# Advances in Mapping from Remote Sensor Imagery

## Techniques and Applications

Xiaojun Yang ▪ Jonathan Li

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EDITED BY

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# Preface

Remote sensing is the science and technology of acquiring the information about physical objects and the environment through recording, measuring, and interpreting imagery and digital representations of electromagnetic radiations derived from noncontact sensors. With the recent advancement in data, technologies, and theories in the broad arena of remote sensing, the use of different aerospace remote sensors and related information extraction techniques to support various mapping applications has received more attention than ever.

This book reviews some of the latest developments in remote sensing and information extraction techniques when applying for topographic and thematic mapping. This is an area in which many exciting advancements have been made over the past decade. This book includes a total of 16 chapters, falling into three major parts. The first part (Chapters 1–3) provides an overview on modern photogrammetry, light detection and ranging (LiDAR) remote sensing, and advanced image classification methods. The second part (Chapters 4–7) reviews the utilities of remote sensing and related image-processing techniques for extracting several types of geographic features that are essential for topographic map production, including elevation, shorelines, and human settlements. The third and final part (Chapters 8–16) showcases some of the latest developments in the synergistic use of remote sensing and relevant data-processing techniques for thematic mapping in environmental and ecologic domains.

This book is the result of extensive research by interdisciplinary experts and will appeal to students, researchers, and professionals dealing with remote sensing, photogrammetry, cartography, geographic information systems, geography, and environmental science. The editors are grateful to all of those who contributed papers and revised their papers one or more times as well as those who reviewed papers according to our requests and timelines. The book project would not have been completed without the help and assistance from several staff members at CRC/Taylor & Francis Group, especially LiMing Leong, Simon Bates, Jennifer Stair, Irma Shagla-Britton, and Saprik Khairunnisa. Acknowledgment also is due to

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# Contents

Chapter 1

# Modern photogrammetric mapping

*Ayman F. Habib*

## CONTENTS



Photogrammetric mapping is traditionally defined as the art and science of generating three-dimensional (3D) spatial and descriptive information from imagery. Photogrammetric mapping is a well-established discipline. In the past few years, however, several technical advances have had an impact on the photogrammetric mapping process—for example, integrated Global Navigation Satellite System and Inertial Navigation System (GNSS/INS) units, medium-format digital cameras, light detection and ranging (LiDAR) systems, and advanced image-processing techniques. This chapter will provide insight into the impacts of recent technical advances in the data acquisition and processing systems on photogrammetric mapping operations. The chapter begins with a brief introduction of the photogrammetric mapping principles. Then, it proceeds with a discussion of the impact of these advances on the photogrammetric mapping practices.

## 1.1 INTRODUCTION

Photogrammetric mapping is traditionally defined as the art and science of generating three-dimensional (3D) spatial and descriptive information from imagery. Photogrammetric mapping is a well-established discipline. In the past few years, however, several technical advances have had an impact on the photogrammetric mapping process—for example, integrated Global Navigation Satellite System and Inertial Navigation System (GNSS/INS) units, medium-format digital cameras, light detection and ranging (LiDAR) systems, and advanced image-processing techniques. This chapter will provide some insight into the impacts of recent technical advances in the data acquisition and processing systems on photogrammetric mapping operations. The chapter begins with a brief introduction of the photogrammetric mapping principles. Then, it proceeds with some discussion related to the following issues:

1. Calibration and stability analysis of medium-format digital cameras for photogrammetric mapping
2. The incorporation of GNSS/INS-based position and orientation information in object space reconstruction
3. System calibration of GNSS/INS-assisted photogrammetric mapping units
4. Line cameras for photogrammetric mapping
5. Feature-based photogrammetric triangulation
6. Integration of photogrammetric and LiDAR data for orthorectification and 3D visualization

## 1.2 PHOTOGRAMMETRIC PRINCIPLES

The main objective of photogrammetric mapping is the derivation of 3D coordinates of features of interest by observing their image coordinates in overlapping imagery. The mathematical model for the photogrammetric point positioning is based on the collinearity of the camera's perspective/projection center, the object point, and the corresponding image point. This model is embodied in the collinearity equations (Equation 1.1). The collinearity equations provide the mathematical expression relating the image coordinates of an image point ($x_i$, $y_i$), the ground coordinates of the corresponding object point ($X_I$, $Y_I$, $Z_I$), the ground coordinates of the perspective center ($X_o$, $Y_o$, $Z_o$), the attitude of the image coordinate system relative to the ground coordinate system as defined by the elements of the rotation matrix ($r_{11}$, $r_{12}$, $r_{13}$, ... $r_{33}$), and the internal characteristics of the camera (principal point coordinates – $x_p$, $y_p$, principal distance – $c$, and deviations from the assumed collinearity condition representation by $dist_x$ and $dist_y$) (Brown, 1966):