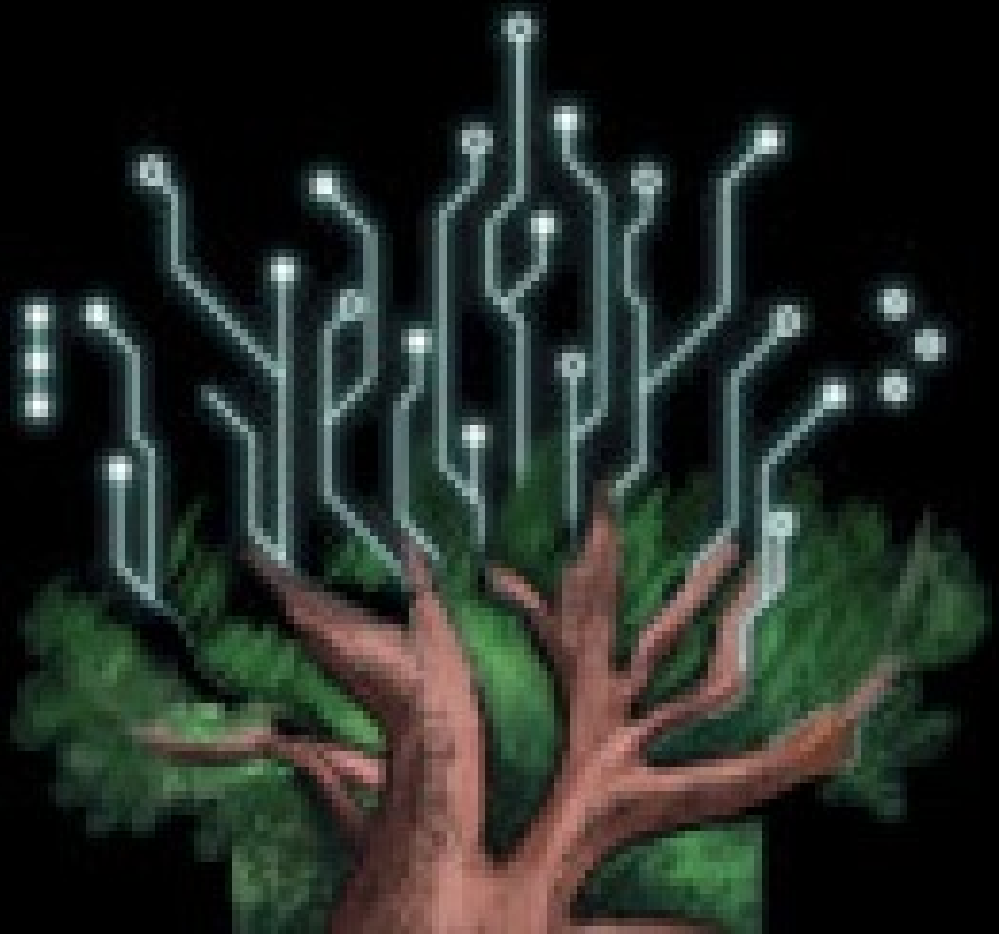
Computational Principles of Mobile Robotics

Third Edition

GREGORY DUDEK
MICHAEL JENKIN



Computational Principles of Mobile Robotics

Mobile robotics is a multidisciplinary field involving both computer science and engineering. Addressing the design of automated systems, it lies at the intersection of artificial intelligence, computational vision, and traditional robotics. Now in its third edition, this textbook for advanced undergraduates and graduate students covers algorithms for a range of strategies for locomotion, sensing, and reasoning.

The new edition includes recent advances in robotics and intelligent machines, including coverage of human–robot interaction, robot ethics, and the application of advanced AI techniques to end-to-end robot control and specific computational tasks. This book also provides support for a number of algorithms using ROS 2, and includes a review of critical mathematical material and an extensive list of sample problems. Researchers as well as students in the field of mobile robotics will appreciate this comprehensive treatment of state-of-the-art methods and key technologies.

Gregory Dudek is Distinguished James McGill Professor of Computer Science at McGill University. He is also a member of the Center for Intelligent Machines, and associate member of Mila, and has been co-author of over 300 refereed publications on robotics, machine learning, and computer vision. He has also served as a Vice President with Samsung Electronics and founding Lab Head for the Samsung AI Center in Montreal, Canada. With Michael Jenkin, he has played many roles in the field including co-founding Independent Robotics Inc. and establishing the Canadian Robotics Research Network.

Michael Jenkin is Professor of Electrical Engineering and Computer Science at York University. Working with intelligent autonomous machines for over thirty years, he has helped develop autonomous systems that have operated on and below the water's surface, and has worked on robot systems that were designed to operate in environments ranging from nuclear power plants to contaminated crime scenes.

'This book is an indispensable tool for any – both pre-university and university – course on mobile robotics. In relation to the first edition, this current one has been sufficiently updated. I recommend this book to researchers – particularly those who study localization or mapping – and doctoral students who are interested in investigating the latest approaches and techniques in the mobile robotics field.'

Ramon Gonzalez Sanchez, *Computing Reviews*

'. . . a great resource for an intermediate or advanced course on mobile robotics.'

R.S. Stanbury, *Embry Riddle University, Choice*

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CAMBRIDGE
UNIVERSITY PRESS

Shaftesbury Road, Cambridge CB2 8EA, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi - 110025, India

103 Penang Road, #05-06/07, Visioncrest Commercial, Singapore 238467

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www.cambridge.org
Information on this title: www.cambridge.org/highereducation/isbn/9781108498470

DOI: 10.1017/9781108682404

First published 1997
Second edition 2010

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging-in-Publication Data
Names: Dudek, Gregory, 1958- author. | Jenkin, Michael, 1959- author.
Title: Computational principles of mobile robotics / Gregory Dudek and Michael Jenkin.
Description: Third edition. | New York : Cambridge University Press, 2023. | Includes bibliographical references and index.
Identifiers: LCCN 2023033779 (print) | LCCN 2023033780 (ebook) | ISBN 9781108498470 (hardback) | ISBN 9781108736381 (paperback) | ISBN 9781108682404 (epub)
Subjects: LCSH: Mobile robots. | Robotics–Mathematics.
Classification: LCC TJ211.415 .D83 2023 (print) | LCC TJ211.415 (ebook) | DDC 629.8/932–dc23/eng/20230812
LC record available at https://lccn.loc.gov/2023033779
LC ebook record available at https://lccn.loc.gov/2023033780

ISBN 978-1-108-49847-0 Hardback
ISBN 978-1-108-73638-1 Paperback

Additional resources for this publication at www.cambridge.org/dudek-jenkin3e.

For Krys and Heather

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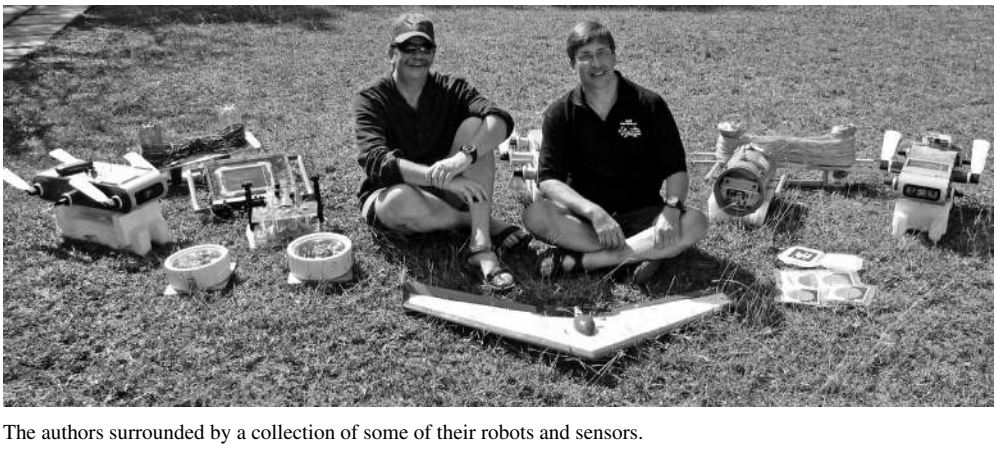
Preface



The authors surrounded by a collection of some of their robots and sensors.

A great deal has changed in mobile robotics since the second edition of this book. A revolution in neural networks has had significant impact on sensor processing and algorithms for a range of robotics tasks. The need for effective human–robot interaction has been driven by the deployment of autonomous systems in a range of different domains, and the cost of autonomous systems has dropped to the point that drones are ubiquitous and many houses have robot vacuum cleaners operating within them.

As the field of robotics has expanded and matured, so has the material that is presented in this volume. The third edition of this text includes new chapters related to human–robot interaction, the application of deep learning to robotics, and roboethics. When teaching robotics in a single semester course, it becomes more and more difficult to cover the entire field, and it is common in an introductory course to focus on certain aspects of robotics and to only touch lightly on other topics. For example, in a computer science program it might be prudent to only lightly review chapters related to robot hardware (e.g., Chapters 3, 4, and 5), and to concentrate more heavily on deep learning (Chapter 6), algorithms related to planning (Chapter 7), system control (Chapter 8), pose maintenance (Chapter 9), and mapping (Chapter 10). Students from an engineering background, on the other hand, might find Chapters 3 through 5 particularly relevant and might instead prefer to only touch lightly on robot collectives (Chapter 11) and human–robot interaction (Chapter 12). Robot Ethics (Chapter 13), Robots in Practice (Chapter 14), and the Future of Mobile Robotics (Chapter 15) are relevant for most courses in robotics and provide a conclusion to the material.

In teaching robotics, a common question involves how close to the hardware does one need to go. Advances in the development of a common robot middleware has made dealing with real robots more practical in an introductory course. This book is supported by an online repository at www.cambridge.org/dudek-jenkin3e, which includes ROS 2 code that supports many of the examples given in this text and an introduction to ROS 2 as well.

Acknowledgments

This book would not have been possible without the active support of our students and colleagues who suffered through early drafts, provided imagery and papers, and put up with us while this volume was being put together. The list of people who helped is much too long to include here, but some require special mention: the International Joint Conferences on Artificial Intelligence (IJCAI), for letting us do a tutorial on mobile robotics that started us on the journey; students at McGill and York, including Eric Bourque, Andrew Hogue, and Yiannis Rekleitis, who suffered with photocopies of early drafts; Prof. Evangelos Milios for his helpful comments and Prof. Evangelos Papadopoulos for his help on space robots; Rob Sim for his figures; and Louis Dudek for his proofreading and helpful comments.

Finally, we thank Lauren Cowles and Cambridge University Press for encouraging us do this in the first place.