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FUNDAMENTALS
OF POLARIMETRIC
REMOTE SENSING

JOHN R. SCHOTT

Tutorial Texts in Optical Engineering
Volume TT81

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Introduction to the Series

Since its inception in 1989, the Tutorial Texts (TT) series has grown to more than 80 titles covering many diverse fields of science and engineering. The initial idea for the series was to make material presented in SPIE short courses available to those who could not attend and to provide a reference text for those who could. Thus, many of the texts in this series are generated by augmenting course notes with descriptive text that further illuminates the subject. In this way, the TT becomes an excellent stand-alone reference that finds a much wider audience than only short course attendees.

Tutorial Texts have grown in popularity and in the scope of material covered since 1989. They no longer necessarily stem from short courses; rather, they are often generated by experts in the field. They are popular because they provide a ready reference to those wishing to learn about emerging technologies or the latest information within their field. The topics within the series have grown from the initial areas of geometrical optics, optical detectors, and image processing to include the emerging fields of nanotechnology, biomedical optics, fiber optics, and laser technologies. Authors contributing to the TT series are instructed to provide introductory material so that those new to the field may use the book as a starting point to get a basic grasp of the material. It is hoped that some readers may develop sufficient interest to take a short course by the author or pursue further research in more advanced books to delve deeper into the subject.

The books in this series are distinguished from other technical monographs and textbooks in the way in which the material is presented. In keeping with the tutorial nature of the series, there is an emphasis on the use of graphical and illustrative material to better elucidate basic and advanced concepts. There is also heavy use of tabular reference data and numerous examples to further explain the concepts presented. The publishing time for the books is kept to a minimum so that the books will be as timely and up-to-date as possible. Furthermore, these introductory books are competitively priced compared to more traditional books on the same subject.

When a proposal for a text is received, each proposal is evaluated to determine the relevance of the proposed topic. This initial reviewing process has been very helpful to authors in identifying, early in the writing process, the need for additional material or other changes in approach that would serve to strengthen the text. Once a manuscript is completed, it is peer reviewed to ensure that chapters communicate accurately the essential ingredients of the science and technologies under discussion.

It is my goal to maintain the style and quality of books in the series and to further expand the topic areas to include new emerging fields as they become of interest to our reading audience.

James A. Harrington
Rutgers University
Dedicated to the undergraduates who have forced me to look at old problems in new ways, the practicing scientists and engineers who have kept me grounded, and the graduate students who have opened new doors for me. You have enriched my life. I hope I have, in some small way, returned the favor.
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Preface

This book was motivated by a short course on polarimetric remote sensing that I taught for industry about a year ago. I had supervised three doctoral students on thesis topics involving this subject and when I was asked to teach the course I thought it would be relatively easy to pull the course material together. In the months leading up to the course I discovered two things. First, as is so often the case, in preparing to teach the topic I found I knew far less than I thought I knew and dramatically less than I needed to know to teach a course. Second, I found that while there is a good treatment of polarization principles in the electro-optics literature, the treatment from the remote sensing perspective was quite scarce. In particular, while there were many journal and conference papers on specific topics, there was nowhere to send a student to get a good start on the fundamentals that they would need to prepare to delve into the more specific topics in the journals. So, to make a long story short, with considerable effort, I pulled together a variety of material and taught the course.

Afterwards, I realized I had the foundation for an introductory book that might save others getting started in this field from a similar effort. As a result, I spent the last year fleshing out the initial material, with a good deal of help from dedicated colleagues. The final book focuses on passive electro-optical polarimetric remote sensing in the visible through the thermal infrared (0.4–14 μm).

Polarimetric remote sensing is a relatively new field. It has champions who tout that polarimetric measurements are uncorrelated with traditional measurements of the magnitude and spectral content of the electromagnetic signal and should therefore add significant information. Likewise, it has detractors who point out that often the sought for contrasts between targets and backgrounds or between phenomena are not observed or are not as dramatic as they might be using some other sensing approach. I believe the jury is still out regarding how much utility we will eventually find in passive polarimetric remote sensing and what its role should be relative to other sensing approaches (e.g., multispectral). One of the main reasons for this is that polarimetric signatures are a rather involved function of source, target, and sensor geometry. Potential users must develop a more thorough knowledge of the relevant source-target-propagation-sensor physics to determine the true utility of this modality for their application. Once we understand and apply the relevant physics, we can develop tools to make it easier for
other users to guide collection, processing, and analysis to improve signature contrast and determine the true utility of polarimetric remote sensing. It is for these students of the relevant physics (myself included) that I have written this book. I hope you find it a useful starting point for exploring this largely unexplored field.

As I listen today to the waves crashing on the beach, drowned out periodically by the thunder rumbling across the sky and watch the bay lit up by lightning, I can’t help but be reminded how rich and complex nature is and how rewarding its study can be.

John R. Schott, Ph.D.
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February 2009
Acknowledgments

Let me begin by introducing and thanking the coauthors. They are nearly all current or former students and several are colleagues at the Digital Imaging and Remote Sensing (DIRS) Laboratory at RIT. Lieutenant Colonel James R. Shell II, Ph.D. (Chapters 6, 7, and 10) and Dr. Michael G. Gartley (Chapters 10, 11, and 12) did their Ph.D. work on polarimetric scene simulation in the reflective and thermal infrared regions, respectively. I drew on their work and expertise not only in the chapters cited but throughout the text. Chabitha Devaraj is a current student and David Pogorzala, Dr. David Messinger, and Dr. Adam Goodenough are members of my research staff. They helped in particular with some of the scene simulations in Chapter 7. Finally, Scott D. Brown (Chapters 7 and 10) has been the engine behind the DIRSIG software for many years, as well as friend and colleague. He contributed to essentially all the DIRSIG results.

I also want to thank my graphics and administrative team who made this book a reality in a short time. Sharah Blankenship provided artistic guidance, graphics, and layout for the entire text, as well as the visuals for the various courses I’ve taught based on these materials. Cindy Schultz provided typing, editing coordination, and overall administrative support to all of us, as well as to our reviewers.

In an effort to avoid propagating blunders in this field that we are all studying, I asked a number of colleagues to review chapters, or in a few cases, the entire book, to catch errors and recommend improvements. Many thanks to Dr. Emmett Ientilucci and Dr. David Messinger of DIRS, Christopher Tome at ITT, Dr. Scott Tyo at the University of Arizona, Dr. Bradley Henderson at Los Alamos National Laboratory, and Dr. Thomas Caudill and Matthew Fetrow at AFRL. I am also grateful for editorial help from Dara Burrows at SPIE.

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