HYPERSPECTRAL IMAGING

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TECHNIQUES FOR SPECTRAL DETECTION AND CLASSIFICATION

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This book is dedicated to the memory of my late father, Hsun Chang (張洵) for his constant support of my career. It is also dedicated to my mother, Kuo Kuei-Lan Chang (張郭貴蘭) for her timeless support and countless encouragement during the course of preparing this book as well as to my sister, Feng-Chu Chang (張鳳珠)'s family, my sister Mann-Li Chang (張曼莉) and my brother Chein-Chi Chang (張建祺)'s family, particularly, my beloved little youngest nephew, Yu-Rei Raymond Chang (張育瑞).

PREFACE

Hyperspectral imaging is an emerging technique in remote sensing data processing that expands and improves capability of multispectral image analysis. It takes advantage of hundreds of contiguous spectral channels to uncover materials that usually cannot be resolved by multispectral sensors. This book is an outgrowth of my research in hyperspectral image processing and personal communications in response to many people who are interested in my work previously published in various journals. At the first glimpse, this book may look like a collection of papers authored and co-authored by me. As a matter of fact, it is not the case. The book has been organized in a way that all the chapters are logically connected and can be referred back and forth one another for more details. In particular, most of computer simulations and experiments have been reworked out in order to have a consistent treatment throughout the book. The title of "Hyperspectral Imaging: Techniques for Spectral Detection and Classification" is used to reflect its focus on spectral techniques, i.e. non-literal techniques that are especially designed and developed for hyperspectral imagery rather than multispectral imagery. Although many techniques already exist in multispectral image processing, some of them may not be effective when they are directly applied to hyperspectral imagery. This book takes an opposite approach to develop techniques from a hyperspectral imagery viewpoint where noise is generally not Gaussian and interference plays a more dominant role than does noise in hyperspectral image analysis. More importantly, the detection and classification is performed and carried out by targets of interest rather than pattern classes.

A significant difference from other books is that this book explores applications of statistical signal processing techniques in hyperspectral image analysis, specifically, subpixel detection and mixed pixel classification. It includes many techniques developed in my lab with my former and current Ph.D. students, and systematically integrates these techniques in such a unified framework that readers can capture how the ideas were developed and evolved. Since many readers whose background is not engineering may find a gap in understanding the concepts presented in this book, another objective of this book is to make it self-contained so that readers can easily pick up and implement the techniques without much difficulty. In doing so, I have included detailed mathematical derivations and experiments for illustration. Nevertheless, it by no means claims to be comprehensive; rather, it can be viewed as a recipe book that offers various techniques for hyperspectral data exploitation. Some of these techniques such as OSP (Orthogonal Subspace Projection), CEM (Constrained Energy Minimization) are mature for practical implementation. They are treated in the book in great detail. In addition, many techniques developed in this book may also become handy for years to come. Due to limited scope of the book, many well-known techniques, such as linear spectral mixture analysis that can be found in numerous references, will not discussed in this book.

Instead, this book only covers the work that has been done over the years in the Remote Sensing Signal and Image Processing Laboratory (RSSIPL) at the University of Maryland, Baltimore County.

Like most books, this book owes much credit to many people who deserve my sincere gratitude. These individuals are my former Ph.D. students, Drs. Mark L.G. Althouse, Clark Brumbley, Shao-Shan Chiang, Qian Du, Joseph C. Harsanyi, Daniel Heinz, Agustin Ifarragaerri, Chien-Shun Lo, Hsuan Ren, Chuin-Mu Wang and Ching-Wen Yang as well as my current Ph.D. students, Ms. Eliza Yingzi Du, Ms. Kerri Guilfoyle and Ms. Jianwei Wang. Specifically, I would like to thank Drs. Shao-Shan Chiang and Hsuan Ren who spent so much time in helping me generate most of figures in this book. This book cannot be completed without their contributions. For the data used in this book I would like to thank the Spectral Information Technology Applications Center (SITAC) and Dr. Harsanyi who provide me with their HYDICE and AVIRIS data respectively. My sincere thanks also go to Mr. Paul Lewis and Ms. Judy Powelson who read part of this book and provided valuable suggestions.

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