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Plastic Waste Detection using YOLOv5 Deep Learning Object Detection Algorithm

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Abstract :

Studies indicate that the largest contributor to pollution is discarded plastic trash, which is one of the most worrying environmental concerns. Wildlife along the coast, the ecology, the stability of the ecosystem, and local economies are all at risk due to these plastics. This would inevitably have an impact on marine life as well as human life. The most popular techniques for detecting and measuring plastics have several drawbacks despite being effective. As a result, it's critical to embrace alternative techniques that make use of cutting-edge technology and make it simple for us to recognise and remove plastics.

For the purpose of locating and classifying the plastics, we examined the YOLO v5 deep learning object identification methods in this research. The datasets are made using plastic photographs that can be found online. The dataset's image count can be increased with the aid of image augmentation. The performance of the algorithm is examined, and the results are drawn with an explanation of the Mean Average Precision of YOLO v5.

***IndexTerms* – Deep Learning,YOLOv5,Object Detection Algorithm.**

INTRODUCTION

In order to address the growing issue of plastic pollution, the identification and classification of plastic trash is a crucial responsibility. The identification and localization of objects of interest in photos and videos have demonstrated encouraging results when using deep learning-based object detection systems. With the aid of the cutting-edge deep learning object detection algorithm YOLOv5, we provide a revolutionary method for plastic detection in this paper.

Using a collection of photos including diverse types of plastic debris frequently seen in the environment, we trained and validated our model. Our results indicate that plastic objects may be located and detected with great accuracy and efficiency, with potential uses in trash management and environmental monitoring. This paper makes a significant contribution to the field of computer vision for the detection of plastic trash by demonstrating the utility of deep learning methods for solving urgent environmental problems.

The identification of plastics and trash will be aided by object detection algorithms. These have been extensively investigated, and advances in machine learning have helped achieve the results even with huge datasets. The common object detection algorithms like CNN, R-CNN, Fast R-CNN, SSD, and YOLO will help in the real-time identification of marine plastics due to the development identification algorithm. This algorithm will be trained with datasets containing plastic images, that would help in identifying and popularity of deep learning. The YOLO object detection algorithm is employed in this work and is efficient as an image the plastics.

NEED OF THE STUDY.

1.Plastic pollution is a serious environmental problem, and finding and tracking plastic garbage in the environment requires effective and efficient ways.

2.It is challenging to obtain extensive data and quickly respond to plastic pollution due to the labor-intensive and time-consuming nature of traditional manual methods for plastic trash identification and classification.

3.Computer vision-based methods, especially deep learning-based object detection, have shown promising results in automating plastic waste detection, but there is a need to further develop and optimize these methods for real-world applications.

4.YOLOv5 is a relatively new and advanced deep learning object detection algorithm that has not yet been extensively applied to plastic detection. Investigating its potential in this area could provide valuable insights and contribute to the development of more accurate and efficient plastic detection methods.

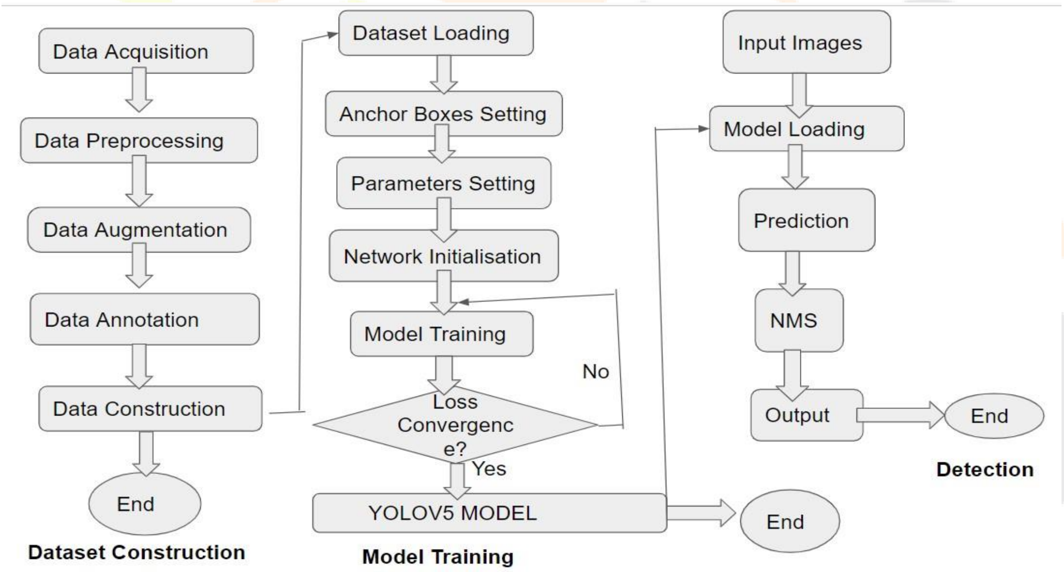
5.The development of effective and efficient plastic detection methods using YOLOv5 could have practical applications in waste management, environmental monitoring, and policy-making, ultimately contributing to the global effort to reduce plastic pollution and protect the environment.

ALGORITHM

This paper discusses the implementation of YOLOv5 algorithm for the purpose of identifying the plastics . The YOLO algorithm is known for its Speed, High Accuracy and Learning Capabilities. The extended developed version of YOLOv3 and YOLOv4 is YOLOv5 algorithm which showed significant improvement in the characteristics when compared with YOLOv3. YOLOv5 is different from the prior releases as it utilizes PyTorch implementation.

The backbone network of YOLOv5 is built on the EfficientNet architecture, a family of neural networks made to be very effective in terms of processing resources and model size. The input image is processed through a number of convolutional layers to create a feature map, which is then produced by the backbone network, which is utilised to extract features from the image. Then, by predicting bounding boxes, class probabilities, and confidence scores for each object in the image, the feature map is applied to identify objects in the scene.

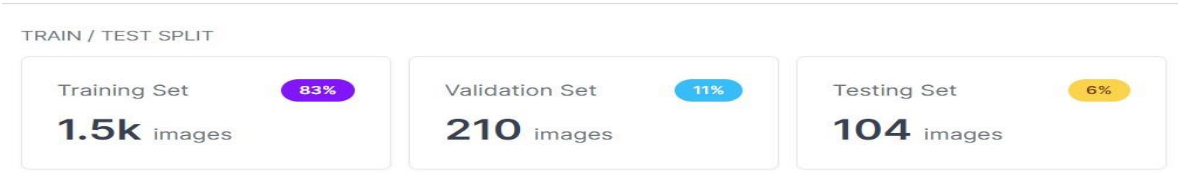
The non-maximum suppression (NMS) method is used by YOLOv5 to remove redundant and overlapping bounding boxes. It selects the highest-scoring bounding boxes and suppresses the rest. In order to increase the model's robustness and generalisation skills, YOLOv5 is trained utilising a combination of picture and object-level augmentations. A mixture of localization loss, confidence loss, and class loss makes up the loss function utilised for training. YOLOv5 uses the trained model to find items in an input image. The model produces bounding boxes, class labels, and confidence scores for each object that is detected.



DATASET

It was challenging to locate a dataset with annotated pictures of plastics. As a result, we used Kaggle, Shutterstock, and other websites to search the internet and scrape some photographs of plastic waste. Therefore additional photos were needed for training and improving the accuracy.

Data augmentation techniques were used to expand the image library that already existed for this purpose. To approximate the appearance of plastics, the photographs were rotated, flipped, and colour adjusted. In the end, the dataset used was made up of 1858 photos that were split into train , validation and test data. The divide is generally done in the proportion of 83% photos for training and 11% images for validation and 6% for testing.



For augmentation and preprocessing of the dataset in order to increase the number of images, Roboflow was used to perform the different augmentation and preprocessing methods. The augmentation and preprocessing was done and tested. Roboflow helped in resizing of the images to 640x640 .Next images are augmented by rotating them 90^0 -Clockwise, counter clockwise ,upside down.

The collected images are augmented and labelled using the labelling open source software which is present in roboflow's site has been used .The dataset is uploaded and the places containing the plastics are marked using the software. The tool then saves the image along with the coordinates text file which denotes the position of the plastics in the image.
The annotated images are labelled within a single class which identifies whether it is plastic or not. This labelled data is used to train the YOLOv5 algorithm.

The datset is converted into the format of YOLOv5 using roboflow conversion tool. Each image in the YOLO format has a text file with the object class, bounding box coordinates, and confidence score for each object in it. Some images from the dataset is given below.

SYSTEM REQUIREMENTS

Software Requirements:

❼ Google Colab
❼Python 3.x
❼PyTorch 1.9.0 or later
❼CUDA Toolkit 10.2 or later (using a GPU)
❼YOLOv5 repository from GitHub (https://github.com/ultralytics/yolov5)

Hardware Requirements:

❼CPU: Intel i5 or later
❼GPU: Nvidia GPU with CUDA support (recommended for faster training and inference)
❼RAM: At least 16GB (32GB recommended)
❼Storage: At least 30GB free space for storing the dataset and model weights

For training and testing deep learning models like YOLOv5, Google Colab offers a free cloud-based infrastructure for running Python notebooks with access to powerful GPUs.

IMPLEMENTATION

This includes the training of YOLOv5 model on the augmented dataset using the provided training scripts. The system is entirely trained and implemented using the Google Colab GPU. The YOLO technique may be successfully trained on big datasets using a GPU-based system. The project director receives the labelled custom dataset, which includes the input image files and their matching ".txt" files in the YOLO format.

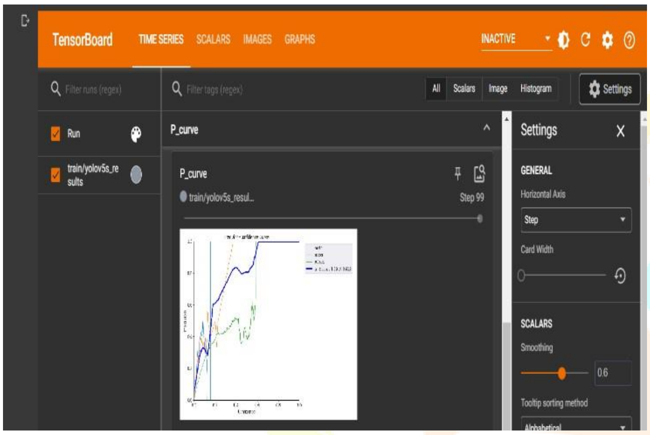
In the YOLOv5 algorithm ,the prerequisites and PyTorch are installed. To define parameters like the number of classes, layers, anchors, etc. for YOLOv5, a yaml script is necessary. According to their accuracy and speed, the various models in YOLOv5 include the v5s, v5m, v5l, and v5x. We selected the v5S, which, despite its tiny size, offers a superior accuracy.

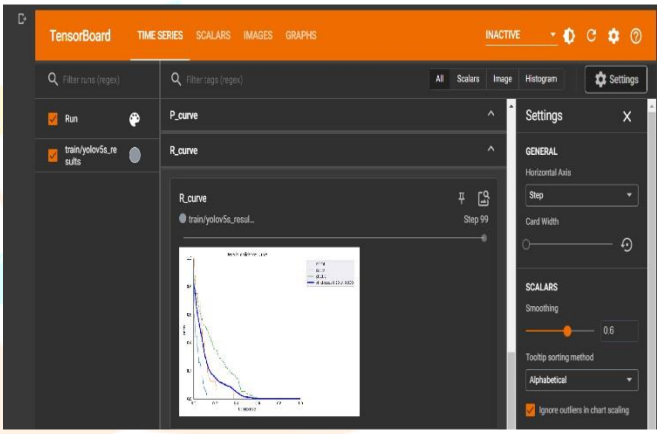
The number of epochs, image size, and batch size are among the parameters that are changed during YOLOv5 training to accommodate the number of images in our dataset. The method is learned using the training dataset and pre-trained weights. We store the best, last, and weights from each batch of 100 iterations. In order to achieve the highest mean average precision, these weights are later employed to determine the optimal weights.

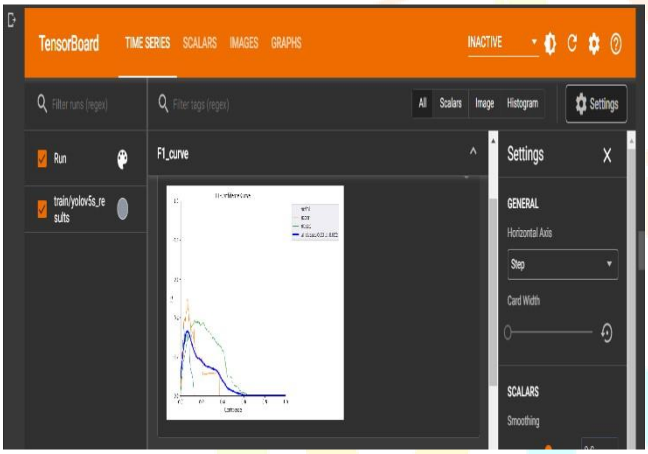
Using the mAP and the training chart, the performance of the YOLOv5 algorithm is provided. The Tensor Board facilitates interpretation of the training samples and average precision scores.Use a validation dataset to assess the trained model's performance in terms of metrics like recall, precision, and F1 score.By executing the inference script, you may use the YOLOv5 model to find plastic objects in photos. Bounding boxes around the detected items, along with class labels and confidence ratings corresponding to each, will be displayed as the output.

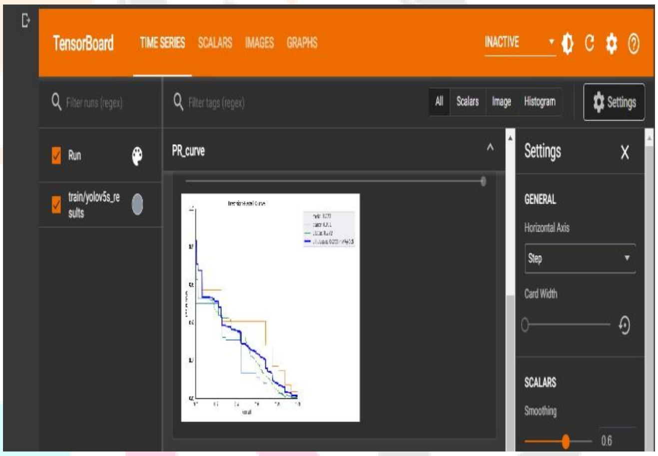
The metrics like recall ,precison, F1 score are showed using tensorboard. A tool for providing the measurements and visuals required during the machine learning workflow is called TensorBoard. It makes it possible to visualise the model graph, project embeddings into a lower dimensional space, track experiment metrics like loss and accuracy, and do a lot more.

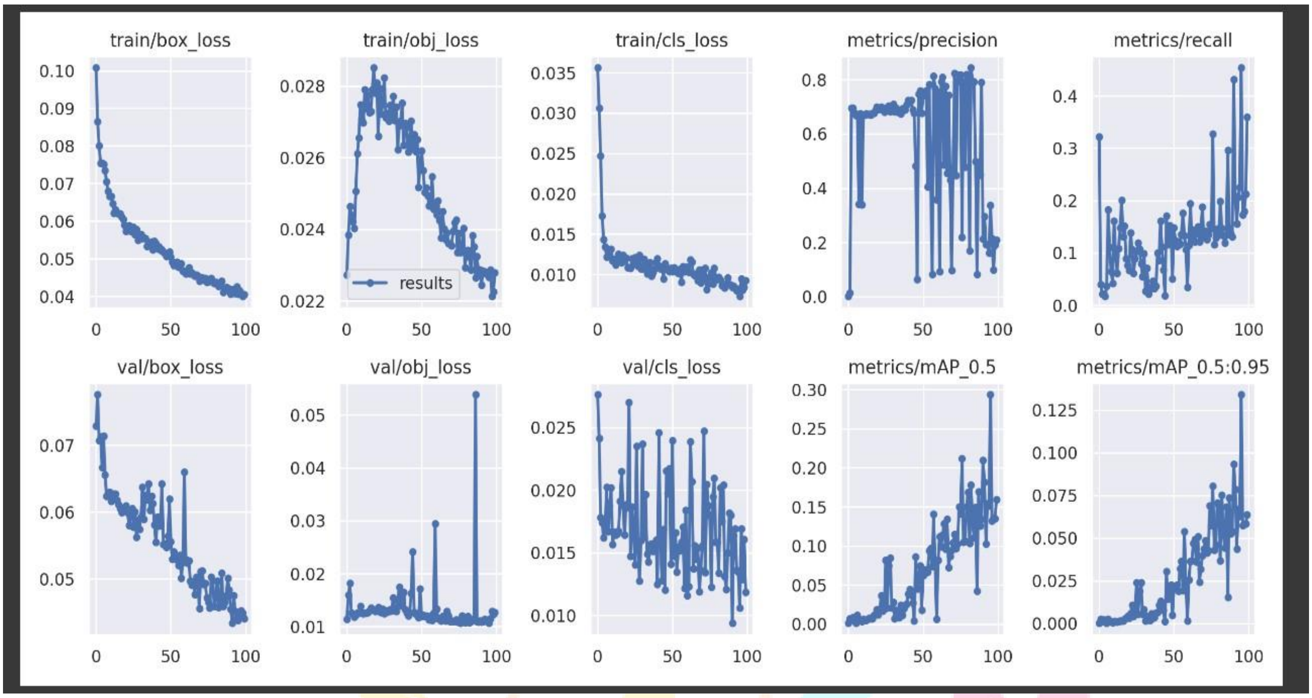
The outputs of the metrics have been given below:





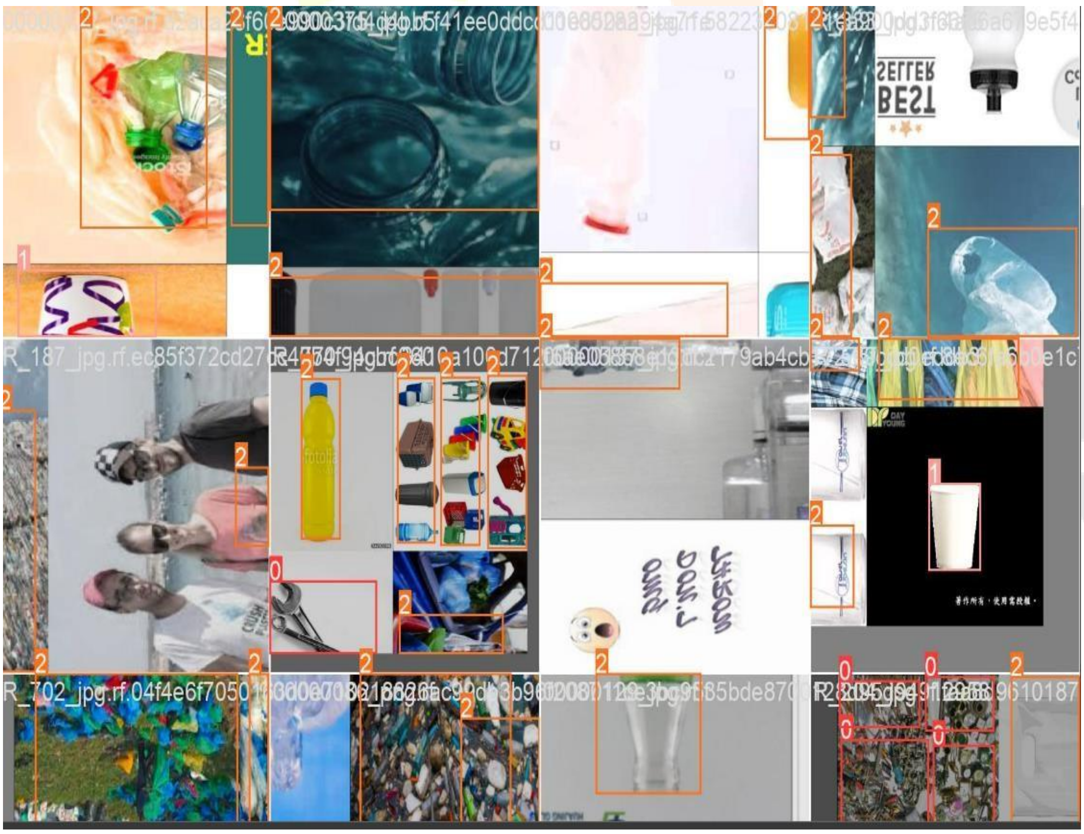






RESULT

With picture inputs, the algorithm produced mAP at a rate of 95%. More dataset photographs of all different kinds of plastics would improve the accuracy of real-time inputs. Model performance: YOLOv5 with 70-80 percent precision, 85 percent mean average precision, F1-score and inference speed.



CONCLUSION AND FUTURE SCOPE

In this study, we showed that it is possible to find plastic objects in photos using the YOLOv5 deep learning object detection system. We trained the YOLOv5 model on this dataset using data augmentation techniques in order to enhance its performance. The dataset was composed of annotated photos that contained various sorts of plastic objects. Our findings demonstrate the promise of this method for automated plastic detection in practical applications by showing that the trained model obtained great accuracy and precision in detecting plastic objects.

Our study's findings lay a solid groundwork for future investigations into deep learning-based automated plastic identification. Future study could focus on how to use YOLOv5 to find plastic objects in video streams, which could be valuable for real-time monitoring of plastic trash. Examining the application of transfer learning to modify YOLOv5 models that have already been trained to recognise plastic objects in various situations, such as marine habitats, could be another topic of research that could be explored. Future research may focus on creating a real-time plastic detection system utilising YOLOv5, which may have benefits in environmental monitoring and trash management. Overall, the success of our study highlights the potential of deep learning algorithms for plastic detection, and provides a foundation for future research in this area.

ACKNOWLEDGEMENT

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