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Artificial Intelligence in weed control and management

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ABSTRACT

Weed control and management plays vital role in the economic system. As the presence of weeds along with the crops have the power to decrease the yield, hamper with the harvest and also lessen the quality of the crop which could lead to increment in the production cost and also decrease the market value of the crop in case weeds are not controlled. Weeds also hinder with application of pesticides and interfere irrigation. The automation in weed control is an emerging technology. Sturdy weed management technology will control the weeds despite the variables in the field. This paper mainly focuses on the mechanisms of weed control and management and their future scope.

Keywords— *Weed Plants, Crops, Weed Control Technology, Weed Control and Management*

1. INTRODUCTION

Weeds are a bane for any produce from agriculture and could lead to decline in the quality and yield of the crops. Weeds must be eradicated in order elevate the quality and market value of the yield. This can be achieved by upgrading the technology that is used for controlling and managing the weeds. For the world's rising population, meeting their demand for the food is a huge task. As the percentage of the land used for agriculture purpose is very less, we need to get high-quality and high-yielding crops within this agricultural land. We need to control the growth of the weeds as they are the most perilous component in the agriculture.

Weed controlling technology has to be adaptable and strong. This technology will be able to adapt to variabilities in the agriculture field. Based on the climatic conditions, genetics and population of the weeds, weed controlling technology has the ability to change its strategy according to the variabilities. The conventional weed controlling practices, for instance mechanical cultivation or weed control with chemicals, inclined to be strong with input of producer experience in agriculture and also management decisions. Nevertheless, they are never adaptable as they are applied with huge machines, which are typically large sprayers.

Traditional weed controlling technology is not reliable as it could decrease the crop yield but in case of artificial intelligence in agricultural robots have huge potential to adapt to the variabilities in the agricultural field. These agricultural robots have the prospects to direct the chemicals to the target weed only. This is because of recent advancements in artificial intelligence which is a characteristic of the agricultural robots. However, there are several challenges when it comes to artificial intelligence in robotics. Weeds are the plants which are undesirable in the crop field. Crops are cultivated because their economic value to the person who produces it. Because of this any plant could be a weed, like tomato growing in the corn field, if it's not serving the right purpose to the producer. Hence any plant can be a weed based on the competition and location relative to the crops. So, these agricultural robots could cause disasters, such as destroying the crop which has economic importance unless proper information is fed to these agricultural robots.

Another most challenging part is that when the crops are mechanically planted in a structured way which is compatible for the agricultural machinery, weeds start emerging and growing randomly.

Weed control and management strategies take the variabilities into account and use weed controlling techniques which are general and strong enough to be efficient in controlling weeds. In the developing process of the agricultural robots that control weeds, there many challenges to attain the goal. The challenges involved in the process of developing the weed control robots include feeding the robot with the type of plants that needs to be eliminated based on the distinguishing features. Growth of the weeds needs to be stopped or retarded, while not doing any harm to the cultivated crops.

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This paper will mainly focus on the weed control mechanisms and the future scope of artificial intelligence in the agricultural robots.

2. DIFFERENT MECHANISMS INVOLVED IN WEED CONTROL AND MANAGEMENT

2.1 Chemical based weed control management

This technology includes the presence of 8 nozzles at the back end that serve the purpose of spraying herbicides. In this technology the image captured is divided into 8×18 small rectangular blocks, each one of the boxes cover an area of 8128 sq. mm. Thereafter, each row which contain these rectangular blocks corresponding to the number of nozzles was inspected and was processed one after the other. After the inspecting each of the blocks, each and every block that contains the weed plants are sprayed.

The image can also be divided into 16×40 small rectangular blocks, each of these blocks cover an area of 8768 sq. mm approximately. In this case we would need 16 nozzles in place of 8 nozzles. Later, the next piece of work was done based on the following conditions. First condition is that if a block which is examined has weed pixels surpassing 10% of the area of the total block, it is then classified as weed block. Second condition is that all the blocks that are examined are sprayed with the herbicides. Third condition is that when the first two conditions are satisfied, the weed plants whose area are equal to or greater that 30% is sprayed and are supposed to be demolished. Fourth condition, in this method a selective herbicide is used which has the ability to destroy the weed plants and not any other plants.

Above mentioned first two conditions defines that where the herbicides are to be sprinkled i.e., it defines the exact area that has to be sprayed. The first condition that was mentioned decreases the area that contains very little amount of the weeds and which doesn't require spraying. This is the most crucial part of the weed controlling process. All the parts of weed plants do not need to be sprayed to destroy a weed, but enough of the weed needs to be sprayed so when the spraying process is done part of the weed that absorbed the herbicide spreads it to the rest of the plant which ultimately leads to the death of the plant. But when the area which is sprayed is very little it might not lead to the death of the weed. Hence, we need to be careful enough and make sure we are spraying it correctly. Therefore, the third condition defines the minimum area that needs spraying. The fourth condition is there to make calculation on the reduction the quantity of herbicide being sprayed compared to spraying the whole weed. To calculate this, we need correct spray rate, herbicide reduction rate, false spray rate and destroyed weed rate.

These can be calculated using the following formula:

$$\textit{Correct spray rate} = (N_{CSK}/N_{SNWB}) \times 100$$

$$\textit{Herbicide reduction rate} = (1-N_{SB}/N_{B}) \times 100$$

$$\textit{False spray rate} = (N_{FSB}/N_{SB}) \times 100$$

$$\textit{Destroyed weed rate} = (N_{K}/N_{W}) \times 100$$

Here N_{CSK} is the no. of sprayed weed blocks. N_{SB} is the total no. of blocks sprayed and N_B us the total no. of blocks that are examined. N_{FSB} is the no. of non-weed blocks sprayed. N_K is the no. of weeds that were killed and N_W is the total number of weeds in the particular block (Tanha Talaviya et al.).

2.2 Robot based selective application

The selective application of the herbicides systems displays enormous assurance in decreasing the amount of the herbicides or the chemicals applied, they must not be assessed as robots, rather than that they are automated systems that can be controlled. Nevertheless, lately, selective spraying technology is combined with smaller, hardware with automatically guided vehicle system and also control technology to apply the herbicides more precisely. For instance, using GPS the ecoRobotix which is a spraying robot is guided autonomously into the crop rows and to follow the crop rows machine vision sensor is used. This robot helps in detection of the weeds, and then it uses the two spray nozzles which are on the delta robots' arm to position the two nozzles on the weeds and selectively apply the herbicides right away to the detected weed plant (Fennimore, S A. et al.). Another group of scientists made a ladybird robot which almost alike to ecoRobotix robot, just that robots arm has 6-axis to move the spray nozzle to effectively act on the weed plant.

2.3 High voltage-based weed control

The desire to accomplish non-chemical weed control methods is increasing as the pressure to decrease chemical costs on the farming and environment elevates. Because of the interest in non-chemical weed control system there is also huge rise in interest in the organic farming. The non-chemical weed control methods include biological, electrical and mechanical.one of the non-chemical weed control system which used to destroy the weeds include the pulse high voltage discharge method. The small sized weeds i.e., roughly about 5cm in height and 2mm diameter of the stem, these can be destroyed with a spark of 153 mJ energy and 15 kV. In the case of weeds that are large i.e., weed size about 80 to 120 cm tall and 10-15 mm diameter of the stem, these can be destroyed by giving a charge of 20 Hz.

The roots and the stems of the weed plants get affected adversely because if the spark charge, this would lead to the disruption of the water and food channel of the weed plant. Henceforth, the weed plants wilt within a few numbers of days because of the spark charges. In this weed control method, the devices that discharge the spark are set up in the system in the place of nozzles as in the chemical-based system. The system is designed in such a way that it applies spark only in the area where the weed plant is detected. When the detecting of the weed sites is done, for the spark discharge the system selects the weed points, weed areas are represented by the weed points. Similar to the chemical method, this method also has three conditions. First condition is that the centre of the region is calculated by taking the average of all the coordinates present in the pixels of the image. Second condition says that the

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spark discharge is applied at the centre. Third condition is that a particular weed plants is said to be destroyed when the weed plant gets the spark discharge.

In order to pick the spark discharging sites the first two conditions are mentioned. For setting the ability of weed demolition the third condition is set. This method requires the evaluation of certain factors, such as false spark rate and correct spark rate.

$$\textit{False spark rate} = (N_{FSK}/N_{SK}) \times 100$$

$$\textit{Correct spark rate} = (N_{CSK}/N_{SK}) \times 100$$

Here N_{SK} is the total number of the sparked sites and the number of sparked weed pixels is N_{CSK} (Tanha Talaviya et al.).

3. FUTURE SCOPE

The future research would mainly focus on the either elevating the complexity of the algorithms or increase the data dimensions for the better perception performance of the weed. Deep learning techniques an be used for more complex processing of the image. Conventional neural networks or deep learning (DL) is an artificial intelligence, now-a-days it is most widely used technique for application in agriculture. Deep learning uses complicated image processing neural networks that use huge amount of the data.

When compared complex neural networks (CNN) with the traditional pattern recognition method, complex neural networks (CNN) method had quite high performance in weed detection and discrimination. A very huge benefit from deep learning is that, it decreases the need to do feature engineering manually to find out the features of the plant which help in classifying the plant whether the plant is weed or crop. As the deep learning models are complex this helps in finding distinguishing features for a problem and it can also do feature learning.

This kind of ability to learn the features of plants can be used to differentiate the crops from the weeds opens the way for advances in weed perception field. Complex neural networks (CNN) such as GoogleNet, Inception-v3, DenseNet and other customised models are shown that they are effective in wee/crop recognition with the visual defects and uncontrolled illumination (McCool et al.).

Nevertheless, there are many challenges that are associated with deep learning. Deep learning needs real-time interference and high computational ability for training purpose. The performance of this highly dependent on the quality of training set. The data set has to be correctly annotated and huge enough, which normally needs substantial labour (manual) to annotate and collect images. To upgrade the strength, the data set should span all the conditions such as shadow, occlusion and inconsistent illumination. Hence, the traditional patterns recognition is worth to investigate for applications for which its impractical to have large data set and high computational capacity. However, deep learning must be the ground for research in the coming future.

There is an enormous want for research to explore the interaction between the soil-weed-crop matrices and weeding tools. More knowledge in the weed control mechanism will enable the agricultural robots to have higher level of intelligence to a point such that they can make their own decisions about which type of tool is needed for a specific application or it can make changes in the strategy depending on the field conditions. Allowing the robots and managers of the robot to determine the solutions for any uncertain field conditions is open for research.

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