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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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

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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 penyelidikan 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 mensinkronisasikan 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 melerai radiasi ke dalam lingkungan band spetral. Julat spektral yang berkesanan 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. Penangkapan 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.
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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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
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>ABSTRAK</td>
<td>v</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>viii</td>
</tr>
<tr>
<td>APPROVAL</td>
<td>ix</td>
</tr>
<tr>
<td>DECLARATION</td>
<td>xii</td>
</tr>
<tr>
<td>LIST OF TABLE</td>
<td>xii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xii</td>
</tr>
<tr>
<td>LIST OF ABBREVIATIONS</td>
<td>xii</td>
</tr>
<tr>
<td><strong>CHAPTER</strong></td>
<td></td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Background</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Problem Statement</td>
<td>7</td>
</tr>
<tr>
<td>1.3 Research Objectives</td>
<td>8</td>
</tr>
<tr>
<td>1.4 Research Scope</td>
<td>10</td>
</tr>
<tr>
<td>1.5 Research Contribution</td>
<td>10</td>
</tr>
<tr>
<td>1.6 Overview of Thesis</td>
<td>11</td>
</tr>
<tr>
<td>2. LITERATURE REVIEW</td>
<td>12</td>
</tr>
<tr>
<td>2.1 Introduction</td>
<td>12</td>
</tr>
<tr>
<td>2.2 Near-Infrared Technology</td>
<td>14</td>
</tr>
<tr>
<td>2.2.1 Overview of Near Infrared Spectroscopy</td>
<td>14</td>
</tr>
<tr>
<td>2.2.2 Typical Applications of NIR Spectroscopy</td>
<td>14</td>
</tr>
<tr>
<td>2.2.3 NIR Technology in Fruits and Vegetables</td>
<td>18</td>
</tr>
<tr>
<td>2.3 Machine Vision System</td>
<td>19</td>
</tr>
<tr>
<td>2.3.1 Background</td>
<td>19</td>
</tr>
<tr>
<td>2.3.2 Limitations</td>
<td>21</td>
</tr>
<tr>
<td>2.3.3 Future Trends of Machine Vision</td>
<td>21</td>
</tr>
<tr>
<td>2.4 Components of Computer Vision System</td>
<td>23</td>
</tr>
<tr>
<td>2.4.1 Illumination</td>
<td>23</td>
</tr>
<tr>
<td>2.4.2 Camera</td>
<td>24</td>
</tr>
<tr>
<td>2.4.3 Frame grabber</td>
<td>24</td>
</tr>
<tr>
<td>2.4.4 Computer Hardware and Software</td>
<td>24</td>
</tr>
<tr>
<td>2.5 Applications of Computer Vision System</td>
<td>24</td>
</tr>
<tr>
<td>2.6 Machine Vision as a Controlled System</td>
<td>25</td>
</tr>
<tr>
<td>2.7 Machine Vision as a Real-Time System</td>
<td>27</td>
</tr>
<tr>
<td>2.7.1 Onboard Real-Time Processing</td>
<td>29</td>
</tr>
<tr>
<td>2.8 Hyperspectral Sensing and Imaging</td>
<td>31</td>
</tr>
<tr>
<td>2.8.1 Brief Overview</td>
<td>31</td>
</tr>
<tr>
<td>2.8.2 Hypercube Formation</td>
<td>32</td>
</tr>
<tr>
<td>2.8.3 Components</td>
<td>35</td>
</tr>
</tbody>
</table>
2.8.4 Advantages 36
2.8.5 Limitations 37
2.9 Analysis of Hyperspectral Images 37
   2.9.1 Calibration 38
   2.9.2 Pre-processing 38
   2.9.3 Spectral Data Analysis 39
   2.9.4 Image Processing 39
2.10 Application of HSI to Food Quality and Safety 40
   2.10.1 Defect Detection 40
   2.10.2 Bruise Detection 41
   2.10.3 Disease Detection 41
   2.10.4 Contaminant Detection 42
   2.10.5 Quality Evaluation 42
2.11 Summary 44

3. Research Methodology 46
   3.1 Introduction 46
   3.2 Concepts and Characteristics 47
   3.3 Hardware Architecture 47
      3.3.1 Select Sensor 48
      3.3.2 Operating of Imaging Spectrograph 53
      3.3.3 Select Objective Lens 59
      3.3.4 Mounting Objective Lens 63
      3.3.5 Connecting ImSpector to CCD camera 65
      3.3.6 Frame grabber and Camera Interface Options 66
      3.3.7 Illumination 72
      3.3.8 Stages and Platform 77
      3.3.9 Computer System 78
   3.4 Software Architecture 81
      3.4.1 Camera Parameters 81
      3.4.2 Capture and Frame rate Settings: 87
      3.4.3 Examples of how to use Capture timers and counters: 89
      3.4.4 Key features of Image Acquisition Toolbox 90
   3.5 List Prices of whole system: 91
   3.6 Laboratory Work 93
      3.6.1 Alignment 94
      3.6.2 Adjustment 95
      3.6.3 Characterization 95
      3.6.4 Calibration 96
   3.7 Materials and Methods 98
3.7.1 Sample Preparation
3.7.2 Image Acquisition
3.7.3 Acquiring Real-Time Ground based Hyperspectral Images
3.8 Image Processing and Analysis
  3.8.1 Reflectance Calibration
3.9 Summary

4. RESULTS AND DISCUSSION
  4.1 Introduction
  4.2 Developing a Graphical User Interface
  4.3 Image Processing Toolbox
    4.3.1 Color Transformation
    4.3.2 Image Enhancement
    4.3.3 Image Registration
    4.3.4 Image Segmentation
    4.3.5 Image Analysis
  4.4 The key capabilities are described below:
  4.5 Example of a hyperspectral system for early detection of bruise damage
    4.5.1 Experimental Results and Evaluation
    4.5.2 Histogram Filter
    4.5.3 Homogeneity Edge Detector
    4.5.4 Difference Edge Detector
    4.5.5 Sobel Edge Detector
    4.5.6 Canny Edge Detector
    4.5.7 Bayer Dithering Thresholding Filter
    4.5.8 Otsu Thresholding Filter
  4.6 Summary

5. CONCLUSION AND FUTURE WORKS
  5.1 Research Summary
  5.2 Evaluation of the Contributions
  5.3 Futures Work

REFERENCES
BIODATA OF THE STUDENT
LIST OF PUBLICATIONS