability that other objects are included as well. The Figure 5 displays the neural network using the SoftMax activation function. The first two levels are the hidden layers and the last layer is the SoftMax layer and they are completely linked. The first hidden layer obtains the data from the ROI pooling by flattening the feature maps. In the second it performs some layer calculation to update weights. And in the final layer (SoftMax layer) the picture is categorized based on the probabilities of the materials. A SoftMax layer contains total n+1 numbers of output parameters that predicts the items in the area concept. In our instance we have 3 units in the SoftMax layer. The 1st unit is linked to paper, the 2nd one is related to plastic and the 3rd one is related to the metal. And based on the highest projected likelihood of the items, it is going to determine the kind of garbage in the provided area.

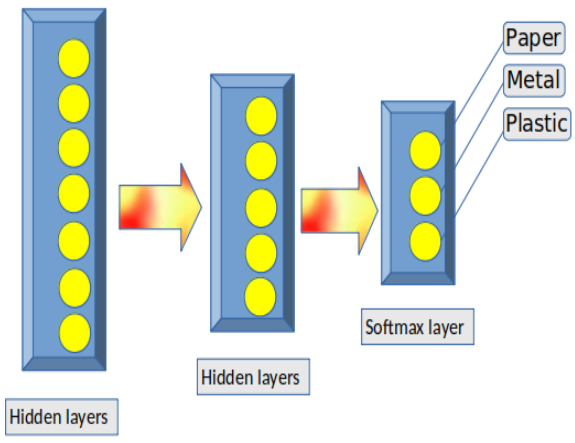

Figure 5: Neural Network with Softmax Activation Function

The Bounding-Box Regression (BBR) is one of the approaches to filter or find localization boxes in the object identification algorithms. BBR are required to regress from region suggestions to suitable bounding boxes of specified target object types. A bounding-box regression layer consists of four*n output parameters. This regresses the bounding container area of the object inside the picture [14] . From the method we have passed a picture with trash through the model and obtained area using bounding-box regression and kind of item using A SoftMax layer as demonstrated in the above Figure 5.

IV. CONCLUSION

This article offers us a new way to identify the type of waste items and their location utilizing the current methods inside the field of computer vision and deep learning. Presently, the trashes are distinguished manually/ in this process we have built a basic model of one class and it performed nicely. But its accuracy was not that much better therefore we have put additional data in its Finlay obtained a better model yet we can enhance the model by adding more data but data pre-processing takes very large time thus we can able to train the model with 4080 number of pictures and tested on the unseen data of size 1020. There also our approach worked very effectively. We have built a GUI (Graphic User Interface) using a PyQtLibrary. This article will help to repair the problems with waste control. In future work, we need to collect additional data given as deep learning needs a lot of data. And after that, it can be used in robots utilizing the digital camera, raspberry-pi, and hardware components to suppurate wastes and to store in a suppurate area depending on the kind of item. Further, changing or deleting a few factors to make the model more robust, and then the robotics portion may be applied to the model to make the model more dynamic.

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