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Crop Infection Detection Using Yolo

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Abstract-Agriculture is the backbone of a country. It is important to note that without agriculture, there is no economic growth in the country. As Technology has improved a lot and improving a lot day by day, these technologies can be utilized in farming and agriculture so that there will be maximum utilization of crops and less wastage of crops. To achieve this, we need to come across a few challenges. Which crops can be grown depending on certain weather conditions? Identification of disease in crops so that we can prevent it and maximum yield of crops. Prevention is better than cure the famous quote says. Artificial Intelligence is one of the greatest inventions, using AI we can train the machine with images to detect disease in crops. The problem of the underutilization of crops can be achieved. This paper proposes a model for implementingcropinfectiondetection and maximum yield of crops using Convolution Neural Networks (CNN) and You Look Only Once(YOLO).

Keywords-Agriculture; Crop disease; yield, image detection; CNN; YOLO.

I. INTRODUCTION

Agriculture is essential in the country's economic growth. The primary sector of an economy comprises agriculture and other activities which is significant to the Gross Domestic Product (GDP). For decades, agriculture has been associated with the productions of a maximum of crops, food, and other raw materials to the country. At present, agriculture includes farming, fruits, vegetables, dairy, mushrooms, etc.

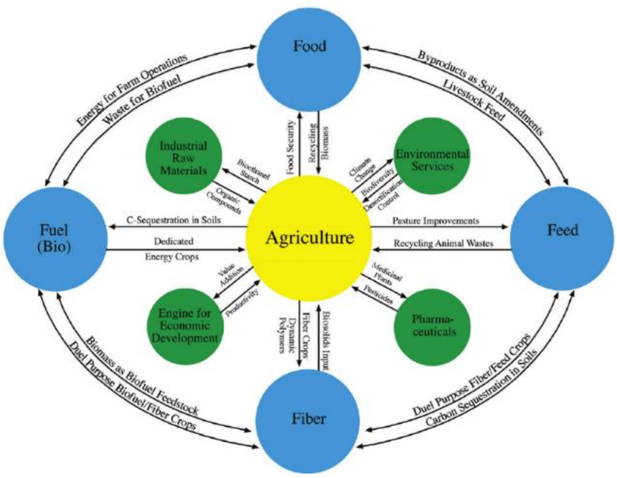

Fig 1. Role of Agriculture.

Agriculture not only provides food it also provides employment opportunities to a very large percentage of the population of a country. Crops are living plants grown by farmers. The majority of the crops are food-related, such as fruit, vegetables, and grains. Some crops are grown for fabrics like cotton, pharmaceuticals like quinine, and other products like wood and rubber.

Most of the crops are destroyed due to the rain or due to other climatic conditions. Most of the crops are grown and are affected by diseases, and these diseases are spread over the crops. If we overcome these challenges, we can achieve maximum yield and we can overcome the underutilization of crops.

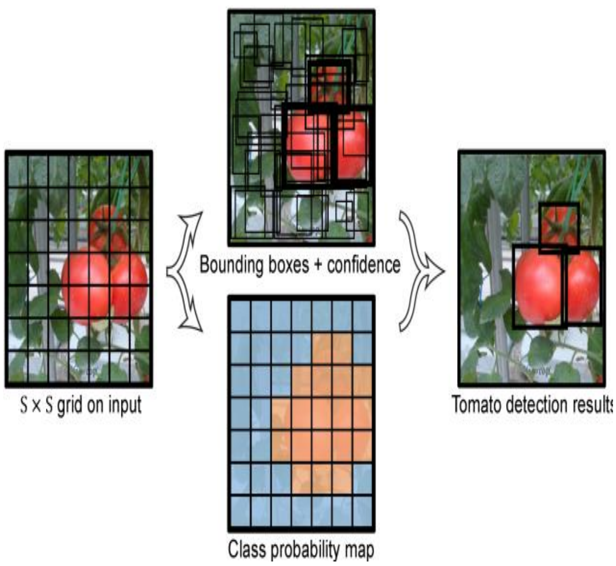

Fig 2. YOLO Object Detection.

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Our proposed model provides the solution in the agriculture field. YOLO which was discovered by Joseph Redmon provides the best result in detecting the disease present in the crops.

A plant's leaf is the first part of the plant which shows symptoms of diseases affecting the plant. Object detection using the YOLO model is applied to plants leaf to detect disease that occurred in the plant at an earlier stage before itsaffects the entire plant. Figure 2 demonstrates how YOLO works in the objection detection of a plant.

Using this YOLO Object detection we will spot all the infected places in a leaf and put a bounding box. If a leaf is healthy the same bounding box will be put indicating the leaf is healthy.

Fig 3. Healthy Leaf

Fig 4. Bacteria Infected Leaf

1.Motivation:
The main motive of our proposed modes is as follows.

- Identifies which area of the plant/leaf is affected and preventive measurements can be taken care of.
- Predicting the number of defects in individual plants to understand
- This application will be installed in the farmland once the occurrence of the disease is found necessary pesticides can be applied to the affected area.
- Identifying the infected plant manually consumes more time and also error in identifying them is more. This also requires more labor, Using our proposed model sorts all these issues.

2. Problem Statement:
Farmers have been able to identify crop diseases with their naked eye since the beginning of time, and they continue to do so today, which forces them to make difficult decisions about which fertilizers to employ. It necessitates a thorough understanding of disease kinds as well as a great deal of expertise to ensure accurate disease identification. Farmers are frequently perplexed by diseases that appear to be almost identical. The below image showsmore details.

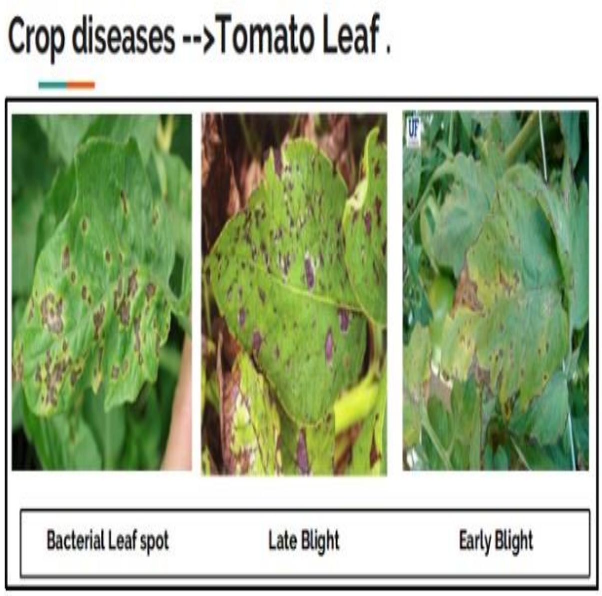

Fig 5. Crop Diseases.

In Today's agriculture, the crops grown by the farmers are underutilized. Weather conditions fluctuate a lot. Most of the time crops are damaged by rainfall. The following are the few problems in today's agriculture:

- Crops are damaged due to climatic changes such as rainfall, temperature, etc.
- Wrong seasonal crops are grown.
- Crop diseases and the spreading of these diseases to other crops.

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- Wastage of crops (Underutilization) due to diseases of crops.
- Less yield of crops.

The leaf in the above fig 5, all are similar and it is very important to identify which plant leaf it and which fertilizer should be used to avoid crop diseases.To avoid this, excellent recommendations on which fertilizer to use, accurate diagnosis of crop bacterial infection, and the capacity to distinguish between two or more interdependent types of diseases in visuals by adding bounding boxes are all required.

3. Objectives:
The main objective of our proposed model is to help farmers in the prevention of crop diseases at an earlier stage by using deep learning techniques such as objection detection, computer vision. The occurrence of disease in a plant leaf is detected. All the affected area is identified using the bonded box. By this farmer can apply necessary medicines to that area or remove that part of the plant before it affects the entire plant.Building end-to-end application where YOLO is used for object detection.

The plant village dataset is trained using Convolution Neural Network for several iterations this trained model is used for deployment using the Django framework. This will provide a user interface for the farmers by which they can identify the occurrence of disease in the plants. Then they can spray pesticides on these plants and protect the plant before the whole plant is affected.

II. LITERATURE REVIEW

There are many systems developed to detect disease in crops and to achieve maximum yield. But the performance and stability problems.In [1], Wang R et al. proposed a system that's based on the detection of diseases in plants using Image processing Technology using Mat lab. This system works well in but when it comes to practical implementation such as direct detection using cameras, this system may fail to give accuracy, where we can achieve using python (YOLO).

In [2], Dengshan et al. proposed a system that's based on Crop disease Detection using Image Segmentation which uses Image processing and K-means clustering Technique. The problem might be the initialization of K clusters. And K-Means clustering technique has been applied to solve low-level image segmentation tasks.

In [3], Ferentinos et at. have used convolution neural network to identify plant disease they have trained for 58 different classed dataset that consists of 25 different plants. this system achieved 99.53% accuracy in making the prediction this was achieved by using VGG architecture.

III. IMPLEMENTATION

1. Dataset:
The data set consists of 54000 leaf images of various plants. This dataset consists of images of both healthy and diseased plants images. The healthy category is to make the model understand which plants are disease-free and keep a track of them. In the disease category, there are more than one disease labels based on the kinds of diseases that the particular plant gets affected.

We have trained for around 38 distinguish classes. This category includes most of the plants commonly grown by farmers. A diseased category is identified if a small area of the leaf is defective and want kind of disease caused that disease.A small snippet of our dataset is shown in figure fig 6. Here we can see that the labeling of a class is given by plant name followed by the disease it is affected if any else it's labeled by plant name followed by healthy as its category.

Fig 6. Crop Diseases Dataset

The dataset includes plant image such as
- Strawberry
- Tomato
- Soybean
- Potato
- Corn
- Orange
- Blueberry
- Cherry
- Grapes
- Peach
- Pepper
- Raspberry
- Squash
- Apple

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There are 14 different plants in total. The kinds of diseases caused to them are viral disease, bacterial diseases, disease due to mite, common diseases, and diseases caused by mold.

2.ImageAnnotation:

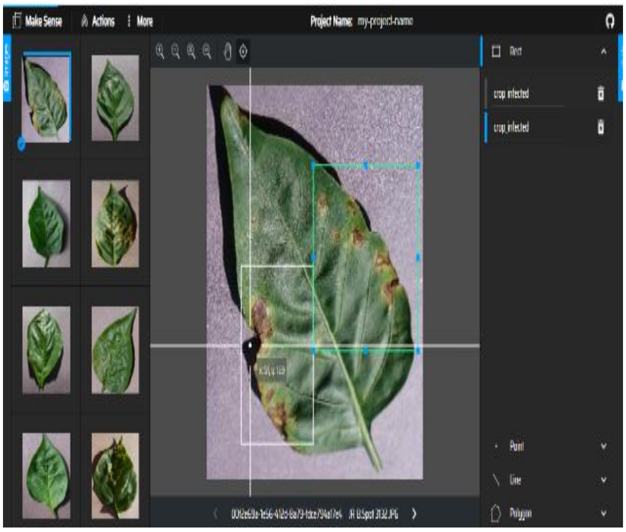

Fig 7. Image Annotation

Image annotation is one of the most important tasks in Computer Vision. Image annotation is the human-powered task of annotating the images with labels. Here annotating in the sense, we are manually putting the bounding boxes on the images and labelingthem using annotating tools which are available online.

There isa lot of annotation format. For YOLO .txt format is used with the same name of the image file in the same directory thefile will be created.
Each .txt file contains
<object-class><x><y><width><height>
Example:
0 45 55 29 67
1 99 83 28 44

3. Convolution Neural Networks (CNN):
The Convolution Neural Network is an algorithm that is particularly constructed for pickle-related data. This is a deep learning algorithm generally used for processing and recognizing image-related datasets.

Unlike other classification algorithms, CNN requires less pre-processing of the data. This algorithm was inspired by neurons in the human brain particularly called as Visual Cortex which is present in the occipital lobe and this is responsible for visual information.

The image acquired is converted into pixel data which is on processing according to CNN architecture will be fit into Artificial Neural Network architecture. ANN will process and produce/predicts the output. YOLO Object Detection uses the CNN algorithm.

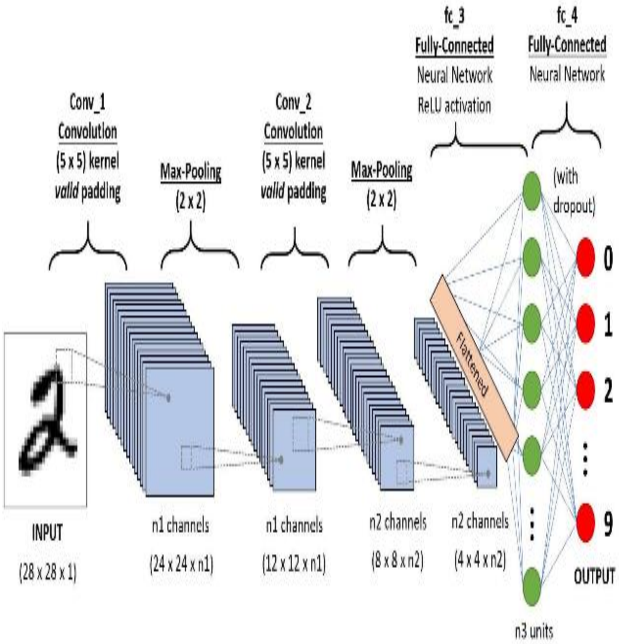

Fig 8. Working of Convolution Neural Network

4. Object Detection:

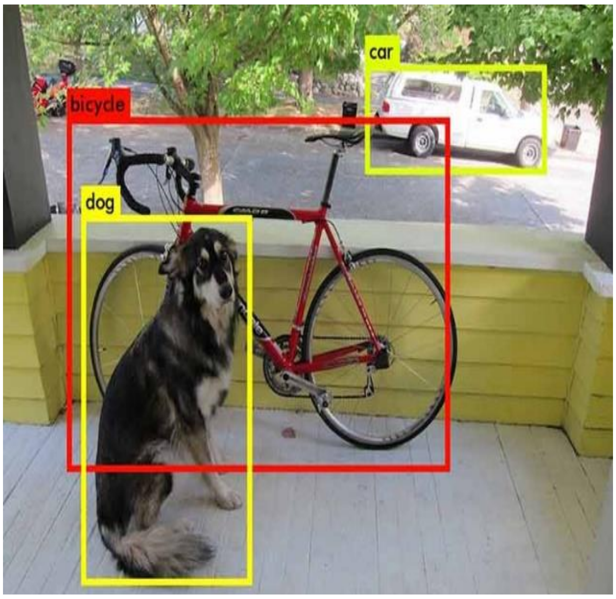

Fig 9. Object Detection

Object detection is the task of detecting the instances of objects of a certain class. There are many Object detection algorithms, You Only Look Once (YOLO) is one of them. YOLO uses CNN in the backend and learns from the annotated images.

5. You Only Look Once (YOLO):
"You Only Look Once" (YOLO) is one of the most popular object detection algorithms used for real-time object detection tasks. YOLO has been widely used since its first release.

1. Previous YOLO Versions

1. YOLOv1:
YOLOv1 was first introduced in May 2016 by Joseph Redmon with paper [4]. This was one of the biggest evolutions in object detection.

2. YOLOv2:
In December 2017, JosephRedmon introduced another version of YOLO with paper [5] and it was known as YOLO 9000

3. YOLOv3:
After a year release of YOLOv2 in April 2018, the most stable version of YOLO was introduced and it was released with paper YOLOv3 [6]

4. YOLOv4:
Finally, in April 2020, Alexey Bochkovskiy introduced YOLOv4 with paper [7]. YOLOv4 was introduced with some amazing new features, it outperformed the previous version YOLOv3 with a high margin and also has a significant amount of average precision when compared to EfficientDet Family.

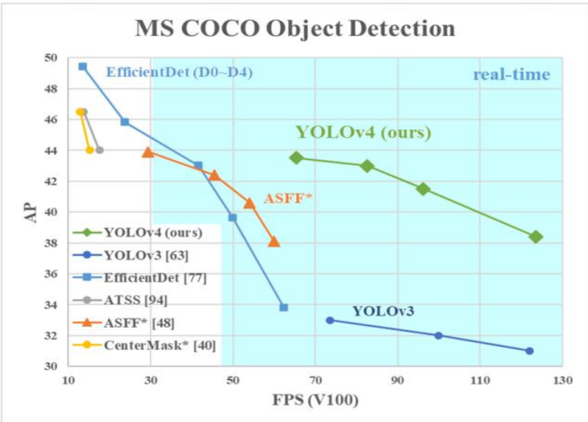

Fig 10. YOLOv4 Improvements

IV. YOLOV4 WORKING

YOLO takes an entire image in a single shot and predicts the bounding box coordinates and class probabilities for these boxes. The Biggest advantage of YOLO is its lightning speed of execution. It's incredibly fast in execution and can process up to 45 frames per second.

YOLO also understands generalized object representation. The network does not look at the entire image, only at the parts of the images which have a higher chance (probabilities) of containing an object.

YOLO first takes input images and then divides the images into grides.

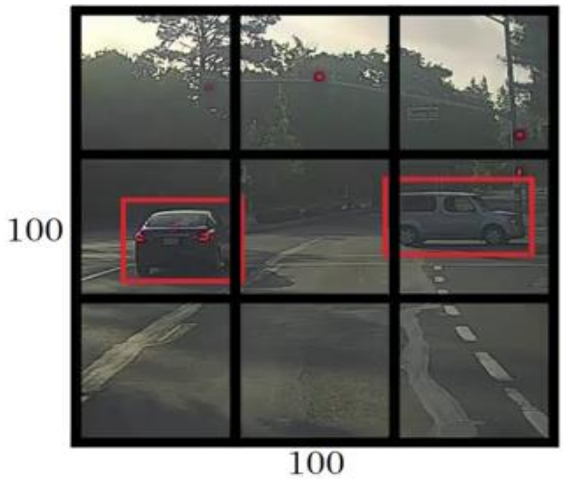

Fig 11. Image Divided into grides

For each box, it checks whether an image is present or not. It calculatesthe following:

1. X – Coordinate of the bounding box center inside the cell (0;1with respect to grid cell size)
2. Y – Coordinate of the bounding box center inside the cell (0; 1with respect to grid cell size)
3. W – Bounding box width [0;1] with respect to the image.
4. H – Bounding box height [0;1] with respect to the image.
5. C – Bounding box confidence(object in the box)

PC
C1
C2
C3
X
Y
W
H

PC represents whether an object present in the grid or not (Probability)

X, Y, H, andW represents the bounding box of an object
C1, C2, and C3 represent the class of objects say car, bike, bus, etc
If PC = 0 then C1, C2, C2 = 0
If PC = 1 it tries to find the centre of the object available.
If it finds multiple bounding boxes it uses Intersection Over Union (IOU) to find the best bounding box.

$$\mathbf{IOU} = \frac{\textbf{Intersection region}}{\mathit{Totalareaoftheboxes}} \textbf{(1)}$$

If IOU > 0.5 then it takes the highest probability.

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Once we get the best bounding box of which object exits it uses CNN to classify the images.
This is the basic working of YOLOv3.

Most people and Scientists in the field today use YOLOv3, which is already producing excellent results. YOLOv4 has improved again in terms of accuracy and speed (Frame Per Second), the two metrics we generally use to evaluate an object detection algorithm.

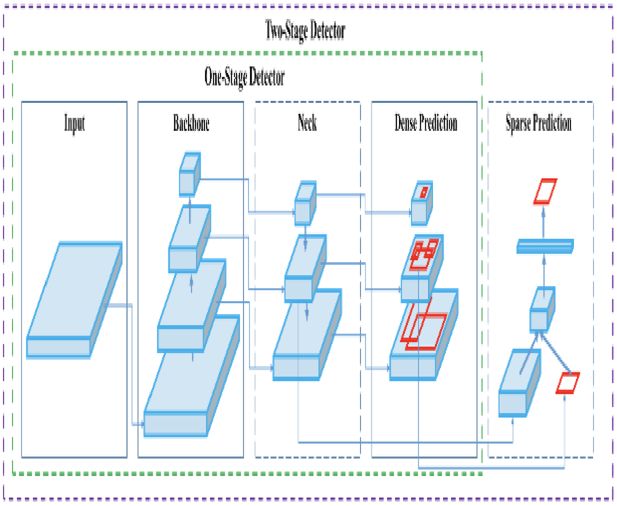

Fig12.YOLOv4 Architecture.

In YOLOv4 we have 3main blocks after the input image is processed:

- Backbone
- Neck
- Head(Dense Prediction)

	Type	Filters	Size	Output
	Convolutional	32	3 x 3	256 x 256
	Convolutional	64	3 x 3 / 2	128 x 128
	Convolutional	32	1 x 1	
1x	Convolutional	64	3 x 3	
	Residual			128 x 128
	Convolutional	128	3 x 3 / 2	64 x 64
	Convolutional	64	1 x 1	
2x	Convolutional	128	3 x 3	
	Residual			64 x 64
	Convolutional	256	3 x 3 / 2	32 x 32
	Convolutional	128	1 x 1	
8x	Convolutional	256	3 x 3	
	Residual			32 x 32
	Convolutional	512	3 x 3 / 2	16 x 16
	Convolutional	256	1 x 1	
8x	Convolutional	512	3 x 3	
	Residual			16 x 16
	Convolutional	1024	3 x 3 / 2	8 x 8
	Convolutional	512	1 x 1	
4x	Convolutional	1024	3 x 3	
	Residual			8 x 8
	Avgpool		Global	
	Connected		1000	
	Softmax			

Fig13.YOLOv4 Backbone Darknet-53

1. Backbone:

Backbone here refers to the feature-extraction-architecture. Here the backbone can be EfficientNet, ResNeXt,ResNet, Darknet53,SpineNet, or VGG. In the official YOLOv4 paper they have used CSPDarknet53 architecture.

2. Neck:

The main purpose of the neck block is to add extra layers between the backbone and the head (dense prediction) block.

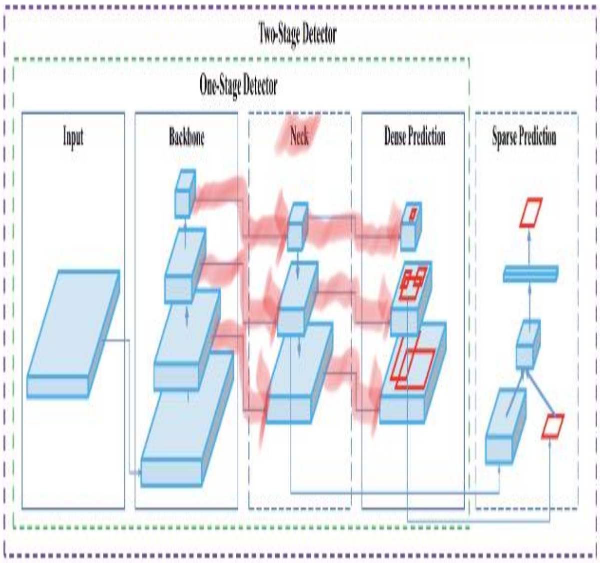

Fig 14.Different feature maps used in YOLOv4.

3. Head (Dense Prediction):

The head block has two parts:

- Locate bounding boxes.
- Classify the image inside each box.

This process isthe same ashow YOLOv3 works. The network detects (x, y, w, h) and a confidence score for a class.

V. PROPOSED MODEL

In our proposed model we aim to identify the bacterially infected part of the leaf. If there is any infected part, we identify it by putting a bounding box on it with the disease name.We have annotated the images using an online tool and we have trained the YOLOv4 for about 6000 to 10000 epochs for 1000 images per class.We have trained with 14 different varieties of the crops and their diseases with YOLOv4. If the model identifies the diseases and bacterial infected part, the model will suggest some of the fertilizers which can be used to improve the quality of the crops and hence increase yield.

If there is no bacterial infected part then the same model will put a bounding box saying it's healthy.We can use this model on live cameras and able to get some recommendations regarding crop disease and fertilizers to improve the quality of the crops.

It is often very difficult to identify the type of crop disease by looking at the leaf. And we have to be very careful in identifying the type of fertilizers for each crop. Using suitable fertilizers for the crops helps farmers to get a good yield for the year.

VI. EXPERIMENTAL RESULTS

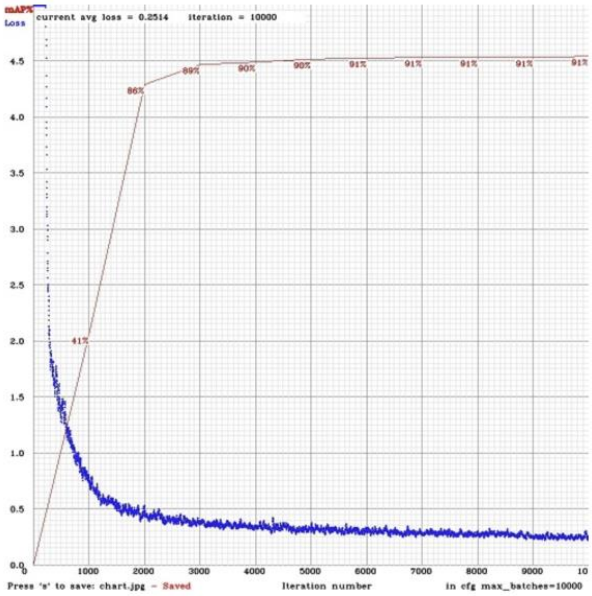

Fig 15.Training plots

Fig 15 shows the training graphs which was plotted during model training. It is a graph between Loss vs Epochs. Here the model is trained around 10000 epochs.

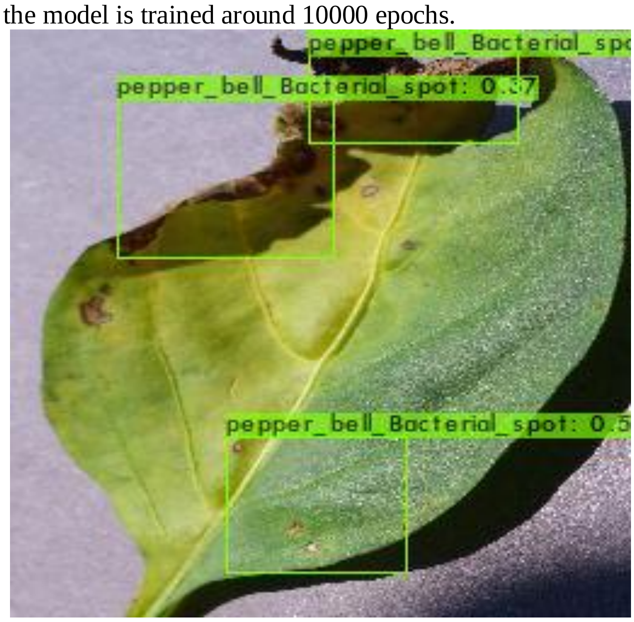

Fig 16. Model Prediction – Infected Spot.

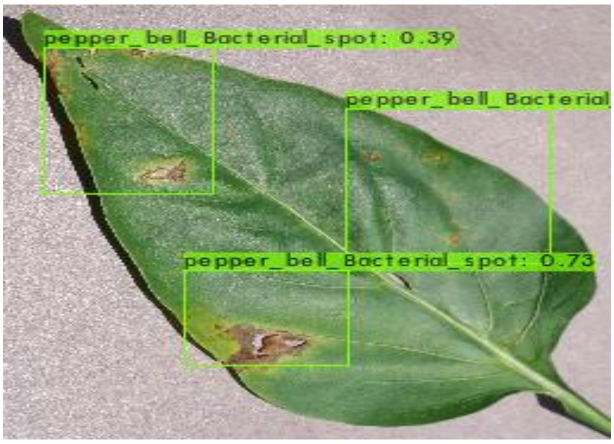

Fig 17. Model Prediction – Multiple Infected Spots.

We can see our proposed model identified multiple bacterial infected spots. The model has trained about 10000 epochs and we got amazing results on test data. Upon increasing the number of images per class and epochsthese results can be still improved with better bounding box confidence. Once we get this output from the model with the bounding box and its crop type, we can able to suggest some fertilizers which can be used to overcome the infection.

Fig 18. Model Prediction – Pepper Bell Healthy.

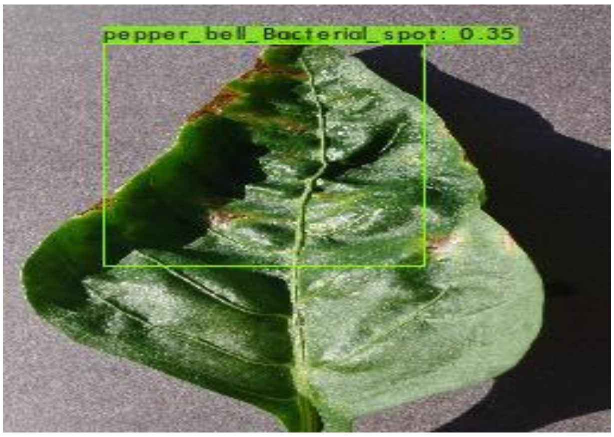

Fig 19. Model Prediction – Infected Spot.

Fig 20. Model Prediction – Pepper Bell Healthy.

VII. CONCLUSION

YOLOv4 an object detection algorithm was used to identify whether the plant is healthy or infected by any diseases, suppose the plant is affected then the model will identify what kind of disease that the plant is affected and our application will recommend the farmers which pesticides to be sprayed or recommends feasible solution in recovering from that disease. This helps farmers in increasing the production of the crop and decreases the labour force which helps to get better profit in the market.

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