UNIVERSITI PUTRA MALAYSIA

HYPERSPECTRAL IMAGE PROCESSING SYSTEM

SAHAR SABBAGHI MAHMOUEI

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HYPERSPECTRAL IMAGE PROCESSING SYSTEM

By

SAHAR SABBAGHI MAHMOUEI

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

January 2012

To

Whom beyond all thoughts
And the one who Guides me through the thinking path

No amount of experimentation can ever prove me right; a single experiment can prove me wrong.

Albert Einstein

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

HYPERSPECTRAL IMAGE PROCESSING SYSTEM

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SAHAR SABBAGHI MAHMOUEI

January 2012

Chairman: Professor Shattri B Mansor, PhD

Faculty: Engineering

Hyperspectral imaging system is a new technique, which provides an alternative way to increasing the accuracy by adding another dimension: the wavelength. Recently, hyperspectral imaging is also finding its way into many more applications, ranging from medical imaging in endoscopy for cancer detection to quality control in the sorting of fruit and vegetables. But effective use of hyperspectral imaging requires an understanding of the nature and limitations of the data and of various strategies for processing and interpreting it. Also, the breakthrough of this technology is limited by its cost, speed and complicated image interpretation.

We have therefore initiated work on designing real-time hyperspectral image processing to tackle these problems by using a combination of smart system design, and pseudo-real time image processing software. Traditional hyperspectral imaging systems acquire one-dimensional spectral images and require relative motion of sensor and scene in addition to data processing to form a two-dimensional image

cube. There is much interest in developing hyperspectral imagers based on unique prism-grating-prism (PGP) optical design that acquire a 2D dimensional spectral image can be formed and build up an image cube as a function of time.

The main focus of this research is the development of hyperspectral imaging system for laboratory or stationary remote sensing applications. The system consists of a high performance digital CCD camera, an intelligent processing unit, an imaging spectrograph, an optional focal plane scanner and a laptop computer equipped with a frame-grabbing card. In addition, special software has been developed to synchronize between the frame grabber (video capture card), and the digital camera with different image processing techniques for both digital and hyperspectral data. The CCD camera provides 1280(h) x 1024(v) pixel resolution and true 12-bit dynamic range. The imaging spectrograph is attached to the camera via an adapter to disperse radiation into a range of spectral bands. The effective spectral range resulting from this integration is from 400 nm to 1000 nm. The optional focal plane array can be attached to the back of the spectrograph via C-mount for stationary image acquisition. The camera and the frame grabbing board are connected via a PCI interface board, and the utility software allows for complete camera control and image acquisition. The imaging system captures one line image for all the bands at a time and a focal plane array serves as a mobile platform to carry out pushbroom scanning in the along-track direction. Preliminary image acquisition testing indicates that this CCD camera-based hyperspectral imaging system has potential for agricultural and food industry applications.

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

SISTEM PEMPROSESAN IMEJ HIPERSPEKTRA

Oleh

SAHAR SABBAGHI MAHMOUEI

Januari 2012

Pengerusi: Profesor Shattri B Mansor, PhD

Fakulti: Kejuruteraan

Pengimejan hiperspektral adalah suatu teknik baru yang menawarkan satu cara alternatif untuk meningkatkan kejituan dengan menambah suatu lagi dimensi: jarak gelombang. Kebelakangan ini, pengimejan hiperspektral juga telah menerokai pelbagai bidang, dari pengimejan perubatan dalam endoskopi untuk pengesanan barah hinggalah dalam penjagaan kualiti dalam penapisan buah-buahan dan sayur-sayuran.

Tetapi penggunaan yang berkesan pengimejan hiperspektral ini memerlukan pemahaman dari sudut naluri dan had data dan juga strategi yang berbagai cara untuk memproses dan menterjemahkannya. Dan juga, segala penemuan unggul dalam teknologi ini dihadkan oleh kos, kelajuan serta penterjemahan imej yang kompleks.Oleh itu kami telah memulakan kerja-kerja dalam merekabetuk pemprosesan imej hiperspektral dalam masa nyata untuk menangani masalah-masalah ini dengan menggunakan kombinasi rekabentuk system yang pintar dan perisian pseudo-masa nyata.

Sistem-sistem pengimejan hiperspektral yang tradisi memerlukan imej-imej hiperspektral satu dimensi dan memerlukan pergerakan relatif pengimbas dan

pemandangan disamping pemprosesan data untuk membentuk kiub dua dimensi.Terdapat banyak minat dalam pembinaan imej-imej hiperspektral berdasarkan rekabentuk optic prism-grating-prism (PGP) yang memerlukan imej spectral dua dimensi yang boleh dibina dan imej kiub yang bergantung kepada fungsi masa.

Fokus penyelidikkan ini adalah pembinaan satu system pengimejan hiperspektral yang berdasarkan kamera untuk kegunaan makmal dan juga aplikasi-aplikasi pengimbasan jarak jauh.Sistem ini mengandungi sebuah kamera digital CCD berkuasa tinggi, sebuah unit pemproses yang pintar, sebuah pengimejan spektograf, sebuah focal plane array dan sebuah komputer riba dengan kad yang boleh merakam bingkai imej. Selain itu, perisian khusus telah dibangunkan untuk mengsinkronisasikan diantara frame grabber dan kamera digital dengan berlainan teknik pemprosesan imej untuk kedua-dua imej digital dan hiperspektral. Kamera CCD menghasilkan resolusi 1280*1024 piksel dan julat imej dinamik 12 bit.

Spektograf pengimejan dicantumkan ke kamera melalui sebuah alat untuk meleraikan radiasi ke dalam lingkungan band spetral. Julat spektral yang berkesan yang akan terhasil adalah dari 400 hingga 1000nm. Focal plane array juga boleh dicantumkan dihadapan spektograf melalui bingkai-C untuk menghasilkan imej yang stabil. Kamera dan kad framegrabber dihubungkan melalui kad antaramuka PCI dan sebuah perisian membolehkan kawalan kamera yang lengkap dan penangkapan imej.

Sistem pengimejan ini merakam satu garis untuk kesemua band pada satu masa dan focal plane scanner bertindak sebagai asas untuk pushbroom scanning dalam arah kehadapan.Penagkapan imej awal menunjukkan bahawa kamera CCD yang

berdasarkan pengimejan hiperspektral ini berpotensi dalam industri pertanian dan pemakanan dan juga dalam aplikasi-aplikasi sumber asli.

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The main appreciation is always goes to the one that I hope I can be a small manifestation of his kindness and glory.

APPROVAL

I certify that a Thesis Examination Committee has met on **27th January 2012** to conduct the final examination of **Sahar Sabbaghi Mahmouei** on her thesis entitled **"Hyperspectral Image Processing System"** in accordance with the Universities and University Colleges Act 1971 and the Constitution of the University Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the **Master of Science degree**.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Master of Science. Members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

Sahar Sabbaghi Mahmouei
Date: 27 January 2012

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