



Earth Observation: Data, Processing and Applications

Volume 2: Processing

The report is available in PDF format at <http://www.crcsi.com.au/earth-observation-series>
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Publisher:

Australia and New Zealand CRC for Spatial Information

ISBN [ONLINE]:

Volume 2A 978-0-9943019-5-6

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Recommended Citation for Volume 2A:

CRCSI (2017) *Earth Observation: Data, Processing and Applications. Volume 2A: Processing—Basic Image Operations*. (Eds. Harrison, B.A., Jupp, D.L.B., Lewis, S., Sparks, T., M.L., Phinn, Mueller, N., Byrne, G.) CRCSI, Melbourne.

Background image on previous page: Landsat-5 image of Lake Eyre, South Australia, acquired on 9 May, 2009, while the lake was filling. Three images are juxtaposed: a colour composite of bands 5, 4, 2 as RGB on the left, a principal component transformation (with PC3, PC4 and PC1 displayed as RGB) in the centre and a 10 class ISODATA classification on the right.

Source: Norman Mueller, Geoscience Australia

About this Series

This text, *Earth Observation: Data, Processing and Applications*, is an Australian Earth Observation (EO) community undertaking, which has been jointly sponsored by the Cooperative Research Centre for Spatial Information (CRCSI), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Geoscience Australia (GA) and the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC). This publication describes EO data, processing and applications in an Australian context, and includes a wide range of local case studies. It aims to:

- Consolidate EO teaching resources in Australia;
- Encourage a greater number of tertiary courses involving EO in Australia; and
- Promulgate Australia's growing dependence on EO data.

This new text substantially revises and updates two previous books published by CSIRO, namely *Introduction to Remotely Sensed Data* and *Introduction to Image Processing*, which were written to support users of the microBRIAN Image Processing system and used as tertiary texts throughout Australasia for over a decade. The new series comprises multiple volumes, with the option to expand into the future. Unlike the previous publications, the new text is envisaged as an ongoing, community resource, involving a broader range of professionals from academia, government and industry, with relevance to a wider audience. Each volume has been prepared by an editorial panel of local experts, supported by contributing authors who have written and/or reviewed application chapters and case studies. Planning and production of the series has been overseen by advisors from the sponsor organisations.

This series currently comprises three volumes:

Volume 1: Data

This volume outlines the basics of EO in terms of energy sources, data acquisition, sampling characteristics, and image availability. Discussion focuses on the scientific foundations of EO. This volume also considers the interactions of electromagnetic radiation with various targets and media, as relevant to understanding optical, thermal, passive microwave and radar imagery. Volume 1 comprises three sub-volumes:

- 1A—Basics and Acquisition
- 1B—Image Interpretation
- 1X—Appendices

Volume 2: Processing

Volume 2 describes the various options involved with image representation, analysis, transformation, integration and modelling, including details of relevant algorithms, with emphasis on their underlying mathematical and statistical principles. It comprises six sub-volumes:

- 2A—Basic Image Operations
- 2B—Image Rectification
- 2C—Image Transformations
- 2D—Image Integration
- 2E—Image Classification
- 2X—Appendices

Volume 3: Applications

This final volume introduces the Australian environment in terms of topography, climate, ecoregions, land use and vegetation dynamics, then covers a broad range of application areas reliant on EO data. Specific case studies are included to demonstrate individual applications as appropriate. Volume 3 currently comprises two sub-volumes:

- 3A—Terrestrial Vegetation
- 3B—Surface Waters

This structure has been designed to easily enable expansion of volumes in the future.

The resulting publication aims to be both comprehensive and current. It will also enable consistent definitions to be established within the Australian EO sector. Ongoing inclusion of methods, applications and case studies, which utilise a wide range of data sources, will enhance its value to our whole community.

About this Volume

Image processing allows digital image data to be displayed, enhanced, analysed or output in colour or grey-scale format. Most Earth Observation (EO) image data is generated directly by sensing the object of interest, as occurs with remote sensing scanners or digital cameras carried on satellite and aircraft. Various aspects of EO data acquisition are detailed in Volume 1.

Digital imagery is manipulated using image processing operations to enhance the information it contains. Processing may involve enhancing or detecting features of interest, changing the image geometry, extracting patterns, removing noise, or reducing data volume. Image processing uses mathematical operations with digital image data to achieve these results flexibly and quickly. Images are typically large datasets, so while the actual processing operations are often quite simple, specialised hardware and software are generally required to perform the functions efficiently.

Volume 2 in this series describes the various options involved with image representation, analysis, transformation, integration and modelling, including details of relevant algorithms, with emphasis on their underlying mathematical and statistical principles. It comprises six sub-volumes:

Volume 2A — Basic Image Operations

Volume 2A introduces image processing in the context of EO imagery, and is presented in three parts:

- Introduction: describes digital image formats, processing stages and calibration requirements;
- Interpretation: introduces basic processes for improving image contrast, colour, presentation and geometry; and
- Analysis: summarises methods for deriving statistics, classifications and segmentations of EO imagery.

Volume 2B — Image Rectification and Registration

Volume 2B describes concepts and processes for correcting EO image geometry, including relevant cartographical background, factors impacting the geometry of EO imagery, models for image rectification, and methods for resampling imagery.

Volume 2C — Image Transformations

Volume 2C details a range of image transformations commonly used with EO imagery, in terms of:

- Mathematical Foundations—filtering operations, linear operations and non-linear operations;
- Single Channel Rescaling—linear rescaling, non-linear rescaling and destriping;
- Single Channel Filtering—smoothing, interpolation, edge enhancement, surface highlights, and texture; and
- Multiple Channel Operations—Principal Components Analysis, channel ratios and vegetation indices.

Volume 2D — Image Integration

Volume 2D considers methods that integrate multiple EO images with other spatial datasets, including multiple image operations, change detection methods and time series analysis.

Volume 2E — Image Classification and Analysis

Volume 2E provides extensive background information for classifying EO images within the structure:

- Background—classification approaches, relevant statistical methods, preliminary considerations;
- Class Definition—enumerating classes, generating class statistics, and measuring separation between classes;
- Allocation—clustering approaches, classification methods and knowledge-based classifiers; and
- Interpretation—labelling and aggregating classes, and assessing classifications.

Volume 2X — Appendices

Volume 2X supplements the information in Volume 2 with detailed discussion of brightness correction models, BRDF models, colour systems and sequences, filters, and matrix algebra.

Preface

It has been suggested that business schools do three things for students¹:

- provide them with a vocabulary that enables them to talk with authority about subjects they do not understand;
- transmit to them a set of principles that have demonstrated an ability to withstand any amount of disconfirming evidence; and
- provide a ticket of admission to a job where they can learn something about these subjects.

Some would say that these characteristics apply to current approaches to education in many other disciplines, including Earth Observation.

It is the aspiration of the authors of this text that students will learn more than the vocabulary of Earth Observation from these pages; hopefully they will acquire the knowledge to develop robust analytical and synthetic skills that will enable this field to advance and expand with insight and integrity.

A range of additional resources to assist readers is compiled in various Appendices. In particular, numerous online tutorials are now available from a range of sources to complement the material presented in this series.

¹ Comments by Russell L. Ackoff in an interview with Robert J. Allio as reported in: Allio, R.J., and Ackoff, R.L. (2003). Iconoclastic management authority, advocates a 'systematic' approach to innovation. *Strategy and Leadership* 31 (3), 19–26.