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Research Article

A Survey on Weed Detection System Using Deep Learning

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Abstract

In agriculture, weed is the major component in the field that affects crop production and crop quality. Therefore, it is essential to detect and classify weed in the field at its early growth stage. To avoid weed growth in the field farmers follow conventional techniques such as cultural, biological, and mechanical methods. Later on, as the technology has been improved the farmers started using chemical substances such as herbicides and pesticides to avoid weed growth and pests in the field. Farmers spray herbicides uniformly throughout the field which will also be sprinkled on the crops and the chemicals in the herbicides causes an effect on crop growth, crop quality, and crop production. The chemical substances that are present in herbicides are causing harm to crops so it's necessary to spray herbicides specifically only on weeds and it results in achieving site-specific weed management. This paper focuses on the deep learning techniques which are used for a weed detection system that achieve site-specific weed management..

Keywords: weed detection system, site-specific weed management, deep learning

1. Introduction

Weed is a wild plant that grows between crops in the field and it competes with the crop for its survival. Weed absorbs water, sunlight, mineral, and nutrients that are provided for crop and it also occupies the space that is allotted for crop yield due to these reasons the crop growth in the field is affected. Weed causes major loss to farmers as it reduces crop growth, crop quality, crop production, and land value. To maintain the weeds in the field farmers spray herbicides uniformly throughout the field which costs high for farmers just to control the weed in the field. Site-specific weed management is a technique of precision agriculture that uses information technology to develop a weed detection system that detects and classifies weed in the field specifically and it helps to spray herbicide only on weeds which results in less usage of herbicides in agriculture.

The weed detection system can be a drone, computer vision system, robot, and image recognition system. Nowadays the deep learning technologies are being applied for face recognition, natural language processing, object detection, image classification, sentimental analysis, and automatic self-driving cars therefore we can utilize the deep learning technique efficiently to develop a weed detection system. The convolution neural network (CNN) is a deep learning method that is widely used in image classification and object detection therefore we can implement this method to develop a weed detection system. The deep learning methods consists of a neural network with hidden layers so that it can extract and learn features automatically. In agriculture, the usage of technology is less compared to other fields in the world and agriculture is the main factor for human survival thus by considering these reasons we can start experimenting with the technology in the agriculture field.

This paper focuses on a survey of the weed detection system using deep learning techniques. In agriculture, there is a huge diversity of crops grown in the field, and based on the soil quality different kinds of weed growth are found in the field. Initially, it is necessary to obtain what kind of crops and weeds are growing in the field, and based on the information that was acquired we have to extract the data to train the model.

2 Methods to Implement Weed Detection System

The methods that we have to follow to develop a weed detection system are as follows:

2.1 Image Acquisition:

The image dataset has to be prepared either by downloading the dataset online or else they can manually capture the images using a camera in the field. The dataset must be acquired by considering what kind of crop and weed they want to develop a weed detection system. The image in the dataset has to be in JPG format and the images have to be in RGB color format as it consists of high-resolution it will be efficient to classify.

2.2 Pre-Processing

The obtained images might be affected with various factors such as noise, light variation, low resolution and there can be an unwanted background in the image whereas all these factors reduce the quality of the image therefore we have to pre-process all these images before they are being passed to train the model. There are certain image pre-processing tools utilized to pre-process the images as per our requirement. The pre-processed images enhance the image for better feature extraction. In the pre-processing step, we can convert the RGB image to a Grayscale image as it consists of one dimension it will be efficient to process the image for feature extraction. The images in the dataset have to be resized as per our model specification and there are some filters and pre-processing methods used to eliminate the noise in the images. The low pass and high pass filters are used to eliminate unwanted signals in the original image and they are also applied to remove unwanted objects in the background.

2.3 Feature Extraction:

After pre-processing the data, we have to apply a feature extraction technique to obtain features from the images. The color, shape, size, texture, and edges in the image are said to be some of the features in the image. The feature extraction technique provides a set of features as an outcome that helps the model to analyze and classify efficiently. Principal component analysis can be applied to reduce the dimension of the feature set and it results in a minimum number of the feature set that has high probability features.

2.4 Classification:

The classification techniques are applied to classify weed and crop. The feature vector that was obtained from the feature extraction technique is passed as input to the classifier to train the model. The classification model should be trained, tested, and validated using the pre-processed data to obtain the best accuracy. Some of the classification techniques are the artificial neural network, probabilistic neural network, convolution neural network, genetic algorithm, and clustering.

3 Literature Survey

The researchers developed a weed detection system by following the above-mentioned methods. The weed detection systems were mostly developed to achieve site-specific weed management and to reduce the impact of weed on the crop. Here are some of the recent techniques that are used to develop a weed detection system.

In [1] the author developed a machine-learning algorithm to classify three kinds of weed and maize crops in the field. The images are captured in the plant laboratory of the institute for agriculture and fisheries research using hyperspectral and NIR cameras. The three weeds mentioned in that paper are arvensis, mays, and rumex also the crop is maize. The images are pre-processed by composing the raw image to 5×5 single-band sub-images and these images are cropped further to calculate the region of interest to obtain the reflectance calibration. They applied PCA to reduce the dimension of the feature vector and to compress the data. The random forest algorithm is used to classify weeds and crops. The random forest algorithm provides valuable information that is used to estimate the importance of features that were permuted. The confusion matrix is referred to evaluate the performance of the classification model. The precision of maize is 94% and the classification accuracy they obtained for three weeds is 0.785, 0.663, and 0.713 respectively. The results define that the crops are been classified better than the weeds as the classifier is confusing among the three weeds. The author suggested a random forest algorithm for classification only if the data distribution is weak and unfamiliar.

In [2] the author demonstrated how a convolution neural network works efficiently in a weed detection task without pre-processing the data. They generated an image dataset that consists of 38 images with labeled patches and there are 45600 labeled patches present in the dataset but due to the limitation of experiment hardware they randomly choose 5000 patches for training and validation. The training set consists of 3000 patches, the validation set consists of 600 patches and the remaining patches are utilized for testing. To normalize the images, they converted the images from RGB space to HSV space in the pre-processing step. They choose the AlexNet model for classification and CNN in the model consist of three convolution layers followed by max-pooling layers, and three fully-connected layers with a final SoftMax layer. To train the model parameter they applied the SGD optimizer and the categorical cross-entropy loss function is used for optimization detection. The model took 40 hours for training and finally it generated two models where one model is trained with its original images and the other model was trained with color normalized image data. Finally, the accuracy for both the models is the same and there is only a 0.2% slight variation in the validation score which doesn't cause any difference in model classification result. As future work, they suggested to perform the task with a greater number of patches using GPU systems as its computing ability is high compared to CPU systems.

In [3] the author presented a weed detection system that classifies crops and weeds using a pixel-based approach when there are occlusion and overlapping of plants. He wants to implement a weed detection system to reduce and avoid the use of herbicides in the field. The dataset consists of sugar beet and carrot images in RGB format and the sugar beet images are captured under natural light using JAI 130-GE camera. The random forest algorithm is used to classify the plant type and the algorithm is been constructed with 10 decision trees. The performance of random forest is tested by computing-fold cross-validation and to ensure better results of the classification model they also evaluated accuracy, precision, and recall values. The author concluded that the attribute profile can be applied to obtain more complex variants which will improve the pixel-based classification. For further improvement, they suggested combining pixel-based and region-based morphological for segmentation and classification of weed and crop.

In [4] author combined two methods to extract robust features that result in stable identification. They took soybean seedings and its weeds for their research. The author wants to extract features initially using feature learning methods because the features which were extracted manually resulted in unstable identification and the quality of features are weak. The weed identification model was built by combining the K-means feature learning algorithm with CNN. The dataset was prepared manually using Canon EOS 70D camera and they captured Soybean fields on the North campus of Northwest agriculture and forest University. In the pre-processing step, they performed data standardization and data whitening steps to extract high-quality data for the feature learning algorithm. The K-means clustering method is used to categorize the data objects based on the nearest data points. The usage of K-means enables the classification model to learn features easily and it lets the model train fast. The CNN consists of five convolution layers, four down sampling layers, and one fully connected layer. Finally, the model consists of four lakh parameters. The model achieved 92.89% accuracy using K-means as a pre-training method which is higher than the random initialization method.

In [5] author evaluated two methods based on shape feature to build weed detection system because it's a challenging task for a robot to classify weed among crop as the similarity between crop and weed features are high. In that paper, they tried to implement a weed detection system based on the pattern feature using SVM and ANN. The dataset is acquired manually by capturing sugar beet fields at Shiraz University. To obtain the shape characteristics of weed they captured the images at the four-leaf stage of weed growth and the resolution of the captured images is 960 × 1280 pixels. The dataset consists of 600 images where each set has 120 images and the captured images are in RGB format. In the pre-processing step, the images are processed to detect greenness in the images, and later on, the RGB images in the dataset are converted to the Greyscale image to extract features. To classify plants, they applied and evaluated two methods SVM and ANN. The artificial neural network is a feed-forward network that has hidden layers and to transfer the data in hidden layers they applied tangent sigmoid and logarithm sigmoid functions. In ANN they included texture features for the discrimination process and PCA is used to reduce the dimensions of input data. The support vector machine is used to classify plant type and the accuracy of SVM is evaluated based on R^2 and RMSE values. To evaluate the performance of ANN they computed the confusion matrix. The accuracy achieved by ANN and SVM is 86% and 88% respectively. The conclusion states that the support vector machine classifies better than ANN when the model is trained with a shape feature.

In [6] the author analyzed weed detection systems based on spectral bands and spatial resolution for weed detection and classification as it's a crucial step in agriculture to achieve area-specific weed control. The main motive of the author is to reduce the usage of herbicides in the field as it harms human health and crops. The performance of weed detection is estimated by comparing and evaluating CNN and HOG. The hyperspectral images were used to analyze the spectral bands and spatial resolution for weed classification. The deep learning method convolution neural network can extract features automatically it will learn high-level features efficiently using hyperspectral images. The images in the dataset are captured using JAI BM-141 camera by applying a brimrose VA210 filter. The hyperspectral data contains images of hyme, Alli, azol, and hyac weed. In the pre-processing step, they applied a data augmentation method to generate 200 image patches of each weed category to analyze the hyperspectral image with spatial resolution. The weed classification is analyzed based on two ways: 1) based on sensitivity to the number of bands with batch size and 2) sensitivity to the resolution with patches. The convolution neural network is used to analyze the sensitivity to the number of bands and sensitive to the special resolution with patch size. The HOG method extracts shape features that are illumination invariant and due to this reason, the author used HOG to compare with the results of the convolution neural network. The overall result concludes that CNN is efficient than HOG in classifying weeds while using a patch-based method.

In [7] the author developed a weed detection system to support smart farming and to reduce the damage of crops caused by the use of herbicides in the field. To build a weed detection system they collected the dataset manually in the agriculture fields and those images are passed as input to SegNet neural network to train the model. The image dataset consists of multispectral images that result in accurate classification of crop and weed.

In [8] author experimented with CNN to build an automated weed detection system as weed is affecting crop production. To perform this experiment, they collected the image dataset from Indian Agriculture Research Institute (IARI) and the dataset consists of Phalaris minor, Dactyloctenium aegyptium, Digera arvensis, Echinochloa colona weed images. The images after pre-processing were passed to CNN to train the model and it provided accuracy of 95%, 65%, 61%, 54% respectively. To obtain better performance and to learn the parameters of the model they applied the transfer learning method.

In [9] author developed an automatic weed detection system using the Raspberry Pi system which can capture the field using a camera and it performs morphological thresholding, erosion, and dilation methods to detect weeds in the images. The system has a spraying mechanism that will be activated when the model detects weed in the image and the system starts splashing herbicides specifically only on the weed. The dataset contains images of the ragi plant and its weeds. The built model can detect the weed and spray herbicide within 4 seconds.

In [10] the author has described an image processing technique to detect weed in the image as weed is affecting the growth of the agriculture field which is the backbone of the Indian economy. They used the Raspberry Pi system to capture the images in the field and it processes the image for weed classification. The model performs an erosion and dilation approach to detect weeds and after detecting weeds the model sends a signal to the system to remove weeds from the field whereas the system is been attached with a cutter to remove weeds efficiently in the field. The advantage of this model is it reduces human work and removes weed directly from the soil instead of spraying herbicides as it affects the crop health.

In [11] the author used CNN to build a weed detection system that can extract features automatically. The system aims to detect weeds and to classify plant diseases. The images to train the model were downloaded from the internet and pre-processed using the data augmentation technique. The building model results in efficient weed detection and plant diseases classification.

In [12] author want to implement an automated weed detection system to reduce human workload and to improve crop quality. The dataset consists of two classes one is crop and the other is crop weed. The data augmentation method is used to pre-process the image and these images are passed as input to CNN to build an automated weed detection system. Finally, the model with pre-processed data achieved 95.45% training accuracy.

In [13] the author's objective is to propose a weed detection system using machine learning algorithms. The classifiers such as CNN, SVM, and ANN are used to analyze the performance of weed detection system. The model is been trained with shape features of crop and weed. The results state that CNN performs better than ANN and SVM.

In [14] the author has done research using precision agriculture tools to manage crops and weeds in the field. Image processing techniques are applied to classify crops and weeds. The medium and morphological filters are applied in the pre-processing step to avoid background such as soil in the image and based on threshold they classify weed in the image. The algorithm implemented can detect weeds specifically in the image just by using low-level characteristics.

In [15] the author aims to reduce the use of chemical substances in the field to achieve sustainable agriculture. They had implemented a robot with CNN to classify crop and weed in the field. As the convolution neural network is combined with encoder and decoder it can automatically classify crop and weed efficiently.

4 Conclusion

This paper presents a survey on a weed detection system using deep learning techniques in the agriculture field. Weeds are the major factor in agriculture affecting crop production and the potential saving of farmers. The weed detection system can be implemented using deep learning techniques to overcome the effects of weed on the crop. To build a weed detection system we have to collect image datasets either manually by capturing the field or else we can download from the internet. The pre-processing method selection is based on the image format and the accuracy of the model is dependent on the number of images used for training the model. In the future, we can develop a weed detection system using GPU which can classify all kinds of crops and weed effectively.

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