RASPBERRY PI BASED PLANT GROWTH MONITORING SYSTEM USING OPENCV

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Abstract : The growth of any plant or crop is directly related to the irrigation system adapted by human being. Thus the growth of the any plant including the agricultural crop is the consequences of many factors such as atmospheric temperature, soil moisture content, pesticides and many more. Human have the in-built capability to estimate the size of an object, and this project is mainly aiming on to proposing a system with such as ability to detect the size of any plant, and the growth is estimated by comparing with a reference image. For this purpose to be fulfilled the first step is taking the crop image and it is done by the use of the V2 camera of Raspberry pi and the further digital image processing is done by the use of OpenCV library running on the Raspberry pi server. Thus this process is aimed to make the plant (especially crop) growth detection process automatic with greater accuracy and precision, to develop an optimized irrigation system.

IndexTerms - **Raspberry Pi, OpenCV, Image Processing, Crop Growth.**

I. INTRODUCTION

Agricultural sector plays a very important and crucial role in the development of economic segment of a country. Thus it provides a valuable contribution to the advanced as well as developed countries and also to its economic prosperity. But now a day it has been seen that many agricultural products mainly crop get wasted due to lake of good and efficient irrigation system and this is directly affecting the overall balance of market as the agricultural production do not meet the food demand of the population. Such situations are created because the farmers apply their instincts and intuitions in the process of harvesting and due to such lack of exact information improper irrigation is taking place. One of the important parameter used by the farmers for the irrigation process is the growth of the crop. [7] Now a day's every agricultural researchers as well as industries are focusing on image processing and machine learning for the development of the agricultural products. This proposed work is mainly aiming to develop a system that will provide the information related to the size of the crop with much higher accuracy and precision automatically with the help of the latest advanced technology, that is image processing. And this information related to size of the crop is enough for the farmer to select proper irrigation system, such as when to water the crop, when to harvest, amount of pesticides, etc., and by doing such development in the irrigation system, farmers will be able to increase the production and meet the on-going market demands. This will not only be beneficial to the agricultural field but also helps in economic stability of a country.

II. PROPOSED HARDWARE SYSTEM

Various steps are included in the proposed work in order to detect the size of the crop. In the very first step the image of the crop is taken with the help of V2 PI camera where the reference plant and the measured plant is placed on the left of the frame as the scanning of the image takes place from the left most side of the frame in order to perform the image processing on the image. The width of the reference object is used to calculate the pixel per metric value which in turn is used to calculate the actual height of the object. The whole system can be divided into three parts:

- Intake of the reference as well as the measured plant image
- Digital image processing on the acquired images
- Generate and display of the result

The overall block diagram representation is shown in figure 1, where the major components used as well as the results that will be displayed is shown. As shown in the figure raspberry pi is used in the model in which the inputs are fed and also the image processing takes place. And the coding is written in python language which is one of the user-friendly language supported by raspberry pi and also suitable for image processing.
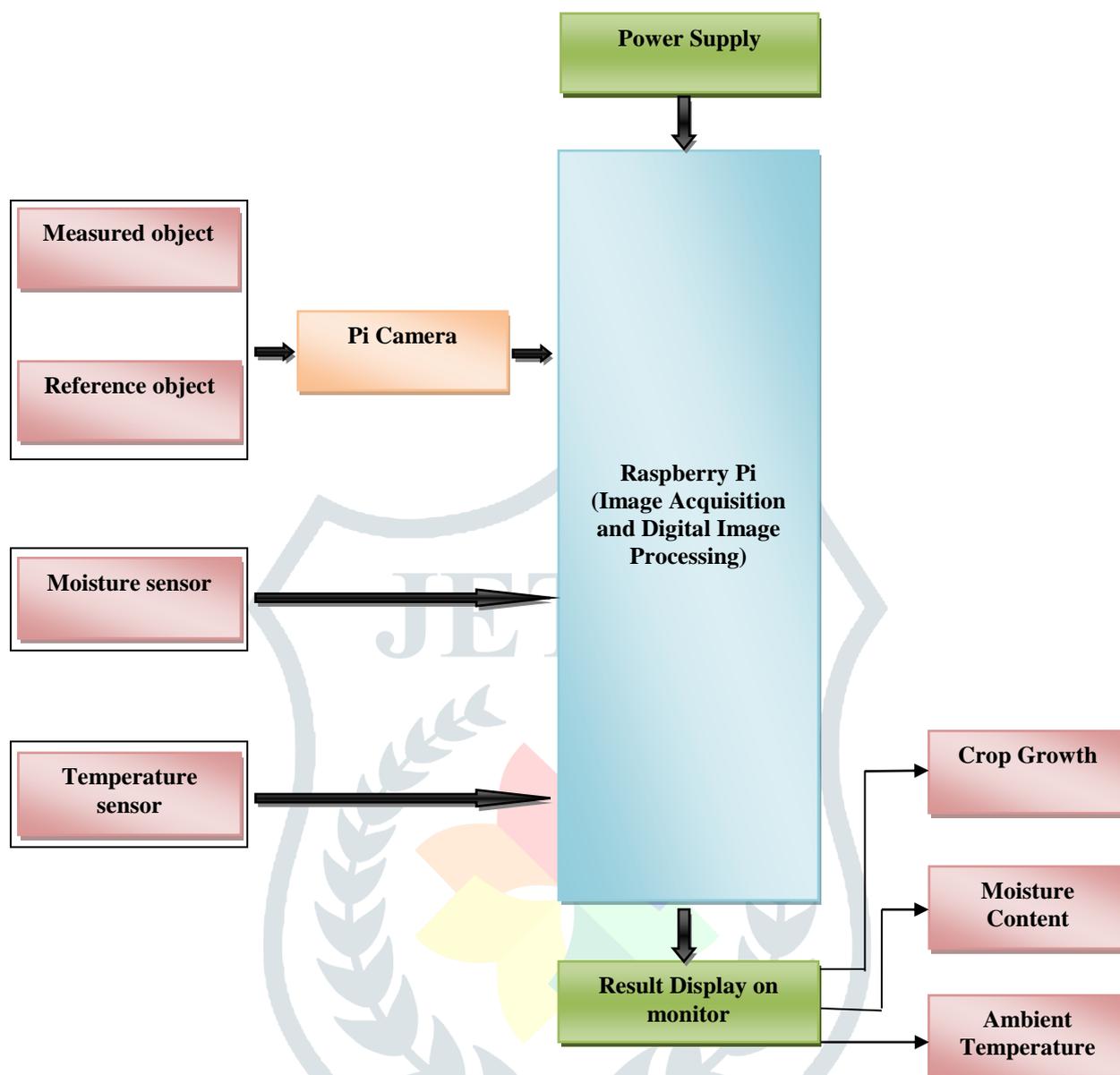
Figure 1: Block Diagram

There are three inputs to the raspberry pi board, which are the object (crop) images (reference object and the measured object), the output of the moisture sensor, and the output of the temperature sensor. Moisture sensor and the temperature sensor is used to provide the information regarding water content of the soil and the ambient temperature respectively. This information along with the height detection can be used to identify the appropriate method for irrigation by the farmers. [8] V2 camera which is a raspberry pi is used to take images of the object (crop) and fed it directly to raspberry pi board. The moisture sensor and the temperature sensor is connected directly to the gpio pins of the raspberry pi board and fed the measured data to the board in digital form.

OpenCV which is a dedicated library that mainly aims at real time image processing is used in this project in order to measure the height of the crop accurately. Various tools available in this library is used such as gray scale conversion, [6] image blur, edge detection, and contour finding. These are the initial steps that are required to be performed on an image in order to make the image suitable for further image processing. This library is pre installed in the raspberry pi board and the codes are written in python language.

 The result can be displayed either on the HDMI monitor that is physically connected to the board or on a laptop connected through VNC server or can be displayed on a web page for global access, as per requirement. The information that will be displayed is the growth of the crop in terms of height, the amount of moisture content on the soil and also the ambient temperature. This information will be helpful to identify the effect of the amount of water and the weather condition for the proper growth of the plant.

III. SOFTWARE IMPLEMENTATION

The initially part of the project is totally hardware based that includes the camera, sensors, raspberry pi board, power supply, monitor. Now the actually processing on an image is done using software called OpenCV that is installed and run on raspberry pi server. [1] OpenCV is one of the popular image processing libraries that consists of a huge image processing tools that includes color changing, various edge detection methods, various image smoothing tools, tools for performing numerical actions, transforming images, detection of object by various methods, etc.

Among these available tools, few of them are used to fulfill our purpose and they are as follows:

- **Color conversion**: As the image captured by the camera is in RGB (red, green, blue) format it is initially converted into gray scale as processing RGB format image is difficult. RGB is a 3 dimensional multichannel data of image and it is of 24 bit that requires more memory for processing and on the other hand gray scale image is a single dimensional binary data which is 8 bit wide, thus require less memory to process.

- **Image smoothing**: [2] When an image is captured from the real world, it is subjected to noise that may affect the information of the image. Thus this is one of the important steps in image processing in order to remove or filter out the noise from the image. OpenCV provides various tools to perform such smoothing action on image such as 2D convolution, image blurring- Averaging, Gaussian filtering, Median filtering, and Bilateral filtering. Among this Gaussian filtering technique is used in the project. In this Gaussian kernel where width and height of the kernel has to be specified and it must be positive as well as odd value. Along with these standard deviation in both the X direction and Y direction of sigmaX and sigmaY has to be specified.

- **Edge detection**: One of the important steps to follow in order to detect the object location and size is detection of the edges of the object in an image. [3] Canny edge detection is one of the popular edge detection taking where various functions are included in one library. The functions are: Noise reduction, finding the intensity gradient, non maximum suppression, and hysteresis thresholding. OpenCV allows single code execution to perform the edge detection operation on any image. In that we have to specify the input image, minimum value, maximum value and the aperture size. The main purpose of using edge detector is to find the boundaries of the object in an image, so that the portion in an image which is not the part of the crop can be distinguished from the boundary and only the crop section can be separated for further processing on that section.

- **Contours**: [4] Contour in an image represents the boundary and in particular the shape of any object by joining multiple point in an image. On the other hand edge detection represents the points where there is change in intensity and not connects the point to detect the shape of the object. Thus before performing contour finding, edge detection is required in order to identify actual object coverage area. In this step the background image is separated from the actual object (crop) and forms a boundary around the crop.

Other libraries included are:

- **Numpy**: It is referred to as numerical python and it is used for performing numerical operations in python programming language. It supports high level of mathematical functions to perform operations on matrices and mainly on multi-dimensional arrays. In this project Numpy is used to perform numerical operations on the image represented in array.

- **Imutils**: This library is a python based series of functions that is mainly used for some basic image processing such as resizing of image, rotation, displaying, and many more.

The programming language used in writing the code and performing image processing using OpenCV is python. [5] Python is one of the most suitable general purpose languages for handling images, and for image representation. It is user friendly English like syntax and supports multi platform such as Windows, Linux, etc.
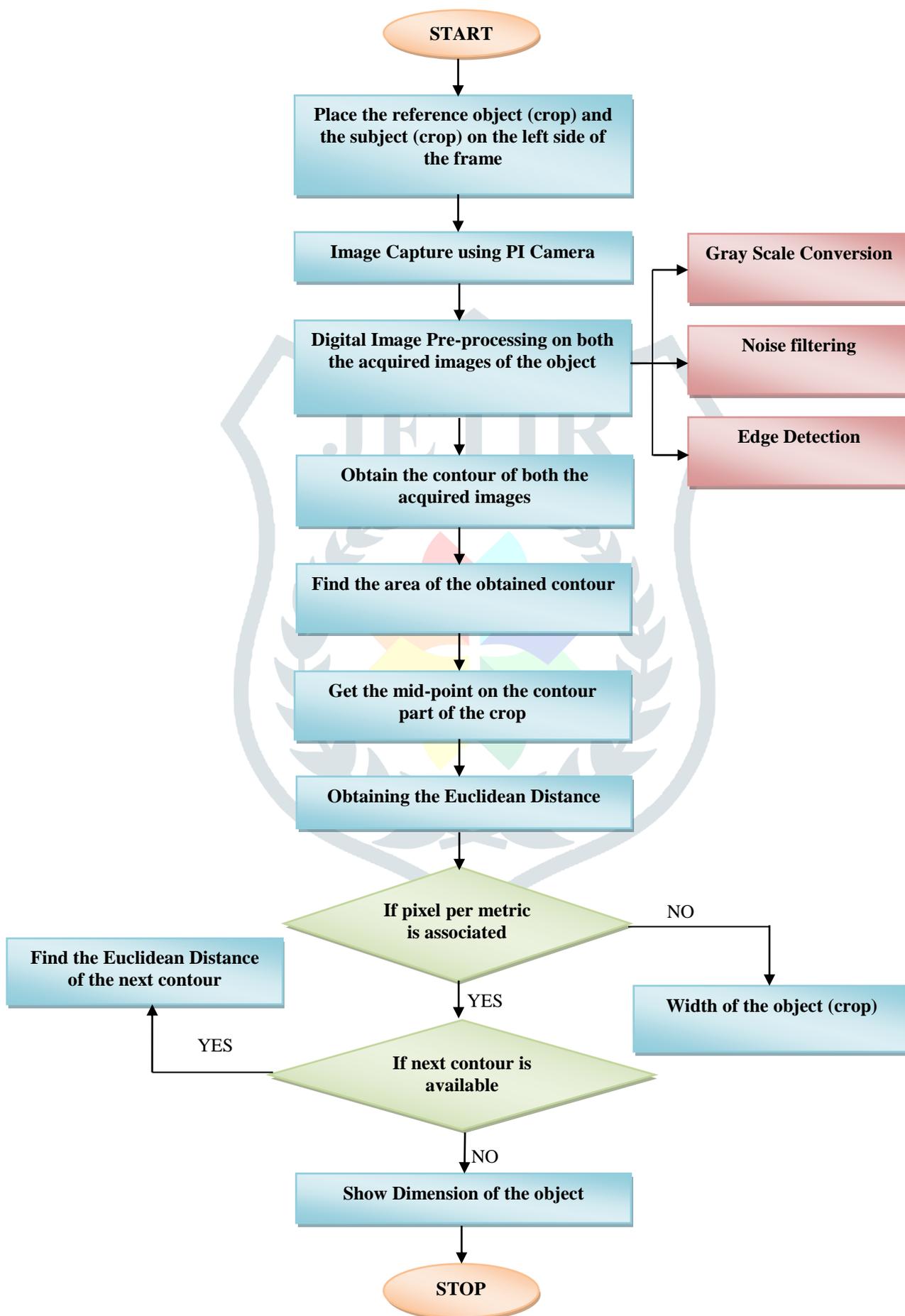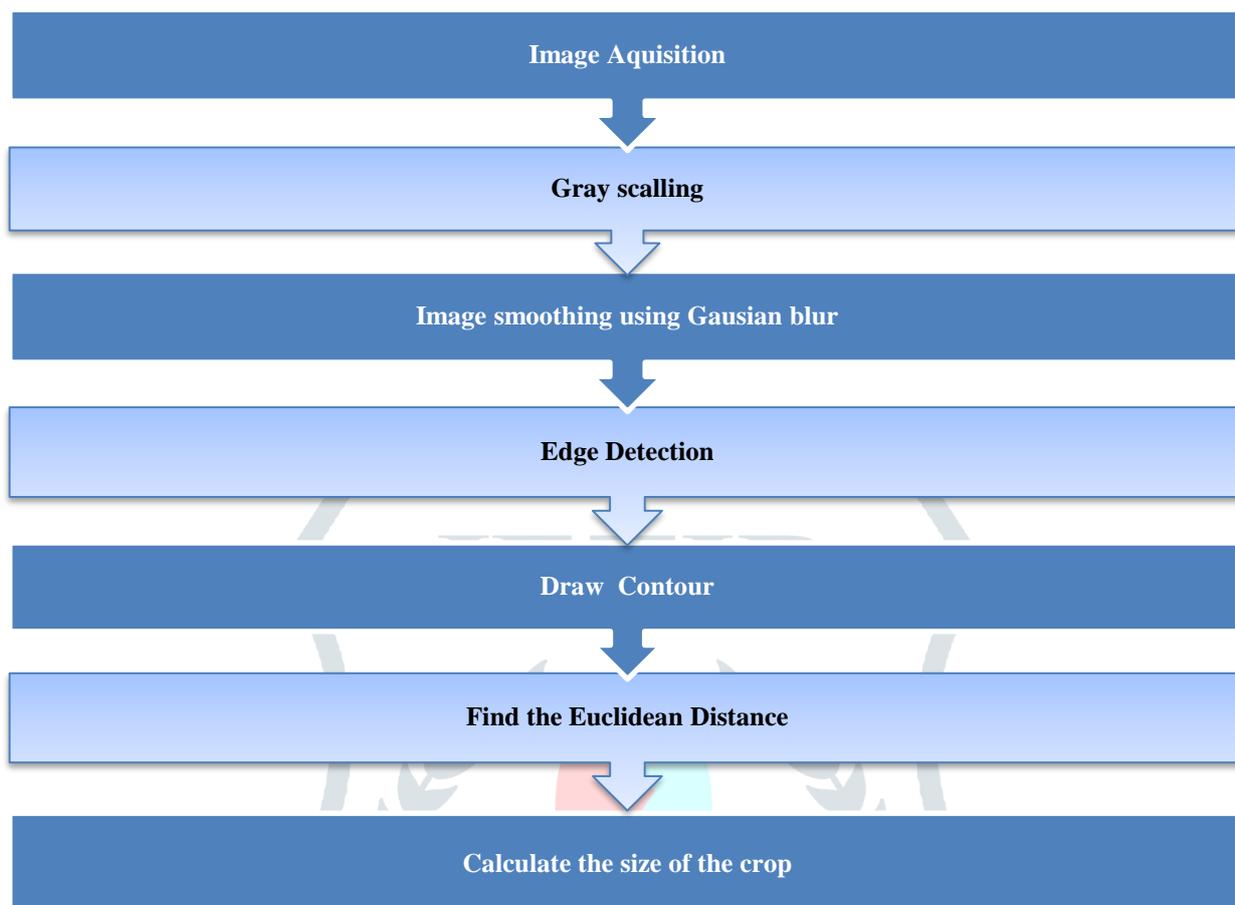
IV. FLOW CHART

Figure 2: Flow chart

V. PROCEDURE

Image Aquisition

Gray scalling

Image smoothing using Gausian blur

Edge Detection

Draw Contour

Find the Euclidean Distance

Calculate the size of the crop

The above diagram represents the procedure for measuring the size of any object and here measurement of the size of the crop   is achieved. Every block in the diagram is a representation of a step involved in the process.

The overall procedure can be sub divided into layers of processes, which are explained below:

- As the image scanning procedure is from left to right, thus the initial arrangements is to place the reference object and the measured object (crop) starting from the left side of the frame.
- Provide the dimensions of the reference object as the input for further processes.
- Place the camera in front of the frame in such a way that the crop should be well visualized.
- Initialize the camera to capture the images of the measured crop.
- These captured images are fed to the server of raspberry pi.
- Then all the pre-built software procedures are handled by the PI board and the procedures are as follows.
  a) Perform pre-processing on both the reference and the image captured by the camera. Pre-processing includes Gray-scaling, Gaussian blur, Edge detection, and finding mid-point using OpenCV image processing library.
  b) Then the measurement calculations take place to find the contour as well as the Euclidean distance of the captured crop to the find the height of the plant (crop).
- These calculated sizes are superimposed on the displayed image on the terminal.
- Thus the output size is available on the monitor

The result also includes the moisture sensor and temperature sensor data on the monitor along with the height of the plant (crop). This information of size, moisture content of the soil, and the atmospheric temperature around the plant gives valuable information regarding the affect of the soil moisture and the ambient temperature on the growth of the plant (crop), thus this will be beneficial in deciding the appropriate amount of water provided to the plant root and the weather conditions for any particular type of crop. Thus this will be a step towards developing agricultural practices.

VI. RESULT

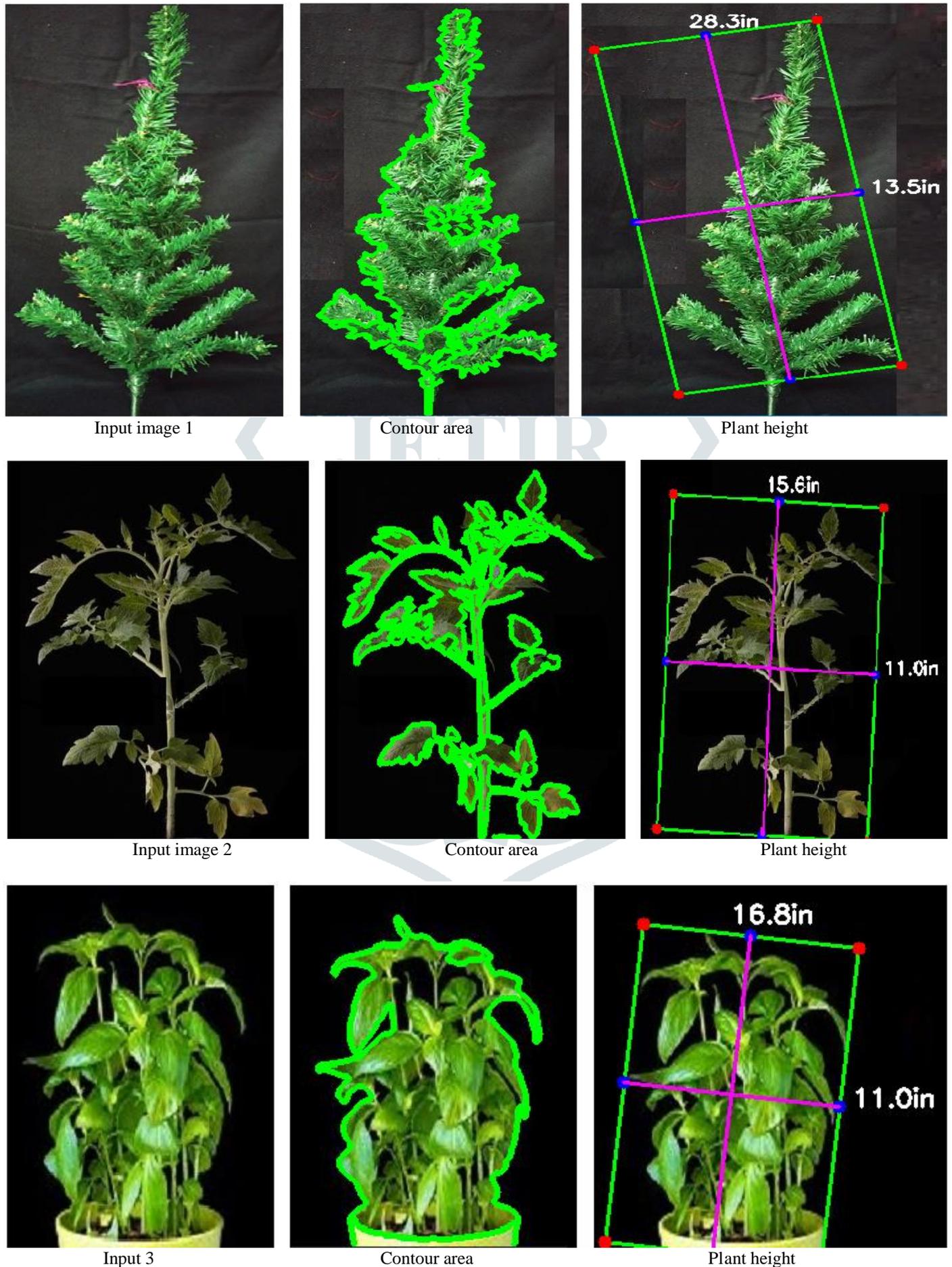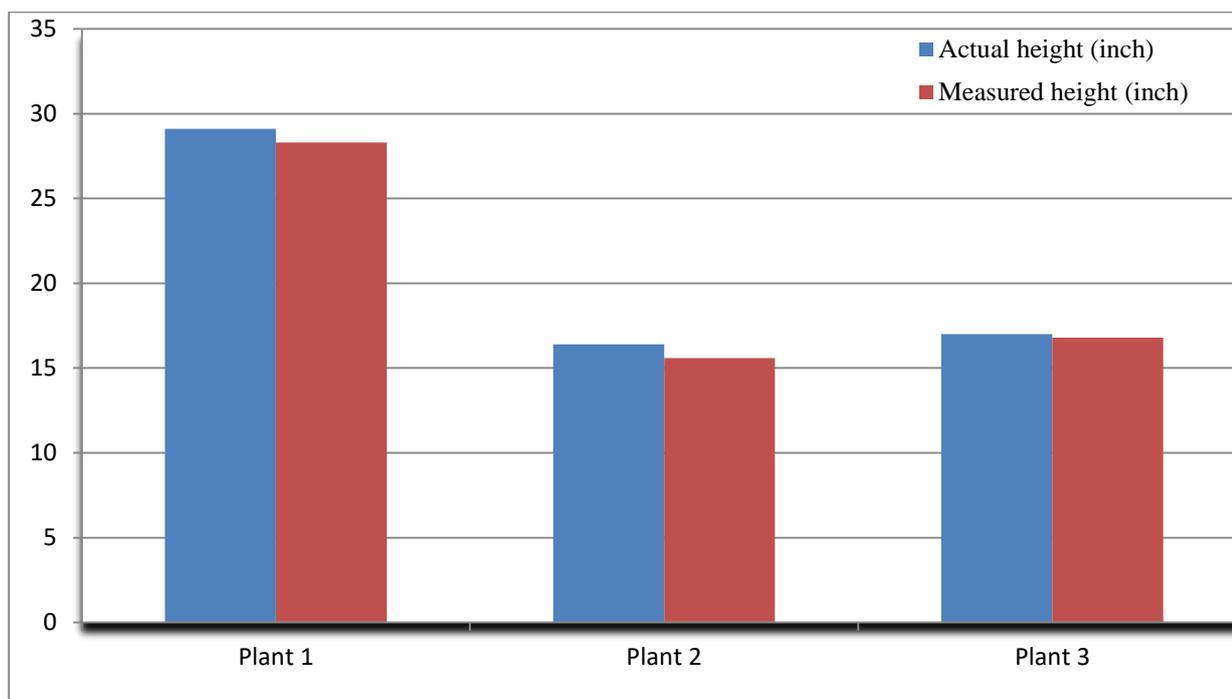|		
Input image 1	Contour area	Plant height
Input image 2	Contour area	Plant height
Input 3	Contour area	Plant height

Figure 3: Input plant, contour area covered, and the plant heights

In the above figure 3 images of three different types of plant is shown that is capture by camera and fed to raspberry pi, then these images are pre-processed and the contour area is obtained. Finally the Euclidean distance and the height of the contour area is obtained as result and displayed on the monitor screen around the plant.

In figure 4 a graphical representation that shows the comparison between the actually height measured with a measuring tape and the measured height after image processing is shown. Using this graphical comparison the accuracy of the image processing can be calculated. And the result provides around 90% to 95% accuracy.

VII. CONCLUSION AND FUTURE WORK

Conclusion:

This research paper is an effort to proposed system that includes the on-going technology such as image processing in order to take a step towards technological advancement in the agricultural sectors and to improve the overall production as well as the quality of the food products. Thus this will help to maintain balance in the agricultural market, economical graph and the society in general. For that different image processing libraries are used to perform operations on the image and find the height of the crop.

Future scope:

The concept of image processing and neural networking in agricultural advancement is a vast area of interest for many researchers and lot many developments and advancements are possible in this field. One of the major possibilities for future of image processing in agriculture is to combine this work of classifying different types of crop with the highly advanced technology of satellite mapping, so that exact land area, location and other related information can be achieved. Along with that combining these research idea with weather forecasting technology; crop production can be done according to the climate and environment suitability. This concept will be helpful in growing varieties of seasonal and tropical agricultural products.

VIII. ACKNOWLEDGMENT

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