Preface

This book provides a comprehensive introduction into the emerging field of probabilistic robotics. Probabilistic robotics is a subfield of robotics concerned with perception and control. It relies on statistical techniques for representing information and making decisions. By doing so, it accommodates the uncertainty that arises in most contemporary robotics applications. In recent years, probabilistic techniques have become one of the dominant paradigms for algorithm design in robotics. This monograph provides a first comprehensive introduction into some of the major techniques in this field.

This book has a strong focus on algorithms. All algorithms in this book are based on a single overarching mathematical foundation: Bayes rule, and its temporal extension known as Bayes filters. This unifying mathematical framework is the core commonality of probabilistic algorithms.

In writing this book, we have tried to be as complete as possible with regards to technical detail. Each chapter describes one or more major algorithms. For each algorithm, we provide the following four things: (1) an example implementation in pseudo code; (2) a complete mathematical derivation from first principles that makes the various assumptions behind each algorithm explicit; (3) empirical results insofar as they further the understanding of the algorithms presented in the book; and (4) a detailed discussion of the strengths and weaknesses of each algorithm—from a practitioner's perspective. Developing all this for many different algorithms proved to be a laborious task. The result might at times be a bit difficult to digest for the casual reader—although skipping the mathematical derivation sections is always an option! We hope that a careful reader emerges with a much deeper level of understanding than any superficial, non-mathematical exposition of this topic would have been able to convey.

This book is the result of more than a decade of research by us, the authors, our students, and many of our colleagues in the field. We began writing it in 1999, hoping that it would take not much more than a few months to complete this book. Five years have passed, and almost nothing from the original draft has survived. Through working on this book, we have learned much more about information and decision theory than we thought we ever would. We are happy to report that much of what we learned has made it into this book.

This monograph is written for students, researchers, and practitioners in robotics. We believe everybody building robots has to develop software. Hence the material in this book should be relevant to every roboticist. It should also be of interest to applied statisticians, and people concerned with real-world sensor data outside the realm of robotics. To serve a wide range of readers with varying technical backgrounds, we have attempted to make this book as self-contained as possible. Some prior knowledge of linear algebra and basic probability and statistics will be helpful, but we have included a primer for the basic laws of probability, and avoided the use of advanced mathematical techniques throughout this text.

This book is also written for classroom use. Each chapter offers a number of exercises and suggests hands-on projects. When used in the classroom, each chapter should be covered in one or two lectures. Chapters should be skipped or reordered quite arbitrarily; in fact, in our own teaching we usually start right in the middle of the book, with Chapter 7. We recommend that the study of the book be accompanied by practical, hands-on experimentation as directed by the exercises at the end of each chapter. Nothing more important in robotics than doing it yourself!

Despite our very best efforts, we believe there will still be technical errors left in this book. We will post corrections on the book's Web site, along with other materials relevant to this book:

`www.probabilistic-robotics.org`

We hope you enjoy this book!

Sebastian Thrun
Wolfram Burgard
Dieter Fox