Field Spectroradiometer Data: Acquisition, Organisation, Processing and Analysis on the Example of New Zealand Native Plants

A thesis presented in fulfilment of
the requirements for the degree of

Master of Philosophy
in
Earth Science

at Massey University, Palmerston North,
New Zealand.

Andreas Hueni

2006

Abstract

The purpose of this research was to investigate the acquisition, storage, processing and analysis of hyperspectral data for vegetation applications on the example of New Zealand native plants. Data covering the spectral range 350nm-2500nm were collected with a portable spectroradiometer.

Hyperspectral data collection results in large datasets that need pre-processing before any analysis can be carried out. A review of the techniques used since the advent of hyperspectral field data showed the following general procedures were followed:

1. Removal of noisy or uncalibrated bands
2. Data smoothing
3. Reduction of dimensionality
4. Transformation into feature space
5. Analysis techniques

Steps 1 to 4 which are concerned with the pre-processing of data were found to be repetitive procedures and thus had a high potential for automation. The pre-processing had a major impact on the results gained in the analysis stage. Finding the ideal pre-processing parameters involved repeated processing of the data.

Hyperspectral field data should be stored in a structured way. The utilization of a relational database seemed a logical approach. A hierarchical data structure that reflected the real world and the setup of sampling campaigns was designed. This structure was transformed into a logical data model. Furthermore the database also held information needed for pre-processing and statistical analysis. This enabled the calculation of separability measurements such as the JM (Jeffries Matusita) distance or the application of discriminant analysis.

Software was written to provide a graphical user interface to the database and implement pre-processing and analysis functionality.

The acquisition, processing and analysis steps were applied to New Zealand native vegetation. A high degree of separability between species was achieved and using independent data a classification accuracy of 87.87% was reached. This outcome required smoothing, Hyperion synthesizing and principal components transformation to be applied to the data prior to the classification which used a generalized squared distance discriminant function.

The mixed signature problem was addressed in experiments under controlled laboratory conditions and revealed that certain combinations of plants could not be unmixed successfully while mixtures of vegetation and artificial materials resulted in very good abundance estimations.

The combination of a relational database with associated software for data processing was found to be highly efficient when dealing with hyperspectral field data.

Acknowledgements

I would firstly like to thank my supervisor Mike Tuohy for his time and thoughtful advice throughout the preparation of this thesis.

I would also like to thank Mike Hedley and Bambang H. Kusumo for their valuable input in terms of end user requirements for spectral processing software.

Table of Contents

List of Figures

List of Tables

1 Introduction

Spectroradiometry has become increasingly popular in the last few years. The technology has advantages over conventional techniques, allowing the non destructive sampling of objects and enabling users to gain critical information more quickly and cheaply. The operation of the equipment tends to be relatively easy and data are collected quickly. However, the interpretation of these data is not dealt with quite as easily. The main issue when dealing with hyperspectral data is their dimensionality. Hyperspectral data are more complex than previous multispectral data and different approaches for data handling and information extraction are needed (Vane and Goetz, 1988; Landgrebe, 1997).

The Institute of Natural Resources, Massey University, had acquired a spectroradiometer built by ASD (Analytical Spectral Devices) and a study utilizing this instrument was considered to be of interest.

The goals of this study were: Enhance the knowledge of the Institute in the field of hyperspectral remote sensing utilizing the recently acquired FieldSpecPro spectroradiometer; study the processes of field data acquisition, data processing and analysis; create a spectral database of New Zealand native vegetation; analyze the spectral separability of New Zealand native vegetation; investigate the problem of mixed signatures; suggest a basis for the classification of land cover using Hyperion data

While the main focus of this research was on hyperspectral data, the simulation of Landsat7 ETM+ was also undertaken, mainly to provide a basis for further investigation of the problem of atmospheric correction. Landsat7 imagery of New Zealand has been successfully corrected for atmospheric influences by Landcare Research, Palmerston North.

During the project, support was given to a Soil Science PhD study at Massey University and to a study on soils and pastures at Landcare Research, Palmerston North, in terms of sharing expertise, collecting data and subsequent processing. These collaborations led to further development of the database and processing requirements and widened the focus of this study to include data from soil and pasture studies. As a result of this, a section on correlation of spectral data with other physical properties was added to the literature review. It serves to complete the picture of the analysis that can be applied to hyperspectral data. The above mentioned collaborations also supported the hypothesis that tools for efficient data handling, organisation and processing were of high interest to scientists.