Preface

In recent years, technological advances have resulted in the rapid development of a new exciting research direction – the interdisciplinary use of sensors for data collection, systems analysis, and monitoring. Application areas include military surveillance, environmental screening, computational neuroscience, seismic detection, transportation, along with many other important fields.

Broadly speaking, a sensor is a device that responds to a physical stimulus (e.g., heat, light, sound, pressure, magnetism, or motion) and collects and measures data regarding some property of a phenomenon, object, or material. Typical types of sensors include cameras, scanners, radiometers, radio frequency receivers, radars, sonars, thermal devices, etc.

The amount of data collected by sensors is enormous; moreover, this data is heterogeneous by nature. The fundamental problems of utilizing the collected data for efficient system operation and decision making encompass multiple research areas, including applied mathematics, optimization, and signal/image processing, to name a few. Therefore, the task of crucial importance is not only developing the knowledge in each particular research field, but also bringing together the expertise from many diverse areas in order to unify the process of collecting, processing, and analyzing sensor data. This process includes theoretical, algorithmic, and application-related aspects, all of which constitute essential steps in advancing the interdisciplinary knowledge in this area.

Besides individual sensors, *interconnected systems of sensors*, referred to as *sensor networks*, are receiving increased attention nowadays. The importance of rigorous studies of sensor networks stems from the fact that these systems of multiple sensors not only acquire individual (possibly complimentary) pieces of information, but also effectively exchange the obtained information. Sensor networks may operate in static (the locations of individual sensor nodes are fixed) or dynamic (sensor nodes may be mobile) settings.

Due to the increasing significance of sensor networks in a variety of applications, a substantial part of this volume is devoted to theoretical and algorithmic aspects of problems arising in this area. In particular, the problems of information fusion are especially important in this context, for instance, in the situations when the data

collected from multiple sensors is synthesized in order to ensure effective operation of the underlying systems (i.e., transportation, navigation systems, etc.). On the other hand, the reliability and efficiency of the sensor network itself (i.e., the ability of the network to withstand possible failures of nodes, optimal design of the network in terms of node placement, as well as the ability of sensor nodes to obtain location coordinates based on their relative locations – known as *sensor network localization* problems) constitutes another broad class of problems related to sensor networks. In recent years, these problems have been addressed from rigorous mathematical modeling and optimization perspective, and several chapters in this volume present new results in these areas.

From another theoretical viewpoint, an interesting related research direction deals with investigating information patterns (possibly limited or incomplete) that are obtained by sensor measurements. Rigorous mathematical approaches that encompass dynamical systems, control theory, game theory, and statistical techniques, have been proposed in this diverse field.

Finally, in addition to theoretical and algorithmic aspects, application-specific approaches are also of substantial importance in many areas. Although it is impossible to cover all sensor-related applications in one volume, we have included the chapters describing a few interesting application areas, such as navigation systems, transportation systems, and medicine.

This volume contains a collection of chapters that present recent developments and trends in the aforementioned areas. Although the list of topics is clearly not intended to be exhaustive, we attempted to compile contributions from different research fields, such as mathematics, electrical engineering, computer science, and operations research/optimization. We believe that the book will be of interest to both theoreticians and practitioners working in the fields related to sensor networks, mathematical modeling/optimization, and information theory; moreover, it can also be helpful to graduate students majoring in engineering and/or mathematics, who are looking for new research directions.

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