Preface

In papers, reports, or websites related to navigation and transportation, the terms *wayfinding* and *navigation* are often used interchangeably. Although these terms overlap semantically, there is an important but subtle difference between them, namely, that wayfinding involves finding routes between pairs of locations whereas navigation involves traveling and receiving continuous real-time guidance while on a chosen route. Another way to observe the difference between these two terms is through common technologies used for wayfinding and navigation. Geographic information system (GIS) technology is commonly used for wayfinding, and an integration of GPS and GIS technologies (as well as others) is used for navigation. There are also differences between "wayfinding and navigation systems" and "wayfinding and navigation *services*." The former is a reference to specialized devices that provide wayfinding and navigation solutions without the need for communication links or connection to other systems and without third-party providers. The latter is a reference to services (more recently through smartphones) that provide wayfinding and navigation solutions only through wired-wireless communication links to remote systems supported by third-party providers. From a computing perspective, wayfinding and navigation systems are centralized platforms, and wayfinding and navigation services are decentralized (distributed) platforms, distributed over clients (on smartphones) and servers (maintained by providers).

Wayfinding and navigation systems and services for cars driving outdoors have been around for a long time and have become indispensable in people's mobility, in particular in unfamiliar environments. The popularity and the high demand for car wayfinding and navigation systems and services can mainly be attributed to GPS technology, which has become compact, affordable, and ubiquitous. A similar trend but a different technology (i.e., smartphones) has been the impetus for building pedestrian wayfinding and navigation systems and services. Since pedestrians seamlessly walk between different environments (outdoor to indoor and vice versa), and different data and technologies are required for indoor wayfinding and navigation, the interest in building wayfinding and navigation systems and services indoors has significantly increased, though they are still in their infancy.

While, conceptually, wayfinding and navigation in outdoor and indoor environments involve similar activities, from the physical space and functionality perspectives, there are differences between them. For example, the physical space (or environment) for pedestrian wayfinding and navigation outdoors generally involves sidewalk networks consisting of sidewalk segments and intersections, regardless of the city or the neighborhood in which wayfinding and navigation activities are needed. This is different from the

physical space (or environment) for wayfinding and navigation indoors, where building structures are not uniform (e.g., different floor plans for different floors of a building and single-story vs. multistory buildings). Another difference with respect to the physical space is that while it is possible for wayfinding and navigation systems and services outdoors to provide solutions using only 2D map data, in buildings they must contain 3D (or 2.5) map data to allow travel between floors. An example of difference with respect to functionality is that unlike wayfinding and navigation systems and services outdoors, which are predominantly based on GPS as the sole positioning sensor, there is no single positioning sensor suitable for navigation in all buildings. In short, wayfinding and navigation differences indoors pose unique challenges that are not present in wayfinding and navigation outdoors.

The purpose of this book is to provide the breadth and depth of knowledge needed for understanding the issues and challenges in building wayfinding and navigation systems and services for indoors and the current approaches, techniques, and technologies considered for addressing them. This book is unique because the cognitive, positioning, mapping, and application perspectives of indoor wayfinding and navigation are discussed in one collection. This mix of different perspectives in this book helps readers better understand the issues and challenges for building indoor wayfinding and navigation systems and services, how these systems and services are different from those used outdoors, and how they can be used efficiently and effectively in challenging applications. Nonetheless, despite these unique features, to be consistent with the general perception about the terminology, as reflected in the literature, the chapters of this book sometimes reference *wayfinding* and *navigation* as they were defined previously; in other times they are used interchangeably.

The cognitive aspects of wayfinding and navigation are the subjects of the first two chapters, whereas several possible sensors for indoor positioning and a unique positioning sensor for indoor environments are discussed in chapters 3 and 4. Chapter 5 provides an example of a unique environment, while chapter 6 discusses map-aided indoor navigation. Chapters 7 through 10 focus on wayfinding and navigation issues related to the blind/visually impaired (B/VI) and discuss current approaches, techniques, and technologies for them. The last chapter addresses the privacy concerns in indoor wayfinding and navigation. The following paragraph provides the details in each chapter.

Chapter 1 discusses navigation of complex environments from the cognitive perspective. This is important in that wayfinding and navigation systems and services, like systems and services for other applications, can provide desired and reliable solutions if they are designed based on cognitive principles related to wayfinding and navigation. In chapter 2 an experiment related to indoor spatial knowledge is described. Considering that there is no sole positioning sensor that can provide acceptable positional accuracy for navigation indoors, like GPS, which has become ubiquitous for

outdoor navigation, several possible positioning sensors suitable for indoor positioning are described in chapter 3. To provide a rather unique example of a positioning sensor, chapter 4 presents indoor positioning through magnetic technology and techniques. Similarly, to provide a rather unique example of the indoor environment, localization techniques and technologies in underground tunnels are presented in chapter 5. Considering that maps are a core component of wayfinding and navigation systems and services in any environment, chapter 6 discusses map-aided indoor navigation. While building indoor wayfinding and navigation systems and services poses challenges that are different from those for outdoors, there are different and unique challenges for adequately addressing the wayfinding and navigation requirements of people with disabilities. The next four chapters are devoted to the discussion and analysis of wayfinding and navigation requirements for B/VI individuals and possible approaches, techniques, and technologies for addressing them. Chapter 7 provides the challenges of indoor wayfinding and navigation for B/VI individuals. Chapter 8 discusses various suitable technologies that can be used to aid B/VI people for indoor wayfinding and navigation. Chapter 9 discusses the NavPal suite of tools that can be used to assist B/VI travelers in wayfinding and navigation in indoor environments. Chapter 10 discusses future directions in indoor wayfinding and navigation technology for B/VI travelers. Issues of privacy in indoor wayfinding and navigation systems and services are discussed in chapter 11.

This book is suitable for anyone interested in learning about approaches, maps, sensors, techniques, technologies, and applications, among other things, for indoor wayfinding and navigation. Researchers can learn about the latest research developments related to indoor wayfinding and navigation in indoor environments, developers can learn about the issues and challenges in building new indoor wayfinding and navigation systems and services, and students can learn about the fundamentals of indoor wayfinding and navigation.