

Cambridge University Press

978-0-521-51611-2 - Image Registration for Remote Sensing

Edited by Jacqueline Le Moigne, Nathan S. Netanyahu and Roger D. Eastman

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IMAGE REGISTRATION FOR REMOTE SENSING

Image registration employs digital image processing in order to bring two or more digital images into precise alignment for analysis and comparison. Accurate registration algorithms are essential in supporting Earth and planetary scientists as they mosaic remote sensing satellite images and track changes of the planet's surface over time for environmental, political and basic science studies. The book brings together invited contributions by 36 distinguished researchers in the field to present a coherent and detailed overview of current research and practice in the application of image registration to satellite imagery. The chapters cover the problem definition, theoretical issues in accuracy and efficiency, fundamental algorithms used in its solution, and real-world case studies of image registration software applied to imagery from operational satellite systems.

This book is an essential reference for Earth and space scientists who need a comprehensive and practical overview on how to obtain optimal georegistration of their data, an indispensable source for image processing researchers interested in current research, and the ideal text for teaching a special topic university graduate course.

JACQUELINE LE MOIGNE is the Assistant Chief for Technology in the Software Engineering Division at NASA Goddard Space Flight Center where she leads the strategic vision and the development of goals and objectives for advanced software and information system technologies. During her 20 years experience at NASA, Dr. Le Moigne has performed significant work in the processing and the analysis of remote sensing data. She has become an international expert in image registration, especially as it relates to the use of wavelet analysis, high-performance and onboard processing. She has published over 120 refereed papers and has been an Associate Editor for the *IEEE Transactions on Geoscience and Remote Sensing* and for the journal *Pattern Recognition*.

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ROGER D. EASTMAN is an Associate Professor of Computer Science at Loyola University Maryland, with over 25 years of experience in image matching and registration for medical, robotic and Earth science applications. Professor Eastman has collaborated with NASA-Goddard researchers in Earth science registration on techniques for generalizing and evaluating algorithms, and for robust subpixel registration, and with NIST-Gaithersburg researchers on advanced sensors for manufacturing robotics for general assembly. He regularly reviews articles on image registration for the *IEEE Transactions on Geoscience and Remote Sensing* and other remote sensing venues.

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University Printing House, Cambridge CB2 8BS, United Kingdom

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9780521516112

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First published 2011

4th printing 2015

Printed in the United Kingdom by Print on Demand, World Wide.

A catalog record for this publication is available from the British Library

Library of Congress Cataloging in Publication data

Image registration for remote sensing / edited by Jacqueline Le Moigne,
Nathan S. Netanyahu, Roger D. Eastman.

p. cm.

Includes bibliographical references and index.

ISBN 978-0-521-51611-2

1. Image registration. 2. Image analysis. 3. Remote sensing. 4. Image processing –
Digital techniques.

I. Le Moigne, Jacqueline. II. Netanyahu, Nathan S.

III. Eastman, Roger D. IV. Title.

TA1632.I4826 2010

621.36'78 – dc22 2010041514

ISBN 978-0-521-51611-2 Hardback

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*To my mother, Noëlie Le Moigne, for teaching me
that all dreams can be achieved through determination.
To Gavin, Lauriane and Gordon,
for all the hours I spent on this endeavor.*

Jacqueline Le Moigne

*To my precious children, Aviv and Yovel, and to
my beloved partner and closest friend, Ella Aviram,
for their love, support, and endless patience!*

Nathan S. Netanyahu

*To my wife Michele and son Daniel
for their support and understanding.*

Roger D. Eastman

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*We dedicate this book to the memory of Professor Azriel Rosenfeld, who
inspired us with a love of image processing*

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Foreword

In recent years, image registration has become extremely important in remote sensing applications. Image registration refers to the fundamental task in image processing to match two or more pictures which have been taken of the same object or scene, for example, at different times, from different sensors, or from different viewpoints.

The main reason for the increased significance of image registration in remote sensing is that remote sensing is currently moving towards operational use in many important applications, both at social and scientific levels. These applications include, for example, the management of natural disasters, assessment of climate changes, management of natural resources, and the preservation of the environment; all of which involve the monitoring of the Earth's surface over time. Furthermore, there is an increasing availability of images with different characteristics, thanks to shorter revisiting times of satellites, increased flexibility of use (different acquisition modalities) and the evolution of sensor technologies. Therefore, a growing need emerges to simultaneously process different data, that is, remote sensing images, for information extraction and data fusion. This includes the comparison (integration or fusion) of newly acquired images with previous images taken with different sensors or with different acquisition modalities or geometric configurations – or with cartographic data. The remote images can, therefore, be multitemporal (taken at different dates), multisource (derived from multiple sensors), multimode (obtained with different acquisition modalities), or stereo-images (taken from different viewpoints).

The different images are initially in different coordinate systems. The registration process spatially aligns them by considering one of the images as a reference and transforming the remaining images one at a time. Therefore, a selection of corresponding structures/elements (e.g., pairs of good control points, linear features, etc.) in the reference and in each of the other images is necessary to determine an appropriate transformation. After the completion of the registration process, the

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images can be processed for information extraction. The registration procedure can both be manual and automatic. A wide variety of situations requires diverse registration techniques, spanning from quite simple to very complex and flexible ones, depending also on the degree of heterogeneity of the images and on the level of accuracy needed by the user or by the next computerized analysis stages to which the registration results are addressed. A number of approaches can be put under the umbrella of image registration. Geolocation and geometric correction are examples of such techniques.

Although a few books have been written on image registration in general and several for specific application fields, like medical imaging, in particular, no book has until now been available on image registration research in remote sensing. Therefore, this book edited by Dr. Jacqueline Le Moigne, Professor Nathan S. Netanyahu, and Professor Roger D. Eastman, is very welcome and is of great importance to researchers in remote sensing. The editors are renowned experts in the field of image registration of remote sensing data, and they have selected a group of outstanding authors to cover the most important topics in image registration for remote sensing.

The book is very well organized and split into four main parts. The first part gives an overview of image registration in remote sensing and discusses its importance. The next two parts discuss specific topics in the image registration chain, i.e., similarity metrics and feature matching. Finally, examples on several important applications and systems are given in part four. The book has the significant advantage that it is written in such a way that it is suitable not only for those who are advanced in processing of remote sensing data but also for those who are new to the field, including students. Newcomers to the field will get a clear understanding of what image registration for remote sensing is about after studying a few chapters in the book.

*Professor Jón Atli Benediktsson**President**IEEE Geoscience and Remote Sensing Society**Pro-Rector of Academic Affairs**University of Iceland*

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Acknowledgements

The editors would like to acknowledge Dr. Harold Stone, Dr. Ilya Zavorin, and Professor Arlene Cole-Rhodes for their long-standing research collaboration and their help in preparing this book. They would also like to acknowledge Professor Arthur Goshtasby for his forthcoming advice on the notation used in the book and Dr. Jeffrey Morisette for his thoughtful insights on many Earth science issues. The editors are grateful to Professor Jón Benediktsson for writing the Foreword and Professor Sebastiano Serpico for his book endorsement. Finally, the editors are deeply indebted to all the contributors to this volume for their expertise, dedicated work, and patience.