UNIVERSITI PUTRA MALAYSIA

APPLICATION OF MULTI-LAYER PERCEPTRON TECHNIQUE TO DETECT AND LOCATE THE BASE OF A YOUNG CORN PLANT

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APPLICATION OF MULTI-LAYER PERCEPTRON TECHNIQUE TO DETECT AND LOCATE THE BASE OF A YOUNG CORN PLANT

By

MALIK ARMAN BIN MORSHIDI

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

August 2007

DEDICATION

To,

My mother,
Zubaidah Abdullah

My father,
Morshidi Sa'et

Brothers and sisters,
Mariana, Mizan, Maya, Mujibuddin

My wife,
Siti Mastura Ahmad

My son,
Luqman Alhakim

My daughter,
Nurin Batrisyia

Thanks for all your support…
May Allah bless all of you a better place in this world and the hereafter…
Amin…

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

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August 2007

Chairman: **Mohammad Hamiruce Marhaban, PhD**

Faculty: **Engineering**

Vision based techniques have been widely used in precision farming especially to control the application of chemical products on a specific area. This can help minimizing the risk of soil and water pollution due to excessive application of chemical products. Machine vision can be used to gather information while the vehicle pulling the herbicide sprayer is in motion. This information can be processed, analyzed, and transformed into inputs for a decisional algorithm that controls the sprayer nozzle action in real-time. In this research, a vision system algorithm has been developed to identify and locate base of young corn trees based upon robot vision technology, pattern recognition techniques, and knowledge-based decision theory. Results of studying color segmentation using machine-learning algorithm and color space analysis is presented in this thesis. RGB (red, green, blue) color space data points on an image are projected into HSV (hue, saturation, value) color space to provide data points that are insensitive to the variations of illumination in outdoor environment. Multi-layer perceptron (MLP) neural network trained using backpropagation algorithm is used to segment the color image. The results of color

segmentation show that the algorithm is able to segment the images reliably with less appearance of small blobs. Morphological operation is applied to remove the small blobs. Prior to localization of the base of young corn tree, skeletonizing operation is performed to get the basic shape of the object. Another structure of MLP trained using backpropagation algorithm is used to detect and locate the base of the young corn tree using the skeleton of the segmented image. Prior to choosing the MLP structures for both color segmentation and object detection, a number of experiments have been conducted to find the best MLP structures that can give considerably good recognition and classification rate with considerable amount of processing time required. Results of the experiments to find the best MLP structures are presented together with the discussion. The recognition rate is presented and compared with another related research work, where the results show equal performance of both algorithms. This shows that machine-learning algorithm such as MLP is a viable method for color segmentation as well as object recognition.

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

PENGGUNAAN TEKNIK RANGKAIAN NEURAL BERBILANG LAPISAN UNTUK MENGECAM DAN MENENTUKAN LOKASI DASAR POKOK JAGUNG MUDA

Oleh

MALIK ARMAN BIN MORSHIDI

Ogos 2007

Pengerusi: **Mohammad Hamiruce Marhaban, PhD**

Fakulti: **Kejuruteraan**

Kaedah-kaedah menggunakan penglihatan telah digunakan secara meluas dalam pertanian jitu lebih-lebih lagi untuk mengawal penggunaan bahan-bahan kimia pada sesuatu kawasan. Ini boleh membantu mengurangkan risiko pencemaran tanah dan air yang disebabkan oleh penggunaan bahan-bahan kimia secara berlebihan. Penglihatan robot boleh digunakan untuk mengumpul maklumat ketika jentera yang membawa penyembur bahan kimia sedang bergerak. Maklumat ini boleh diproses, dianalisa, dan ditukar menjadi input kepada sistem penentu yang mengawal tindakan muncung penyembur dalam masa-nyata. Dalam kajian ini, satu kaedah sistem penglihatan telah dibangunkan untuk mengesan dan menentukan lokasi dasar pokok-pokok jagung muda berdasarkan teknologi penglihatan robot, teknik-teknik pengecaman corak, dan teori penentuan berdasarkan pengetahuan. Keputusan daripada kajian pengasingan warna menggunakan kaedah pembelajaran-mesin dan analisis ruang warna telah dibentangkan dalam tesis ini. Titik-titik data daripada ruang warna RGB (merah, hijau, biru) pada sesuatu imej diarahkan ke dalam ruang

warna HSV (ton, kecerahan, nilai) untuk menghasilkan titik-titik data yang tidak peka kepada variasi perubahan cahaya pada persekitaran luar pintu. Rangkaian neural berbilang lapisan (MLP) yang dilatih menggunakan kaedah rambatan balik telah digunakan untuk mengasingkan imej berwarna. Keputusan pengasingan warna menunjukkan bahawa kaedah ini berupaya mengasingkan imej-imej tersebut secara berkesan dengan berkurangnya kehadiran tompok-tompok kecil. Operasi morfologi digunakan untuk membersihkan tompok-tompok kecil tersebut. Sebelum penentuan lokasi dasar pokok jagung muda tersebut, operasi penghasilan rangka dilakukan untuk mendapatkan bentuk asas objek tersebut. Satu lagi struktur MLP yang dilatih menggunakan kaedah rambatan balik, digunakan untuk mengesan dan menentukan lokasi dasar pokok jagung muda menggunakan rangka imej yang telah diasingkan. Sebelum memilih struktur-struktur MLP untuk pengasingan warna dan pengecaman objek, beberapa eksperimen telah dilaksanakan untuk mencari struktur MLP terbaik yang boleh memberikan kadar pengecaman dan pengklasifikasian yang baik dengan masa pemprosesan yang sesuai. Keputusan-keputusan eksperimen untuk mencari struktur-struktur MLP terbaik dibentangkan bersama-sama dengan ulasannya. Kadar pengecaman telah dibentangkan dan dibandingkan dengan satu lagi kajian yang berkaitan, di mana keputusan menunjukkan pencapaian yang sama oleh kedua-dua kaedah. Ini menunjukkan kaedah pembelajaran-mesin seperti MLP satu kaedah yang boleh dipercayai untuk pengasingan warna dan pengecaman objek.

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Not to forget my research group members. I sincerely appreciate the knowledge that you share among us in our meetings and discussions.

I certify that an Examination Committee has met on 15th August 2007 to conduct the final examination of Malik Arman Bin Morshidi on his Master of Science entitled "Application of Multi-Layer Perceptron Technique to Detect and Locate the Base of a Young Corn Plant" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Professor and Dean
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Date: 15 November 2007

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions

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MALIK ARMAN BIN MORSHIDI

Date: 26 September 2007

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LIST OF ABBREVIATIONS

RGB	Red, Green, Blue
HSV	Hue, Saturation, Value
NN	Neural Network
MDT	Multivariate Decision Trees
ANN	Artificial Neural Networks
RMS	Root Mean Square
IPC	Individual Plant Classifier
kNN	k-Nearest Neighbors
MLP	Multi-Layer Perceptron
FLC	Fuzzy Logic Controller
PIC	Programmable Interface Controller
PWM	Pulse Width Modulation
RoboCup	Robot World Cup Soccer Games and Conferences
FRE2006	Field Robot Event 2006
SSE	Intel Streaming Single Instruction Multiple Data Extension

CHAPTER 1

INTRODUCTION

1.1 Preface

The ability to locate and identify crops and weeds automatically in digital images could lead to many useful inventions. In recent years, modern farming relies on chemical control apply to crops, weeds, pests, and diseases. Economic pressure, environmental concerns, and increased consumer demand for organic foodstuffs had led to the development of precision agriculture techniques to reduce and optimize chemical use. Precision agriculture has also enabled reduction of the area of management from the whole farm field down to sub field level. Due to the increased data processing required to cover a complete field at the individual plant level, only certain operations could be carried out using human intervention and therefore different forms of automation, especially in high value crops, are needed.

Machine vision-based crops and weeds sensing shows promise because it not only utilizes spectral information, but also spatial and textural information. Johnson et al.[1] investigated two techniques of real-time weed sensing, one using photodetectors, another using machine vision. Photodetector weed sensing technology has difficulty reaching high-resolution levels, whereas machine vision can easily be set at high resolution. With machine vision sensors rather than

photodetectors, larger sensing area could be covered for spatial analysis. Weed could be separated from crop by using color and geometric information. One challenge in outdoor machine vision crops and weeds sensing is to overcome variable lighting conditions when using conventional CCD cameras. Much of machine vision crops and weeds sensing research have been done with controlled lighting conditions and not much attention has been paid to the issue of real-time operation. Woebbecke et al.[2] studied color indices for weed segmentation with shaded and unshaded plant surfaces presented in the image, and found that the best segmentation occurred with the modified hue and excessive green contrast index.

1.2 Problem Statement and Motivation

Increasing farm sustainability and protecting water quality are two major goals of current agricultural research. United States farmers applied about 1.2 billion pounds of pesticides in 1995, representing a significant portion of the variable costs of agricultural production [8]. Many of these chemicals are soil-applied (pre-emergence) herbicides, which are more prone to movement into ground water and surface water supplies. Soil-applied herbicides such as atrazine and alachlor are potential threats to the safety of drinking water supplies. At numerous sites, concentrations of these herbicides in the ground and surface water supplies have exceeded federal health levels [9]. Public concerns about health risks associated with herbicide residues have increased as more cases of herbicide contaminated water supplies have been reported [18].

Since hand labor is costly, an automated control of chemical application may be economically feasible. Machine vision can be used to gather information while the vehicle pulling the herbicide sprayer is in motion. This information can be processed, analyzed, and transformed into inputs for a decisional algorithm that controls the sprayer nozzle action in real-time. In this research, a vision system algorithm has been developed to identify and locate base of young corn trees based upon robot vision technology, pattern recognition techniques, and knowledge-based decision theory.

1.3 Aims and Objectives

The aim of this project is to develop a vision-based algorithm to identify and locate the base of young corn trees on the field. Specific objectives are to:

1. Develop and implement a colour machine vision algorithm using image processing techniques to identify and locate the base of young corn trees,
2. Investigate the use of Multi Layer Perceptron classification method for colour segmentation,
3. Investigate the use of a different structure of Multi Layer Perceptron to identify and detect the location of the base of young corn trees, and
4. Investigate on how the different Multi Layer Perceptron structures can affect the learning performance as well as the processing time.

1.4 Scope of Work and Contribution

The vision system developed in this research is part of an intelligent autonomous chemical sprayer to create an intelligent sensing and spraying system. The main focus is on method to detect and locate the base of young corn trees on the field. Hence, the technical details on the development of the robot structure, chemical spraying system, and the navigation system are out of the scope of this thesis. The system can perform the recognition task as long as the objects are not occluded. It is only limited to recognizing images that contain only young corn trees on the field.

1.5 Thesis Layout

This thesis is divided into five chapters where each chapter reviews different issues related to this research.

Chapter 2 describes the literature review and theoretical background of related researches on precision agriculture. The main objective of this chapter is to highlight the real time machine vision system defined by previous researchers and the techniques they used to tackle the problems. The applications of neural network technique in machine vision are also studied. At the end of Chapter 2, all reviews are discussed analytically which leads to the conclusion why this research topic is chosen.

Chapter 3 explains the methodologies used throughout the accomplishment of this research. At the beginning of the chapter, the image acquisition process is briefly described. Then, few image-processing techniques are used to during the pre-processing and feature extraction procedures. Neural network is used for the recognition part.

Chapter 4 provides the analysis, results, and discussions about the outcome of the research. The results and analysis are obtained from a number of tests.

Chapter 5 concludes the overall findings of this research. Performance comparisons between the results obtained in this research and the previous researches are also discussed in this chapter. The achievements of this research as well as the recommendations of future research are highlighted.