BOOK REVIEWS

Gerald McGrath

By Any Measure, Fifty Years of Surveying and Geomatics at the University of New Brunswick, by Wendlynn Wells, 2010, Copies can be obtained from: University of New Brunswick Bookstore, Printed in Fredericton, N.B. Taylor Printing Group Inc., ISBN: 1-155131-143-7; 978-1-155131-143-2, 272p., \$35.

This book presents in a skilful way the formation, development and achievements of the Surveying Engineering / Geodesy and Geomatics Engineering Department at the University of New Brunswick (UNB) from its inception to the mature age of fifty. Beginning as part of the Civil Engineering Department, it achieved in 1965 independent status as a Surveying Engineering Department, and on July 1, 1994 changed to the Geodesy and Geomatics Engineering (GGE) Department. It was the first Surveying Engineering Department in North America at university level, which provided a comprehensive, integrated education in the broad field

of Surveying Science and Engineering that included geodesy, traditional surveying, photogrammetry, remote sensing, engineering and mining surveying, land information and hydrography, all that is now defined as Geomatics. The integration of the “old” and the “new” in surveying, timely response to the demands of the information society and an impressive, multidisciplinary research programme that made some international dent, are illustrated in the pages of this book. These efforts established the Department as a leading world-class centre for Geospatial Information Science and Technology.

The format of this book is unlike a standard history. It has many authors. Most of the “stories” are written by former students and staff members, and come from newspapers, magazines, journals and research reports. It could be compared to a choir of many different voices skilfully conducted by Wendlynn Wells. Some duplications are unavoidable in such a format and initially evoke critical reaction; but on reflection your reviewer has come to appreciate them because they have given different perspectives on the same events, research projects and personalities.

The book comprises a preface, six chapters and Curriculum. The six chapters are Out from the “heavy hand” of Civil Engineering, Memories of the 1960s; Expansion and Solidification, Memories of the 1970s; Innovation and Inspiration, Memories of the 1980s; Riding the Wave of Success Memories of the 1990s; The Millennium Decade, Memories of the 2000s; and Yesterday Today and Tomorrow.

The perseverance in the efforts of visionaries such as Gottfried Konecny, Willis Roberts, Sam Gamble and others to establish a Surveying Engineering Department at UNB is illustrated; and the formation, development and impressive achievements of the GGE Department under the leadership of Konecny, Hamilton, McLaughlin (who later became

President of UNB), Coleman and their successors are described. The hosting of national and international conferences, and research projects in areas such as geodesy, GPS, land information, digital mapping, remote sensing and ocean mapping, reflect the interdisciplinary spectrum of the activities of the GGE Department.

The establishment of the Chair of Ocean Mapping has put the Department of Geodesy and Geomatics Engineering at the international forefront in this field. The staff of GGE Department participated in international geomatics projects sponsored by CIDA in places such as the former Soviet Union, Malawi, Brazil and Peru as well as in the UNB-Waha University exchange programme.

The Department is accredited by the Canadian Council of Professional Engineers, the Canadian Council of Land Surveyors, and the Royal Institution of Chartered Surveyors, and has academic accreditation from the International Hydrographic Organization.

Although not specifically articulated, the enormous positive influence of the Geodesy and Geomatics Engineering Department of UNB on the Canadian Geomatics community at all levels of government and industry can be clearly gleaned from the pages of this book.

This book will be of interest to all involved in Geomatics, particularly to those who are in the process of, or are planning to set up, a Geomatics Engineering Department at a university or a college.

GEORGE J.M. ZARZYCKI

MEMS-Based Integrated Navigation, by Priyanka Aggarwal, Zainab Syed, Aboelmagd Noureldin, Naser El-Sheimy, 2010, Artech House, ISBN: 978-1-60807-043-5, 208p., Hardcover, \$109.

GPS-aided inertial integrated navigation has revolutionised georeferencing imageries in airborne, land and marine applications, and since the 1990s has become the core of directed-georeferencing technology. Nowadays, research and development in multi-sensor integrated positioning and navigation is one of the essential subareas in geomatics. Since the beginning of this millennium, MEMS (Microelectromechanical Systems) inertial sensors have gradually attracted more and more attention from academia and industry while the tactical grade of inertial sensors is still the dominating component in directed-georeferencing products. The phrase “low-cost” can be found more frequently and represents a growing tendency in aided inertial integrated navigation, which is mainly related to MEMS-based integrated navigation. Although plenty of research has been completed, there are still numerous challenging tasks ahead that need to be overcome in order to utilize low-cost MEMS-based inertial sensors more fully in commercial products.

Apparently, there is a pressing need for a book about MEMS-based integrated navigation. This reviewer is very glad to see this book in print, and hopes it will assist readers in systematic fundamental understanding of the subject.

The book is comprised of eight chapters and one appendix. As the preface states, “The book that we have today is a combined effort of all of the authors”. Dr. Noureldin was in charge of the book as a whole and authored chapter 7. Dr. Aggarwal contributed chapters 1, 3 and 8. Chapter 2 contains materials from Dr. El-Sheimy’s lecture notes, and additional sections have been contributed by Dr. El-Sheimy and Dr. Syed. Chapters 4, 5 and 6 were written by Dr. Syed with editing by Dr. Noureldin. The eight chapters may be subdivided into three parts: MEMS inertial technology (chapters 1 to 4), fundamentals of integrated navigation (chapters 5 and 6), and nonlinear filtering (chapters 7 and 8). Authors begin each chapter with an introduction in which a flowchart about the chapter is given, and a reference list is provided at the end of each chapter.

The first four chapters focus on MEMS inertial technology from the general MEMS technology, MEMS inertial sensors, and MEMS inertial sensors errors and initial alignment. Chapter 1 on MEMS introduces different applications of MEMS inertial devices with the emphasis on vehicle navigation applications and possible ways in which MEMS-based inertial navigation can assist. This chapter conceptually summarizes nine different applications and the sources of assistance in three different domains.

The second chapter on MEMS Inertial Sensors describes the working principles of MEMS accelerometers and gyroscopes, and their classifications. It then deals with MEMS inertial sensors, and three possible ways to deduce the minimum number of sensors for land navigation. It concludes with results and analysis of sensor drifting errors with and without nonholonomic constraints.

The third chapter focuses on MEMS Inertial Sensors Errors. After a brief introduction, the second section begins with a flowchart of MEMS inertial sensor errors and further describes six different sensor systematic errors: bias, scale factor,

nonorthogonality/misalignment errors, run-to-run bias/scale factor, in-run bias/scale factor, and temperature-dependent bias/scale factor, which are the most important errors with MEMS inertial sensors. A section on Calibration of Systematic Sensor Errors describes the 6-position static test, angular rate test and thermal calibration test, and is accompanied by the abstracted mathematic details and certain numerical analysis. In the second last topic of the chapter, random/stochastic errors and stochastic modeling are discussed. This chapter ends with sensor measurement models for accelerometers and gyroscopes.

Chapter 4 on Initial Alignment of MEMS Sensors is about how to determine the initial attitude angles—pitch, roll and heading—and different alignment methods that can be used for low-cost MEMS sensors. Regarding the design of a portable navigation system, section 4.3 discusses the advantages and disadvantages of two implementable relative alignment strategies, one with the help of GPS through a navigation Kalman filter (KF) having the initial attitude errors as the states and the other realized through restricting the orientation to an allowable limit. Section 4.4 also discusses the economic considerations of partial MEMS and complete six degrees-of-freedom inertial sensors. Static absolute alignment is then described. At the end of the chapter, velocity matching alignment and transfer alignment are summarized briefly.

The authors condense the fundamentals of integrated inertial navigation into chapters 5 and 6. Chapter 5, which focuses on Navigation Equations, first introduces mathematical relations and transformations between frames, and then discusses the realization of east-north-up and north-east-down motion models. It ends with a high level summary of solving mechanization equations. Aiding MEMS-Based INS is the topic of chapter 6, which begins with a conceptual introduction of loosely coupled and tightly coupled integration architectures, and moves on to the

Kalman filter from an introduction and the algorithm itself to the extended Kalman filter (EKF).

Two attractive nonlinear filtering techniques, Artificial Neural Networks (ANN) and Particle Filters, are discussed in the last two chapters. After a very comprehensive introduction to artificial neural networks, chapter 7 provides a brief background on three types of widely used ANNs for INS/GPS integration, i.e. Multilayer Perception Neural Network, Radial Basis Function Neural Network and Adaptive Neuro Fuzzy Inference System. Its last two sections describe two ANN-based INS/GPS integration architectures. They are "Whole Navigation States Architecture" explained through position update, and position and velocity update, and "Navigation Error States Architecture". Here the focus is on system implementation and architectural considerations for INS/GPS integration from the basics to the ANN/KF augmented approach. Chapter 8 begins with a brief introduction of particle filters. Then three essential techniques - the Monte Carlo Principle, Importance Sampling Method and Resampling Methods - are discussed before moving on to the central subject of the chapter, particle filters. This covers basic particle filters, types of particle filters and the hybrid extended particle filters.

The book ends with an appendix on the Linearization Process for the EKF for Low-Cost Navigation to summarize system models of loosely coupled and tightly coupled approaches together with the corresponding GPS measurement models.

The reviewer respects the authors' research achievements and expertise in MEMS-based integrated navigation, and appreciates the authors' efforts to fill the gap in writing this book for research and development of MEMS-based integrated navigation technology. This book is definitely an appropriate book for education, especially as fundamental reading material or a reference book for senior undergraduate students, graduate students, and even academicians and industry developers

in geomatics and other relevant areas. Readers can easily follow the content of each chapter after its introduction. The carefully selected reference list helps readers with further study of the topics of interest. The book is quite suitable for readers who are initiating their research in low-cost integrated navigation.

JIAN-GUO WANG

Navigation Signal Processing for GNSS Software Receivers, by Thomas Pany, Artech House, 685 Canton Street, Norwood MA 02062, USA, 2007 ISBN 978-1-60807-027-5, Hardcover, 352 p, Hardcover, \$139, also available in e-book format.

Navigation Signal Processing for GNSS Software Receivers is the latest title in the Artech House GNSS Technology and Applications Series. The book is a very detailed theoretical look at the principles behind designing a completely general Global Navigation Satellite System (GNSS) software receiver that can be easily modified to acquire and track any GNSS signal. This is a book for specialists. A navigation engineer, even one who has trained as an electrical or communications engineer, who is seeking to learn

about software-defined receivers should first read a more introductory treatment of the topic to review the general principles before diving into the details in this book. However, for anyone planning to implement a software GNSS receiver, this book is an excellent resource as all of the steps required are described thoroughly.

The book is divided into 11 chapters that in some cases do not appear in the most obvious order. Chapter 1 begins with an introduction to a theoretical general signal model that is then developed into examples that cover the GPS C/A code, Galileo E1 code, and finally two pulsed signals. The purpose of this is to show that a general model can be used in further development, and the specific signal inserted into various equations at the end to allow for easy development of a receiver that could track any imaginable signal. However this level of mathematical derivation so early in the book seems strange considering that the general concept of software-defined radio, which is the main enabling technology of the book, and the motivation for software GNSS receivers, are not introduced until Chapter 2.

Chapter 3 provides a detailed description of the software structure and data flow of a specific software receiver implementation developed by the author. The first three sections of the chapter at least describe a somewhat general architecture and data flow for a typical software GNSS receiver. But section 3.4 documents a specific reference receiver design in a way that reads more like internal code documentation than a textbook about software GNSS. Chapter 4 briefly treats the issue of GNSS signal acquisition and tracking in a generalized way by lumping the entire topic under a broad heading of signal estimation. The chapter attempts to be exhaustive of all possible methods, starting with parameter estimation, Cramer Rao Lower Bound (CRLB) estimation, correlation, discrimination, estimation in the case of multipath, and Kalman filtering as applied to GNSS tracking

loops. Similarly Chapter 5 contains a long list of signal detection concepts ranging from hypothesis testing to coherent integration to high sensitivity GNSS concepts such as long integration and differential detection. These two chapters together are an excellent reference for an expert as almost every mathematical method employed by a software GNSS receiver is described in minute detail.

A major weakness of the book is the way in which it is organized. It covers many topics, each in its own section of a chapter; but each is presented as a standalone concept and at times it is not clear why each is presented nor how they all relate to each other. Additionally many quantities and terms are used in lengthy theoretical derivations of generalized expression before they are defined. While this will not be a problem for an expert reading the book as a reference manual, for a newcomer to the subject area, the first five chapters could be quite confusing until after the reader has finished the whole book. Thankfully most of these undefined terms and concepts are cross-referenced

to their full definitions and development in later sections.

Only in Chapter 6, after all of these disparate methods and topics have been discussed, does the book start to follow a more logical pattern. Here, and for the next two chapters, three different building blocks of a software receiver are described in the order in which they are encountered in the data flow of a typical receiver. They are Sample Preprocessing (Chapter 6), Correlators (Chapter 7), and Discriminators (Chapter 8). Each of these chapters contains a very thorough description of the operation of each receiver component. These chapters form a complete and accurate reference to the general operation of the first three stages of a software GNSS receiver. Then Chapter 9 describes the operation of a receiver built from these components, along with many other specific details of implementation.

The final major chapter describes the conceptual use of a software GNSS receiver implementation for a real-time kinematic GNSS system. The author identifies correctly that the combination of powerful low-cost portable computers with ubiquitous data networks means, at least in principle, that any laptop, tablet, or

smart phone equipped with a low cost GNSS front-end could become an Real Time Kinematic (RTK) rover or base-station; and that mass market applications of RTK, without prohibitively expensive equipment, are indeed possible. Chapter 10 continues with implementation details and descriptions of tests conducted on a prototype system. The book concludes with a three-page chapter describing some representative source code available from the publisher's web site, and several mathematical appendices.

This book contains a vast amount of information about many aspects of signal processing for GNSS software receivers, and the author is clearly an accomplished researcher in this area. Although it is an excellent reference and resource for an expert, it is not suitable for a reader who is new to the area and hoping to learn about the general steps involved in building a software GNSS receiver. □

KYLE O'KEEFE

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