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Different analytical methods of plant's growth measurement

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Abstract : *Growth analysis of stem variations information without interrupting natural growth of the crops is important for the water-saving irrigation. Three different approaches Illumination, Strain gauge and Image processing methods are applied to the growth data to model the growth of plant. In illumination method the imaging system uses a background illumination source to improve the quality of images of stems. The strain gauge is used as a sensor to detect the changes in micrometer for every 1μm changes. In Image processing Sobel Edge Detection is performed on a plant image to determine its height, maximum and minimum width.*
Keywords : *Growth analysis, stem diameter and height, Strain gauge, Edge detection.*

I. Introduction

To determine growth analysis of plants, various research methods were conducted to obtain the best results [1]. Among the studies that have been discussed here is using computer vision and embedded systems [2]. Under this circumstance, stem diameter measuring device was developed based on smart camera, near infrared light source, computer vision technology and embedded DSP processor technology. On the other hand, strain gauges are sensors that rely on the change in gauge resistance in determining the strain within the gauged section. Several criteria in selecting the right gauge wire material for an application includes the degree of strain to be measured, environmental variables such as temperature and non-material considerations such as cost. These researches tried to provide most excellent accurate and précised results in comparison to traditional approaches.

The traditional analytical methods analyzed the growth variations with caliper and LVDT. Unfortunately caliper technique is discontinuous and insensitive. LVDT's while better than caliper used sensors in order to acquire the stem diameter has some severe shortages such as that we need to change sensors of different scale to fit the different range of diameters. We can only get the increment of the diameter while leaving the real value of the stem diameter unknown to us. The sensor may restrain the natural growth of the crops. These are very inconvenient approaches for measurement and do not present smooth vision and exact and précised values. These just offer the rough idea of change in stem diameter and height.

II. Different Analytical Methods

2.1 Illuminating Method

This paper attempts two illumination methods: illuminating the plant stem and illuminating the background. When we choose to illuminate the plant stem and keep the background with dark color. An infrared light source can be placed near the lens. Under this circumstance, we could suppose the brightness of the plant stem is higher than the back ground. As a result, we can use the brightness to separate the stem from the back ground. However, this kind of illuminating approach has an obvious shortage that is the plant stem has not a unified brightness, or in other word, the brightness of different part of the plant stem is different. This point of view can be greatly substantiated by following discussions.

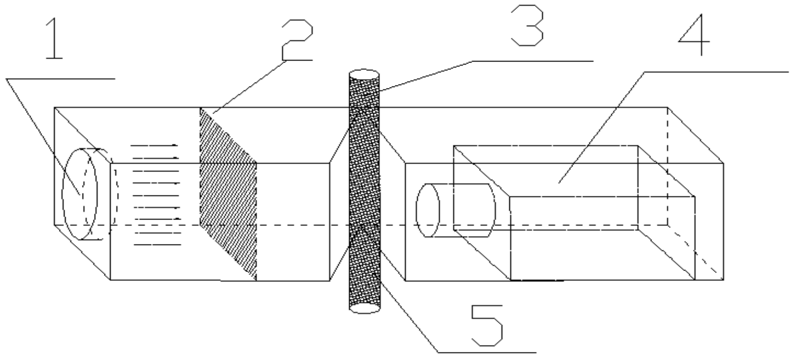


Figure 2.1 The construction of the vision measurement system

1, light source 2 background screen 3 plant stem 4 smart camera 5 opening for fixation of plant stem
Because the plant stem is a cylinder, when light comes from the same side as lens to the cylinder. The surface of the plant has different brightness due to the different angle of surfaces and illumination direction.
As showed in the left of Fig 2.2. The edge of this picture is not prominent. And the defect in the surface of the plant stem will reduce the edge detection quality. To overcome the shortage of conventional illumination method, another solution of illumination approach is testified to be effective. This time we choose to illuminate the background instead of the stem itself. The background screen is on the other side of the stem and behind the screen there is the light source (Fig 2.2). The aperture is adjusted to make the stem dark enough and the background bright enough. In order to decrease the background noise, we make the brightness of background screen slightly exceed the scale of the CCD. So the background is pure white with every pixel value 255(full scale of 8 bit ADC). This help us to resist the background noise that edge detection program brings about, moreover, the area of plant stem remains the unified dark with each pixel value nearly zero. This is quite easy for us to separate the target from the background. As Fig 2.2 shows.

Figure 2.2 **A** illuminating the plant stem **B** illuminating the background screen

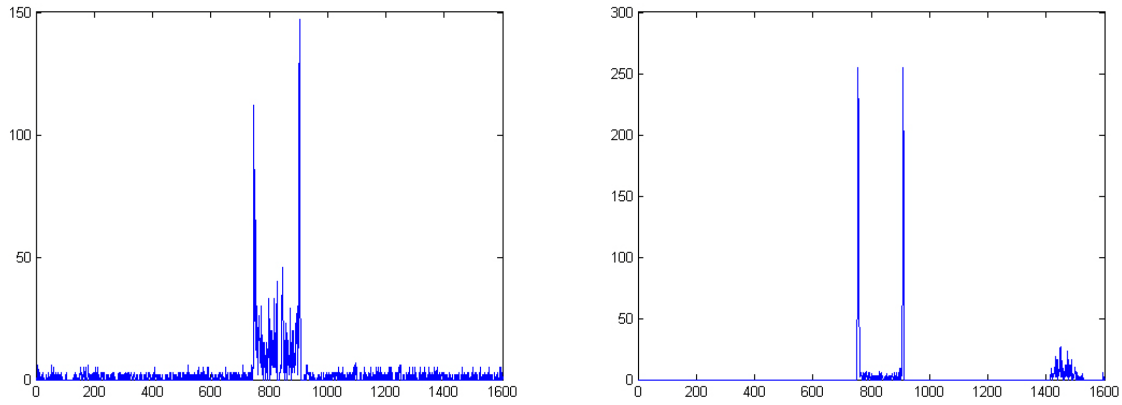
Edge detection algorism

The prevailing method of edge detection algorism is to use the gradient as the indicator for edge. In this article the Sobel edge detector is selected to detect the horizontal edge. The implementation of the edge detector is to use a 3×3 templet to convolute with the image. The template of the Sobel detector is shown as following [2]:

-1	0	+1
-2	0	+2
-1	0	+1

Measurement of plant stem only needs to know the horizontal edge so we need not use edge detector in the vertical direction. As the following figure shows that this kind of illuminating method is more effective than the conventional one showed on the left. We can learn from the figure that the right image is sharper and clearer than the left one. This improvement enables us to have a more effective edge detection method.

We use one line (line 400) of the picture to draw an edge intensity graph as following Fig 2.3.



A illuminating the plant stem **B** illuminating the background screen

Figure 2.3 Edge intensity of one line (400)

Figure on the right side have the edge intense value near 255 and the left one only has 150. In the other word, by illuminating the background screen we can obtain a higher quality of image that enable us to have a more precise parameter without the interruption of the detail defects of the surface of plant stem.

2.2 Strain Gauge

Strain gauge sensor is used to measure the voltage at the stem of the plants. The type of strain gauge used is cooper nickel alloy; size 5mm, G.F 2 with resistance of 120 Ω. However, the output signal (volt/amp) strain gauge are small and weak and mostly of the order of 10-3 or less. Direct measurement of these signals is inappropriate to draw meaningful conclusions. In addition, noise may cause the task more cumbersome. Hence, these signals are amplified. Further, for better accuracy and precision, circuit strain gauges utilized double strain gauge, low pass filter and buffer. Double strain gauge is meant to reduce the thermal effect or known as temperature-induced apparent strain. Thermal effect is caused by two concurrent and additive effects in the strain gauge installation. The electrical resistivity dependent on the grid conductor temperature and the effect is strain gauge varies with temperature. The second is when strain gauge material band, thermal output is due to the differential thermal expansion between the grid and the test part [3]. Next, a low pass filter is added to reduce noise and any unwanted signal. Lastly buffer is added at strain gauge circuit to minimize loss of signal strength in analog systems due to excessive loading of output nodes. The operational amplifier buffer circuit used is based on an operational amplifier (op amp) with unity-gain feedback. The open-loop gain of the operational amplifier should be very high.

Based on the experimental analysis, firstly, the strain gauge is bended about 0.5mm from 0 to 3mm using micrometer. Double strain is used and comparison is made with single strain gauge. Fig 2.4 and Fig 2.5 showed the gauge characteristic (mv) versus distance (mm). During this experiment, the temperature and humidity of the laboratory is 26.70c and 50.4% RH respectively. The accuracy of humidity and temperature is programmed using PIC with tolerance of ±2%.

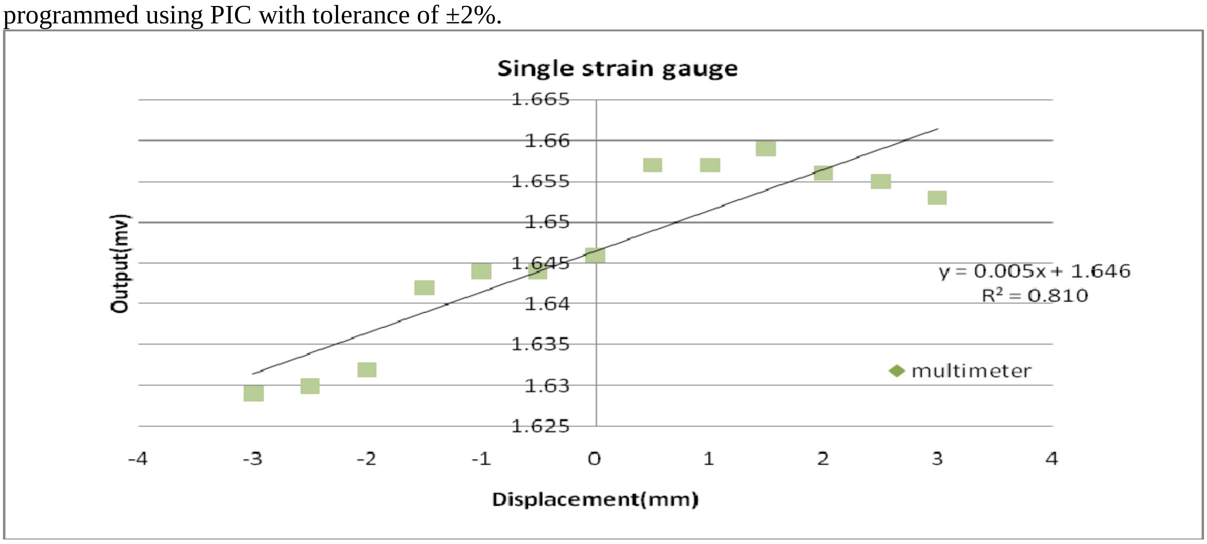


Figure 2 4: Single strain gauge

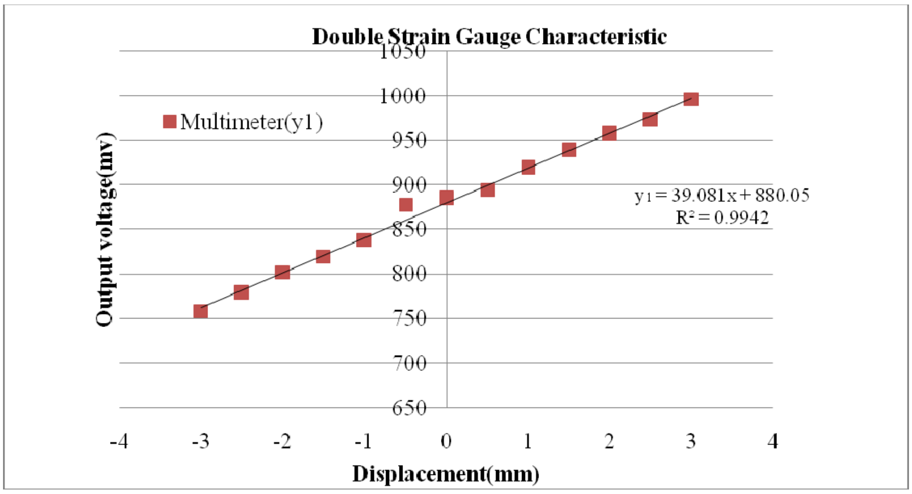


Figure 2.5: Double strain gauge

As seen from both Figure 2.4 and Figure 2.5, the correlation coefficient between sensor output and micrometer displacement, R2 for double strain gauge was higher than single strain gauge with percentages difference of 18.83%. Double strain gauge is able to minimize the thermal effect occurred during the experiment. Thermal effect will influence the readings since any changes of temperature will affect the strain gauge [4].

2.3 Image Processing

In image processing system the image of a plant is firstly received at the PC from camera. Then we developed a program in matlab to calculate parameters of plant using Sobel Edge detection algorithm. A matlab GUI has been developed for performing Sobel Edge Detection on a plant image to determine its height and width [5]. Fig 2.6 shows the two different options for the selection of a plant image. That is either we can manually cropped the image (pressing 2) or select the full image (pressing 1).

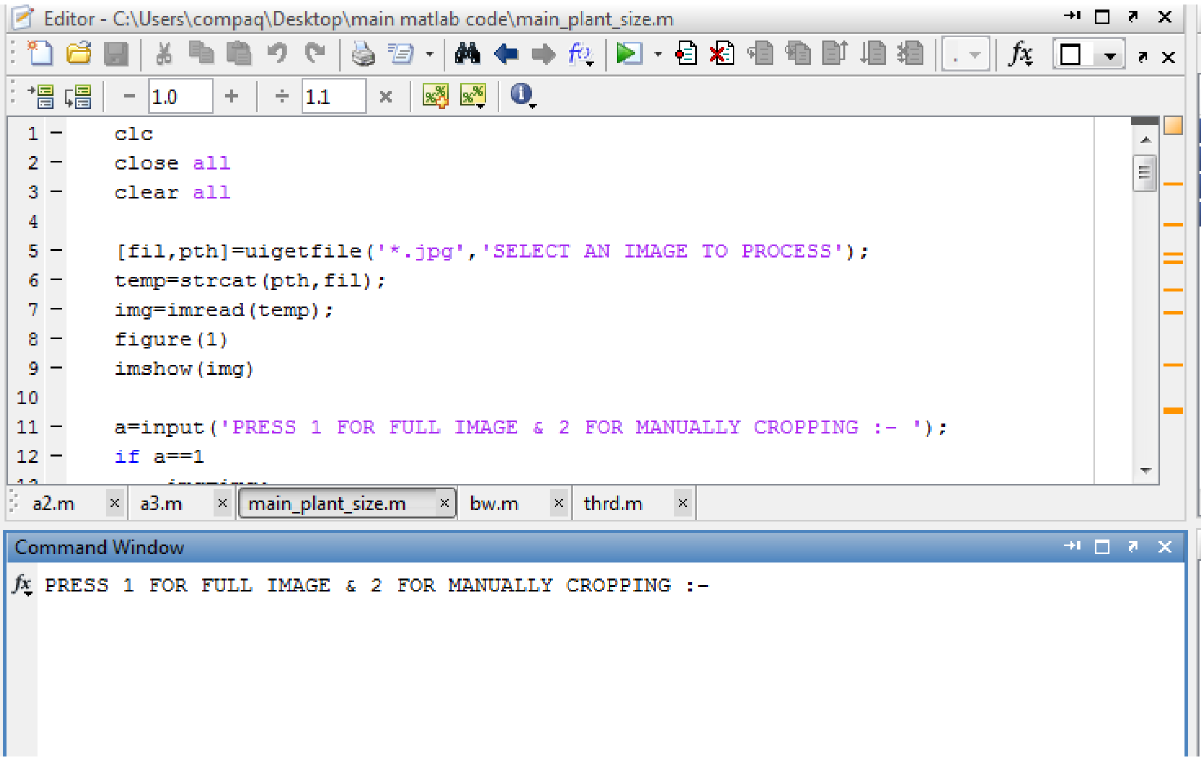


Figure 2.6 Image selection criteria

First of all selected area of image is cropped by pressing 2. Fig 2.7 is presenting the plant image with highlighted edges as well as the measured values of height, maximum and minimum width of a plant in terms of pixels.

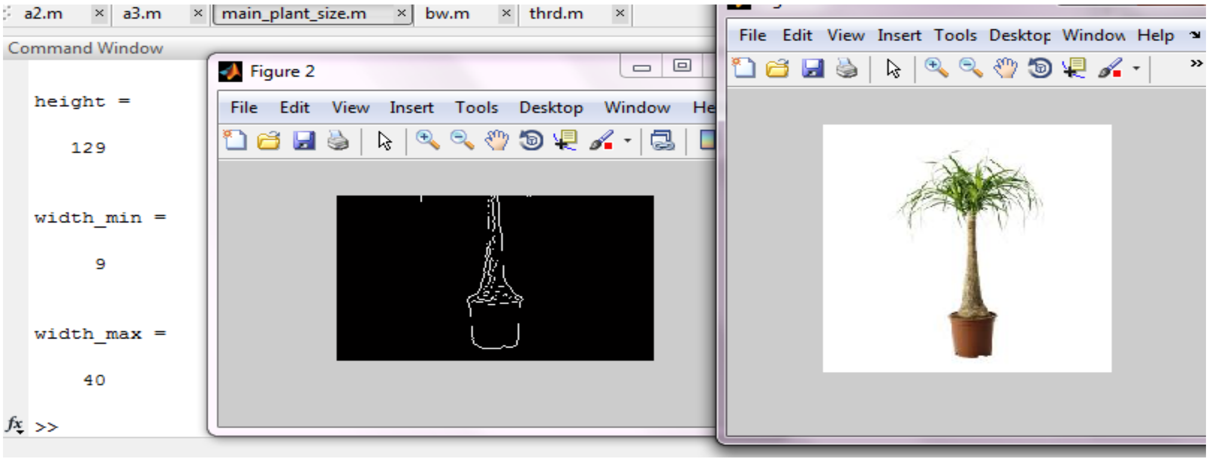


Figure 2.7 Edge detected image

In Figure 2.8 full image is selected by pressing 1. It is presenting the full plant image with highlighted edges as well as the measured values of height and width (minimum and maximum) of a plant in terms of pixels.

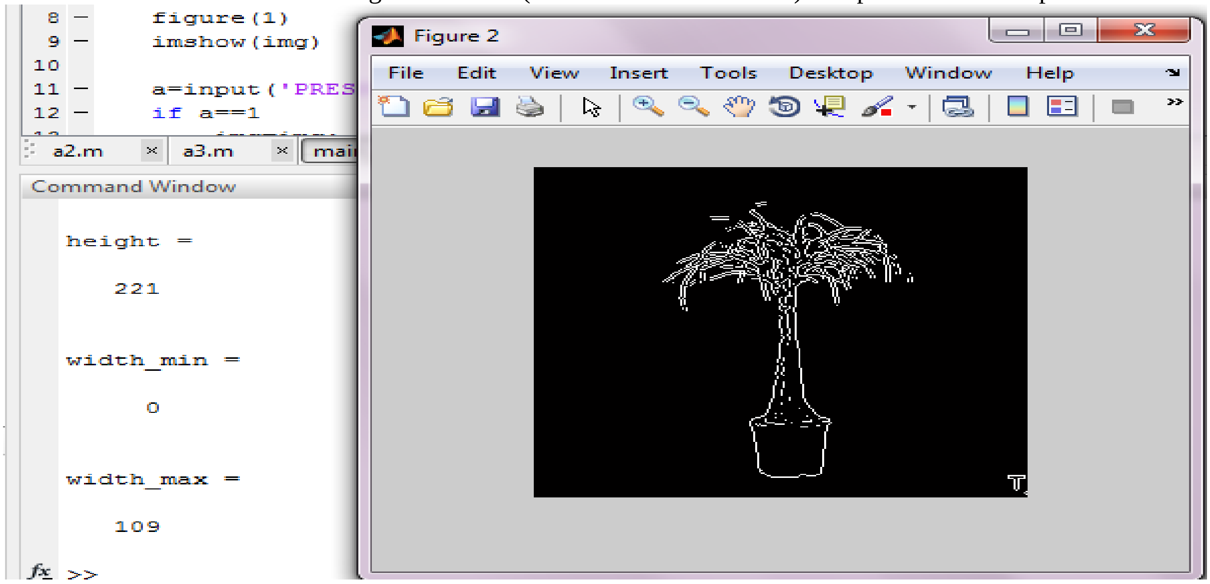


Figure 2.8 Edge detected for full plant's image

III. Conclusion

As a conclusion, the double strain gauge along with low pass filter and buffer are capable to detect small changes for each millimeter tested. In addition, more accurate reading is obtained using double strain gauges as compared to single strain gauges. It is concluded that the measurement using illuminating method is more efficient than traditional methods. Edges are smoother in comparison to PC based image processing system. Although two different types of options for the selection of a plant image are provided in image processing system. Either we can select the full image or crop the image according to need. The algorithm provides height and maximum and minimum width of the plant's stem in terms of pixels.

References

[1] Michele Dalponte, Lorenzo Bruzzone,A System For The Estimation Of Single-TreeStem Diameter And Volume Using.

[2] Jiaxing Che, Chunjiang Zhao, Yunhe Zhang, Cheng Wang, Xiaojun Qiao, Xinlu Zhang, "Plant stem diameter measuring device based on computer vision and embedded system," World Automation Congress (WAC), 2010, pp.51-55, 19-23 Sept. 2010.

[3] http://www.measurementsgroup.com/guide/tn/tn504/504index.htm.Strain Gage Thermal Outputand Gage Factor Variation with Temperature.

[4] N.M.Khairi, M.A.Marni Shah Rizam, M.S.B. Tahir, N.M. Naimah, M.I. Zainol Abidin,"Optimization of strain gauge for stem measurement using PIC based instrumentation," *System Engineering and Technology (ICSET), 2011 IEEE International Conference*, pp.196-199, 27-28 June 2011.

[5] Ramandeep Kaur and Balwinder Singh, "Design and development of sapling Monitoring System", International Journal of Computer Science, Engineering and Application(IJCSEA) Vol. 3, No. 5, October2013.

[6] Ariff, E.A.R.E. Suratman, M.N.Abdullah," Stomatal conductance, chlorophyll content, diameter and heightin different growth stages of rubber tree (Hevea brasiliensis) saplings," *Business, Engineering and Industrial Applications (ISBEIA), 2011 IEEE Symposium*, pp.84-88, 25-28 Sept. 2011.

[7] S.O.Link, M.E.Thiede and M.G.van Bavel, "An improved strain-gauge device for continuous field measurement of stem and fruit diameter," Journal of Experimental Botony, Vol.49, No. 326, pp. 1583- 1587. September 1998.

[8] Elias Fereres, David Goldhamer et.al., "Continuous trunk diameter recording can reveal water stress in peach trees," California Agriculture, Vol. 53, No. 4, July-August 1999.

[9] Klepper B, Browning VD, Taylor HM. "Stem diameter in relation to plant water status", *PlantPhysiology*,1971(48) 683-685.

[10] Mcburney T, Costigan PA. "The relationship between stem diameter and water potentials in stems of young cabbage plants", *Journal of Experimental Botany*, 1984(35)1787-1793.

[11] C.Y. Liao, V.V. Podrazsky, and G. B. Liu, "Diameter and height growth analysis for individual white pine trees in the area of Kostelec nad Cernymilesy," *Journal of Forest Science*, vol. 49, pp. 544-551, 2003.

[12] T. Kärki, M. Maltamo, and K. Eerikäinen, "Diameter distribution, stem volume and stem quality models for grey alder (Alnus incana) in eastern Finland," New Forests, vol. 20, pp. 65-86, 2000.

[13] X.H. Sang, Y.Y. Wu, Y.G. Zhao, and M.Y. Xu, "Comparison of growth of four types of Atractylodes Lancea (Thunb.) DC," *Journal of Anhui Agricultural Sciences*, vol. 36, pp. 7726 - 7727, 2008.