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Faster RCNN for detection of Garbage in Tensor flow

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Abstract:
Several reasons can be considered for the occurrence of pollution. One of the main reasons include throwing garbage. Even several methods have introduced to eradicate the problem of massive garbage contamination like throwing wastes packing them in plastic bags or bean bags but they did not solve the problem and lead to several other problems of plastic pollution. When these garbage bags are thrown into the river water or small ponds causes the problem. Nearly 60% of the pollution caused due to plastic bags. We came up with a suggestion by developing a model for detecting these garbage bags and container wastes thrown on roadsides or in water. This tool was developed using the Faster RCNN network with supporting framework Tensor Flow.

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Abbreviations: *RCNN – Regional Convolution Neural Network, YOLO – You Look Only Once*

INTRODUCTION

Taking the situations present in the present world there are many problems which are occurring at the global level and one of the main problems is Garbage. There are many sub-problems which are resulting from this throwing garbage everywhere irrespective of the place. These wastes are grouped in one place and turn into solid wastes. To reduce this one of the solutions found was throwing these wastes by packing them in bean bags, but even this did not clear the problem and resulted in many other problems like when these bean bags are left without removing, they are turning into massive wastes. The serious problem which will occur due to this is as they are made of plastic material when they are thrown into water it will pollute the water and cause damage to many lives who all are depending on that water. One and only one solution to our problem is to find where these garbage bags are found one has to recognize them and clear them for recycling. But it is difficult for each individual to find them as everyone is busy in their work. So, linking this solution to present technology we can come up with a good solution, i.e., by building a machine that can detect these garbage bags or containers of garbage at any place if they found. With this tool, one can use this in many applications such as garbage notification agent, or smart vacuum cleaner, or can be used as an assuring agent in applications related to cleanliness. There are many ways to make machines, detect an object from an image using deep learning, computer vision and image processing. The more general term in computer vision is object detection and it is being used for many purposes in many fields and the most famous example, one can say is google lens one can find from the article [1]. Deep learning is the buzzing word in present days which made the bench mark for Machine learning in terms of learning a machine and made machine to work in the standards of human with more accuracy.

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Deep learning uses different types of algorithms and neural network models for learning during training period and while classifying or detection. Different types of classifiers and models used for training and detecting objects are HAAR cascade classifiers[2], Neural networks [3]families such as YOLO[8] (You Look Only Once), RCNN family includes R-CNN, Faster- RCNN. Here we have used TensorFlow with Faster-RCNN Neural Network model for detecting garbage bags and containersand also a small comparison made between TensorFlow object detection with Faster RCNN and HAAR Cascade classifier in detecting the object and this is comparison is made based on the dataset which is taken as a common base between two models for training.

DEPENDENCIES USED IN THEALGORITHM

OpenCV(OpensourceComputerVision)

In our own words Open CV can be simply defined as a library with all the functionalities which can be applied on images on screen such as reading an image as an array, resizing, gray scaling, rotating, skewing, marking on the images, etc., and it is supported in many languages such as C, CPP, Python, JAVA, and frameworks for object detection such as TensorFlow and it is supported by operating systems such as LINUX, Windows, MAC-Os.

Pillow 1.0 (Python Imaging Library)

Pillow is the free library available in python and it is used forfunctions such as opening, closing, saving and manipulating the images. This library is forked by Alex Clark.

Lxml (HTML and XML in Python)

lxml is an open-source library in python which is used to access xml and html type documents in python. Here in this project it helps access the xml documents where the annotated images are saved in xml format.

TF-Slim:

TF-slim is the lightweight TensorFlow based library and it is composed of many modules supported for easy definition of neural network models with less code.

Matplotlib:

Matplotlib isthe most used and useful library in python which is available as an open-source library and it is used for visualizing the data and one can create graphs, bar charts, histograms and also with less amount of code.

TensorFlow:

TensorFlow library was introduced by Google and the purpose of the library is numerical computation. It makes operations easier to do in ML and DL by making machine to learn faster and easier.TensorFlowhelps train the models, classification and in doing predictions.

COCOAPI(Common Objects in Context):

Coco is the predefined collection of pre-trained data setof common objects such as animals, several daily used objects, etc., models and they can be used many purposes such as object detection, recognition, classification.

METHODOLOGY

The methodology we followed for the detection of the garbage bags and containers is the most general method followed in any machine learning object detection model. I.e. the first step is the collection of data set which is here the collection of images that contains garbage bags and containers. Then after proper data set is collected next step to be followed is annotating the images in the data set but this is required for some network classifiers but may not be required for few classifiers such as the HAAR classifier where we will follow the procedure of positive and negative images. This annotation can be done using many open source tools such as yolo mark, labelImg, using IBM cloud annotation tool,

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etc.,After annotation immediate step is to train the annotated images using preferred method i.e. in TensorFlow by choosing any neural networks such as RCNN, Fast RCNN, Faster-RCNN, YOLO [8], SSD(single shot detector) or in HAAR Cascade classifier. After training it will result in a trained model of the object. With the resultant trained model, the detection of an object can be tested.Here we have chosen TensorFlow object detection API for training the faster RCNN network pretrained model with the custom data set. We have taken custom data set of these garbage bags, cardboards and containers from the source [4].This data source consists of 994 images and nearly 4110 objects are annotated such as 1842 containers, 1069 garbage bags and 1199 cardboard.Fast RCNN contains three parts and each part is designed for its purpose. The first one is convolution layers; every image has to pass through these convolution layers when the image passed through these convolution layers they act as filters to the image. Convolution layers[9][10][11] filter out the unnecessary parts of the image and forward the annotated specific parts in the image.The Second one is RPN (Regional Proposal Network) which is present on the last slide of convolution layers and the purpose of this is to predict whether an object is present or not and if present it also predicts the bounding measures of the object. The last part of the network is the prediction of bounding boxes and classes and here the neural network which is present is fully connected.TensorFlow is the framework for either training or detection or classification of that object. Tensor flow[12][13][14] help neural network to make predictions easier by making numerical calculations and make sure about the flow of the image over the neural network.It is very difficult to construct the model from scratch and requires more specifications which will cost and also take more time. So, we have taken Faster RCNN network model 'faster_rcnn_resnet101.config' which is alreadya trained model on different data set and use its parameters to build a new model. These models in our required neural network can be found in model zoo [5] and the code reference for object detection using TensorFlow is taken from source [6].We also did the garbage detection using HAAR cascade classifier with the same dataset but the procedure followed in HAAR cascade training is little different than the general procedure of annotation. It requires images to be divided into two categories positive and negative where positive images contain the images of the object to be detected and here 994 images are taken as the positive images. Negative images contain the images which do not have the object to be detected. Nearly 2200 negative images are taken and trained in the HAAR cascade model using the Cascade Trainer GUI tool.

PERFORMANCE MEASURES OF THEALGORITHM

In most of the object detection algorithms there are some metrics to follow for the calculation of performance measure of the model.Such metrics are Accuracy, Precision, F1, Recall. All these measures are calculated based on the confusion matrix.

Confusion Matrix:

It is considered as the representation of the detection model results which is conducted on n number of images or test cases.

	Predicted = TRUE	Predicted = False
Actual = True	TP (True Positive)	FN (False Negative)
Actual = False	FP (False Positive)	TN (True Negative)

The Following are the measures that can be derived from the above matrix.

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Specificity:

$$\text{specificity} = \frac{\text{number of true negatives}}{\text{number of true negatives} + \text{number of false positives}}$$

Precision:

$$\text{Precision} = \frac{tp}{tp + fp}$$

Accuracy:

$$\text{Accuracy} = \frac{tp + tn}{tp + tn + fp + fn}$$

Recall:

$$\text{Recall} = \frac{tp}{tp + fn}$$

ALGORITHM USED

The following is the algorithm followed by the Faster RCNN model while training an object or classifying an object.It takes an image as the input and provides a trained model as an output during training that can be further used for the detection of the trained object.

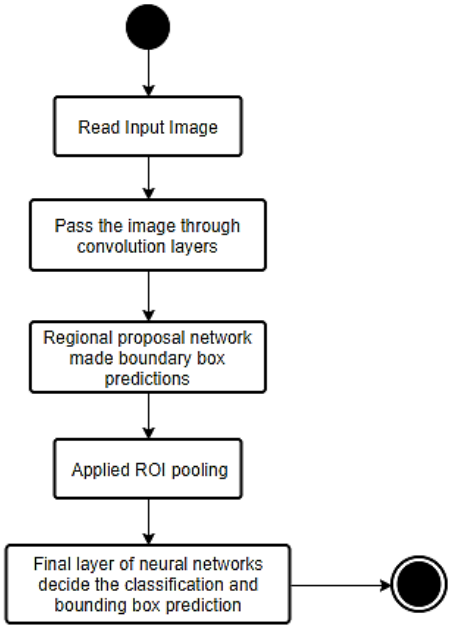

Fig.1 Flowchart of the Faster RCNN algorithm

RESULTS

The following are the results thatare calculated by testing the resultant training model. A sample of 100 images was taken out of which 60 are actual positive samples and 40 are actual negative samples. Out of 60 positive samples 58 are detected but 2 are not detected correctly. And out of 40 negative images in 3 images object was detected even there is no object.

Table-1 Confusion Matrix Report

	Predicted: Yes	Predicted: No
Actual: Yes	58	2
Actual: No	3	37

Table-2 Proposed algorithm report

	Precision	Recall	F1-score
0	0.95	0.97	0.96
1	0.93	0.95	0.94
Macro average	0.94	0.96	0.95
Weighted Avg	0.94	0.96	0.95

The following are the resultant imageswith bounding boxes of output after the detection code is run. Model correctly detected the garbage from an image if the image does not have extreme disturbances:

Fig.2Detection of garbage bags from an image without any disturbance

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Fig.3Detection of garbage and containers in real-time image

Fig.4 Detection of garbage and containers in an unclear image

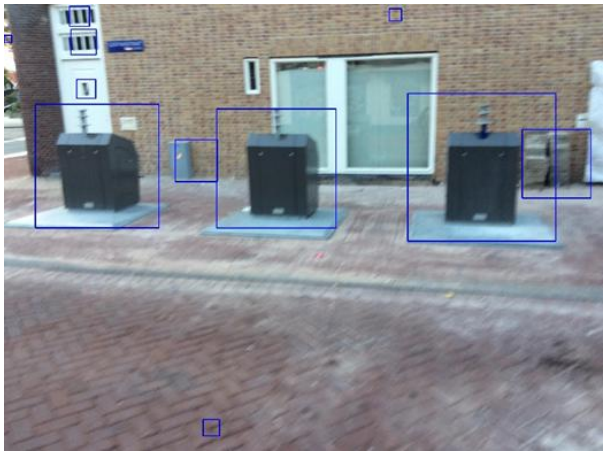

Fig.5 Resultant image of HAAR Cascade classifier detection with same dataset

Fig.6 Same Image when detected with Faster-RCNN model

We have tested detection using HAAR Cascade classifier with considering the same dataset of 994 images as positive images and nearly 2200 images are taken as negative images but the results are not accurate and along with containers it is also detecting other unnecessary objects as garbage and in the case of garbage bags it is detecting them with very less accuracy.

Table-3 Accuracy for compared methods

	Yolo v2 + Mobile Net for decoration garbage	YoloV2 for decoration garbage	Our Model
Accuracy (%)	89.1	89.2	94.2

Conclusion

This paper proposed a detection model for garbage bags, containers and cardboards as garbage using neural network Faster RCNN by taking a pre-trained network model and tried creating Haar classifier by training with the same data set but the accuracy is varied with more difference. The cases we have to consider for getting low accuracy is maybe data for training the required model is not sufficient and not precise. But we can conclude that with less data set we can get more accurate results from using the Faster RCNN network. This paper suggests that using garbage detection tools in different applications such as smart garbage collection, smart garbage notification agent etc., we can eradicate the

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problem of damages caused due to contamination of garbage.

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