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A Waste Management Technique to detect and separate Non-Biodegradable Waste using Machine Learning and YOLO algorithm

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***Abstract*—This research Paper proposes an application of Image Processing that works on the principle of machine learning and YOLO (You Only Look Once) algorithm was used to detect the custom object. The proposed application is a method to detect non-biodegradable waste from the bins so that the non-biodegradable waste can easily be separated from the bins. Data was divided into three major categories of non- biodegradable waste that were glass, metal and plastic. 450 -500 images of each category were collected in order to train the model. Each image was labelled using a labelling tool in the format of yolo. A machine learning model was created that was trained on the data set of all three categories of the images of non- biodegradable waste. After completion of training a number of files were obtained that were further used in testing model of the application. After completion of testing and checking the accuracy of the model on the webcam all the files were finally imported on the raspberry pi camera. Final testing was done on raspberry pi camera and results were verified accordingly and accuracy was calculated on the basis of the output received.**

Keywords—waste separation; non-biodegradable waste; image processing; image detection

I. INTRODUCTION

Image Processing is a field of artificial intelligence in which large number of images are processed in order to extract some information from the images. Sometimes, image processing is used to enhance the images while performing different operations on them. Image processing is growing rapidly in today's world thus it forms core research areas within the IT field. [18] It includes processing of images that is input will always be taken as images and results/ outputs will be altered according to the user's interests that is results can be either in the form of images or it can be characteristics/features that are associated with the images. Image processing basically includes three steps: -

1. Annotating the images through any image annotating tool.
2. Analysing the image performing operation accordingly.
3. Output includes either the images or characteristics associated with the images.

A. Types of Image Processing

1) Analog Image Processing

Analog Image Processing technique [19] is basically performed on hardcopies of the images like paintings, medical reports, printouts etc. It only processes images through the analog signals that have only 2 physical dimensions. It basically works on the principle of continuous image processing. Analog Image Processing is comparatively slower process and is economically more expensive.

2) Digital Image Processing

Digital Image Processing [17] is performed on digital images that includes matrix of pixels and elements. For processing and analyzing the images we have number of software and tools available. Color processing, image recognition and video processing are some of the examples of Digital Image Processing technique. This method improves the digital quality of the image. It works on the principle of segmentation that is a picture is divide into tiny segments then it is being processed. Digital Image Processing is a faster process for processing of images and is comparatively cheaper.

Digital Image processing is a field that is growing rapidly nowadays because of advancements in technologies and adoption of modern IT techniques. Digital image processing is not only affecting the industries all over the world but it leaving a strong impact on each and every individual around the world.

B. Working of Image Processing

1. Image labelling – This step includes dimensioning of image that is processing/scaling of an image.
2. Image enhancement – This step is all about highlighting the features of the image. It involves improving the quality of image by changing brightness, contrast etc.
3. Image restoration – It is an objective type technique used for improving the appearance of the image.
4. Color Image processing – This step has significance because of increase in the use of digital images. This step majorly includes color modelling of the image.

5. Multiresolution processing – This step basically involves representation of the images in a particular degree of resolution. [20]
6. Compression – This step includes compressing of images to reduce the storage that is required to save the image.
7. Morphological Processing – It deals with the tools for extracting images that represent shape of the images.
8. Segmentation – This process involves dividing the images into various segments/parts.
9. Representation and Description – This process includes two steps. Representation includes output given in the form of raw data and description includes using that raw data to describe the features of the images using computer processing.
10. Object Recognition – This step involves labelling the image that is categorizing the image to an object based on its descriptions.

II. LITERATURE REVIEW

Many different researches and work have been performed in the field of image processing. Image processing is a vast field having a lot of application base and in order to achieve the results many different approaches are followed.
Some of the previous works performed on image processing are listed below:
In paper [1], D.Vinodha, et al. proposed an idea of implementing IoT for garbage separation. In this, the main objective was to make Raspberry-Pi equipped smart bin which was integrated with sensors like ultrasonic sensors and a Pi camera for image processing using YOLO algorithm. The solution proposed is very innovative but equipping each bin with Raspberry -Pi, sensors, motors, and the camera will increase the cost of the bin.

In research article [2], Shobhit Khandare, et al. recommended a smart robot to pick the waste lying outside and around the bins. In these authors have used techniques like image processing, an ultrasonic sensor which is used to detect object and distance. Here the waste is not segregated but image processing is used to deal with wildlife. So that the robot is safe.

In paper [3], Shubhi Jain, et al. used haar cascade classifier method to detect foreign particle motion generated by vehicles then using this garbage is detected by analyzing the nature of the foreign particle. In this, image processing is used to detect the vehicle.

In article [4], Usha S M, et al. proposed an idea which is to use OpenCV, Raspberry Pi with a shrewd framework. Image processing is used to identify and the robot will gather trash and then after a notification is sent to the user. The robot used here is RC and is then useful with far assistance. The major usability of this robot is when a giant park is to be cleaned.

The article [5] mainly focusses on waste generation and management by Municipal Solid waste of Ontario, Canada. Miyuru Kannangara, et al. developed a machine learning and deep learning models for the same in Matlab software. The accuracy of neural network model was 72% of the variation in the data.

In paper [6], Xitong Zhao, et al. tries to present real-time detection of fire protection facilities based on YOLOv3 algorithm. This research article also compares different algorithms to find the best results. The most problematic thing in this project is the mixture of dry and wet waste.

In article [7] Nilima Kulkarni gave the idea of smart bins which will segregate the waste into wet and dry but everything comes with a price. They were using a lot of sensors like object sensors and temperature sensors, hence increasing the cost of the product.

Research article [8] includes various waste sorting techniques using machine learning algorithms to separate waste into different types. The 2 popular learning algorithms used in this paper were deep learning with CNN and Support Vector Machine (SVM). Each algorithm separates waste into 3 categories which are plastic, paper, and metal. Both the models are imported into Raspberry Pi and then compare them and the result came out as SVM achieved higher accuracy than CNN.
In paper [9], Ying Liu E, et al. proposed a YOLO v2 model that is enhanced for decorative waste detection, detection by grouping target window sizes, pre-training network classification, other optimized accelerated light processing methods and delivering to the integrated monitoring station. The testing shows that the cost is more than half compared to conventional tracking systems, which can effectively save labour and material resources and improve detection accuracy.
In paper [10], Dr.PL. Chithra and P.Bhavani focuses on Image purchase, image pre-processing, adding and fetching source and image type which offers better performance but the quality of the image sharpness makes the most of the it. The author focus more onto the future work which is to make a more efficient algorithm for image processing, introducing the ability to use CCTV images in the sewer.
In paper [11], Sangeet Saha, et al. summarizes the work done in the field of image processing, with particular emphasis on the implementation of image processing devices and the secure transmission of the image data. Further work will focus on the filter motor, digital image watermark and other image security issues.
Many image processors, tools, and techniques help extract complex functions from the image. Image processing works from a one-dimensional image to a multidimensional image and controls what really happens in it. Image processing is the heart of many emerging real-time technologies. Therefore, the article [12] deals with an overview of applications, tools and techniques of image processing.
In paper [13], Bobulski, et al. often discusses the classification of wastes selected for the four main classes taking place without any flaw. A 15-layer allows you to achieve high performance for a two-dimensional image than a 23-layer grid

with images of 227 x 227 pixels. Future work tells the ability to prepare networks in real conditions.

In paper [14], Rokade, et al. explained that there is a smart waste sorting robot that can sort the damaged and non-perishable waste. When the interference sensor is activated, the camera works and the image is processed by the image processing and the waste must be disposed of in an appropriate container.

In Paper [15], Piotr Nowakowski and Teresa Pamula has presented a new approach to identifying photography and e-waste category, using CNN to classify e-waste type and using R-CNN to see e-waste category and amount in images. The applied classification and detection algorithms showed a high degree of identification efficiency.

In paper [16], Md. Wahidur Rahman, et al. have proposed a model which is considerably divided into two parts. Architectural layout with a lot of waste using Raspberry Pi with camera module and machine learning. Another is an IoT smart trash box with a dreary makeup microcontroller with multiple sensors for real-time waste disposal. This paper represents the data calculation methodology of proposed CNN model, ultrasonic sensor and load measurement sensor. Also, this article also presents several experimental data analyses to provide the effectiveness of the proposed method.

III. PROPOSED APPLICATION

A raspberry pi camera was designed which was used to detect three categories of non- biodegradable waste.

A. Proposed Application Description

Step 1. 450 -500 images of each category (glass, metal, plastic) were collected. Some of images were self-clicked in order to improve accuracy and detect object from different angles.

Step 2. All of the images were labelled in YOLO (You Only Look Once) format using a labelling software.

Step 3. A python code was created for making a training model which took around 14 hours to complete. Training was done taking all of the data set.

Step4. After completion of training two files were generated as the output of the training code which was further used in testing model.

Step 5. Testing model was created using python and was initially tested on random images. After the model was completed and was successful on random images, the model was then tested on webcam of laptop.

Step 6. After testing of model on webcam of laptop, accuracy of the model was calculated accordingly.

Step 7. Finally, all the files were imported on raspberry pi-camera and final testing was done.

Step 8. Final accuracy was calculated using the results received after testing on raspberry pi camera.

B. Working of Raspberry Pi Camera

Raspberry Pi Camera plays an important role in the project as it is the camera which is responsible for detecting the non- bio degradable waste.

Step 1. After switching on the camera, first of all it will detect whether the waste is non- bio degradable or not.

Step 2. It will capture the image and receive the image in the format understandable by it.

Step 3. If the waste is biodegradable it will again go to the first step where detection of waste will be done

Step 4. If the waste is non- biodegradable that means non- bio degradable waste has been detected successfully and the pi camera will further send the information to hardware using automated commands.

A hardware robot (the final part of the machine) will be created in future which will take the instruction from automated commands and after detection of non-biodegradable waste it will separate the non- biodegradable waste from the bins.

C. Proposed Application Flowchart

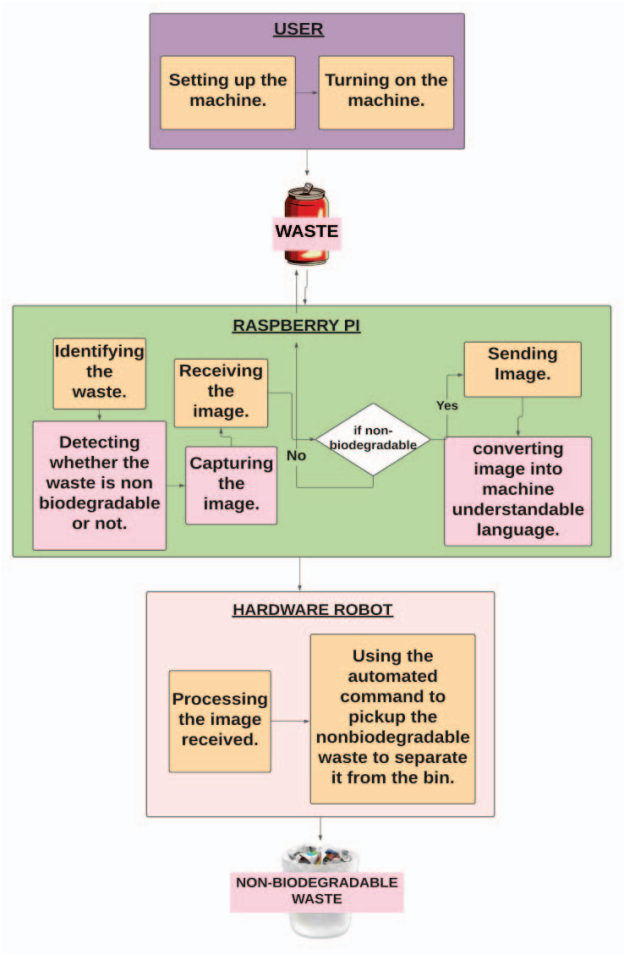

Fig 1. Describing workflow of the model

IV. EXPERIMENTAL ANALYSIS AND RESULTS

The following figures shows the images taken from the live detection on material on Raspberry Pi using Pi Camera. Results were taken depending upon the type of material

A. TYPES OF NON-BIODEGRADABLE WASTE

1. Metal

Fig shows the result of Metal. We tested the Live detection of metal 20 times using Pi Camera. It easily differentiates among categories.

Fig 2. Metal Detection

2. Plastic

Fig shows the result of Plastic. We tested the Live detection of Plastic 20 times using Pi Camera.

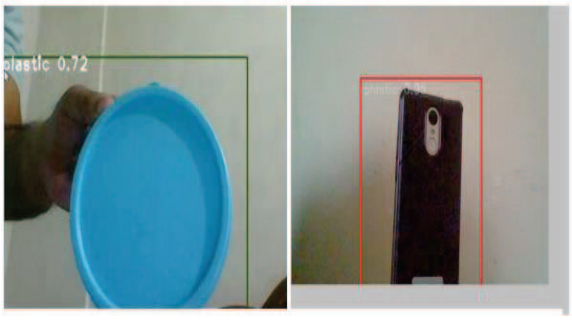

Fig 3. Plastic Detection

3. Glass

Fig shows the result of Glass. We tested the Live detection of Glass 20 times using Pi Camera.

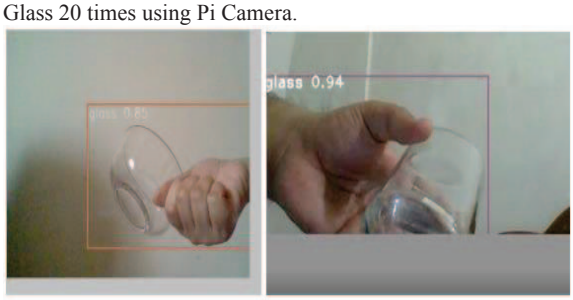

Fig 4. Glass Detection

B. COMBINE RESULT

Table shows the total evaluation of the result. Here, we have tested 20 items of each category. we have tested our code 20 times and each time we have tested 20 products of each type and every time we shuffled the items and tested each one-by-one. Number of corrected and incorrected predictions are represented in this table.

TYPES OF MATERIAL	TOTAL ITEM TESTED	DETECTED CORRECTED	DETECTED WRONG	ACCURACY
METAL	20	15	5	75%
PLASTIC	20	13	7	65%
GLASS	20	12	8	60%

Table 1. Evaluation of result

C. ACCURACY

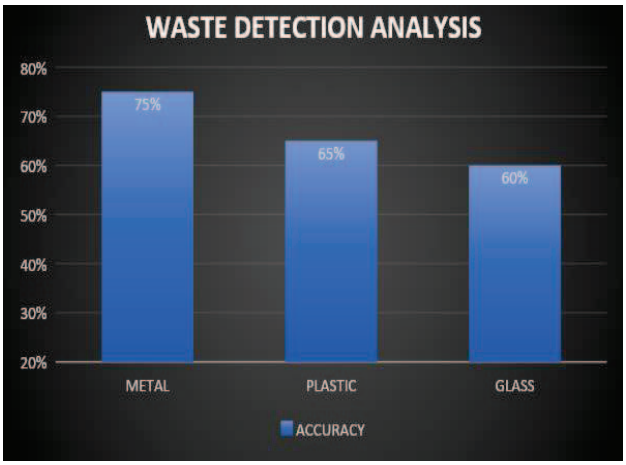

Fig 5. Graph for Analysing Accuracy

Graphical representation of accuracy of result. According to the result the accuracy of detecting metal 75% which means according to our testing of 20 items it detects 15 items corrected but detect 5 items wrong. In case of Plastic its accuracy came out to be 65% which each while detecting plastic out of 20 items it is detecting 13 items under their category and 7 items wrongly. And, in case of Glass accuracy is lowest i.e. 60% which means it detects 12 items correct and 8 items wrong out of 20 items.

V. CONCLUSION AND FUTURE SCOPE

Waste is separated manually by the human efforts, which leads to many severe diseases which are untreatable. So, to replace that tradition we have developed a software to detect waste and separate it according to their categories. According to our result accuracy of detecting metals is maximum which is 75%. It was difficult to distinguish between a plastic and a glass material sometimes human also are not able to distinguish between a plastic and a glass. Due to this our accuracy for plastic and glass is low as compare to the accuracy of the metal.

Accuracy of the model will be increased by increasing dataset of each category of waste. More images through various sources will be collected and trained so that results become more accurate and precise.

In future a robot will be created which will take the instruction from automated commands and after detection of non-biodegradable waste it will separate the non- biodegradable waste from the bins.

REFERENCES

[1] Vinodha, D., J. Sangeetha, B. Cynthia Sherin, and M. Renukadevi. "Smart Garbage System with Garbage Separation Using Object Detection.", International Journal of Research in Engineering, Science and Management, May-2020.

[2] Khandare, Shobhit, Sunil Badak, Yugandhara Sawant, and Sadiya Solkar. "Object Detection Based Garbage Collection Robot (E-Swachh).", International Research Journal of Engineering and Technology (IRJET), March-2018.

[3] Jain, Shubhi, Naman Gupta, Ashish Khanna, Ankita Gupta, and Deepak Gupta. "Detection of Garbage Disposal from a Mobile Vehicle Using Image Processing." In International Conference on Innovative Computing and Communications, pp. 699-709. Springer, Singapore, 2020.

[4] Usha, S. M., Hemant Mukund Naik, R. Harshith, S. L. Indresh, and Manoj Kumar. "Garbage Detection and Collection Using Computer Vision.", International Journal of Scientific Research and Engineering Development-– Volume 3 Issue 3, May – June 2020.

[5] Kannangara, Miyuru, Rahul Dua, Leila Ahmadi, and Farid Bensebaa. "Modeling and prediction of regional municipal solid waste generation and diversion in Canada using machine learning approaches." Waste Management 74 (2018): 3-15.

[6] X. Zhao, L. Cheng, J. Kuang, and J. Liu, "Research on Real-time Detection of Fire Protection Facilities based on Improved YOLOv3 Algorithm," 2020 39th Chinese Control Conference (CCC), Shenyang, China, 2020.

[7] Kulkarni, Dr. Nilima and Mahendrakar, Akshay and Molak, Omkar and Kumar, Shivam and Chitnis, Piyush, Smart Waste Bin (April 27, 2020). 2nd International Conference on Communication & Information Processing (ICCIP) 2020.

[8] Sakr, George E., Maria Mokbel, Ahmad Darwich, Mia Nasr Khneisser, and Ali Hadi. "Comparing deep learning and support vector machines for autonomous waste sorting." In 2016 IEEE International Multidisciplinary Conference on Engineering Technology (IMCET), IEEE, 2016.

[9] Liu, Ying & Ge, Zhishan & Lv, Guoyun & Wang, Shikai. "Research on Automatic Garbage Detection System Based on Deep Learning and Narrowband Internet of Things." Journal of Physics: Conference Series, 2018.

[10] Dr.PL. Chithra, P.Bhavani. "International Journal of Emerging Technology and Innovative Engineering Volume 5, Issue 5.", May 2019.

[11] Sangeet Saha, Chandrajit pal & Rourab paul, Satyabrata Maity,Suman Sau, "A brief experience on journey through hardware developments for image processing and it's applications on Cryptography.", 2017.

[12] R. Ravikumar & Dr V. Arulmozhi, "Digital Image Processing-A Quick Review", International Journal of Intelligent Computing and Technology (IJICT), Vol.2, Iss.2, pp.11-19, 2019.

[13] Bobulski, Janusz & Kubanek, Mariusz. (2019). "Waste Classification System Using Image Processing and Convolutional Neural Networks", May, 2019.

[14] Rokade, Rani & Maurya, Avdhesh & Khade, Vaishnavi & Swetatandel, & Mali, Jyoti. (2019). Smart Garbage Separation Robot with Image Processing Technique. International Journal of Engineering and Technical Research.

[15] Piotr Nowakowski & Teresa Pamula, "Application of deep learning object classifier to improve e-waste collection planning.", May 2020.

[16] Md. Wahidur Rahman, Rahabul Islam, Arafat Hasan, Nasima Islam Bithi, Md. Mahmodul Hasan & Mohammad Motiur Rahman, "Intelligent waste management system using deep learning with iot.", August 2020.

[17] P.Prabhu " digital image processing techniques – a survey", May, 2016.

[18] P.L, Chithra and P, Bhavani, "A Study on Various Image Processing Techniques" International Journal of Emerging Technology and Innovative Engineering Volume 5, Issue 5, May 2019.

[19] Leonid P. Yaroslavsky, "Linking Analog and Digital Image Processing", April, 2011.

[20] Ravindra S Hegadi, "Image Processing: Research Opportunities and Challenges", December2010.