UNIVERSITI PUTRA MALAYSIA

VIDEOGRAMMETRY TECHNIQUE FOR ARM POSITIONING OF BIO-PRODUCTION ROBOT

MOHD. HUDZARI RAZALI

VIDEOGRAMMETRY TECHNIQUE FOR ARM POSITIONING OF BIO-PRODUCTION ROBOT

By

MOHD. HUDZARI RAZALI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfillment of the Requirement for the Degree of Master of Science

September 2002

DEDICATION

" Indeed We have sent Our Messengers with clear proofs, and revealed with them the Scripture and the Balance (justice) that mankind may keep up justice. And We brought forth iron wherein is mighty power, as well as many benefits for mankind, that Allâh may test who it is that will help Him (His religion), and His Messengers in the unseen. Verily, Allâh is All-Strong, All-Mighty."

(Al-Quran means, AL-Hadiid (iron), 25)

Abstract of thesis to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

VIDEOGRAMMETRY TECHNIQUE FOR ARM POSITIONING OF BIO-PRODUCTION ROBOT

By

MOHD. HUDZARI RAZALI

September 2002

Chairman: Prof. Dr. Ir. Wan Ishak Wan Ismail

Faculty: Engineering

This thesis describes the development of the 'robot eye' system for agriculture robot to predict actual distance of the target object. Videogrammetry technique and triangulation method were used to measure distance of the target object. By 'clicking' on the image displayed on the user interface, the 3-dimensional (3D) distance of the target from robot arm will be generated and sending a signal to the robot to grip the selected target. The mathematical model of the robot arm applied real time simulation and was developed for use in the computing process. The 'robot eye' used WebCam digital cameras for 3D coordinate measurement that displayed the real environment in the user interface that was created using Visual Basic Version 6. The robot tool was designed, built and modified for this project using computer control and pneumatic drive system. The emphasis of the fabrication was to emulate the function of picking and harvesting of agricultural products. Robot communication was developed using ICP- DAS I/O modules that remotely sense up to a distance of 100 meters. This conceptual project is suitable for further research on

‘robot eye’ development using the non-contact measurement of 3D coordinate detection of the target object in real time mode.

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

VIDEOGRAMMETRY TEKNIK UNTUK PENENTUAN PERGERAKAN LENGAN ROBOT PERTANIAN

Oleh

MOHD. HUDZARI RAZALI

September 2002

Pengerusi: Prof. Dr. Ir. Wan Ishak Wan Ismail

Fakulti: Kejuruteraan

Tesis ini mengolah tentang pembangunan sistem 'robot eye' untuk robot pertanian yang berkeupayaan untuk menentukan jarak sebenar objek sasaran. Teknik Videogrammetry dan penyegitigaan digunakan dalam menentukan ukuran jarak objek sasaran. Dengan 'mengklik' imej pada paparan antaramuka penguna di skrin monitor komputer, kordinat 3-dimensi (3D) titik sasaran dari robot diperolehi dan isyarat akan dihantar ke robot seterusnya bergerak untuk mencapai objek sasaran. Model matematik telah dibangunkan dalam komputer bagi menghasilkan simulasi robot masa sebenar. Sistem 'robot eye' ini menggunakan dua buah kamera digital berjenama WebCam bertujuan untuk memaparkan imej persekitaran pada paparan antaramuka penguna di komputer yang dibangunkan mengunakan perisian Visual Basic Versi ke-6. Dalam projek ini, sistem robot telah melalui proses rekabentuk, penyambungan dan pengubahsuaian dengan mengambilkira sistem kawalan berkomputer dengan pemanduan sistem berkuasa pneumatik. Tujuan utama sistem adalah untuk menjalankan kerja menuai dan memungut produk pertanian.

Sistem komunikasi robot dibangunkan dengan menggunakann ICP-DAS I/O modul yang dapat dikawal secara kawalan tanpa wayar berjarak 100 meter. Konsep projek yang dijalankan adalah sesuai diterokai dalam membangunkan 'robot eye' yang berkebolehan untuk menentukan sasaran kordinat 3D tanpa sentuh dalam masa sebenar.

ACKNOWELDGEMENTS

ALHAMDULILLAH, PRAISES and THANKS belong ONLY to **ALLAH S.W.T** for giving me the opportunity to interact with the following people throughout the course of this study which I hope will contribute to the welfare of mankind for **LIFE AND HEREAFTER** successfully.

First and foremost, I would like to express sincere thanks and gratitude to those involved direct and indirectly in giving advice, encouragement, guidance, understanding and assistance throughout this research project and in the preparation of the thesis. They are Prof. Dr. Ir. Wan Ishak Wan Ismail, whose excellent supervision and numerous discussions were instrumental for the completion of the thesis and members of the supervisory committee, Assoc. Prof. Dr. Napsiah Ismail, Dr. Abdul Rashid Mohamed Shariff and Assoc. Prof. Dr. Md. Nasir Sulaiman.

My deepest appreciation also goes to Mr. Zakiria Ismail, the laboratory technician, for his ideas and support and to officer science Mr. Mohd Saufi Mohd Kassim, research engineer Mr. Mohd. Sal Salsidu, master student Mr. Steven Lim and not forget also to my colleagues at STMicroelectronics, Muar and KUiTTHO, Parit Raja for their invaluable assistances.

Finally, I would like to thank my parents, family and members who cared, supported, prayed and motivated me to seek knowledge and to complete the research project.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

LIST OF TABLES

LIST OF ABBREVIATIONS

API	: Application Programming Interface
ASIC	: American Standard Intergrated Circuits
BASIC	: Beginner's All Purpose Symbolic Instruction Code
CCD	: Charge Couple Device
CMOS	: Complementary Metal Oxide Semiconductor
CPU	: Computer Processing Unit
D-H	: Denavit and Hertenberg
DLL	: Dynamic Link Library
DOF	: Degree of Freedom
f	: Focus Len
FDP	: Forward Dynamic Problem
ICP-DAS	: Industrial Computer Processing – Data Acquisition System
IDE	: Integrated Development Environment
IDP	: Inverse Dynamic Problem
INCA	: Intelligent Camera
I/O	: Input/Output
IK	: Inverse Kinematic
OGP	: Optical Gauging Product
PLC	: Programming Logic Controller
RF	: Radio Frequency
RS	: Remote Sensing
UI	: User Interface

USB	: Universal Serial Bus
VB	: Visual Basic
VMS	: Vision Metrology Service
Ai	: Joint Link no.
θ_i	Rotation angle including axes x_{i-1} and x_i about z_{i-1} axis
α_i	: Rotation angle including axes z_{i-1} and z_i about x_i axis
d_i	Translating distance of intersection z_{i-1} from x_i along z_{i-1} axis
a_i	Translating distance of intersection x_i from z_{i-1} along x_i axis
3D	: 3-Dimension

CHAPTER 1

INTRODUCTION

Malaysia is a developing country with a rapidly growing manufacture-based economy. With the recent economic recession, agriculture emerged as a fundamental resource which is once again gaining increasing importance in our economy. For several decades, Malaysia was the largest producer of agricultural products especially palm oil and rubber. This makes Malaysia a model to emulate for other third world countries seeking information and technology relating to our agricultural activities. The onus is on researchers and academicians to carry out value-added research to modernise our agricultural sector towards vision 2020.

The idea of applying robotics technology in agriculture is new. Today, there are many projects related to robot development for agriculture that is mostly related to application of industrial robot and information technology on agriculture. Robots and automation in agriculture are required mainly at the harvesting stage, irrigation, fertilization and monitoring activities For instance the fruit picking robot and sheep shearing robot are designed to replace human labour. The agricultural industry is lagging behind other industries in using robots because agriculture involves jobs that are not mechanized and though repetitive, the tasks change with time. In most cases, several factors have to be considered like size and colour of the fruit to be picked before the commencement of a task.

The agricultural sector is very different from the industrial sector. Unlike in the industrial situation, where each component on a production line is the same, variability is ever present in agricultural sector. Despite the best efforts of plant and animal breeders, agricultural products even if genetically identical are quite different when measured in engineering terms. The physical properties of agricultural products such as size, colour, shape, hardness are vary even when they are of the same variety and the robot for agricultural sector are required to work under various conditions as above such as natural illumination, hilly terrain and weather conditions. These robots have to be robust to withstand the problems caused by water, dust and weather conditions and still needs to review with certain consideration and suitability.

As agriculture deals with the natural world, fabrication of robots is difficult, as it has to meet variable requirement. Few, if any, robotic systems have reached commercial realization for example, milking, mushroom harvesting and grass cutting (the latter being an amenity rather than an agricultural application). Thus, agricultural robotics is mainly appears to be an area of research interest to research scientists and engineers to industrialise the nature variability. Natural variability generally means that any agricultural robot needs to sense changes in the products to be handled. Perhaps the most investigated sensing technique is machine vision where the attractions include the non-contact nature of the sensor, the large amount of data delivered, the cheap and commonly available hardware, and the realization to make very effective use of vision application. The downside to machine vision is that it is at least as difficult as robotics, especially when dealing with natural situations.

The retina of the human eye does not perceive light in a precisely uniform manner. Further, the eye tends to overestimate or underestimate the level of intensity of an image under varying conditions, such as in situations when relative contrasts are exceptionally high or low. Also, the eye tends to become fatigued over time. The variations of lighting intensity from time to time and place to place, causing difficulty in developing a complete vision system in terms of automatic recognition of the object's colour especially the mature fruit. The developed system should have a bundle of mature fruit database including a variant degree of illuminating intensity at certain times and place, the object or fruit pattern, weather condition, example cloudy. During the system operation, all databases will be retrieved and compared with various models of expected results to infer the true nature of the original or set of objects from images formed. The system should also be able to coordinate the distance of the recognized object in random space. According to the rules of Images Process:

- The pixel dynamics is 256 grey values per pixel (picture elements) measured on bit 8 bit digital value.
- A grey value 0 means completely black while a grey value of 255 means completely white.

This principle was widely used in machine vision system, where programs can be developed to sense every reading of grey values of pixels in digital terms, which can be manipulated for controlling such devices. From this point of view, the entire video scene can be programmed according to the specific requirements of user applications.

In this project, the developed system was able to generate 3D coordinates of the object based on information given by the video and picture scene and the picture character can controlled which burden the illumination problem that happen on existing vision development system using RGB camera. Inside the camera control box there is brightness controller, illumination and sharpness. These 3D coordinates were applied in mathematical model approach for the movement of robot manipulator simulation. By predicting the robot's work area, a scale was developed to simulate the robot's working area in the computer system where the robot will move to a selected target using a mouse click action with the actual and visual robot movement being exactly the same. This method referred to as Videogrammetry, uses video to ascertain the geometry of the object. It has an advantage in terms of non-contact measurement application that has emerged from the contact measurement technology like using laser range sensor. The video and picture will be collected in a dynamic scene mode using stereo camera. By developing the interface software, the above concept can be applied on robotics and combined with solenoid robot for developing an actuating device. The communication between the interface software, the camera and the solenoid valve will be activated using driven software that can be stored in any computer system termed Dynamic Link Library file (DLL). Visual Basic programming language can be used to manipulate it according to requirements.

Objectives

The use of engineering equipment in agriculture activities is projected to increase the productivity compared to the conventional methods. Even though, the use of robotics is very new but as a starting point there should be an extensive research to identify all the challenges in the agriculture field. Each component on agriculture is an ever present whereby most variable concerns are the position of the fruit.

This project used an application of the stereo camera to predict the 3D target distance by using 'mouse clicking' action on a computer screen. This distance value will be sent through the mathematical algorithm on developed software and finally will act as electrical signals to trigger solenoid valves causing real time robot movement. Otherwise the general aim of this research is to introduce the application of a non-contact measurement system for the agriculture robot.