Automated Waste Segregation

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Thesis titled **"Intelligent Field"**, submitted by Bhity Das, ID No: 152-15-563 Rijoanul Hasan, ID No: 152-15-572 and Effat Ara Daijy, ID No: 152-15-574 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on date

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DECLARATION

We hereby declare that, this project has been done by us under the supervision of **Toufik Ahmed Emon, Lecturer, Department of CSE and** co-supervision of **Mr. Md. Mahfujur Rahman, Lecturer, Department of CSE** Daffodil International University. We also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

Improper management of waste is causing serious effect on our planet which caused the damaging health of people, animals and even the condition of our own planet. To manage waste properly, first of all we need to segregate the waste in a proper way so that we can proceed to further steps of waste management. Bangladesh is a developing country and the waste management is very poor in here. As we look some develop country, they use different bins to collect different categorized waste. But in our country, it's a rare case where we can find a well-formed waste management system where waste is sorted when collected. Rather than we can see all kind of waste are in one place, mixed and messed up. It's a serious issue for a person who walk beside those places because no person, animal or our environment would be in good condition with this type of scenario.Use of technology in waste management is not that much usable we can see till now in Bangladesh. So, we proposed a way to segregate household regular waste to find out waste by categories before the further process of waste management.

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TABLE OF CONTENTS

INTRODUCTION

Overview:

As we moving forward more modernized future, more challenges appearing day by day. The growth of waste production is the most serious issue for us. What will be the condition of our human life, animal life, our society even of our planet if we don't take the necessary steps to improve the waste management system, we are not enough aware about taking this case seriously. Waste management is a process by which we can solve which kind of waste is recyclable, which king of waste is composable and which kind of waste is belongs to trash. By following a well-formed waste management system, we can treat those waste which is recyclable and use them as resource, compostable waste for farmers field, food for animal or birds and many others.

To obtain a well-formed waste management system, the most important and primary process is to segregate waste in different categories. By segregate waste, we can sort them which category they belong to. But, if we consider our country when we talking about waste management, the scenario is very poor. What we were talking about to segregate waste, this part is also horrible in our country. If we look at the condition of urban areas, no one would be look twice at the scenario of waste management system of Bangladesh. It is a rare scenario in our country where we could see the waste are being sorted in different categories. Rather than all kind of waste are mixed up and put into one place and make those places horrible.

In our work, we proposed a waste segregation system by which we can sort different kind of waste with deep learning algorithm.

Problem statement:

The main issue we've found that before go further steps of waste management system, it is the primary work to find the categories of waste. By finding the category of waste, we can proceed to further steps of waste management with more efficiency. But the problem is most of the case people often not aware of the importance of waste segregation for obtain a better and accurate sorted waste, we mixed up all kind of waste and trash them.

Objectives:

Our aim is to propose a waste segregation method by using deep learning algorithm. After that we can classify different kind of waste in different categories by analyzing then still image or captured or real time video of waste.

LITERATURE REVIEW

After reviewing some previous work we've found out that, traditional waste segregation system is well. But all of them used analog sensors to detect waste category except few of them designed waste segregation system by using deep learning methods to classify waste from camera sensor or digital image of the waste.

One of the worksproposed a waste selection system which can recognize waste by image recognition system to identify the type of solid waste.[1]

Another work proposed waste classification by using DCNN. This algorithm is also based on training process of categorized waste. But they work with classifying bottle object only and big drawback is their system also classify one waste object at a time.[2]

A paper based on Indian waste management system proposed a system for uncollected garbage with machine learning technique which also requires training process. They got over 85% accuracy on their work. But again, their system could identify one waste object at a time. [3]

A well implemented system shows that they have used deep learning to identify trash images. They used TensorFlow library to retrain their dataset with MobileNet model and they let the training process for 500 steps. But the big drawback here again is they could identify single trash image at a time. [4]

By using microcontroller-based sensors, another paper proposed a waste segregation system identify household waste in three different categories as dry, wet and metallic waste. They used resonant impedance-based sensors mechanism and capacitive sensing mechanism to identify metallic waste and wet and dry waste. Their result show that the segregation process of sorting as they proposed three different categories metallic, dry and wet waste has been implemented successfully. But again, we've found that their system has same limitation of detection one categories waste at a time. So, this is a drawback we've found. [5]

After reviewing all of the previous work we've found so many excellent works which shows us the different types of method used for classifying categories of waste by analog sensors and deep learning. But the overall conclusion for all of the work is the limitation of segregation of waste one category at a time.

METHODOLOGY

Introduction: The process starts with collection information about waste that is given to the system. The information can be collected from still image or a video of waste that we want to segregate. After that, using our pretrained deep learning algorithm (Faster R-CNN) will give an output as the same format still image or video what we gave to segregate earlier. The output contains the waste categories with bounding box and detection score with percentage that how accurately waste is detected.

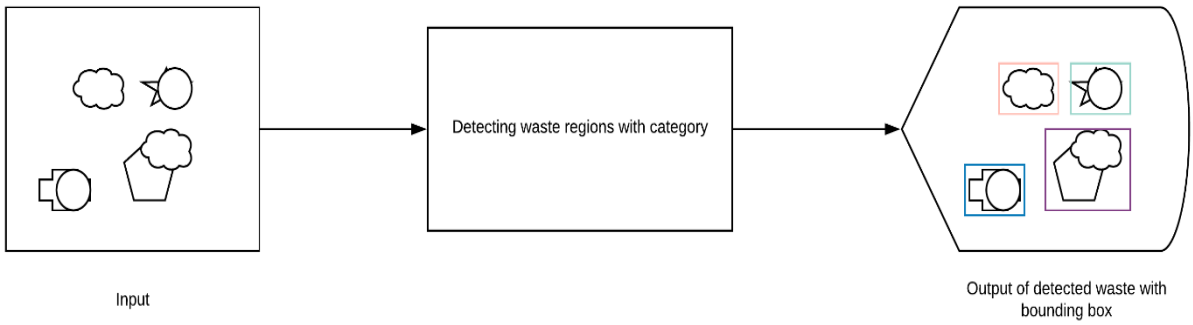

Figure 1: Waste detection process of our system

After that waste detection process, we can find out biodegradable and non-biodegradable waste that will be the most important part of waste management system with efficiently use of further process.

Materials used for waste detection:

Google Colaboratory: As our waste segregation system requires deep learning algorithm to train waste dataset before detecting a specific waste in categorically, it requires huge amount of calculation to train our dataset which is cost huge amount of time with a general-purpose computer with CPU support.So, we've used GoogleColaboratory, a free cloud service based on Jupyter Notebooks Python programming language. Most amazing part is Google Colaboratory also provides GPU support for free [6]. As we don't have high computational computer to do task like implement deep learning models, we found Google Colaboratory as solution of our high computitions.The platform also supports some popular libraries to work with deep learning and we will use Tensorflow. To work with Google Colaboratory and our necessary files, dataset we've use Google Drive which is supportable with Google Colaboratory.

Tensorflow: TensorFlow is an open source library released by Google in 2015 to build and design Deep Learning models [7]. In our waste segregation system, we used TensorFlow library to train our waste detection classifier to detect waste regions with their category as trained.From TensorFlow library, We've used a model called 'faster_rcnn_inception_v2_coco'[8] which is pretrained on COCO dataset[9] which contains 330K images available in their database and among them more than 200K images are labeled. Now why we used a pretrained model? Well, to train a complex deep learning model like Faster R-CNN, it requires millions of data to get accuracy over expected outcome of the trained model. As we don't have millions of real-life data, we've used the pretrained model with COCO dataset which already have millions of data and the model also do similar task that is detect an object with region, so it's a bonus point for us to use that pretrained model with our little amount of data. With understandable name of this pretrained model that we described till now is known as Transfer Learning [10]

Table 1: COCO dataset

COCO Dataset	
Images	330K
Labeled Images	more than 220K
Object Instances	1.5 million
Object Categories	80

LabelImg:

Before training process on our dataset, it is important to get information about a specific category of waste within a picture with its label. So that our model can segregate a specific waste from another.‘LabelImg’ is a graphical image annotation tool which helps us to label our dataset and get the information about a specific categorized waste and save that information in XML form[11].

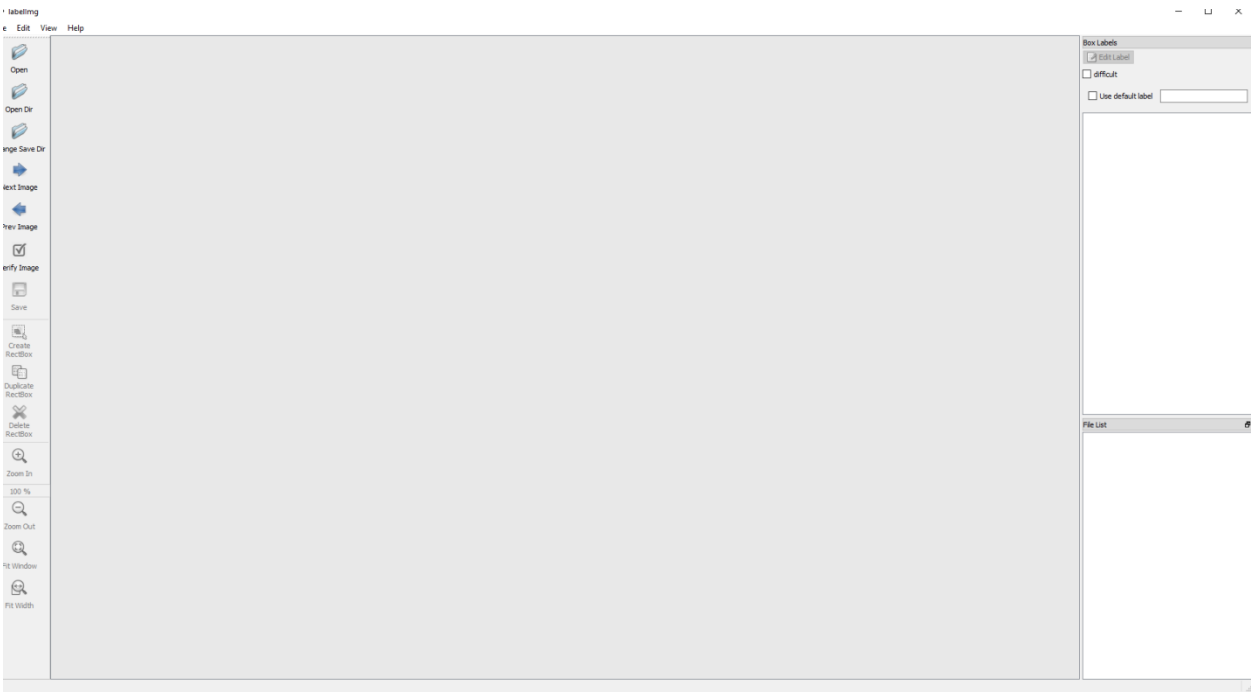

Figure 3: LabelImg

Format Factory:
We've gathered image data from different sources. Because of that those image data contains different image format. Also, there was different size of image more than 2MegaBytes. we wanted every individual data to be less than 200Killobytes. Because larger size image increases the computation time. So, we've used a Format Factory software to convert our image data in same format and keep their size to not exceed 200Killobytes.

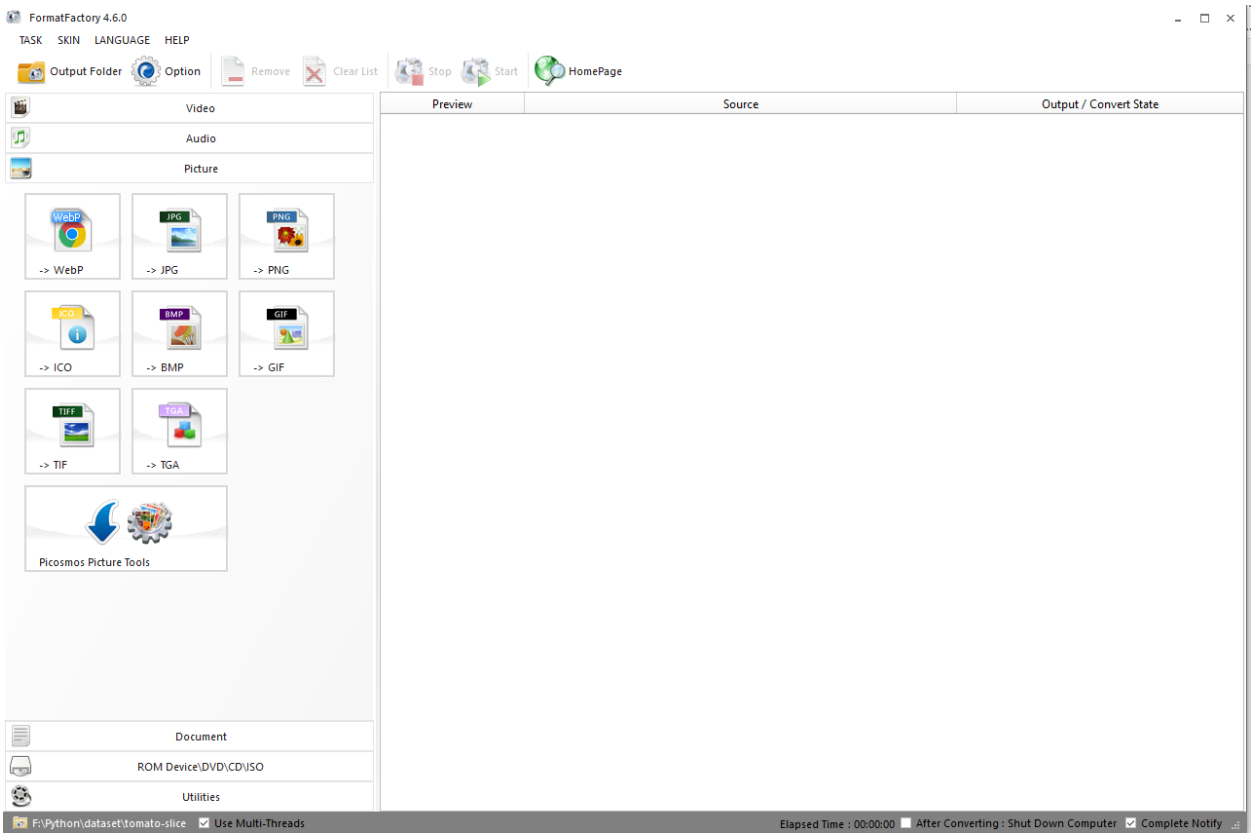

Figure 4: Format Factory

Microsoft Azure: To prepare our model to preform waste segregation task, we need to train our dataset before perform the segregation. As we used Google Colaboratory platform to do the huge computational task of training process, it is requiring to get uninterrupted power and internet supply on our general-purpose computer from which we are doing all these kinds of things. Otherwise our training process may stop during which will cause unexpected result. But depending on where we are keep working with our system, it is impossible to get uninterrupted power and internet.So, we found **Microsoft Azure** which is cloud computing service created by Microsoft which solves our problem for getting uninterrupted power and internet.

Table 2: Our used specification of Microsoft Azure cloud computing

Type	Name	Information (if available)
Virtual Machine	deeplearningvm	Nill
Virtual Network	deeplearning-vnet	Nill
Disk	Deeplearningvm_OsDisk	128 GB Premium SSD
Network interface	Deeplearningvm946	104.211.88.88(deeplearningvm-ip)
Operating System	Windows Server 2012 R2	6.2 (Build 9200)
Memory	Standard B1s	1 GB
Cost	Cloud Computing	0.0174 USD/hr

Training Procedure:

Install and setup TensorFlow directory:
As we are using Google Colaboratory which already contain all possible Python libraries, so we don't need to setup TensorFlow libraries. Instead of this, we connect our Google Drive, connect it with Google Colaboratory and make a new directory to setup TensorFlow directory.Also, we didn't forget to endbling the GPU support for which we are using the Google Colaboratoryplatform.

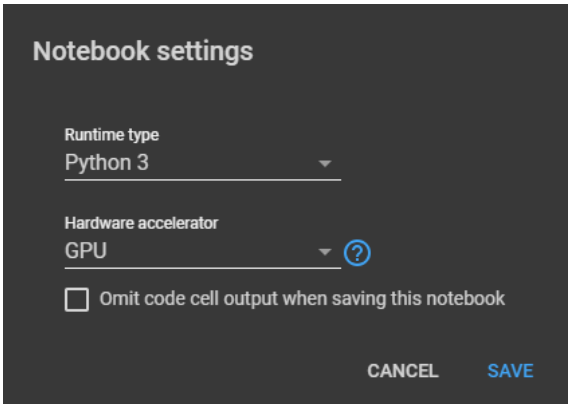

Figure 5: Enabling GPU support in Google Collaboratory

Gathering training data:
Because of using a pretrained model for waste segregation, we don't need to gather millions of data to train our model. But still we need enough data to train them in our model so that the result would be more accurate. So, we used Google Advance Image Search to gather those data which is free to use, share or modify, even commercially. Also, we've used some opensource data from trashnet[12].

Table 2: Our used dataset

Our useddataset	
Images	1250
Labeled Images	1250
Object Categories	10
Train Images	1029
Test Images	221

Labeling image data:
With the help of 'LabelImg', we labeled all of our gathered image data one by one. This process took the most of our time in our whole working system. We carefully labeled all of our image because it was very necessary to label every individual object accurately. After the labeling process, we got all of our labeling information in xml format for 1250image data where there was 1029 image data for training and 221 image data for testing

Splitting image data:
After the gathering and labeling part of image data, we split them in two-part, train and test data. train data contain 80% and test data contain 20% of overall data that we've collected.Actual amount of 80% train data contain 1029 image data and 20% test data contain 221 image data.

Generating Training Data and configure training:
To make our raw data into TensorFlow library readable format which is works as input data in the training process, we generated all of our xml files into a csv file. As we split our image data in train and test category, we got two csv file. One is for training data and another one is for testing data. Also, we've defined all of our waste label name and return separate integer number for every individual waste. After that we generated our desired TensorFlow library readable '**.record**' format for both train and test data.After that we mapped every individual waste of class name to class id which will help our training model to keep the training process with all categorized training data as an integer number rather than their label name. computationally that is more efficient to work with numeric data rather than string type.
The configuration stage requires the number of waste object we are training, paths of our '**.record**' file that we generated previously which will act as input of our training model during the training process and the file that we defined to recognize each waste object classes as integer number.

Training and Export inference graph:

After that we run the training and we keep the training process for4 hours. Number of steps it took during the training process is 58,628 steps.After that we stopped the training process.

To test our proposed waste segregation system, we need to export the inference graph in '.pb' format which contain our desirable waste detection classifier.

Training procedure flowchart:

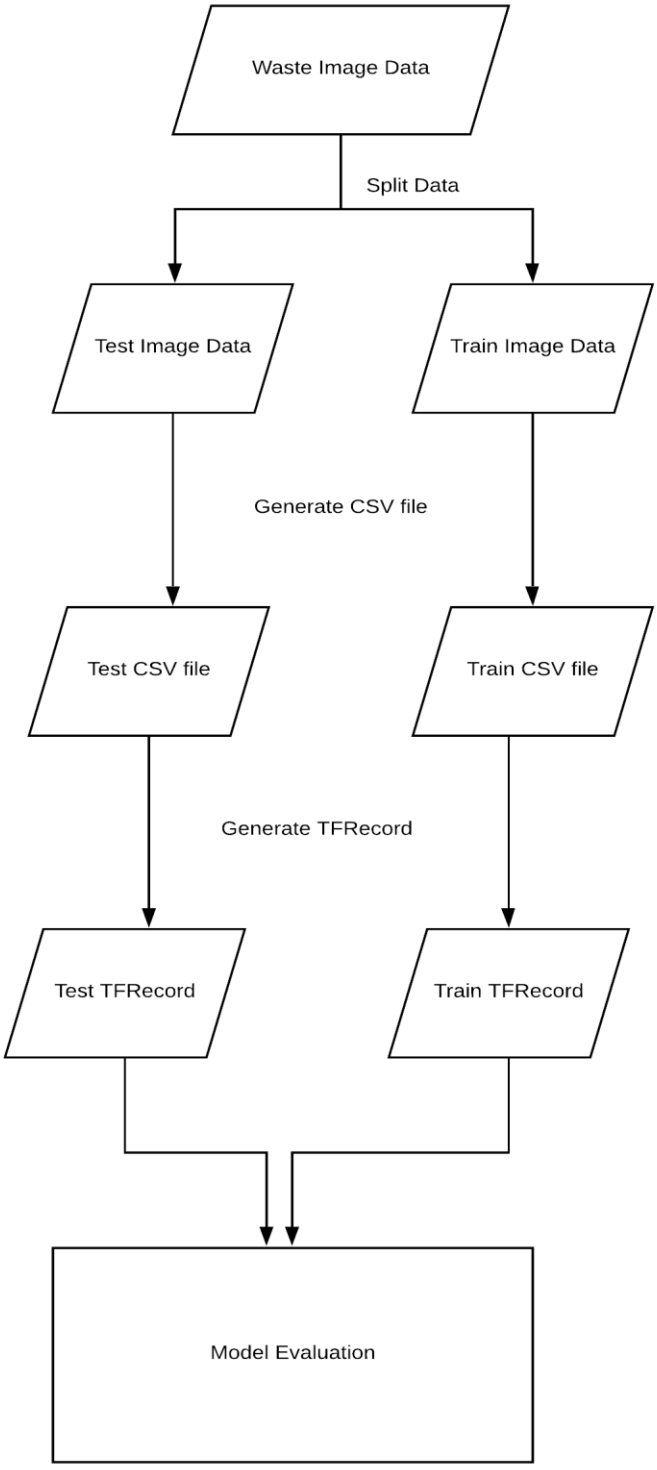

Figure 2: Training procedure flowchart

DISCUSSION

After completing the training process, we checked information and graphs of the training process. One of the most important graphs is the Loss graph which shows us the overall loss of the classification over training time. Also, the output of the whole training data is generated to frozen inference graph which we used to test our waste segregation system. This section discusses all output according to the training and testing process of our waste segregation system.

CONCLUSION

The rate of waste growth and improper waste management should be the first priority issue for our society, country and our planet. Otherwise we will lose our environment balance very soon.

In that case, we proposed an automated waste segregation system to classify categories of waste mainly in two different categories. Biodegradable and non-biodegradable waste. The most important part is our system could segregate waste from not only one object but also from different kind of object at the same time. This may help us to take valuable part in waste management system. We could dispose biodegradable in such ways that could be used as other useful purposes and non-biodegradable could be used for another purpose. Most importantly we can get rid form mixed up of different kind of waste that causing different kind of serious issue to our environment because our system can segregate different kind of waste at the same time.

RECOMMANDATIONS

Our proposed system could take part more advance system in future by adding anautomated robotic arm which could find the localized segregated waste and sort them in necessary categories.

In addition, our proposed model could be used in waste collection systems with a camera sensor which could classify waste real time in specific categories. After detecting biodegradable waste, we can dispose/compost them in place. That could reduce the volume of waste in waste collection systems.

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