Springer Tracts in Advanced Robotics

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Federico Cuesta · Aníbal Ollero

Intelligent Mobile Robot Navigation

With 109 Figures

Springer

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Foreword

At the dawn of the new millennium, robotics is undergoing a major transformation in scope and dimension. From a largely dominant industrial focus, robotics is rapidly expanding into the challenges of unstructured environments. Interacting with, assisting, serving, and exploring with humans, the emerging robots will increasingly touch people and their lives.

The goal of the new series of *Springer Tracts in Advanced Robotics (STAR)* is to bring, in a timely fashion, the latest advances and developments in robotics on the basis of their significance and quality. It is our hope that the wider dissemination of research developments will stimulate more exchanges and collaborations among the research community and contribute to further advancement of this rapidly growing field.

The monograph written by Federico Cuesta and Aníbal Ollero builds upon the application of fuzzy logic to the area of intelligent control of mobile robots. Reactive, planned and teleoperated techniques are considered, leading to the development of novel fuzzy control systems for perception and navigation of nonholonomic autonomous vehicles. The unique feature of the work lies in its comprehensive treatment of the problem from the theoretical development of the various schemes down to the real-time implementation of algorithms on mobile robot prototypes. As such, the book spans across different domains ranging from mobile robots to intelligent transportation systems, from automatic control to artificial intelligence.

Remarkably, the doctoral thesis at the basis of this monograph was a finalist for the First EURON Georges Giralt PhD Award devoted to the best PhD thesis in Robotics in Europe. A fine addition to the series!

Naples, Italy
November 2004

Bruno Siciliano
STAR Editor

Preface

This book presents the results obtained in the framework of several projects both at a national and international level in the area of intelligent mobile robotics navigation, and fuzzy control system design and stability analysis.

The book deals with the design, stability analysis and implementation of new intelligent fuzzy control systems for perception and navigation of nonholonomic autonomous vehicles. Reactive, planned and teleoperated techniques are considered. Simulations and real experiments with the autonomous vehicles ROMEO-3R and ROMEO-4R, designed and built at the University of Seville, illustrate the application of the methods. Autonomous parking of ROMEO-4R backing up a trailer is also considered. The book emphasizes the application of fuzzy logic to the above topics. An important point is the stability analysis of the fuzzy reactive navigation. Thus the book presents an overview of stability analysis techniques for nonlinear fuzzy systems including Lyapunov, input-output analysis, frequency response methods and bifurcation theory analysis and their application to the stability analysis of fuzzy reactive navigation in an autonomous vehicle. These methods can be of interest for students and researchers in the areas of nonlinear systems, robotics and fuzzy control. Thus this book can be of interest for different scientific communities: Robotics, Intelligent Transportation Systems, Automatic Control and Artificial Intelligence, among others.

This book originates from the PhD thesis of the first author at the University of Seville, supervised by the second author. This thesis obtained the *Excellence Doctorate Award* from the Univ. of Seville and it was nominated for the *1st EURON PhD Award in Robotics in Europe*. The book collects, in an integrated way, works that have been published in several international journals. Moreover, some recent works have also been included.

It would not have been possible to compile this book without the precious help and the contributions of the following persons that are gratefully acknowledged here:

- We are indebted to Javier Aracil and Francisco Gordillo for their contributions to the material presented in Chapter 2. We also want to thank Karl-Erik Årzén and Mikael Johansson from the Lund Institute of Technology (Sweden) and Robert Babuska from the Delft University of Technology (The Netherlands) who closely collaborated in the FAMIMO project.

- We thank Enrique Ponce and also Javier Aracil for their significant contributions to the bifurcation analysis presented in Chapter 3.
- We are especially indebted to Begoña Arrue and Reinhard Braunstingl with whom we have closely collaborated in the material presented in Chapter 4.
- We are grateful to Fernando Gómez Bravo for the fruitful collaboration in the domain of nonholonomic vehicle maneuvering and the autonomous parking methods presented in Chapter 6.
- We also want to thanks the people that contributed to the adaptation of the ROMEO vehicles. The experimental results contained in the book would not have been possible without their help.

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