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Image Processing in Agriculture

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Abstract: 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 paper we implemented image processing using MATLAB to detect the weed areas in an image we took from the fields.

Keywords: Image Processing, Agriculture, weed detection, patch spraying, Arduino uno

I. INTRODUCTION

In olden days weed detection was done by employing some men especially for that purpose. They will detect the weed by checking each and every place of the field. Then they will pluck them out manually using their hands. Later with the advancement in the technology they started using the herbicides to remove the weeds. But to detect the weeds they are still using manual power in many parts of the world.

Later there came few methods to detect the weeds automatically but due to lack of their accuracy they are unable to reach to the people. Then they started using image processing for this purpose.

In this paper our main aim is to detect the weed in the crop by using image processing. Then we will give the inputs of the weed areas to an automatic spray pesticide only in those areas. For this we need to take a photograph of the field with good clarity to detect the weeds with more accuracy. Taking a photograph can be done by attaching a camera to a tractor or taking them manually. Then we will apply image processing to that image using MATLAB to detect the weed.

In this paper we have implemented two methods for weed detection. They are:

1. Inter row weed detection
2. Inter plant weed detection

The final result will be containing the weed areas which we will give as inputs to the automatic sprayer, implemented using 'Arduino uno' microcontroller.

II. WEED DETECTION

A weed is a plant considered undesirable. Weeds have no botanical classification value, since a plant that is a weed in one context is not a weed when growing where it is wanted. It is applied to any plant that grows or reproduces aggressively, or is outside its native habitat. The term is occasionally used to broadly describe species outside the plant kingdom that can live in diverse environments and reproduce quickly. These have seeds that persist in the soil seed bank for many years. They compete with the desired plants for the resources that a plant typically needs, namely, direct sunlight, soil nutrients, water, and (to a lesser extent) space for growth.

Weed classification is a serious issue in the agricultural research. Weed classification is a necessity in identifying weed species for control. There are two types of weed based on the frequency of the edges present in them. They are:

1. Weed with narrow leaves (have less edge frequency).

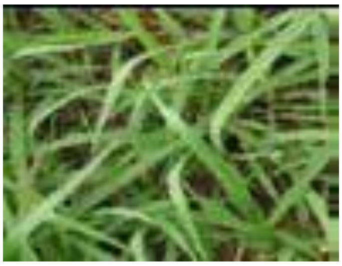

Fig 1: weeds with narrow leaves

2. Weed with wide leaves (have more edge frequency).

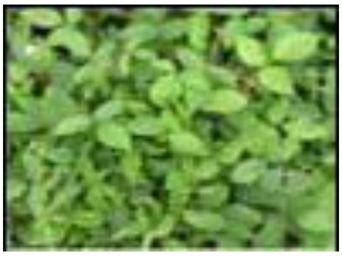

Fig 2: weed with wide leaves

III. INTER ROW WEED DETECTION

In this method we can detect the weed that is present in between the rows of the crop. Here it will process the images taken in real time to get the weed areas. We will take pictures at 25 frames per second. Each frame needs to be operated for 0.04 sec. Here we will take the first eight frames generated in 0.3 sec time and we will perform the logical AND operation between them to get a reference image called crop row image. This reference crop row image will be changed after 0.3 sec and will be replaced by the new crop row image formed by the AND operation of the frames obtained in next 0.3 seconds.

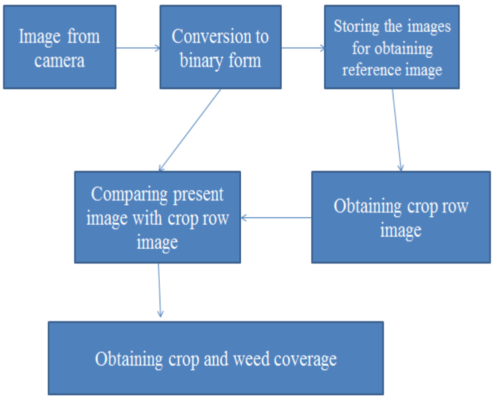
Image from camera
Conversion to binary form
Storing the images for obtaining reference image
Comparing present image with crop row image
Obtaining crop row image
Obtaining crop and weed coverage

Fig 3: Algorithm showing the method followed in inter row weed detection.

After obtaining the reference image we will compare the next coming image with it and we will get the weed output. The things which are present in the processed image and are absent in the reference image will be treated as the crop. For this we will do XOR operation of the processed image with the already existing reference image will give the output image containing the weed that is present in between the rows.

The main disadvantage of this method is that it cannot identify the weed that is present in between the plants in a crop row. Also if the crop is present outside the row then it will take that as a weed. So we cannot relay much on this method to detect the weed.

IV. INTER PLANT WEED DETECTION

Inter row weed detection does not deal with the weed between the plants in the rows. In order to overcome this problem Inter Plant Weed Detection is employed

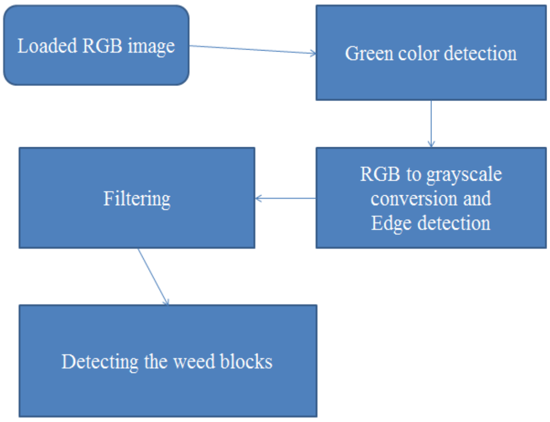
Loaded RGB image
Green color detection
Filtering
RGB to grayscale conversion and Edge detection
Detecting the weed blocks

Fig 4: Algorithm showing steps followed in interplant weed detection.

This part of the algorithm prepares an image for further advanced processing and is consists of: Loading the image from source, color segmentation and edge detection.

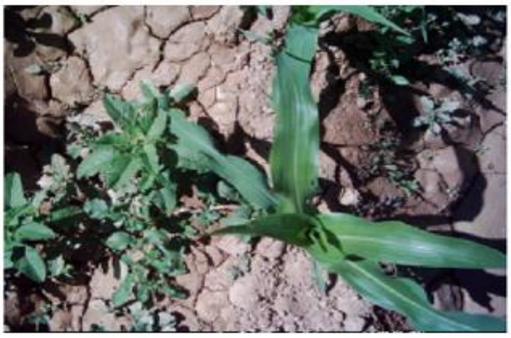

Fig 5: This is the input image we have taken for weed detection.

Color segmentation is one of the image segmentation method used to separate the crop (which also include weed) from the background. This is done through Kmeans clustering. The method helps in separating all the visually distinguishable colors from one another. The L*a*b* color space (also known as CIELAB or CIE L*a*b*) enables to quantify these visual differences. The L*a*b* space consists of a luminosity layer 'L*', chromaticity-layer 'a*' indicating where color falls along the red-green axis, and chromaticity-layer 'b*' indicating where the color falls along the blue-yellow axis. All of the color information is in the 'a*' and 'b*' layers. The difference between two colors can be measured using the Euclidean distance metric.

Clustering is used to group the pixels of same colors into group of objects, thereby making it easy to segment. The output image comprises of only two colors. The desired image after color segmentation consists of green color (the crop and the weed) and the remaining part of image black, making the image feasible to the step in the process, edge detection.

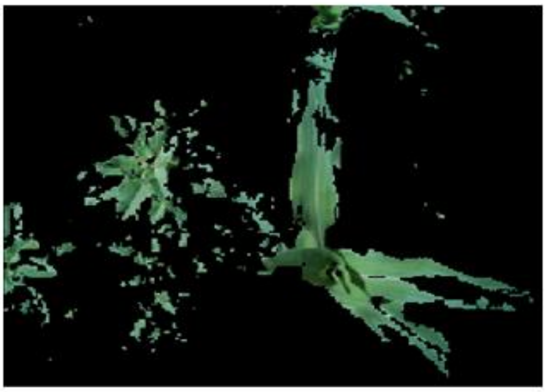

Fig 6: Output image after color segmentation.

Edge detection is also a method of image segmentation which uses the fact that the edge frequencies and veins of both the crop and the weed have different density properties (strong and weak edges), to separate the crop from the weed.

The image after both color segmentation and edge detection is left with the edges and veins of both the crop and the weed in white and the remaining part completely black.

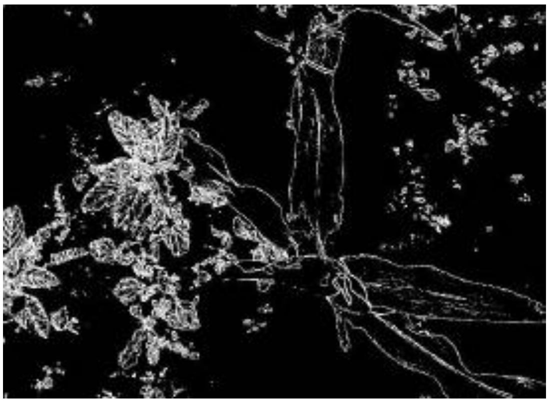

Fig 7: Output image after edge detection.

Although several sophisticated and accurate methods for color segmentation exist, many of them are not fast enough for real-time purposes. As in color segmentation, several methods with different accuracy and speed are available which their most well-known ones are Canny and Sobel edge detection algorithms. The operations like color segmentation, edge detection make the image ready for the next operation called filtering.

Filter here is used for recognizing regions in which edges appear with a frequency in a specific range (weed frequency range). Here the image after the edge detection in above step as input. To apply filtering the image has to be divided into blocks of certain size. There is a trade-off between the block size and gained accuracy. If the block size is too large, frequency estimation can be faulty due to existence of both crop and weed in the same block. If it is too small, the frequency cannot be calculated correctly because of inadequate number of edges in a block. A small block may detect the inner part of the weed leaf as the crop because of less number of edges in it. Also in choosing the threshold value we need to take care because its value depends on two factors. They are:

1. Type of weed present
2. Type of crop

The above factors affect the threshold value in this way: if we have narrow crop leaves and wide weed leaves then we can say that weed has more edge frequency than the crop, so here the threshold value will be more. Otherwise threshold value will be less. In this paper we take the case of corn crop where the edge frequency of weed is more than that of crop. For knowing the value of the edge frequency here, first we took a image which contains pure weed and calculated the number of edges in it by using ‘for’ loops and then we have calculated the number of edges per block for pure weed. That turned out to be approximately 900. Then we did the same by taking pure plant image and its edge frequency is approximately 100. So in this paper we took 500 as threshold value so that all weed can be detected. Coming to our case in this project we have taken an image of the size approximately 400 x 500 pixels. And we have divided it into 100 blocks each of size 40x50 pixels. In the program which we wrote, we have used for loops for counting the number of pixels and if loop for keeping the threshold value. If the edge frequency is greater than the threshold value then we detect that block as weed block and again by using for loops we convert all the pixels in that block into white pixels. As a result we will be getting an image which contain weed blocks as total white blocks and other blocks remains unchanged. We will also display the block number by using display function in MATLAB. The resulting image will look like:

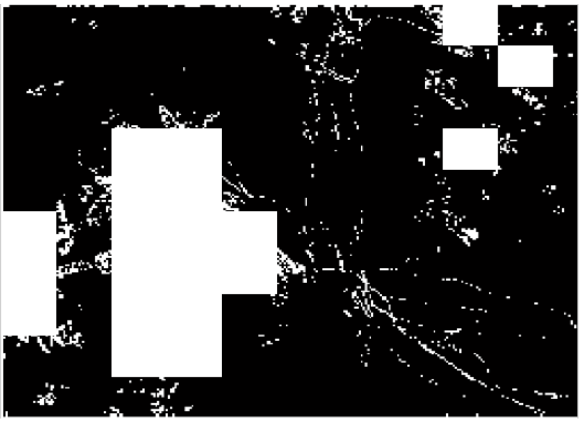

Fig 8: Final output after filtering showing the weed affected areas as white blocks.

V. AUTOMATIC SPRAYER

To reach our ultimate goal of reducing pesticide usage, we need to spray it only in the weed areas. Here we will make use of the image from filtering by taking the weed block numbers. The sprayer we use may be a robotic hand or a set of sprinklers or motors etc.

Here as per the previous image we have got a total of 100 blocks. So to spray pesticide we use a frame that has got exact dimension of the area for which the photograph is taken. So the frame will have 10 rows as we have got 10 rows in the previous image (image 10x10 blocks). We will be placing 10 motors one each in all the 10 rows. Then we will connect them to a driver which is then connected to ‘Arduino uno’ microcontroller.

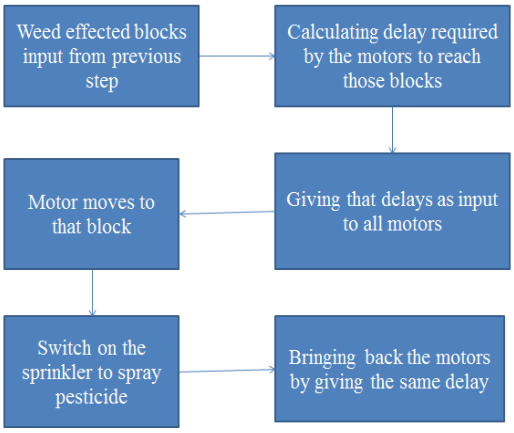
Weed effected blocks input from previous step
Calculating delay required by the motors to reach those blocks
Giving that delays as input to all motors
Motor moves to that block
Switch on the sprinkler to spray pesticide
Bringing back the motors by giving the same delay

Fig 9: Algorithm showing steps followed in automatic sprayer.

The Arduino Uno is a microcontroller board based on the ATmega328 chip. It contains everything needed to support a microcontroller, simply connect it to a computer with a USB cable or power it with a AC to DC adapter or a battery to get started.

First we will check the first row of the filtering output to find any weed blocks. . If any blocks are found we will give inputs to the controller in a way that the sprayer goes to that block and sprays the herbicide. The only input we need to give to the sprayer is the time for which the motor has to move to get to the weed block site. This can be given to the sprayer by using the function 'delay' available in the arduino uno.

Let us consider that the frame we took is of 2 meter length. Means each motor has a maximum distance of 2 meters to cover. Length of each block in a row of the frame we built is 0.2 meters. The motor in each row has two side wheels arranged to that row of the frame So the motor moves as per the movement in the wheels. Let us consider that the motor covers a distance of 1 meter in 4 seconds of time. By making use of the circumference of the wheel we can calculate the number of rpm required for the same.

In order to move the motor we need to give the time delay as input to the controller. Time delay is the time motor travels in a direction. As per the data we have:

Time to travel 1 meter is = 4 sec
Time to travel for one block(0.2 m) is = 0.8 sec
Time taken by the motor to travel 'x' blocks from the initial positions is = 0.8*x seconds.

So the only input we need to give is the value of 'x'(weed block number in that row), that will vary from 0 to 9. When our motor reaches that block it will spray the herbicide by making use of the sprinkler connected to it. The pins 3,4,5 of Arduino uno will act as output pins. Pins 3 and 4 are for the movement of the motor and the pin 5 will be for the working of sprinkler. The outlook of the automatic sprayer that we have used here will be:

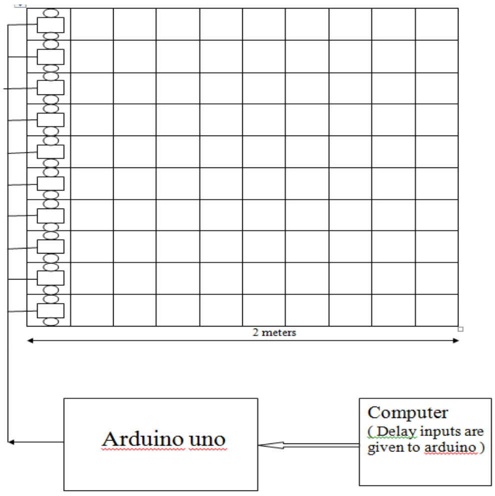

Fig 10: Outlook of the automatic sprayer that we have used.

But here to give the outputs from MATLAB as inputs to the Arduino uno we don't have any automatic method, so we have to take care of it manually.

VI. CONCLUSION AND FUTURE WORK

In this paper we have developed a method by which we can detect weed by using image processing. 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. This will take some time.

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