Sensor and Data Fusion

A Tool for Information Assessment and Decision Making

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To Jonathan, Amy, and Gregory

Contents

List of Figures

List of Tables

Preface

Sensor and Data Fusion: A Tool for Information Assessment and Decision Making is the latest version of *Sensor and Data Fusion Concepts and Applications*, which last appeared as Tutorial Text 35 from SPIE. The information in this edition has been substantially expanded and updated to incorporate recent approaches to data and sensor fusion.

The book serves as a companion text to courses taught by the author on multisensor, multitarget data fusion techniques for tracking and identification of potential targets. Material regarding the benefits of multisensor systems and data fusion originally developed for courses on advanced sensor design for defense applications was utilized in preparing the original edition. Those topics that deal with applications of multiple sensor systems; target, background, and atmospheric signature-generation phenomena and modeling; and methods of combining multiple sensor data in target identity and tracking data fusion architectures were expanded for this book. Chapter 6 on Dempster-Shafer theory now incorporates discussions about several proposed modifications to the original theory, which provide alternate methods for assigning probability mass to compatible and conflicting propositions. Revisions and additions were also made to all subsequent chapters that appeared in previous editions of this book. Most signature phenomena and data fusion techniques are explained with a minimum of mathematics or use relatively simple mathematical operations to convey the underlying principles. Understanding of concepts is aided by the nonmathematical explanations provided in each chapter.

Multisensor systems are frequently designed to overcome space limitations associated with smart weapons applications or to combine and assess information from non-collated or dissimilar sources. Packaging volume restrictions associated with the construction of fire-and-forget missile systems often constrain sensor selection to those operating at infrared and millimeter-wave frequencies. In addition to having relatively short wavelengths and hence occupying small volumes, these sensors provide high resolution and complementary information as they respond to different signature-generation phenomena. The result is a large degree of immunity to inclement weather, clutter, and signature masking produced by countermeasures. Sensor and data fusion architectures are utilized in these multisensor systems to combine information from the individual sensors and other sources in an efficient and effective manner.

This book discusses the benefits of infrared and millimeter-wave sensor operation including atmospheric effects; multiple sensor system applications;

definitions and examples of data fusion architectures and algorithms; classical inference, which forms a foundation for the more general Bayesian inference and Dempster-Shafer evidential theory that follow in succeeding chapters; artificial neural networks; voting logic as derived form Boolean algebra expressions; fuzzy logic; detecting and tracking objects using only passively acquired data; and a summary of the information required to implement each of the data fusion methods discussed.

Weather forecasting, Earth resource surveys that use remote sensing, vehicular traffic management, target classification and tracking, and battlefield assessment are some of the applications that will benefit from the discussions provided of signature-generation phenomena, sensor fusion architectures, and data fusion algorithms. There continues to be high interest in military and homeland defense usage of data fusion to assist in the identification of missile threats, suicide bombers, strategic and tactical targets, assessment of information, evaluation of potential responses to a threat, and allocation of resources. The signature-generation phenomena and fusion architectures and algorithms presented in this book continue to be applicable to these areas as well as the growing number of nondefense applications.

Several people have made valuable suggestions that were incorporated into this work. Henry Heidary, in addition to his major contributions to Chapter 10, reviewed other sections of the original manuscript. Sam Blackman reviewed the original text and provided several references for new material that was subsequently incorporated. Pat Williams reviewed sections on tracking and provided data concerning tracking algorithm execution times. Martin Dana, with whom I teach the multisensor, multitarget data fusion course, reviewed several of the newer sections. His insightful suggestions have improved upon the text. Merry Schnell, Sharon Streams, Eric Pepper, and the rest of the SPIE staff provided, as usual, technical and editorial assistance that improved the quality of the material in the text. That the book has many strengths, I am indebted to these and so many other colleagues. Its faults, of course, are mine.

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