

Introduction to Autonomous Mobile Robots

second edition

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Preface

Mobile robotics is a young field. Its roots include many engineering and science disciplines, from mechanical, electrical, and electronics engineering to computer, cognitive, and social sciences. Each of these parent fields has its share of introductory textbooks that excite and inform prospective students, preparing them for future advanced coursework and research. Our objective in writing this textbook is to provide mobile robotics with such a preparatory guide.

This book presents an introduction to the fundamentals of mobile robotics, spanning the mechanical, motor, sensory, perceptual, and cognitive layers that comprise our field of study. A collection of workshop proceedings and journal publications could present the new student with a snapshot of the state of the art in all aspects of mobile robotics. But here we aim to present a foundation—a formal introduction to the field. The formalism and analysis herein will prove useful even as the frontier of the state-of-the-art advances due to the rapid progress in all of the subdisciplines of mobile robotics.

This second edition largely extends the content of the first edition. In particular, chapters 2, 4, 5, and 6 have been notably expanded and updated to the most recent, state-of-the-art acquisitions in both computer vision and robotics. In particular, we have added in chapter 2 the most recent and popular examples of mobile, legged, and micro aerial robots. In chapter 4, we have added the description of new sensors—such as 3D laser rangefinders, time-of-flight cameras, IMUs, and omnidirectional cameras—and tools—such as image filtering, camera calibration, structure-from-stereo, structure-from-motion, visual odometry, the most popular feature detectors for camera (Harris, FAST, SURF, SIFT) and laser images, and finally bag-of-feature approaches for place recognition and image retrieval. In chapter 5, we have added an introduction to probability theory, and improved and expanded the description of Markov and Kalman filter localization using a better formalism and more examples. Furthermore, we have also added the description of the Simultaneous Localization and Mapping (SLAM) problem along with a description of the most popular approaches to solve it such as extended-Kalman-filter SLAM, graph-based SLAM, particle filter SLAM, and the most recent monocular visual SLAM. Finally, in chapter 6 we have added the description of graph-search algorithms for path planning such as breadth-first, depth first, Dijkstra, A*, D*, and rapidly exploring random trees. Besides these many new additions, we have also provided state-of-the-art references and links to online resources

and downloadable software.

We hope that this book will empower both undergraduate and graduate robotics students with the background knowledge and analytical tools they will need to evaluate and even criticize mobile robot proposals and artifacts throughout their careers. This textbook is suitable as a whole for introductory mobile robotics coursework at both the undergraduate and graduate level. Individual chapters such as those on perception or kinematics can be useful as overviews in more focused courses on specific subfields of robotics.

The origins of this book bridge the Atlantic Ocean. The authors have taught courses on mobile robotics at the undergraduate and graduate level at Stanford University, ETH Zurich, Carnegie Mellon University and EPFL. Their combined set of curriculum details and lecture notes formed the earliest versions of this text. We have combined our individual notes, provided overall structure and then test-taught using this textbook for two additional years before settling on the first edition in 2004, and another six years for the current, published text.

For an overview of the organization of the book and summaries of individual chapters, refer to section 1.2.

Finally, for the teacher and the student: we hope that this textbook will prove to be a fruitful launching point for many careers in mobile robotics. That would be the ultimate reward.