Neural Network Based Weeding Robot For Crop And Weed Discrimination

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Abstract. Weeding is the most difficult process in the field of agriculture, which may consume more manpower, time and money. This paper is designed for detecting out weeds in-between crops and drilling them using blade attached at the end of robotic. Though this robot works autonomously, this does not require more manpower. It offers reduced working time and requires less installation cost. Insufficient labour, improper weeding, pandemic situation like Covid19 are some problems which can be avoided by this robot. This form of weeding is eco-friendly and does not affect the organic nature of the crop. It uses Convolution neural network (CNN) for detecting the image of weed from the crop.

Keywords: weeding, image processing, convolution neural network

1. Introduction
Growth in the agriculture sector may well be judged by the increase in agricultural production over time. This enormous increase in agricultural production can be achieved only by Automation. The advancements especially in the field of agriculture have helped evolve a new era of development and growth of different developing countries. The Automation in this field has been a trademark for the people who are completely dependent on agriculture for their survival and other needs. Weeding requires large amount of manpower and time while involving human beings. To overcome these difficulties an Automatic weeding robot is employed in the fields to help farmers overcome the difficulties faced by them in farming.

There are many research work done to effectively automate weeding. An non-overlapping multi-camera system was used to deal with indeterminate classification delays [1]. Different wavelength using reflection measurement were also used to classification of weed and crop at laboratory level [2]. Now, with the advancement of machine learning, weed detection studies were also conducted at vehicle level [3]. Even aerial images were taken for detecting weeds for applying precision spraying [4]. Rotary weeder blades were also developed by making use of finite element method for weeding [5]. A semi automatic weeding machine for paddy fields was also proposed. [6]. Comparison of various approaches that was under study was also done to determine crop weed classification [7].

Unmanned Ariel Vehicle for analyzing overlapping images for two sunflower field at 30 m and 60 m altitude was also done to design a site specific weed management [8]. Machine vision in a rice field to guide robot in precise row using crop detection algorithm was done mounted and tested. [9]. In paddy field the classification using computer vision was also attempted. Practically many challenges
were faced, which can be avoided if agricultural scientist and data scientist make legal arrangement for data sharing to face the challenges in big data in agriculture[11]. Weed identification was also proposed using probabilistic neural network to distinguish object from background[12].

Here, in this paper, an unmanned robot that offers all the requirement to satisfy the need of farmers in this covid-19 situation to determine, classify and drill out weeds safely from crops without using any pesticides to provide organic crop at low cost using neutral network data analysis is proposed.

In this paper, Section 2 deals with system description. Section 3 deals with simulation studies and section 4 deals with hardware implementation. In section 5 conclusions are drawn.

2. System Description

The function of automatic weeding robot is to carry out weeding process autonomously since weeding process requires 40 to 50% of total expenditure in field. Block diagram of automatic weeding robot as shown in Fig.1 is described below. Special attention has to be given to the adequate knowledge extraction techniques for making sense of the collected data, processing the information for assessing decision makers and farmers in the efficient and sustainable management of the field. Focusing on weed management,

![Fig. 1. System description of weeding robot](image1)

For the system to work autonomously, the system must be equipped with vision system. In this application system must possess the ability to differentiate crop and weed. USB camera is used for capturing images of the field. Since the processor used is raspberry pi, pi-cam can also be used. Images captured are used to detect object i.e.: crop or weed in the field. Processor used must have facility to connect camera to it. To this requirement raspberry pi can be used. Portable, less weight, camera interfacing option and wireless connection with monitor adds advantages to the choice of using raspberry pi gets the input images and performs object detection.

![Fig. 2. Functional block diagram of weeding robot](image2)

Functional block diagram of weeding robot is shown in Fig.2. Function of the robot is completely controlled by raspberry pi. Weeds that are detected by raspberry pi are drilled using robotic arm. When all the weeds that are detected is drilled, the robot is instructed to move to next position. If the
robot reaches the end of the field it is instructed to change direction. The distance between the robot and fencing is found using ultrasonic sensor.

Many types of object detection algorithm are available as a open source content for the use of research and other educational activity. Tensorflow object detection algorithm is used in this work. Tensorflow object detection has different types of algorithm for object detection based on the layers of neural network used for object detection. Convolution neural network (CNN), Region-based Convolution neural network (RCNN) are few example of them. RCNN has more layers of neural network compared to CNN. Since raspberry pi has to perform many operation in this application, loading pi to work with large number of neural network may reduce its efficiency. So CNN is used to detect object. To reduce the load of raspberry pi Tensor flow lite is used which supports CNN but not RCNN. Primary operation of object detection is to create library file which contains information of the sample object. Nearly 100 to 200 images of object are obtained at work place. Object to be detected is marked and training is done. After creating library file, tensorflow is installed in raspberry pi and object detection is carried out.

Since the colour of the crop and weed are same in most of the cases so the crops and weed must be differentiated using its structure. The image of real crop is used for training purpose so the similarity between crop and sample object will be high when compared to similarity between weed and sample object. To this classification a threshold valve must be fixed. Crop must be viewed under vision of robot and its lower similarity value must be noted after viewing the crop at different angles. If it is 85% then the object whose similarity is greater than 85% should be considered as crop and those who are less than 85% should be considered as weeds. The pixel coordinates of weeds are obtained and converted to equivalent coordinates of the field. This coordinates are converted to servo angles and robotic arm is instructed to reach the weeds.

3. Simulation Studies

Performance of the robot is mainly depended on how exactly the weeds are detected and the crops are left undisturbed. To execute this action object detection must have high accuracy.

![Fig. 3. Sample Object Detection Output](image)

Since the crop is the only object that has been trained the simulation output obtained while the crop is placed inside the frame is high as shown in Fig. 3. The minimum accuracy obtained is 98%, almost every time the crop is detected with 99% of accuracy. Different object are placed infront of camera and their similarity to the crop is tested which show various results but the similarity is not as shown for crop. The object tested and their similarity is given in the below Table 1.

| SAMPLE                  | OUTPUT (CORRELATION PERCENTAGE(%) |
|-------------------------|-----------------------------------|
| Actual Object(Plastic Flower) | 99%                              |
| Natural Flower           | 83%                               |
| Natural Bud              | 76%                               |
| Waste Plastic Object     | Not Detected                      |
3.B Classification of Crop and Weed

Actual object that is trained to be detected with high similarity i.e: greater than 98%. Since every plant/crop may not be similar even it is same species, so some relaxation in threshold value must be considered i.e, threshold value is set as 90% instead of 98%. Object whose similarity % is less than 90% is considered as weeds and their pixel coordinates is exported to subroutine program which drills out the weed

3.c ultrasonic sensor

Python code to handle ultrasonic sensor is written and its performance is checked using raspberry pi as shown in Table II. The known distance is measured using ultrasonic sensor. The output of different distance measured is given in the table below. Ultrasonic sensor works with high accuracy only for range of 2cm to 400 cm which is very much enough to detect fence at a good distance. The ultrasonic sensor used is HC-SR04.

| Actual Distance(cm) | Measured Distance(cm) | % Error |
|---------------------|-----------------------|---------|
| 15                  | 14.8                  | 1.33    |
| 30                  | 29.5                  | 1.66    |
| 45                  | 44.2                  | 1.77    |
| 60                  | 58.4                  | 2.66    |
| 75                  | 72.8                  | 2.93    |

4. Hardware Implementation

Manipulator is designed with 3 degree of freedom in this application as shown in Fig. 4. Initially shoulder joint followed by elbow joint and then prismatic joint. These joints are constructed using servo motor. Shoulder joint is programmed to function 180 degree whereas elbow joint can function only 80 degree as total span. Prismatic joint can function upto 100 degree. The end effector in this robotic manipulator is a DC motor with a blade attached to it. The instruction to servo motor is given as PWM using raspberry pi. When the manipulator drills off first weed it is not necessary to bring back the manipulator to initial position, it can be driven directly to next weed by just providing control signal.

Weeding process must be carried out throughout the field so it is important to design the robot to be dynamic in movement. For this requirement motors and wheels are used. DC motor used for this application is 30 rpm. Wheels used can be changed based on the water content and soil of the field. The fencing of the field is detected using ultrasonic sensor. Existing autonomous weeding machine are atleast 40kg, which is not so simple to carry. But this machine is constructed to show up only 8kg, which is easier to carry from one place to another.
Integration of object detection, manipulator and robot movement is the main part this work. This function is carried out by the processor i.e: Raspberry pi. The objects that are detected are classified as crops or weeds. Weeds coordinates alone is converted into servo angles and the manipulator is actuated to drill off the weeds. The weeds that are detected are drilled off. So the main function here is object detection, i.e: the weeds that are detected are drilled off. As of this robot almost all the weeds and crops are detected and weeds are drilled out with 98% accuracy.

To detect the crops and weeds with high accuracy and in short period of time, a neural network stick can be used. This neural network stick has several layers of neural network which compute the given data with the reference data. As this process take place inside stick the load of raspberry pi is reduced and which in turn results in high accuracy and fast computing as shown in Fig. 5. Hence implementing a weeding robot with accurate weed detection is possible at low cost.

5. Conclusion

The Automatic Weeding Robot has a lots of scope in the field of agriculture. Cost and technology wise, this paper proposes a suitable solution for even poor farmers. Addition of solar power, GPS to find the area of field to be weeded, short path algorithm to make sample object library too quick can be done to add development in this field. On developing these things a superior eco-friendly automatic weeding robot or one step forward an automatic humanoid robot for agriculture can be obtained. These developments makes most pandemic situation like COVID 19 has no effect on weeding process. Further, Global positioning system can be used to specify the range of field that is to be weeded, which makes the weeding system fully automated during weeding process.

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