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Identification of Weeds using HSV Color Spaces and Labelling with Machine Learning Algorithms

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***Abstract:** The goal of this project is to detect the weeds in the farmland, for proper distribution of sparing of herbicides in the farm. The crops are separated from the weeds with their color and feature of their appearance. In that cases the features of the weeds are extracted with HSV color space method, it produces higher accuracy comparing to RGB color space model. The extracted feature is compared with the trained data in Neural Networks for more accurate results comparing to SVM or BP methods. NN is used to divide the images into pixel for more accurate value. It can produce maximum of 95% accuracy comparing to other methods.*

***Keyword:** Weed identification, HSV, Feature Extraction, CNN, Image Separation.*

I. INTRODUCTION

Growth of weeds is the major problem in production of crops. Weeds possess the feature of higher growth rate comparing to crops. It absorbs the ability of growth and strength from crops, which lead to fall in the rate of production of crops and it also reduces the speed of growth in crops. Weed has the feature of higher growth rate, consumes larger amount of water and fertilizer. Weeds are highly harmful for growth and production of crops. To reduce the growth of weeds that grows in-between crops herbicides is used. Without knowing the specific location of weeds herbicides are sprayed all over the farmland, this type of spraying of herbicides in the fields also affect the crops and also cause wastage of herbicides. the yielding od crops requires more time in order to eliminate the weeds from the land and then cultivate the crops.

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This process of feature is extraction is done by identifying the luminance information from the plants with the help of *HSV* color space in this *H* denotes hue, *S* denotes saturation and *V* denotes values. This process of extraction with HSV color space is done by computer vision method. In other words computer vision is used to get deeper understanding about digital data. After the extraction of features of images, the collected n number of data which is imported in the get data to make the images into vectors which makes the process of identification easy. For this method of identification the collected datasets are trained in Neural Network (NN) which is built. The process of identification of objects in NN is identical to the biological nervous system. Main objective of neural networks is to make the computer to function and identify the objects same as the human brain does. ANN Artificial Neural Network functions similar to human brain as it learn the data through examples which is used to train the data. There are many specific uses of ANN like pattern recognition. It can be also said as data classification which can be achieved through learning process. NN is used detect the data by extracting the patterns. The advantages of NN are adaptive learning, self-organization, real time operation and fault tolerance via redundant information coding. CNN Convolutional Neural Network is used for recognition of weed in the farm land, to train the neural network sufficient data is feed into the system for training. By this process the images are separated and the feature of the image is extracted to identify the percentage of weeds in the farmland.

II. METHODS

A. Case study

The process weed identification is done because of growth of weed reduce the rate of harvesting the farms. Large numbers of labours are required to identify the weeds apart from plants and to separate them. Instead the herbicides are used it reduces the number of labours but the herbicides are used in large amount since the specific location of weeds are unknown. In this process the weed are segmented from the crops with the help of Images pre-processing methods and it is identified by extracting the feature, then comparing it to the training data set in a neural network.

B. Test cases and outcomes

All the images of specific weed and also the images of crop which is cultivated in the land are collected and stored in a specific location. The data collected used to train the neural network in which the features of the weed and plants are extracted so the when the sample image of the field is feed in the system the information in the image is segmented and identified the feature of object in it.

Now the extracted feature is compared with the data from the data set and so the weed and crop in the image is separately labelled.**[1]** This process of feature extraction and data identification is done by the machine learning process. Neural network is built and collected data sets are trained in the network for the identification. the pathway for weed identification using machine learning procedures is shown in **Fig. 1**.

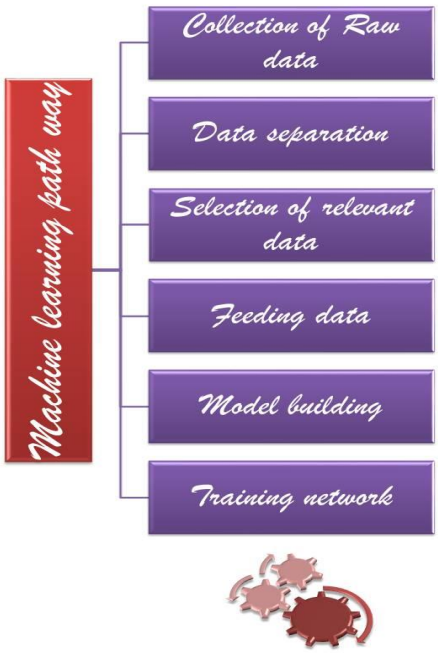

Fig.1. Machine learning procedure for detection

C. Machine learning process

The main objective of this project is to identify the weeds with maximum accuracy using machine learning techniques. The machine learning techniques are classified into three parts: 1. Pre-processing of data: collection of the test image and segmenting it for extraction of feature in the image, 2. Selection of data: selection of similar images of weeds that needed to be detected is feed in the network for training, 3. Building network: Convolutional Neural network CNN is built to provide maximum amount of accuracy in weed detection.

1. Pre-processing of Data

Since there are many objects present in the images other than weed, to train the network to precisely detect only weed the collected data for training are cleaned. The input image feature is also extracted with the help of HSV color spaces method and thresholding process by using computer vision system in python as shown in **Fig. 2** to get complete accuracy in thresholding dilation and distance transformation methods are used.**[2]**Since the features of the images are extracted accurately with the help of thresholding process it makes machine learning algorithm to detect the weed with more accuracy and less time complexity.

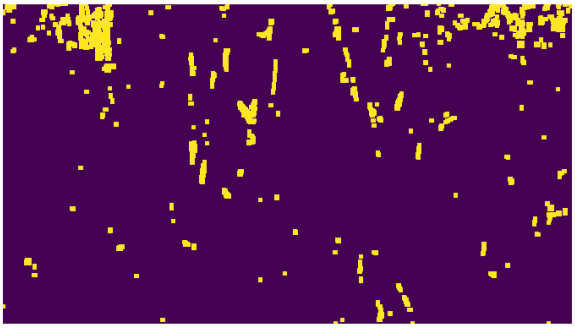

Fig. 2. Identification of weeds precisely for comparison

2. Selection of data

Specific data of weed must be collected according to the farmland and weeds grown and the additional unwanted information should be removed with the with help of data pre-processing methods and the extracted data of the weeds should be selected specifically and collected and saved in a location of training the networkfor identification of weeds **Fig. 3**.it shows the collection of data.**[3]**

Fig. 3. Collection of specifically selected data of weeds

3. Building network

After the collection of accurate datasets of weeds, these data of the images will allow us to build the CNN Convolutional Neural Networks to for training of data. To give more accuracy large numbers of datasets are provided into the network. This neural network is built with the help of Keras and Python. Firstly image classifiers should be built with the help of Convolutional Neural Network and Keras in Python with deep learning concepts.

Image classification follows five steps: convolution, activation, pooling, flatten and dense. Convolution layer of 3x3 is built along with 32 convolutional filters.**[5]**Relu function is used for activation which is used after 2x2 pooling with both direction of x and y. The sets of layers of network follows CONV2D ->RELU -> MAXPOOLING. The remaining sets also follow the same process for creating multiple layers for more accuracy or iteration for more precise image classification it can be also called as Epoch.

The output is finally processed in flatten and dense layers, the final data after pooling is flatten into a single vector.

Dense is used for yielding probability of features of each class after the construction of the network the model is return as a model file as .json for training of the data sets for prediction and the weights are saved for future prediction of data.

Building of network and the process of prediction and functioning architecture is shown in **Fig. 4**.

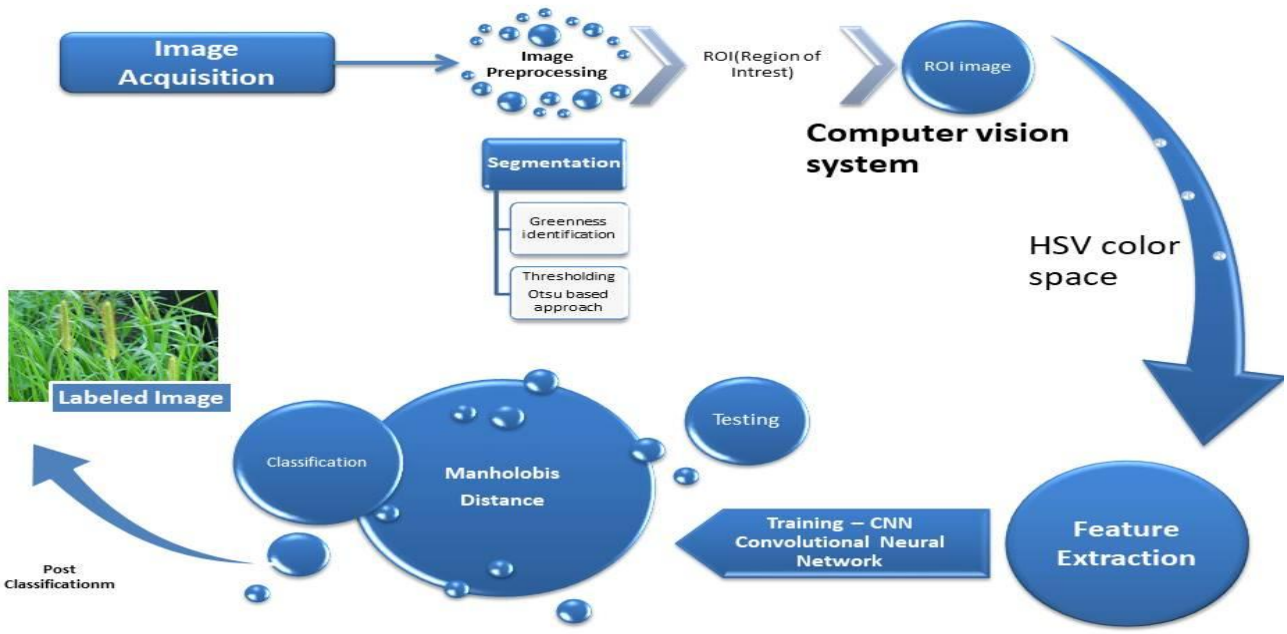

Fig. 4.Functioning Architecture for prediction of data.

D. Model Assessment

Kearas is a feature used in machine learning whioch allows to save the model the saved model can be used for feature prediction. The models are saved as JSON file and the weight of the model is saved as H5 file. The wights are saved for adding more number of additional data in future cases or during the identification of any other weeds.**[5]** Large number of datasets results in higher accuracy which provides accurate prediction of weeds in the farmland. The **Table 1**represents the data of positive and negative present in the confusion matrix which represents the calculation of accuracy, sensitivity and specificity.

Table 1
Confusion matrix

	Positive	Negative
True	TP	TN
False	FP	FN

Accuracy:The model is divided and the patches are reduced in training the data to provide more accuracy, dimension reduction of every image is done with the help of neural network build to specify the accurate data.

Accuracy of model

$$A = \frac{TP+TN}{TP+FP+TN+FN}$$

Sensitivity: The built neural network allows to select the specific patches which classifies the feature of weeds in the data.

$$S= \frac{TP}{TP+FN}$$

Specificity:The trained data also allows identifying the weed precisely in any angle or degree in the image. It segments the image into several patches andidentify the specific location of the weed and excludes the other data irrelevant to the image.

$$SP= \frac{TN}{TN+FP}$$

III. RESULTS

A. Healthy Cultivation

The main objective of this project is to provide healthy cultivation by identifying the weeds in the farm land. The growth of weeds in the farms results reduction in harvesting of crops. To reduces the growth of and optimize the time and labours used in identification weeds this application can be used therefore the weeds can be specifically identified. This results in increase in production and rate of harvesting of healthy crops.

B. Training

If the classification is done between two objects therefore binary cross entropy function in machine learning is applied in the model, it is also called as loss function. But in our case we are performing comparison and training between more than two classes so to swap out the loss categorical cross entropy is used. The training of network is initiated in model fit generator which generates the saved weights of the model. It also supplies data augmentation of the object and number of epochs needed to be performed for better accuracy. As shown in **Table 2**the network is trained for 25 epochs and the maximum accuracy is achieved (99.21%) and this network is efficient that results in optimization of time.

Table 2

Describes the process of epochs and calculation results of accuracy and loss

Epoch	Loss	Accuracy	Val - Loss	Val - Accuracy	Time take (s)
1	0.3467	0.849	0.1533	0.9515	89
2	0.1704	0.941	0.077	0.9744	75
3	0.13	0.9552	0.1168	0.9559	77
4	0.1063	0.9657	0.0735	0.9736	77
5	0.0871	0.9697	0.0719	0.9815	77
6	0.0846	0.9736	0.0347	0.9868	74
7	0.0752	0.9751	0.1023	0.9665	73
8	0.0687	0.9801	0.0263	0.9868	75
9	0.0566	0.9832	0.0919	0.9639	72
10	0.0575	0.9818	0.0325	0.9859	73
11	0.0571	0.983	0.0316	0.9921	75
12	0.0564	0.9855	0.0357	0.9885	72
13	0.049	0.9867	0.0379	0.9894	73
14	0.0534	0.9851	0.0745	0.9815	74
15	0.0474	0.987	0.0255	0.9921	78
16	0.0577	0.9846	0.0283	0.9894	75
17	0.05	0.9861	0.0266	0.9938	74
18	0.0506	0.9867	0.0279	0.9894	73
19	0.0443	0.9875	0.0247	0.9921	73
20	0.0378	0.9892	0.1307	0.9674	73
21	0.0429	0.9884	0.0217	0.993	73
22	0.0423	0.9881	0.0634	0.9877	74
23	0.0387	0.9894	0.0239	0.9894	72
24	0.0432	0.9885	0.0642	0.9868	73
25	0.0441	0.9884	0.0364	0.9921	72

C. Prediction

The test images are used as input and it is imported from the specified location and the images are read by a get_img function that classifies the images into several pixels and compares the pixel with the imported weights of the model. The comparison of the image is done after converting the image into an array so that the unused information can be omitted. After the classification of the image, the test image is predicted whether it is the specified weed or the plant in particular farmland. The weed is denoted ass axis 0 and the plant is denoted as axis 1 so that it helps in specific prediction.

Then the original image is read for the labeling process with the help of the computer vision system. Firstly the thresholding process is done to absorb only the luminous information form the image of a grey scale.**[13]** This process of extraction of data is done with the help of HSV color space modeling.**[2]** Morphology method is used after thresholding for accurate data separation and it is followed by the distance transformation method that calculated the distance from one part of the information to another for good label of an image after prediction.**[7]**

The pre-processed test image is read with the computer vision system and labeling of an image is done with the help of skilearn function. It reads the information needed to be labeled from the image and plotting process of an image is performed according to the dimensions provided. The data region needed to be labeled with mpatch function in skilearn and it follows by drawing a rectangular mark which marks the extracted information after processing.

This method is repeated for several iterations in a loop until all the information has been marked.**[8]** Then finally the labelled image is plotted. The resultant image after prediction is shown in **Fig. 5**.

To attain more accurate prediction we can take selective patches where the required data is located in the image. The image classifier acts as an intermediate to separate if the patch has actual background. This automatically decreases the size off patches as it matches the model and weights stored from training the model. As you can see there will be multiple bounding boxes of the same object which gives the complete marking of the weed any box can be chosen for identification of weed precisely. This method is developed in this script to evaluate the performance of the model using IOU, it is defined as intersection over union.

$$\text{IOU} = \frac{Area\ of\ Overlap}{Area\ of\ Union}$$

This intersection over union method labels and predicts the data in a different way by using the bounding boxes.**[5]** If single box is used for denoting the information then it is considered to be excellent prediction where as if there is any overlapping of boxes the amount of area in intersection of boxes defines the percentage of prediction.

Fig. 5.Prediction and labeling of weeds in the farm land

IV. RESULT DISCUSSION

In our model three layer of CNN is created each layer segments the image pixel by pixel so that accurate information of training data is obtained and collected for future prediction. Each layer of CNN will learn 32 filters which are provided CNN algorithms to extract the data from the image. As an activation function RELU is used, it can be also defined as Rectified Linear Unit which activates the CNN and separates the unwanted data from the training images and makes the specific information available for training. The extracted images are saved as model and the model weight is saved as H5 file.

After training the data models are loaded and saved as weights which has the information about the trained images and the features of the data is stored in a checkpoint. During the time of prediction the data is collected from the logs and Tensorflow is used in backend for image classification resulting in better accuracy. Image Data Generator, it is the function in keras pre-processing of image that helps in image classification and removes the unwanted information from the training data. After obtaining specific information the trained network is ready for comparison now the data is saved as a log which makes the process of prediction easier.

The result of this project shows that CNN Convolutional Neural Network can be used for prediction of desired data with much higher accuracy comparing to any other methods or other neural networks such as ANN. ANN Artificial Neural Network can be also used for object detection but it results in less accuracy. This method results in decrease in loss percentage and increase in accuracy as shown in **Fig. 6** and **Fig. 7**.

The accuracy of the diction can be increased by providing large number of data providing similar information which is needed for comparison and detection of specific information with minute changes in the data that is fed into the network. These data are helpful in training the Convolutional Neural Network more efficiently. Many number of Convolutional Neural Network layers are created for accurate extraction and training of the data provided.
Number of times epoch is performed it results increase inaccuracy and decrease in loss percentage as shown in **Fig. 6**and **Fig. 7**referring **Table 2**.

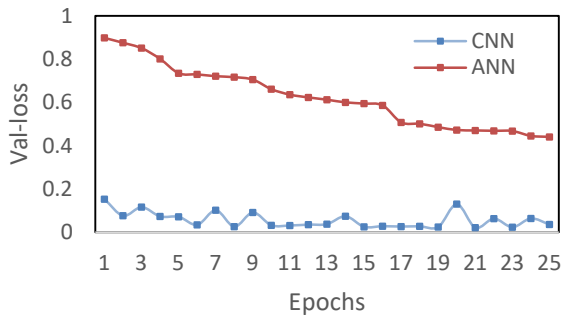

Fig. 6. Value Loss, decrease in loss percentage

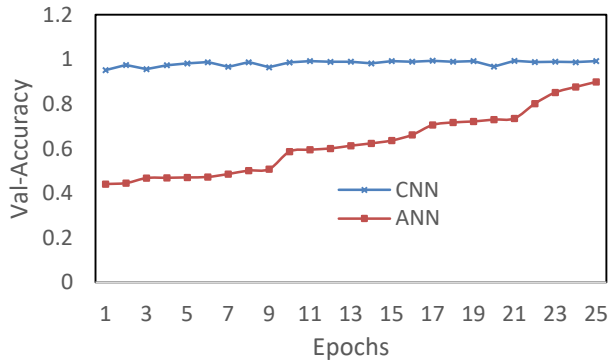

Fig. 7. Value Accuracy, Increase in accuracy percentage

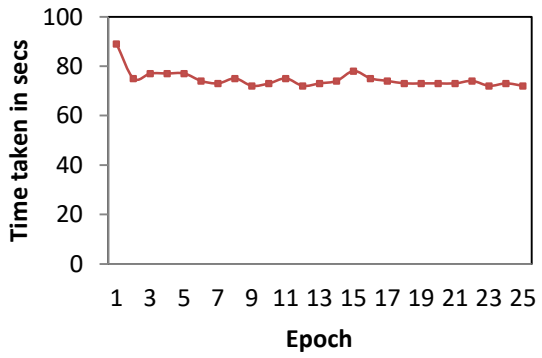

Fig. 8. Optimisation in Time

Our model which optimises the time comparing to other models, as the number of cycles performed by epoch increases gradually time complexity is decreased comparing to first epoch and last epoch.**[10]** Decrease in time taken for compiling is shown in **Fig. 8**.Therfore, this training methodology given higher accuracy and optimizes the time and reduces the loss which makes the model more efficient .

V. CONCLUSION

Various forms of CNN models are tested using number of filters, optimization and with or without augmentation. Pre-trained model is also used comparing to the CNN model used for detection where the pre-trained model shows lower accuracy than the built model. The only disadvantage in using CNN model is time complexity. On the training it consumes more computational time whereas final output is processed with higher accuracy with increase in number of epoch,it also optimises the time of prediction. This method of prediction of weeds provides increase in rate of harvesting and reduction in the amount of herbicides used. That reduces the over usage of herbicides in plants that causes increase in production.

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