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Design of A Weed Detection System For Cotton Field

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Abstract

India basically is an agriculture based country from the age known to till the modern period. It acquires large share of income from the agricultural sector itself. With the increasing risks in the agriculture, the population being involved is decreasing. Cotton has been one of the most important crop form the ancient India; which is now facing a lot of issues. One of the major risks involved is the weeds. Here in this paper, we introduce a simple image processing phenomenon where the weeds can be detected easily by analyzing the taken input image. We have used python 2.7.9 version on Raspberry Pi 2 model B+ version 1.1.For processing the image, we have followed a simple phenomenon of template matching which is widely used for object detection or recognition in an image with multiple objects.

Keywords: *Python, Open CV, Image processing, Template image, input image, weeds.*

INTRODUCTION

Weeds are threat to total yield of the crop if not regulated. But when considered, there is a wide variety of weeds depending upon the type of crop to type of soil etc. There are weeds with narrow leaves, with broad leaves and also here are inter row weeds and inter column weeds. They compete with the crop in sharing resources like sunlight, fertilizers etc. In other words, weeds are the plants which grow by them hosting certain pests and diseases causing interruption in the growth of the required field. This not only effect the growth of the crop but can also reduce the quality of the yield; thus decreasing the market value of the crop. The classic method being implemented in weed removal is manual labor. People shall assemble periodically in the field, taking help of spades or sometimes even only with hands remove the weeds. After certain advancement in the technology, farmers started to use herbicides to regulate the weed growth. Over usage of such chemicals might also disturb the field. Many other techniques are under research to face this problem. We have opted for image processing technique for detecting the weeds. It is more like studying the image for detecting the weeds than processing it.

LITERATURE SURVEY

Faisal Ahmed et. Al., investigated the use of support vector machine (SVM) and the Bayesian classifier for the weed classification from the crops in digital images. It is observed that SVM classifier has outperformed the Bayesian classifier. Robert Bosch designed a system for weed detection powered by solar panels. With the camera fit at bottom of the machine for continuous capturing of the images and wheels are also provided for movement in between the crop rows. This is under study in the field of countries like Germany with not-so-cold not-so-hot moderate climatic conditions. In certain other Eastern European countries, a robot for crushing the weeds as fast as they are detected is developed. While in other Western countries, a system is developed for sweeping off all the unnecessary particles including pebbles, stones etc by moving in between the crop rows. Most of these systems use the principle of image processing. While using the image processing they followed genetic algorithm, some also used the feature extraction technique; but majority has undergone with the filtering techniques which highlights the crop ignoring all other unnecessary surroundings.

DEPLOYMENT OF HARDWARE AND SOFTWARE

We have opted to use raspberry pi because of its small size making it mobile; also raspberry pi now a days is playing a key role in the IOT or internet of things. This is because of its capability of providing a platform to wide range of programming languages.

Fig 1: *Raspberry Pi*

There are quite many software available when the image processing is concerned. Depending on the hardware or the camera module used to capture the camera, certain options are being implemented. For instance, Black fin or Beagle bone Black etc. support C++, JAVA or Python. MATLAB has always been the priority to the researchers and students of image processing. The reason for choosing Python for weed detection is due to its ease of implementation on the hardware; which is Raspberry Pi in this case. The Pi Cam or camera module of the Raspberry Pi also provides service at cheaper cost with better community support.

BLOCK DIAGRAM

The block diagram referring here (figure 2) gives the basic idea about the project.

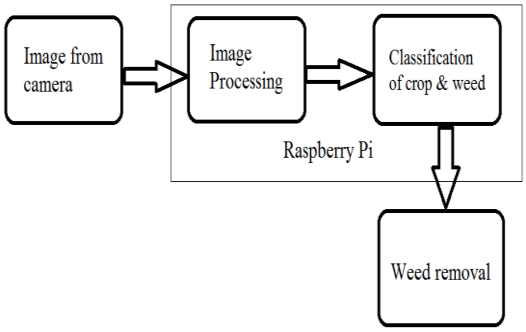


Fig 2: *System Architecture*

The image that is captured is further processed to detect the weeds in between crops and to specify weed locations in the image. The image is captured in a broad day light. Out of all profiles choosing the image with a top view will be the best option since it covers all the weeds that are to be eliminated along with the crop plants.

This image is read and is taken for further analysis. Here, it is always better to opt for the gray scale images since the gray scale images have less number of bits per pixel increasing the speed of computation and gives desired results as fast as possible.

We tried to implement the template matching concept of image processing. Where, the patch image or the template image is two dimensionally convoluted and is matched in the main image.

After processing of the image which has been obtained from the camera, weeds and their locations are marked or in other words highlighted for the easy understanding of the user.

FLOW CHART

The purpose of the flow chart is to mention the followed design flow in the project. The flow chart is shown in the following figure:

When explained in detail, the processor starts the sliding of the template image from the initial starting point of the input image; does the comparison work and moves to the next pixel or the sample for proceeding the analysis.

In other words, it actually studies the properties of the template and compares it with that parameter of the input image. If the obtained result is greater than the provided threshold value, then that position of the image is marked or highlighted. If not, then it continues with the next sample.

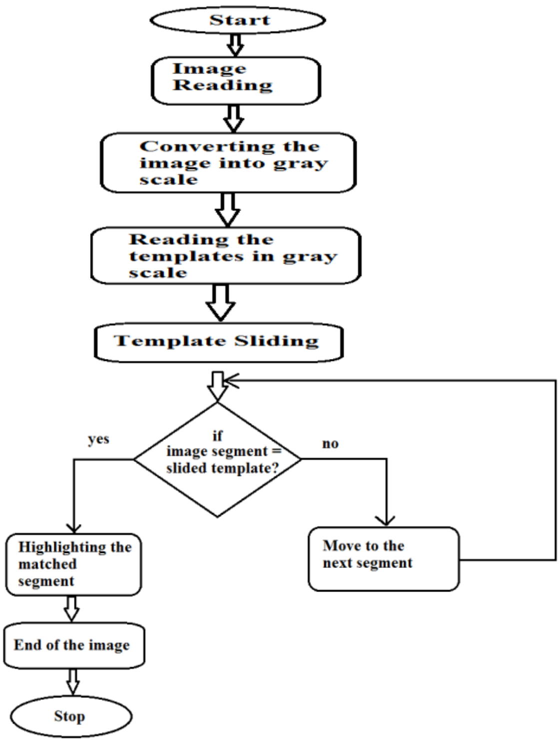


Fig 3: *Flow chart of the image processing execution*

DESIGN AND IMPLEMENTATION

Once the input image and template images are taken, they are converted into gray scale. This is because the gray scale images are faster for processing. We have given a certain number of templates. In fact, these templates are nothing but the reference images. The Raspberry Pi uses these reference images to locate the similar type in the input image.

Open CV provides predefined template matching techniques. The basic concept of template matching is to detect the objects in an image. That can be either a single object or the multiple objects. After verifying the accuracy of those techniques, normalized coefficient template matching is implemented here.

Normalized coefficient method is defined as follows:

$$R(x,y) = \frac{\sum_{x'y'}(T'(x,'y').I'(x+x',y+y'))}{\sqrt{\sum_{x',y'}T'(x',y')^2.\sum_{x',y'}I'(x+x',y+y')^2}}$$

Here, R(x, y) represents the resultant intensity of the pixel obtained by normalizing the coefficients of the template image coefficients T(x, y) and the input image I(x, y). This type of normalized template matching is found to be efficient for detecting the multiple objects in a single image. While mentioning multiple objects, it means that the same type of objects that are multiple in numbers. In detail, following is the picture captured in a cotton field in a broad daylight. It is the top view of the field covering both plant and weeds. The aim of this project is to detect the weeds when they are interfused with the field leaves. Hence we ignore the crop leaves and concentrate on weed plants and their location in between the crop.

***Fig 4:** Input Image from cotton field*

As mentioned earlier, the input image taken is converted into gray scale image for better understanding of the image. This reading of the input image is conformed after displaying the read image. i.e. we plot the read image just in order to avoid any misleading to the processor.

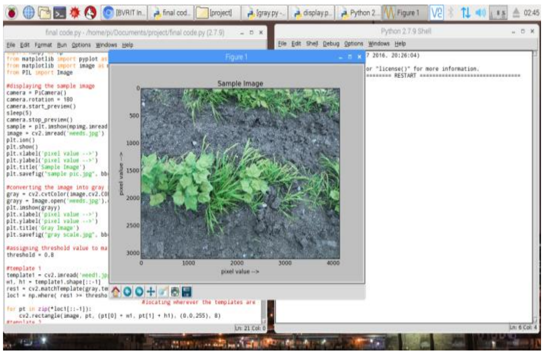


***Fig 5:** Reading the Input Image*

The converted gray scale image of the input image is obtained as follows.

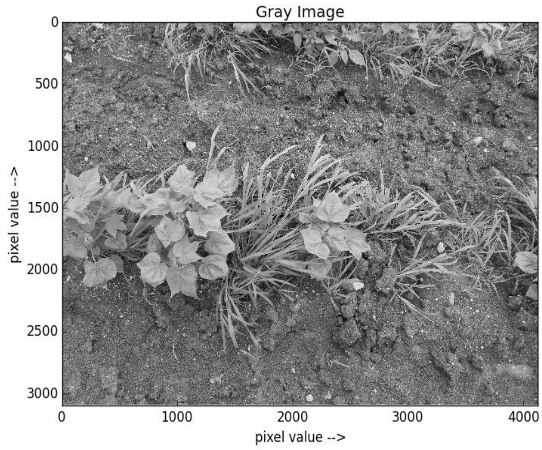


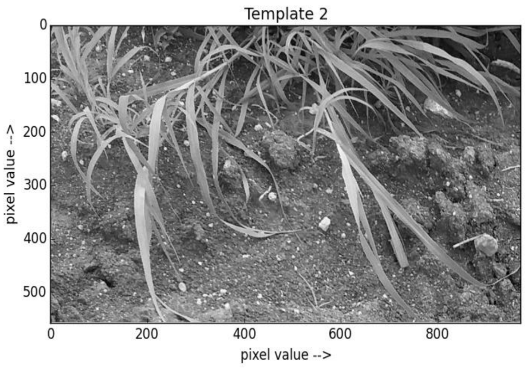
***Fig 6:** Gray Scale converted Image*

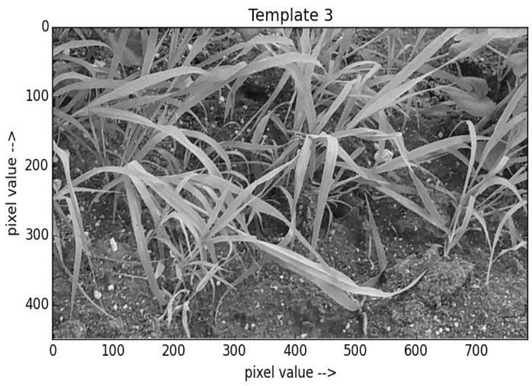
The next step is to pass the templates. Studies have shown that it is better to pass a multiple of two numbers of images as templates for a little more efficiency. It is not compulsory though. Here, the templates are the images that contain weeds. Some of the templates given in RGB color space are shown below:

Fig 7: *Collection of the Template images*

Passing the templates is similar to providing a database to the processor or the controller. In such case, care must be taken in order provide all the possibilities for detecting the required object. In the taken input image, since the crop is in its initial stages of growth, only single types of weeds are observed. That is why; care is taken in order to cover the weed in all possible directions.

These collected templates are converted into gray scale to make it easy for the processor to analyze them and also to increase the processing speed while sliding them over the input image. Such gray scale converted images are shown below:





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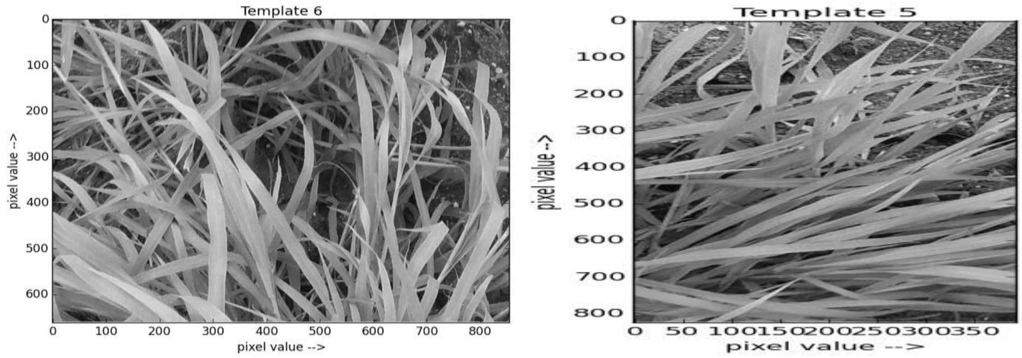

Fig 8: *Reading the Template Images*

The requisites all are ready to proceed further in the project. Now by using the template matching function provided by Open CV; we try to slide the templates over the input image. These template matching algorithms are different depending upon the number of objects that are required to be detected. If there is a single object to be detected, after just simply sliding the template, you can also determine the maximum or the minimum probability of the presence of the object in that location. Just for convenience, we assume that the template sliding which is in progress might look like the following figure.

As aforementioned, the processor firsts reads the templates and then slides them over the image. But there are certain issues when template matching is considered; the first one is that it might not give efficient results if there is any difference in shape, size of the object for which the template is designed. The second one is that it may give the repetitive results if the template of maximum probability is passed for object detection i.e. wherever there is a match in the intensity in the whole input image, the output obtained shows the object that has to be detected in the same position. That is why, care must be taken in passing the templates in every possible way with a unique intensities for each one.

Fig 9: *Template sliding in progress*

After the completion of the reading of the templates and sliding them over the input image, we assume to obtain the output with the objects detected. As a matter of fact the template matching function of the Open CV returns a gray scale image. But for better understanding of the user, we tried to locate the points where the object is detected and to write the result in the same RGB image which was the input image or the base image. This resulted in highlighting of the points of location of the weeds in the entire image on the input color image which comprised both crops and weeds of the cotton field.

The final output thus obtained is shown in following figure.

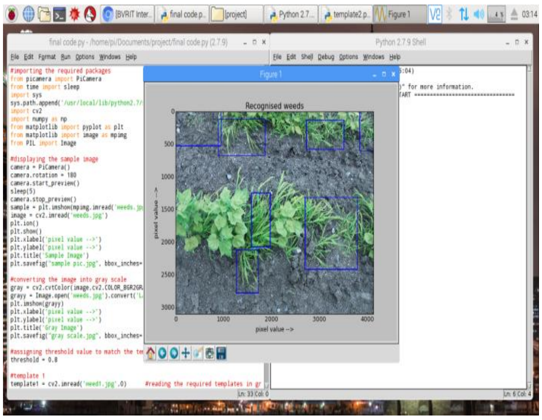

Fig 10: *Output showing the weed locations*

For better view, the final obtained output is shown in the following figure.

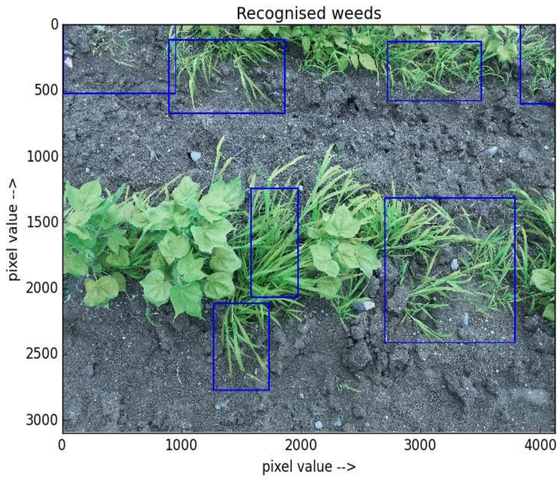

Fig 11: *Image showing the weeds and their locations*

CONCLUSION

When observed, our project aims to detect the weeds and their locations. In other words, it is similar to preparing the database and scanning through it. So once the database is fully prepared, it aims to provide the desired objective of detecting the weeds for every plant and every weed. The main concern is the memory management, which can be further extended using cloud storage. Since Raspberry Pi can also be operated in headless mode i.e. from the remote areas also, there shall be no problem to direct this project towards complete automation.
Also, we have got many other options for weed detection to be done using image processing. But most of the scholars have studied the feature extraction. A little comparative study between feature extraction and the method that is implemented here, the template matching is mentioned here in this section:

Table 1: A *comparative study of feature extraction and the template matching*

Sl.No	Feature Extraction Technique	Template Matching Technique
1	Needs leaf to leaf analysis.	No need of such analysis.
2	Time taking process.	Faster than extracting the feature of all the leaves.
3	Doesn't have any memory constraints.	Memory of the device plays a key role.
4	Involves more steps to distinguish weeds from crop leaves.	It simply matches the given templates.
5	It shows more efficiency if designed to detect the crop than to that of weed.	It simply requires the various weed images that has possibility of growing during various stages of crop growth.
6	Difficult to operate in remote areas unless wireless communication is approached.	It is easy to operate in the remote areas
7	Not compatible for complete automation	Can be developed into a fully automated mechanical device.
8	Change in the shape or of leaf may be due to insect bite etc can affect the overall output.	Only shows undesired results if there is any overlapping of crop leaves.

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