DISPARITY ESTIMATION ON STEREO VISION BASED FRUIT INSPECTION

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To my beloved cat,

COMOT

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ABSTRACT

Star fruit is one of the most popular fruits exported by Malaysia. From 1965, Federal Agricultural Marketing Authority is given the authority to regulate the quality of the star fruit exported by Malaysia. The great interest among the importers of Malaysia's star fruit becomes a great motivation to increase the yield and quality of the star fruit for export. One of the areas where the process can be improved is the fruit inspection. Universiti Teknologi Malaysia Computer Vision, Video and Image Processing Research Group (CvviP) had successfully invented an automatic star fruit grading system. Now, CvviP try to extend the system by experimenting the application of stereo vision in starfruit inspection. Disparity map obtained from the stereo vision can be used to find the size of the star fruit. Thus, this thesis objective is to experiment with stereo vision in order to obtain the disparity map of the star fruit. The experiment result should dictate the feasibility of the stereo matching to be integrated into the current automatic star fruit grading system. The proposed approach consists of hardware and software implementations. The hardware implementations focus on the hardware modeling and setup to acquires the starfruit images. While the software implementation focus on obtaining the disparity map from the images acquired. Based on the result obtained, the proposed approach has potential for practical implementation with some improvements needs to be done.

ABSTRAK

Belimbing merupakan salah satu buah-buahan tempatan yang direkodkan mempunyai jumlah export tertinggi di Malaysia. Di Malaysia, Lembaga Pemasaran Pertanian Persekutuan telah diberi kepercayaan untuk mengawal selia kualiti buah belimbing yang di export oleh Malaysia. Peningkatan permintaan pasaran terhadap buah belimbing Malaysia telah menjadi pemangkin untuk pengeluar buah belimbing tempatan meningkatkan produktiviti dan kualiti buah belimbing yang di export. Salah satu ruang penambahbaikan yang boleh dilakukan ialah semasa proses pemeriksaan buah belimbing. Pasukan penyelidik Visi Komputer, Video, Dan Pemprosesan Imej Universiti Teknologi Malaysia (CvviP) telah berjaya mereka bentuk sistem penggredan buah belimbing automatik. Kini, CvviP ingin menatar sistem sedia ada dengan mengeksperimen aplikasi teori visi stereo. Peta ketaksamaan yang diperolehi dari aplikasi visi stereo, dapat diguna pakai dalam mencari size sebenar buah belimbing. Oleh itu, objektif tesis ini ialah untuk bereksperimen dengan teori visi stereo untuk mendapatkan peta ketaksamaan untuk buah belimbing. Keputusan yang diperolehi sepatutnya memberi indikasi kepada kebolehlaksanaan integrasi aplikasi visi stereo kedalam sistem sedia ada. Pendakatan yang dicadangkan merangkumi perlaksanaan berbentuk perkakasan dan perisian. Konsep visi stereo yang termudah digunakan di dalam projek ini. Keputusan yang diperolehi menunjukan visi stereo sistem mempunyai potensi untuk kegunaan harian jika beberapa penambahbaikan dilakukan.

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LIST OF ABBREVIATIONS

ACS	Ant Colony System
ANN	Artificial Neural Network
BPSO	Binary Particle Swarm Optimization
FAMA	Federal Agricultural Marketing Authority
FPGA	Field Programmable Gate Array
GA	Genetic Algorithm
HSI	Hue, Saturation, Intensity (Colour)
NIR	Near Infrared Region
PCA	Principle Component Analysis
PCB	Printed Circuit Board
PID	Proportional-Integral-Derivative (Controller)
PSO	Particle Swarm Optimization
RGB	Red-Blue-Green (Colour)
SAD	Sum of Absolute Difference
SI	Swarm Intelligence
SNR	Signal Noise Ratio
TSP	Travelling Salesman Problem

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Star fruit or its scientific name, Averrhoa Carambola was originally from Sri Lanka and Indonesia (Trade Wind Fruit, 2012). It is said that star fruit has been spread to other Asian countries for hundreds of years. Star Fruit is a fruit with a reflective surface, uniform color and as well as a symmetric shape with five longitudinal ribs. The side view of the five longitudinal ribs looks like a star which the English name came from. Figure 1.1 is a typical image of a star fruit (Ianluis Team, 2011).

Figure 1.1: Image of a star fruit

Star fruit is listed as one of the most popular fruits exported by Malaysia due to its high quality. The quality of a star fruit is evaluated based on the taste and physical appearance. From 1965, Federal Agricultural Marketing Authority has been given an authority to regulate the quality of the star fruit exported by Malaysia. Based on FAMA (as shown in Figure 1.2), in year 2008, Malaysia exported 2711 metric ton of star fruit with export value of RM25.5 million. The main importers of Malaysia's star fruit are European countries such as Netherlands, France and Germany, which covered almost 97% of the total exports (Mahmood, Z., 2007).

Figure 1.2: FAMA's logo (Source: FAMA, 2012a)

Due to the great interests among the importers of Malaysia's star fruit, it has led to an increase in the quality standard of the star fruit to be exported. Thus, FAMA came out with a quality label, called Malaysia's best, or now being rebranded as 1Malaysia Best, as being illustrated in Figure 1.3 (FAMA, 2012b). For a star fruit to be labeled with the quality label, it has to pass a stringent quality control in every step from harvesting to packaging. One of the most essential steps is the inspection process, where the star fruit has to be inspected for five important criteria: maturity, freshness, free from defects, free from damage, and uniform in size (Amirullah, R. et al, 2010).

Figure 1.3: 1Malaysia Best Label (FAMA, 2012b)

Currently, the inspection and grading processes of the star fruit quality are done manually by humans (Mokji, M. M., and Bakar, S. A. R. A., 2006). The main disadvantages of these manual processes are time consuming. Other than that, the effectiveness of these processes is inconsistent, which depend highly on the knowledge and experience of the evaluators. High volume of evaluations also contributes to the inconsistency of evaluation done by the evaluators due to fatigue. Another problem with this approach is that, it is more difficult and higher cost is required in order to find the qualified evaluators. By automating all these processes, the problems should be solved.

1.2 Problem Statement

As mentioned earlier, there are five important criteria that defined the quality of a star fruit: maturity, freshness free from defects, free from damage, and uniform in size.

R. Amirullah et al (2010) had implemented a machine vision system to classify maturity of the star fruit. The star fruit colour classification algorithm was implemented on the Field Programmable Gates Array.

Based on the literature reviews done by the author, there is no research done to tackle the last two criteria in the quality evaluation. Therefore, in this thesis, the author tries to explore the application of the disparity concept in stereo vision system, in predicting the size of the star fruit. The selection of the star fruit as a case study compared to the other fruits is due to its high reflective surface that creates difficulties in pixel-to-pixel matching.

1.3 Objectives

The main objective of this work is to experiment with the concept of disparity in stereo vision as the first steps in predicting the size of a star fruit. By obtaining more precise information of the size or volume of a star fruit, the weight of a star fruit could be predicted. We can also easily classify whether the star fruit is uniform in size, and flag with obvious physical defects.

1.4 Scopes

As mentioned repetitively in earlier subchapters, the main scope of the work is to experiment with the concept of disparity in stereo vision as the first steps in predicting the size of a star fruit. The scope of the work can be divided into two phases: hardware and software implementations. The first step in completing this project is to prepare the hardware setup for images acquisition. In this case, an illumination chamber with

conveyor is used. A digital camera is needed for the images acquisition. The second step is to prepare a MATLAB program, in order to obtain the disparity of these two images.

1.5 Project Contribution

In the hardware setup, the greatest challenge is to minimize the illumination that can affect the quality of the images acquired. Images that are highly affected with illumination will contribute to a poor performance of the stereo matching algorithm in finding the accurate disparity of the images. The proposed hardware setup also needed to accommodate the modification of the typical two cameras image acquisitions into a single camera for twice images acquisition.

The software has several components: preprocessing to further reduce the illumination, segmentation to extract region of interest, stereo matching the images to obtain the disparity values, and post-processing to enhance the disparity map obtained. Note that the current applications of stereo matching algorithms available are mainly focusing on classifying the layers of objects at a medium range of distances. Thus, the result obtained is useful to study the effectiveness of the stereo matching algorithm for close range object.

The author also introduced the implementation of a stochastic and nature inspired optimization algorithm, called Particle Swarm Optimization in tuning the parameters required by the stereo matching algorithm.

1.6 Thesis Organization

This thesis is organized into five chapters. The first chapter is this chapter, which covered the background of the study, the problem statements, objectives, and scopes of research as well as the contribution of work done. The second chapter introduces reader to several literatures related to fruit grading system, stereo vision, and Particle Swarm Optimization. The third chapter explained the proposed approach. The chapter begins by laying out the brief overview of the proposed approach. Besides that, it describes the hardware setup that was done by the author. Next, explanation on the changes in modeling of the stereo vision system using single camera is touched. The software implementation will also be explained. Result and Discussion are discussed in chapter four where the result analyzed all experiments that had been done and the performance of the proposed approach is discussed. The final chapter consists of conclusion for this work. It also describe the problems arises and recommendations for future research.

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