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Moving Robot and Image Processing based Analysis for Tomato Growth Measurement

Aayesha M. Shaikh[1], V.S. Shingate[2]

[1]M.E.(Electronics) , Department of Electronics Engineering, K.B.P. College of Engineering, Satara, India

[2]Professor, Department of Electronics Engineering, K.B.P. College of Engineering, Satara, India

Abstract: ***Crop grow measurement technologies are important to increase the farm productivity to fulfil the increasing demand of food of growing population. Detection and measurement of fruit volume are useful for forecasting and harvesting applications. Some environmental challenges such as lighting conditions or occlusions make the fruit detection difficult. Our approach is based on features extraction from images using suitable methods of image processing. Then images being described as a number of pixel are used to estimate the fruit volume. This paper tries to develop a robotic system to analyze the growth of the tomato fruit by determining fruit volume using image processing.***

Keywords: Agriculture, Field Robotics, Growth Measurement, Image Processing: image acquisition, pre-processing, segmentation, noise removal, feature extraction, Tomato growth

1. Introduction

Agriculture is the backbone of human existence on earth. Agriculture should be healthy and sustainable to prosper any civilization. Agriculture provides nourishment to the world population and holds the sign of being the source of income for India and other developing nations. The growth in population and rising income results in increasing demand for food. It results in great pressure on agriculture industry to secure the growing demands for the food. Innovations in agriculture are increasingly needed to secure a growing world demand for food, in order to conserve and optimize the use of limited natural resources and to sustain the environment's ability to provide economic, social, and environmental services to society.

At the present era, the farmers have been using various pesticides for crop at regular intervals. Presence of pests and diseases affect the rate of crop cultivation. Also incorrect amount of water and fertilizers have been also given by farmers because they are unable to recognize exact growth of a plant and fruits. So it reduces the crop yield in a significant amount and as a result there will be an increase in poverty, food insecurity and mortality rate. Presently, the monitoring and analysis of plant or fruit growth is done manually by the expertise person in that field. This is a time consuming process. This problem can be completely resolved if we use automatic detection method for the growth of the crop. With the advancement in image processing technology, it is feasible to create an automated mechanism for the detection of crop growth.

Growth of plant is influenced by environmental conditions and topography. So there is need to measure dynamics of plant to understand its growth. Crop grow measurement technologies are important to increase the farm productivity. Tomatoes are in high demand because the world population consumes them daily. So it becomes necessary to improve tomato production and fruit quality through fruit measurement methods.

To measure crop growth, detection and measurement of fruit volume are useful. Some environmental challenges such as lighting conditions or occlusions or any barrier make the fruit growth detection difficult. So we have to develop a robotic system with camera interfaced on it to capture images. Our approach is based on features extraction from captured images. We are going to use color feature of the captured plant image. By measuring area of the tomato's and performing analysis by some image processing operations, growth of the tomatoes will be decided.

2. Literature Review

a) The research done by Rui FUKUI, Julien SCHNEIDER is based on is based on features extraction from images through a sub-image clustering technique. Then images being described as a number of pixels in various labels are used in a regression model to estimate the fruit volume.
b) In Ramandeep Kaur's research, growth of a plant is measured using interface between digital camera and a computer. This interface allows a user to get continuous video of the plants. Testing of different plants at different places has been done. A MATLAB GUI has been developed for performing sobel edge detection on a plant image to determine its height and width. Two different types of options for the selection of a plant image are provided. Either the full image or cropping of the image can be done. The algorithm provides height and maximum and minimum width of the plant's stem in terms of pixels.
c) Ta-Te Lin, Tsung-Cheng Lai has described a stereo vision system which is composed of two off-the-shelf cameras with parallel optical axes was integrated with an image processing algorithm developed to monitor plant growth.
d) Jinweon Suk, Seokhoon Kim and Intae Ryoo propose a non-contact plant growth measurement system using Infrared sensors based on the ubiquitous sensor network (USN) technology. The proposed system measures plant growth parameters such as the stem radius of

plants using real-time Non-contact methods, and generates diameter, cross-sectional area and thickening form of plant stems using this measured data.

3. Whole-Image-Processing-Based-Growth Measurement

a) Proposed Approach

Crop grow measurement technologies are important to increase the farm productivity. To measure crop growth, detection and measurement of fruit volume are useful. Some environmental challenges such as lighting conditions or occlusions or any barrier make the fruit growth detection difficult. So there is a need of a standalone unit that will just click a photo and get result about the growth by analyzing the captured images. So it is necessary to develop a robotic system with camera interfaced on it to capture images. And analysis will be done by whole image processing and result of level of tomato growth would be displayed. The result would be displayed in the form of number of ripened tomato.

b) Methodology

1) Block Diagram

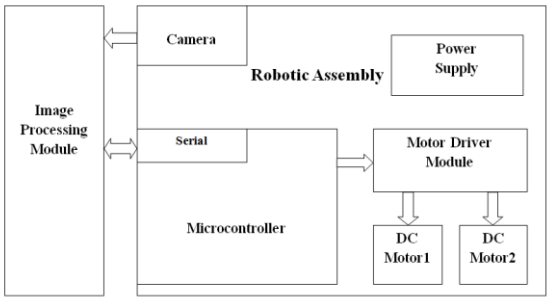


Figure 1: Block Diagram of Tomato Growth measurement system

The block diagram of the proposed system is as shown in figure. Tomato growth measurement system consists of Image processing module, Microcontroller, DC motor driver, two DC motors and Camera. Camera which is placed on a robotic assembly captures the images from crop field and send it to image processing module. In image processing module, image is processed to detect growth of the tomatoes as poor growth, medium growth and good growth and the result will be displayed.

Image captured by camera is a color image. It is converted from RGB to HSV(Hue, Saturation and Value or Brightness). After that, from its hue component we will find red colored area means we differentiate between leaf and tomatoes from the captured image. Then, apply segmentation on the image. Perform noise removal operations. Then, measure area of the tomatoes. According to set threshold, take decision as poor growth, medium growth and good growth of the tomatoes and display it. Image data is send to microcontroller board through serial USB communication.

To take a next image of crop, we are going to use DC motors and driver module. Driver module consists of two DC motors for the movement of robot.

2) Image acquisition Robot System

The above block diagram shows the Robotic Assembly. It consists of microcontroller, DC motor driver, two DC motors and Camera. The DC driver module consists of two DC motors for the movement of robot. Motor driver module is used to drive the motors. Both motor rotates based on the command send from the microcontroller.

Microcontroller

Microcontroller is used to control the camera and movements of the robot. Movement of robot in forward and backward direction is done according to commands send to the motor driver module. Microcontrollers like PIC16F874A/877A is used which controls the robotic movements and has capability of Serial Programming. MikroC software is used for programming of microcontroller PIC16F874A/877A.

Motor Driver Module

The motor driver circuit is also called as “H-Bridge” and “Full Bridge” . The name is derived from the actual shape of the switching circuit which controls the motion of the motor. Basically there are four switching elements in the H-Bridge as shown in the figure below.

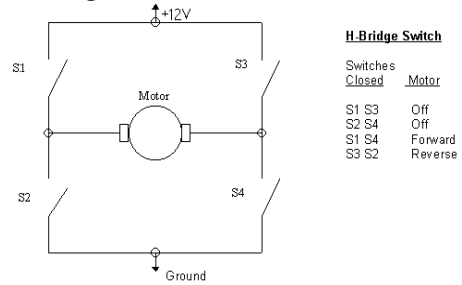


Figure 2: H-bridge basic circuit diagram

When these switches are turned on in pairs, motor changes its direction accordingly. The directions of movement of motor are shown in above table.

High Left	High Right	Low Left	Low Right	Description
On	Off	Off	On	Motor runs clockwise
Off	On	On	Off	Motor runs anti-clockwise
On	On	Off	Off	Motor stops or decelerates
Off	Off	On	On	Motor stops or decelerates

Table: Direction of motor rotation

Multiple softwares components are used. A microcontroller (PIC 16F877A, MikroC for PIC programming) controls the camera and the movement of motors. The programming software on the PC(Matlab, Mathworks) handles the microcontroller and processing of captured image.

3) MikroC for PIC programming

MikroC is a full-featured ANSI C compiler for 5 different microcontroller architectures. It is the best solution for developing code for your favorite microcontroller. It features intuitive IDE, powerful compiler with advanced SSA

optimizations, lots of hardware and software libraries, and additional tools that helps in work

Each compiler comes with comprehensive Help file and lots of ready-to-use examples designed to get you started in no time.

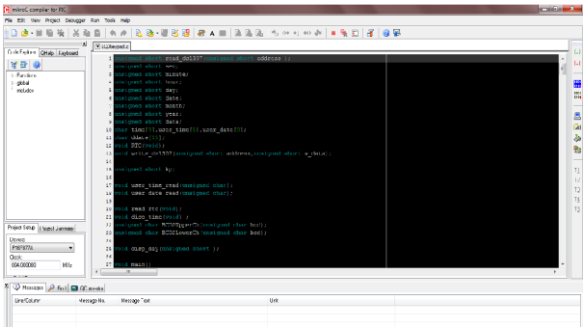


Figure 3: MikroC compiler

c) Measurement and image processing algorithm

For processing of an input image MATLAB, Mathwork on PC is used.

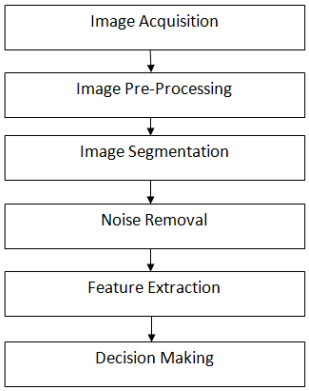


Figure 4: Basic Image Processing Methodology

1) Image Acquisition: It is the process in which images acquire through camera and converted to the desired output format. This image is a color image i.e. RGB image.
2) Image pre-processing: In this process apply color filter and create color transformation structure steps are present. Image Clipping, smoothing and enhancement are three steps included in pre-processing phase. The color image is converted from RGB to HSV(Hue, Saturation and Value or Brightness). After that, from its hue component we will find red colored area means we differentiate between leaf and tomatoes from the captured image.
3) Image Segmentation: Image segmentation is the process of partitioning an image into multiple segments(sets of pixels, also known as super-pixels). Image segmentation is the process of assigning a label to every pixel in an image such that pixels with same label share certain characteristics.
4) Noise Removal: It is the process of removing or reducing the noise from an image.
5) Decision Making: After noise removal operations, measure area of the tomatoes. According to set threshold, take decision of growth of the tomatoes and display it in the form number of tomatoes.

Image data is send to microcontroller board through serial USB communication.

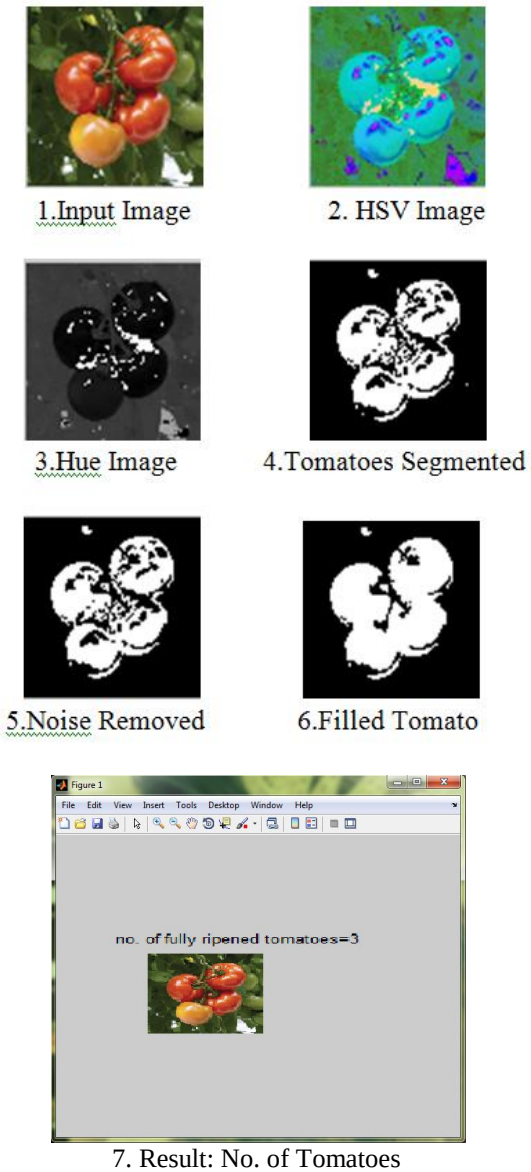
4. Experiment: Performance and Field Evaluation

Purpose of Experiment

To assess the performance of robot and image processing algorithm, the robot is tested in an experimental configuration with red tomatoes. The estimation of experimental performance is tested in greenhouse.

Experimental Results

The image of tomato plant is captured with the help of developed robotic assembly. The captured image is processed with the help of matlab software and the corresponding results are shown below.



7. Result: No. of Tomatoes

Figure 5: Experimental Results of Image Processing

5. Conclusion

Recent developments in agricultural technology have led to the demand for a new era of automated, noninvasive

methods that leave the crop intact and do not interfere with its natural growth. Image processing is very useful for the area of agriculture, allowing us to develop systems that do not interfere with the plant. At the same time, we can measure fast and very close to testing done by laboratories.

Thus Tomato growth measurement based on image processing becomes an automated and noninvasive method which is useful for improvement of fruit production and fruit quality.

6. Improvement to the System

As a future enhancement the system can be made wireless (mobile) by using wireless camera and wireless modules for wireless transmission of data. An another improvement should be made to make the system fully automatic by giving the entire control to the MCU. The limitation of the system developed is that it takes large time for processing the images captured by camera. So someone has to think for the solution to fasten the response time.

Also tomato fruit is affected by many diseases. By detecting the diseased tomato the necessary precautions should be taken to improve the growth.

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