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Survey on Unmanned Aerial Vehicle based Weeds Detection using Deep Neural Networks

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ABSTRACT:

This paper is focused on detection of weeds in the crop through UAV. Usually weeds control consists in spraying herbicides all over the agricultural field. This practice involves significant waste and cost of herbicide for farmers and environmental pollution. One way to reduce the cost and environmental impact is to allocate the right doses of herbicide at the right place and at the right time (Precision Agriculture). Nowadays, Unmanned Aerial Vehicles (UAVs) are becoming an interesting acquisition system for weeds localization and management due to their ability to obtain images of the entire agricultural field with a very high spatial resolution and at a low cost. However, despite significant advances in UAV acquisition systems, the automatic detection of weeds remains a challenging problem because of their strong similarity to the crops. In this paper we propose a deep learning approach, Convolutional Neural Networks (CNNs) with an unsupervised training dataset collection for weeds detection from UAV images. This approach will show impressive results in different complex classification problems. The proposed method comprises three main phases. First, Capturing image of field using UAV. In the second phase, processing the image with CNN. Finally To show the results using Web Application.

Keywords:Convolution Neutral Networks, Deep learning, Quadcopter, UAV, Weed detection.

I. INTRODUCTION

The automation of the agricultural food production is gaining in popularity in the scientific communities and in the industry. The main goal of the automation is to reach the agricultural food demand growth, which currently is lower than the growth of the agricultural food production. The automation in agriculture could be increased by introduction of unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) that can monitor the growth of the crops and automatically react if some factors, such as water shortage, weeds or insect, infestation or plant illness, is detected. The introduction of robotic systems in the agricultural food or resource production is proven to increase the crops yield per land-unit. There are quite a few challenges that need to be overcome to have a fully automated solution that can be used in the industry. One of the challenges is the detection of weeds in the fields. Weeds are present in different forms of plants, it is very difficult to identify these weeds and to take necessary measures to remove them.

Can we distinguish a weeds from a crop seedling? Many weeds and crop seedlings look similar, so sometimes it can be hard to differentiate the two. Although they look alike when they are young, they will eventually grow into totally different plants. This challenge presents itself in many real-world situations. For example, Charlock is an agricultural weeds and an invasive species in some areas outside its native range, while Shepherds Purse, considered

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an herbal medicine, has seedlings of very similar shape to Charlock. Thus, farmers need to differentiate each type of seedling to successfully cultivate without damaging their plants. The dataset contains 4,750 training images and 794 test images, each of which belongs to one of twelve species at several different growth stages. The goal of this project is to build an effective system that identifies weeds present in fields along with the crops using UAV and deep neural networks. The camera fitted to drone will capture images of the field and obtained image is tested with the trained deep learning model using Convolution Neural Networks (CNN) and the results are plotted on canvas representing the land with weeds are marked along with detailed description.

II. LITERATURE SURVEY

Machine vision system for weed detection using image filtering in vegetables crops. [1] Machine vision system for weed detection in vegetable crops using outdoor images, avoiding lighting and sharpness problems during acquisition step. This development will be a module for a weed removal mobile robot with camera obscura (Latin for "dark room") for lighting controlled conditions. The purpose of this paper is to develop a useful algorithm to discriminate weed, using image filtering to extract color and area features, then, a process to label each object in the scene is implemented, finally, a classification based on area is proposed, including sensitivity, specificity, positive and negative predicted values in order to evaluate algorithm performance. The approach of the project is achieving a baseline method for developing a real time weed detection system through binary classification when vegetation is detected, that is, to separate soil and plants, then, to apply a feature extraction for discriminating weed. First, Green plant detection algorithm is implemented to remove soil from image such that image information is reduced. The next steps of algorithm focus only on vegetation, then, median filtering removes noise as "salt and pepper" with advantage of preserving edges. Third, the previous output is converted to binary; at this point, small objects are removed in order to avoid outliers. After, the pixels connected around their neighborhood are labeled, thus, all objects in the image are identified. Finally, area calculation for each object is done. With the values obtained, we set a threshold to differentiate weed from crop, such that the method is a feature extraction criterion based on size. The algorithm used in this project is MATLAB R2015.The algorithm of weed detection system was tested using photos taken perpendicularly to crop lines and the images were labeled manually based on random behavior of weed and the expertise of crops manager, in order to compare and evaluate the performance of the proposed approach to weed detection. The algorithm used in this project leads on unsupervised learning, hence, additional computational cost is reduced compared to the algorithms that require training to identify weed with these descriptors.

Weed detection in soybean crops using ConvNets. [2] Weeds are undesirable plants that grow in agricultural crops, such as soybean crops, competing for elements such as sunlight and water, causing losses to crop yields. The objective of this work was to use Convolutional Neural Networks (ConvNets or CNNs) to perform weed detection in soybean crop images and classify these weeds among grass and broadleaf, aiming to apply the specific herbicide to weed detected. For this purpose, a soybean plantation was carried out in Campo Grande, MatoGrosso do Sul, Brazil, and the Phantom DJI 3 Professional drone was used to capture a large number of crop images. With these photographs, an image database was created containing over fifteen thousand images of the soil, soybean, broadleaf and grass weeds. The Convolutional Neural Networks used in this work represent a Deep Learning architecture that has achieved remarkable success in image recognition. For the training of Neural Network the CaffeNet architecture was used. Available in Caffe software, it consists of a replication of the well-known AlexNet, network which won the ImageNet Large Scale Visual Recognition Challenge 2012 (ILSVRC2012). A software was also developed, Pynovisao, which through the use of the superpixel segmentation algorithm SLIC, was used to build a robust image dataset and classify images using the model trained by Caffe software. In order to compare the results of ConvNets, Support Vector Machines, AdaBoost and Random Forests were used in conjunction with a collection of shape, color and texture feature extraction techniques. As a result, this work achieved above 98% accuracy using ConvNets in the detection of broadleaf and grass weeds in relation to soil and soybean, with an accuracy average between all images

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above 99%. In this work, the SLIC Superpixel algorithm was an efficient segmentation tool for images of plantations captured by UAVs, in addition to optimizing the time spent in the construction of the image dataset. The dataset built in this work is composed of more than fifteen thousand images of soil, soybean and weeds and will be made available. In the set of 15 thousand images, 99.5% average accuracy was obtained between all analyzed images. The compared algorithms also obtained good classification results, but the Neural Networks have the advantage that their results are not dependent on the choice of good feature extractors. In addition, the use of ConvNets can count on the recent benefits of the rapid increase in processing power and memory, which enable the training of large sets of images in a viable time.

Selecting patterns and features for between and within crop row weed mapping using UAV imagery. [3] This paper approaches the problem of weed mapping for precision agriculture, using imagery provided by Unmanned Aerial Vehicles (UAVs) from sun flower and maize crops. Precision agriculture referred to weed control is mainly based on the design of early post emergence site specific control treatments according to weed coverage, where one of the most important challenges is the spectral similarity of crop and weed pixels in early growth stages. Our work tackles this problem in the context of object based image analysis (OBIA) by means of supervised machine learning methods combined with pattern and feature selection techniques, devising a strategy for alleviating the user intervention in the system while not compromising the accuracy. This work firstly proposes a method for choosing a set of training patterns via clustering techniques so as to consider a representative set of the whole field data spectrum for the classification method. Furthermore, a feature selection method is used to obtain the best discriminating features from a set of several statistics and measures of different nature. Results from this research show that the proposed method for pattern selection is suitable and leads to the construction of robust sets of data. The exploitation of different statistical, spatial and texture metrics represents a new avenue with huge potential for between and within crop-row weed mapping via UA imagery and shows good synergy when complemented with OBIA. Finally, there are some measures (especially those linked to vegetation indexes) that are of great influence for weed mapping in both sunflower and maize crops. The proposed method opens a new avenue for agronomical scenarios and especially for weed science. Since the intervention of the user is limited, the main bottle neck of this system is avoided, making its application very easy in practice with the appropriate equipment. Using this approach, the expert would have to intervene only in the data acquisition process (e.g., UAV flying) and the data labelling (validating the results of the automatic algorithm). The rest of steps (data mosaicking, data segmentation, computation of different features and classification) can be run automatically without needed supervision. In this sense, weed maps can be easily produced in time for early post-emergence treatment.

Deep Learning with unsupervised data labelling for weeds detection on UAV images. [4] Unmanned Aerial Vehicle (UAV) is becoming an interesting acquisition system for weeds localization and management. Recently Deep Learning approach has shown impressive results in different complex classification problem. In this paper, we propose a novel fully automatic learning method using Convolutional Neuronal Networks (CNNs) with unsupervised training dataset collection for weeds detection from UAV images. The proposed method consists in three main phases. First we automatically detect the crop lines and using them to identify the interline weeds. In the second phase, interline weeds are used to constitute the training dataset. Finally, we performed CNNs on this dataset to build a model able to detect the crop and weeds in the images. In modern agriculture, most of crops are grown in regular rows separated by a defined space that depends on type of the crop. Generally, plants that grow out of the rows are considered as weeds commonly referred as inter-line weeds. The main common point between the supervised machine learning algorithms is the need of training data. For a good optimization of deep learning models it is necessary to have a certain amount of labeled data. But as mentioned before creating large agricultural datasets with pixel-level annotations is an extremely time consuming task. Little attempts have been made to develop fully automatic system for training and identification of weeds in agricultural fields. The main advantage of such technique is that it is unsupervised and does not depend on the training data. Indeed, based on the hypothesis.

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Intra and inter line vegetation are then used to constitute our training database which is categorized into two classes crop and weed. Thereafter, we performed CNNs on this database to build a model able to detect the crop and weeds in the images. The results obtained are comparable to the traditional supervised training data labelling. The accuracy gaps are 1.5% in the spinach field and 6% in the bean field. The system is interesting in terms of flexibility and adaptively, since the models can be easily trained in new dataset. Later on we plan to use multispectral images because in some conditions near infra-red could help to distinguish plant even if they have a similarity in the visible spectral and leave shape. With the near infra-red we plan also to improve the background segmentation.

Identification of weeds in sugarcane fields through images taken by UAV Random Forest Classifier. [5] In this approach, Sugarcane is one of the most important cultures in the world. The productivity of sugarcane is affected by many factors, among them weeds can cause several problems. Weed control is made usually by herbicides application because sugarcane occupies extensive areas, and due to the same reason, the decision about herbicide type and dosage has been done by sampling. This work mode does not allow variation and causes problems of herbicide application, since the presence and weed type may not be uniform in whole field. There are some solutions based on satellite image analysis that allow the coverage of the entire field, solving the problem caused by sampling sense, but this solution depends on high weed infestation and a clear sky for good results. This work proposes a system for weed surveying, based on image pattern recognition with pictures taken by a UAV (Unmanned Aerial Vehicle); this alternative can take pictures very close to the plants, which allows species recognition in lower infestation levels and without clouds interference. In this work, the Kappa coefficient achieved an average value of 0.73, which can be interpreted as substantial agreement, demonstrating that Random Forest was a good classifier for plant identification. The average of overall accuracy is 82% and can be also considered a good result for a preliminary test. The identification of sourgrass was not quite good, because had a success rate lower than 78%, so the efforts to improve the identification of this narrow leaf weed should be increased. As a continuation of this work, an experimental field will be built with the most noxious weed to verify if the Weed Identification System will have a good performance, the same as or better than this preliminary test.

A new approach for weed detection in agriculture using image processing techniques. [6] In this work we propose image processing technique. We all know agriculture is the backbone of human sustenance on this world. Now a days with growing population we need the productivity of the agriculture to be increased a lot to meet the demands. In olden days they used natural methods to increase the productivity, such as using the cow dung as a fertilizer in the fields. That resulted increase in the productivity enough to meet the requirements of the population. But later people started thinking of earning more profits by getting more outcome. So, there came a revolution called "Green Revolution". After this period usage of deadly poisons as herbicides has increased to a drastic level. By doing so we got success in increasing the productivity but we have forgot damage done to the environment, which will arise a doubt in our sustenance on this beautiful earth. So, in this project we have implemented some methods to reduce the usage of herbicides by spraying them only in the areas where weed is present. In this method we implemented image processing using MATLAB to detect the weed areas in an image we took from the fields. Then we gave the input of the weed blocks to the automatic sprayer which sprays only in these blocks. By doing so we can reduce the usage of weedicides, thus saving the environment. If we have two are more types of weeds of different edge frequencies present in the same field. Then the threshold value must be less than the minimum edge frequency of the weeds present. If a small weed is present separately in the field means not in a group then it cannot be detected because it cannot meet the threshold condition. If both the weed and crop have nearly same edge frequency we should be very careful in selecting the threshold value. The weed block numbers from the filtering step cannot be given automatically to the motor, it has to be done manually.

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Efficient Weed Detection Procedure Using Low-Cost UAV Imagery System for Precision Agriculture Applications. [7] In this work, we use of Unmanned Aerial Vehicle (UAV) imagery systems for Precision Agriculture (PA) applications drew a lot of attention through the last decade. UAV as a platform for an imagery sensor is providing a major advantage as it can provide high spatial resolution images compared to satellite platform. Moreover, it provides the user with the ability to collect the needed images at any time along with the ability to cover the agriculture fields faster than terrestrial platform. Therefore, such UAV imagery systems are capable to fit the gap between aerial and terrestrial Remote Sensing. One of the important PA applications that using UAV imagery system for it showed great potentials is weed management and more specifically the weed detection step. The current weed management procedure depends on spraying the whole agriculture field with chemical herbicides to execute any weed plants in the field. Although such procedure seems to be effective, it has huge effect on the surrounding environment due to the excessive use of the chemical, especially that weed plants don't cover the whole field. Usually weed plants spread through only few spots of the field. Therefore, different efforts were introduced to develop weed detection techniques using UAV imagery systems. Though the different advantages of the UAV imagery systems, they systems didn't draw the user's interest due to many limitations including the cost of the system. Therefore, the proposed method introduces a new weed detection methodology from RGB images acquired by low-cost UAV imagery system. The proposed paper provides a new weed detection methodology that can be used as part of a smart weed management system. Such system can be used for enhancing the use of UAV imagery system for important PA application which is the Site-Specific Weed Management (SSWM). Generally, the proposed weed detection methodology depends on detecting the weed patches from RGB images. The use of RGB imagery sensor will provide an advantage to the system as such sensors are low-cost compared to the use of multispectral imagery sensors, which are currently preferred by other PA applications. The proposed weed detection methodology depends on detecting spots with high vegetation densities in the acquired image. These detected spots are considered as weed patches. Therefore, a grid of blocks is generated to cover the full image. Then, based on comparing the vegetation densities of the blocks, the methodology detects every block with extreme vegetation density compared to other blocks. Later, the proposed methodology was tested through using low-cost UAV imagery system equipped with RGB imagery sensor. Different RGB images were acquired for two agriculture fields at different flight height. Based on the achieved weed images, the proposed methodology proved its ability to detect weed patches. Moreover, the methodology was able to detect the weed patches at the different height, even with less detection quality. Furthermore, the methodology was capable to state if there are weed patches or not in the agriculture field. Also, although the methodology showed high potential for detecting weed patches even from images collected at 120 m flight height, the quality of the detection process faced some limitations. The main reason for such limitation is due to the low quality of the generated vegetation binary image because of the low resolution of the acquired images at that height. Finally, based on the achieved results, it is recommended to work on enhancing the quality of the weed detection process at high flight height. Moreover, such weed detection process could be used as the first step to generate a weed map which provide the user with the positions of the detected weed patches.

III. PROPOSED SYSTEM

The proposed system consists of three parts:

- Capturing Image using UAV / Quadcopter
- Processing the image using trained model of Weeds Detection with CNN.
- Results of presence of weeds by plotting a map

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Capturing Image using UAV/ Quadcopter

A quadcopter, also called a quadrotor helicopter or quadrotor, is a multirotor helicopter that is lifted and propelled by four rotors. Quadcopters are classified as rotorcraft, as opposed to fixed-wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers).

Quadcopters generally use two pairs of identical fixed pitched propellers; two clockwise (CW) and two counter clockwise (CCW). These use independent variation of the speed of each rotor to achieve control. By changing the speed of each rotor it is possible to specifically generate a desired total thrust; to locate for the centre of thrust both laterally and longitudinally; and to create a desired total torque, or turning force.

UAV is designed and camera is fitted to it. The user controls the UAV and captures the image of entire field at height of 3-6 meters from the ground. The collected image samples and subjected to deep learning.

Processing the image using trained model of Weeds Detection with CNN

The obtained image is subjected to deep learning using Convolution Neural Networks and weeds are identified and classified.

Convolution Neural Networks:

In deep learning, a convolutional neural network (CNN, or ConvNet) is a class of deep neural networks, most commonly applied to analysing visual imagery.

CNNs are regularized versions of multilayer perceptron's. Multilayer perceptron's usually refer to fully connected networks, that is, each neuron in one layer is connected to all neurons in the next layer. The "fully-connectedness" of these networks makes them prone to over fitting data. Typical ways of regularization include adding some form of magnitude measurement of weights to the loss function. However, CNNs take a different approach towards regularization: they take advantage of the hierarchical pattern in data and assemble more complex patterns using smaller and simpler patterns. Therefore, on the scale of connectedness and complexity, CNNs are on the lower extreme. They are also known as shift invariant or space invariant artificial neural networks (SIANN), based on their shared-weights architecture and translation invariance characteristics. Convolutional networks were inspired by biological processes in that the connectivity pattern between neurons resembles the organization of the animal visual cortex. Individual cortical neurons respond to stimuli only in a restricted region of the visual field known as the receptive field. The receptive fields of different neurons partially overlap such that they cover the entire visual field.

CNNs use relatively little pre-processing compared to other image classification algorithms. This means that the network learns the filters that in traditional algorithms were hand-engineered. This independence from prior knowledge and human effort in feature design is a major advantage. They have applications in image and video recognition, recommender systems, image classification, medical image analysis, and natural language processing.

Results of presence of weeds by plotting a map

The result obtained after deep learning technique is listed and a map is drawn accordingly to show the presence of weeds in the field. This result is shown through and Web/Android Application along with the details of weeds.

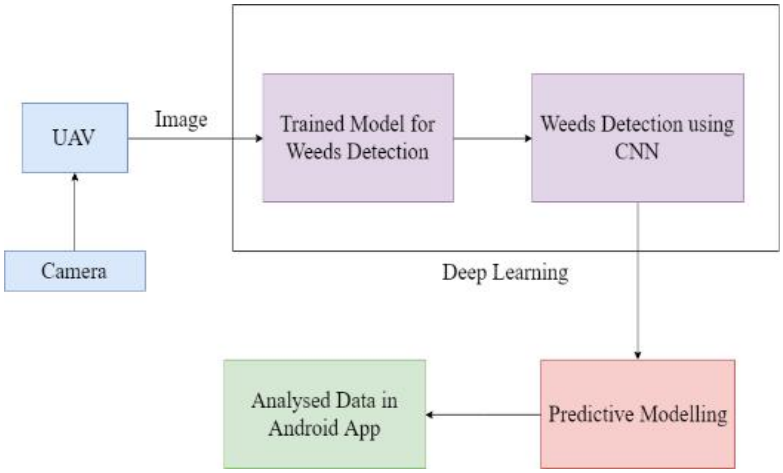

Figure 1.1 Block Diagram for Weeds Detection using CNN.

The figure 1.1 represents the block diagram for weeds detection using Convolutional Neural Networks. Image is captured using UAV, the image is subjected to deep learning technique by using CNN. The deep learning model is prepared by using data sets of weeds. The results obtained from deep learning process is mapped into a web application which shows the presence of weeds.

IV. CONCLUSION

In this paper, UAV imagery was collected over a field, and then the CNN method was proposed for weeds detection and weed mapping of the imagery. The collected images is subjected to deep learning technique. In deep learning, we propose Convolutional neural networks which produces high accuracy. After that, the CNN results are show in web application indicating the presence of weeds in field. Especially for the recognition of weeds, CNN approach achieved the highest accuracy compared with other methods.

However, this concept help in only detection of weeds rather than removal or eradication of weeds. This requirement limits the application of this method. So in the future of this work, we plan to introduce the detection and also removal system like pesticides spraying, laser guided removal technique to reduce the manual work and enhance the ease of application.

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