Smart Herbicide Sprayer And Fruit Counting System For Tomato Plantations

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Abstract- *Agriculture needs automation, among all the other techniques used in agriculture weed control is one among them. As herbicide is used to control the weeds in agricultural field, it is sprayed uniformly all over the field which damages the crop and also plant and soil. The excessive use of herbicide affects the environment and human life as herbicides contains toxic substances.*

The aim of the project is to design a Robot which sprays the herbicide to the weed affected plant only, not to the whole field. This can be done by identification of certain features from captured images of plants which are affected by presence of weeds in their surroundings. Here the plant which is considered is tomato plant whose maximum height is fifteen inches. The robot with height slightly greater than that of maximum height of tomato plant is made, to capture images of all the tomato plants present in the field. The images are processed to identify fruit and weed affected plant. In the early stages of plant if the plant is affected by weed its leaves turns yellow and some parts of plants starts to die and turn brown, such as fruits, stem and leaf.

Decorrelation stretch operation is performed to enhance the difference in colours. Thersholding operation is performed to convert RGB image to binary image, connected component analysis is done to analyse size of dead parts and fruits. Fruits and dead parts of plants are identified by their colour and size.

The weed affected plant is sprayed with herbicide with the help herbicide sprayer. The performance and recognition can be improved by considering different features of the plant like shape of the fruit, shape of dead part of plants.

The robot is detecting the yellow (leaf about to die), brown (dead leaf) and green leaves with high accuracy and spraying 100ml of herbicide once it detects the yellow leaf and dead leaf. The robot is also counting the number of fruits which gives an inference that lesser numbers of fruits are present in where weeds are more. The robot cannot be limited to this application only but in future it can be updated to be used as insecticide sprayer where it will detect the insect and spray the insecticide. Also, it can be implemented in other type of fields other than tomato field. Overall, it can be used for monitoring whole agricultural field..

Keywords: *Agricultural field, Soil, weeds, Herbicide, Tomato, Robot, RGB Image, Binary Image, Threshold, Decorrelation Stretch, Fruit Counting, Sprayer*

I. INTRODUCTION

Since the development of agriculture, most of the food needed to feed the population has been produced through industrialized agriculture. Since the 1960s, the amount of food produced through this type of agriculture has increased drastically, and currently there is enough food produced to feed every human on Earth. Biocides (pesticides, herbicides and weedicides) are used to save the crops and to avoid losses. The increased use of these inputs has saved a lot of crops, especially the food crops from unnecessary wastage. But indiscriminate use of biocides has resulted in wide spread environmental pollution which takes its own toll.

Waterway pollution, Chemical burn, Soil acidification, Air pollution, Mineral depletion are some of the major problems caused by extensive use of biocides. Apart from environmental effects it has also some various adverse effects on our health. In this proposed solution we want to limit the use of herbicide.

II.AUTOMATIC WEED DETECTION

Automation in agriculture monitor various aspects of a field like fruit detection, weed detection and temperature sensing of the field. This is demonstration of how to achieve automation in agriculture in agriculture with low cost and simple method. To detect weeds in agriculture several methods are proposed. Feyaerts and van Goal used a spectrograph camera to identify weeds. They obtained up to 86% classification accuracy, but the scheme was not applicable to in-field purposes [1]. Another approach for weed detection was proposed by Nielsen, M., Andersen. This demonstration is mainly focus on tomato plants. Nielsen analyzed images acquired by a stereoscopic vision system, but ground irregularities had negative impacts on results. There were some other classifications based on height differences [2]. For identifying broad-leaved patches in cereal crops Berge developed a method based on shape parameters and as a result achieved 84 to 90% classification accuracy. Sogaard also used active shape models as a criterion to classify weed species. But the problem of using height as a criterion is that it needs ideal conditions; shape of the leaf should be well displayed. Moreover, because of being shape-based and also wide range of species, they cannot be developed to be used for all of them. Another option for classification is based on textural information of weeds and crops. Machine vision systems present a great potential to be used on data collection for precision agriculture, where images would be used to extract information. Promissory results on automated weed detection were obtained using an image processing method. Another approach for taking images of a field by using CCD camera mounted on a tractor. With the popularity of digital cameras, personal computers, image processing software, and global positioning systems, machine vision systems could be an option to cost reduction in data collection for precision agriculture [3]. R Arvind, M Daman, B S Kariyappa presented a paper in which they developed an algorithm which uses an Erosion and Dilation approach to detect weeds. The color image is converted to binary by extracting the green parts of the image. The amount of white pixels present in the region of interest is determined and regions with higher white pixel count than the predefined threshold are considered as weeds.[4]. K.A. Anjali Rani, P. Supriya, T.V. Sarath presented a paper on automatic detection of weed in corn and curry leaf and showed the accuracy up to 80% [5]. Geo referencing the data could be possible to identify spatial variability on weeds distribution and allow site-specific control, using patch spraying where herbicides are applied only on the areas where the weed population economically justifies the application. Another option is to vary the herbicide to maximize the weed control. The weed maps could also be used as an aid to define management zones. This work is based on the hypothesis that the use of image processing methods can facilitate data collection and identification of spatial variability of weeds [6]. A. H. Kargar B. and A. M. Shirzadifar have used wavelet transform to know the high frequency region in images which is mainly due to weeds which are small in size compared to size of plants [9]. D. J. Sudom, K. J. Runtz and R. J. Palmer detect weeds based on the amount of green pixels found in images; to evaluate green pixels in a region they used histogram analysis [10]. A. M. Smith and R. E. Blackshaw used hyper spectral remote sensing to map weeds in a field, they used integrating sphere (LICOR LI1800) and a field spectroradiometer (ASD Fieldspec PRO) for hyper spectral remote sensing.

III. TOMATO FIELD

The tomato plant is grown worldwide for its edible fruits, with thousands of cultivators. A fertilizer with the NPK ratio of 5-10-10 is often sold as tomato fertilizer or vegetable fertilizer, although manure and compost are also used. Since content of phosphorus and potassium is higher in the fertilizer it can cause chronic kidney problems. The weed affected leaf is of yellow color and once it gets diseased its color changes to brown. The height of a tomato plant is about 24-30 inches and the weed affected area grows up to only 4 inches [7].

IV. PROPOSED SYSTEM

The Smart Herbicide sprayer is a vehicle which has been designed to survey tomato field to detect weed affected areas and even identify fruits. A camera is mounted on the vehicle facing ground and the image captured is processed on raspberry pi to detect red and yellow color. Red color indicates fruit and yellow color indicates weed affected areas, because leafs in weed affected area becomes yellow. When weeds are detected herbicide is sprayed through spay pump which is controlled through Arduino**.**

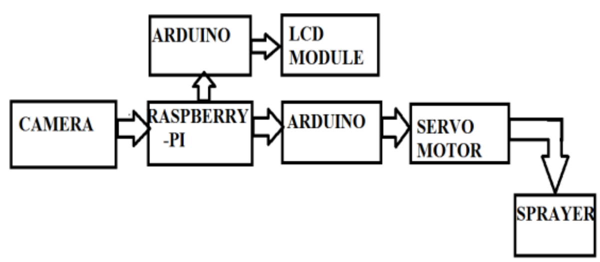

Figure 1 Block diagram of system

A. Camera

The camera used in the project is webcam Logitech Fluid Crystal™ Technology which captures photos up to 3.0 megapixels (software enhanced). It uses hi-speed USB 2.0 (recommended) and it is compatible with Raspberry-pi.

B. Raspberry Pi

The Raspberry Pi a system on chip which uses 1.2GHz 64-bit quad-core ARMv8 CPU. Raspberry Pi is used to process the image and set the corresponding GPIO pins high and low.

C. Arduino

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). When the Arduino gets the input from Raspberry Pi it executes the c code dumped into it and performs the task assigned for it.

D. Servo motor

This High-Torque MG996R Digital Servo features metal gearing resulting in extra high 10kg stalling torque in a tiny package. A high torque is needed to squeeze the herbicide out of bottle. To achieve the task MG series servo motor is used which pulls out the sprayer handle when it rotates.

E. Sprayer

The sprayer used in the project is normal plastic sprayer which is attached with servo motor and sprays the herbicide when motor rotates.

F. LCD Module

A liquid- crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. It displays the number of fruits in the field.

V. ALGORITHM FOR IMAGE PROCESSING

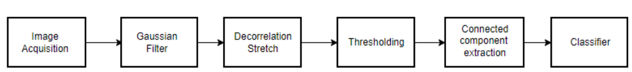

Figure 2 Algorithm

Image is captured from camera when robot stops moving. Captured image is passed through Gaussian filter to remove noise. Decorrelation stretch operation is performed on image to enhance the color differences, after this process RGB image is converted to binary image by thersholding. Value for thersholding is determined by trial and error method, our aim is to extract light brown and yellow regions from the image. Thersholding values have to be changed for cloudy and sunny environment. Once thersholding is done white patches of area whose value ranges between some predetermined values is extracted. Since crops in the field are evenly placed only one plant is captured in every image. We determine whether the plant is affected by weedicide or not by based on the size and number of patches. This array of size and number of patches is fed as a vector to a trained classifier which gives the decision.

VII. WORKING

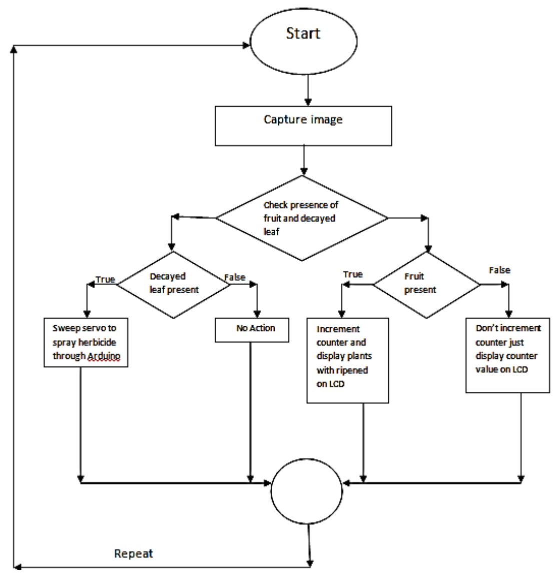

Figure 3 Pseudo code

Pseudo code

Pseudo code for Herbicide spraying system and fruit counting system

Step 1: Start.

Step 2: Import the standard library files of Python.

Step 3: Capture image.

Step 4: Check weather decayed leaf and fruit is present in image.

Step 5: If present make GPIO pins 18 and 17 pins high or accordingly.

Step 6: Check GPIO pin 18 through Arduino and enable servo motor.

Step 7: Check GPIO pin 17 through Arduino and increment count in LCD.

Step 8: Repeat from step 3.

Pseudo code for Robot

Step 1: Start and move in forward direction.

Step 2: Stop and wait till raspberry pi checks presence of weed affected plant.

Step 3: Repeat step 2 and step 3.

VII. RESULTS

Validated the effectiveness and advantages of proposed methodology by software testing, each module of the program was verified with various test cases. The device was programmed in such a way that it uses the available memory of Raspberry Pi efficiently. The prototype was well designed to implement all the software modules and tested with all possible cases. The basic functionalities mentioned in the proposed solution were successfully implemented in the prototype.

Experimental Setup

The experimental setup of the system is shown in Figure 4
The experimental setup consists of few modules that are used to achieve the following functionalities.

- The 4 DC motors attached to robot, rotates clockwise with a delay of 10 seconds in order to move the robot.
- Bottle sprayer, sprays the herbicide when yellow leafs is detected.
- LCD module shows the number of tomato present in the field. Whenever, red color is detected it increments fruit count.

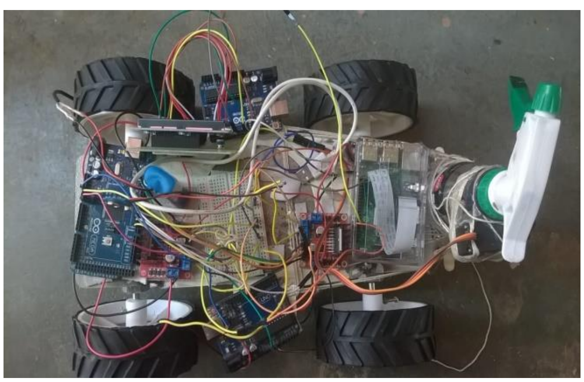

Figure 4 Robot

The project was tested in different types of conditions such as daylight, in room, dawn time, and during night on the leaves shown in Figure 6.2. Accuracy of the algorithm for different conditions was different which is plotted in graph shown in figure 9. There was a significant difference between the accuracy of algorithm for the leaves tested in room and in outdoor conditions and the synthetic images from internet. The average accuracy in each case is given below.

Figure 5 Test case leaves and its result

The herbicide was sprayed for the yellow and brown leaves shown in figure 5 and figure 6 and no action was taken for the leaves shown in Figure 7.

Figure 6 Yellow leaves and its result

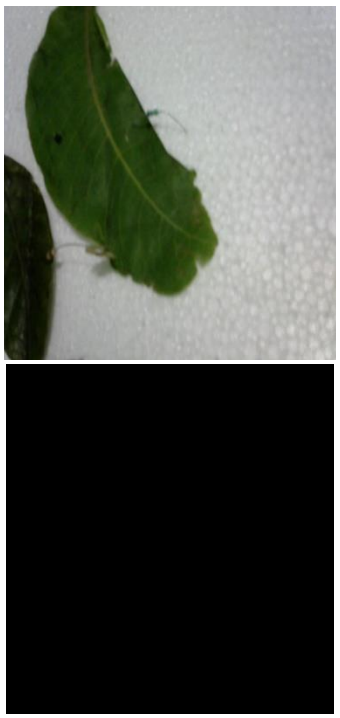

Figure 7 Green leaves

The accuracy of the results was highest during daytime followed by room light.

The LCD module of the robot counted the number of fruits present in the field. A sample of fruit and result of algorithm for it is shown in Figure 8.

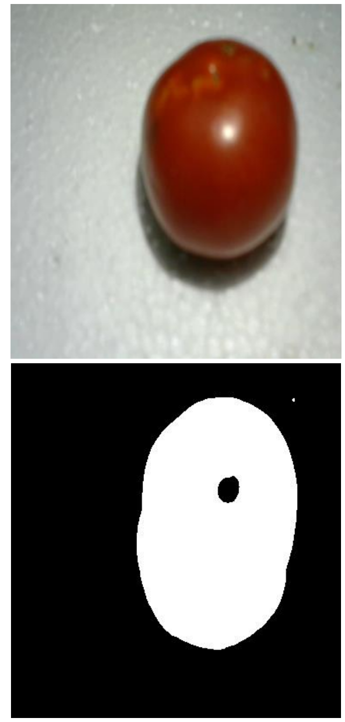

Figure 8 Sample fruit and result

Accuracy of algorithm in different conditions

Cases	Accuracy
Synthetic images	76.2%
Outdoor conditions	59.1%
Under artificial light in room	69.3%

Table 1 Accuracy in different conditions

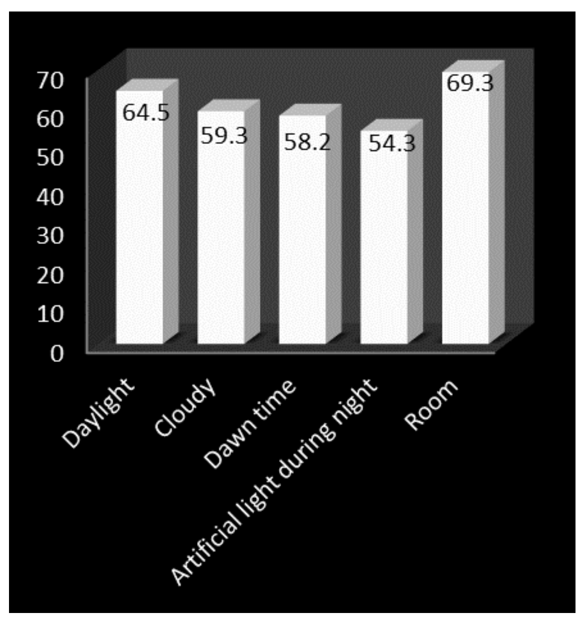

Figure 9 Plot of Accuracy for different conditions

VIII. FUTURE WORK

The scope for future work is to advance this project where it can detect an insect and spray the insecticide for the insect. And it can be made implementable in other type of fields also. Overall, it can monitor whole agricultural field. Computational Neural Network (CNN) can also be used to have more accuracy.

IX. CONCLUSION

It is required that herbicides entering food chain must be limited to stop bio magnification and must be sprayed on crops precisely. So by implementation of this project it reduces farmer's work of spraying herbicides and reduces bio magnification. By considering this project government and other organizations can cause drastic improvements in agriculture field.

The project is detecting the yellow leaves with an high accuracy and whenever it detects the yellow leaf it sprays the 100ml of herbicide which is required for the tomato field. It is also counting the number of fruits which gives the idea about weed density of field lesser numbers of fruits are present where weed is more. To meet the objective a robot with an attached sprayer was built which sprays the 100 ml of herbicide whenever Pi send a high signal to servo motor. The project was tested in different type of light such as daylight, dusk time and even in room light. The results obtained have the highest accuracy in daylight followed by room light.

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