

Advances in Intelligent Autonomous Systems

Edited by

SPYROS G. TZAFESTAS

*Department of Electrical and Computer Engineering,
National Technical University of Athens, Greece*



KLUWER ACADEMIC PUBLISHERS

DORDRECHT / BOSTON / LONDON

ISBN 0-7923-5580-6

Published by Kluwer Academic Publishers,
P.O. Box 17, 3300 AA Dordrecht, The Netherlands.

Sold and distributed in North, Central and South America
by Kluwer Academic Publishers,
101 Philip Drive, Norwell, MA 02061, U.S.A.

In all other countries, sold and distributed
by Kluwer Academic Publishers,
P.O. Box 322, 3300 AH Dordrecht, The Netherlands.

Printed on acid-free paper

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Printed in the Netherlands.

Advances in Intelligent Autonomous Systems

International Series on

MICROPROCESSOR-BASED AND INTELLIGENT SYSTEMS ENGINEERING

VOLUME 18

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Preface

The field of Intelligent Autonomous Systems (IAS) has attracted over the years the attention of numerous research and industrial groups and has by now arrived at an advanced level of development. The results have been achieved through the synergetic use of concepts, techniques and technologies drawn from electrical and mechanical engineering, control engineering, systems science, computer science and management science. Currently, the majority of working systems in practice are of the semi-autonomous type needing some level of human intervention. Therefore much effort is presently devoted in academic, research and industrial environments towards further increasing the level of autonomy.

This book provides a collection of essays which cover the latest research in the IAS field and present a rich set of results accompanied by detailed descriptions of the relevant concepts, tools, techniques and hardware/software designs.

The book contains twenty three chapters grouped in the following parts:

Part 1: *General concepts, architectures and technologies*

Part 2: *Mobile, walking and snake-like robots*

Part 3: *Applications*

PART 1 involves the first seven chapters which deal with generic issues.

Chapter 1 (by S. G. Tzafestas) provides some background material, accompanied by a description of two research IAS prototypes, namely a car-disassembly robotic system and a semi-autonomous/autonomous robotic wheelchair.

Chapter 2 (by G. Bolmsjö, M. Olsson and K. Brink) presents a generic event-based control system structure for the control of a robotic workcell, including its implementation, where the autonomous operation is achieved via reactive replanning and configurable corrections.

Chapter 3 (by M. Seitz, A. Weigl, K. Hohm and K. Kleinmann) gives an overview of visual, tactile and range sensing techniques for perceiving the required information of the robot work space, and discusses some experiences on sensor-integrated robotic manipulators.

Chapter 4 (by R. Sanz, F. Matia and E. A. Puente) outlines the ongoing developments on an intelligent-control architecture (ICa) which is a metarchitecture designed to support the design and implementation of IAS.

Chapter 5 (by W. Jacak and S. Dreiseitl) develops and implements the concept of an autonomous robotic agent which is capable of showing machine (life long) learning and reactive behavior.

Chapter 6 (by V. Klingspor) describes a distributed planning and plan execution system (SHARC) which applies to a real world robot operational concepts learned from training sequences.

Chapter 7 (by E. M. Nebot) describes a set of internal and external sensors commonly used for robot navigation with emphasis on land vehicle applications.

PART 2 starts with *Chapter 8* (by D. Floreano J. Godjevac, A. Martinoli, F. Mondada and J. -D. Nicoud) which gives an overview of the theory, the practice and the applications of autonomous mobile robots (AMRs) with details on the work carried out at the LAMI laboratory of EPFL (Lausanne).

Chapter 9 (by E. Stella and A. Distanto) analyzes key problems related to the use of visual techniques for AMR navigation, considering two approaches: viz. absolute and relative techniques.

Chapter 10 (by R. Jarvis) is concerned with the interplay between localization, environmental mapping and path planning/execution in support of indoor and outdoor autonomous robotic navigation in time-varying obstacle fields.

Chapter 11 (by E. M. Nebot) addresses the problem of developing ultra-high integrity navigation systems for large outdoor autonomous guided vehicles.

Chapter 12 (by S. G. Tzafestas, M. P. Tzamtzi and G. G. Rigatos) presents a brief overview of the existing results on path/motion planning of mobile robots, manipulators and mobile manipulators. Then it develops a solution to the AMR motion planning and control problem in uncertain terrains via a combination of sliding-mode control with the minimum interference strategy.

Chapter 13 (by K. Watanabe, Y. Shiraishi, J. Tang, T. Fukuda and S. G. Tzafestas) presents a dynamic model for an holonomic omnidirectional mobile robot with orthogonal-wheel assemblies, and develops a resolved acceleration control system based on this model. Practical experimental results are included.

Chapter 14 (by E. Pereira da Silva, F. Lobo Pereira and J. Borges Sousa) proposes a hierarchical control architecture for AMRs that considers structural, functional and behavioral (operational) directions, and satisfies autonomy, mission reliability, modularity and fault tolerance requirements.

Chapter 15 (by R. E. Reeve) summarizes the history of walking research from the study of body parts and the construction of clockwork automata to the understanding of neural rhythm generators and the control of robotic somersaulting. The interdisciplinary issues of the field are highlighted and the commercial use of walking robots are discussed.

Chapter 16 (by M. A. Jiménez, P. Gonzalez de Santos and J. Tabera) presents a technique for changing the crab angle for a quadruped robot based on the wave-crab gait. The algorithm allows a numerical stability analysis to be carried out which is a key requirement in quadruped robot design.

Chapter 17 (by T. E. Krikochoritis, C. S. Tzafestas and S. G. Tzafestas) deals with the kinematic and dynamic modeling of a 9-link biped robot, and presents two controllers based on the model derived, namely a sliding-mode robust controller and an adaptive controller which are shown via simulation to exhibit similar performances.

Part 2 ends with *Chapter 18* (by K. J. Kyriakopoulos, K. Sarrigeorgides and G. Migadis) which presents the design issues, the components' specifications and a motion planning

algorithm for a novel snake-like robot which is kind of multiarticulated mobile robot. Test case results are also included.

PART 3 presents five applications of IAS. *Chapter 19* (by E. S. Tzafestas) reviews and critically discusses the fundamental issues of the autonomous agent approach to modern cellular manufacturing and describes a case study concerning the tool management giving a comparative study of several motivational schemes for the tool manager robot.

Chapter 20 (by G. Bourhis and Y. Agostini) discusses the class of intelligent (smart, sensor-based) wheelchairs with particular reference to the compromise between small cost and high robustness, and then focuses on the human-machine interface embodied in the wheelchair developed in the research project VAHM. Experimental results obtained in a test environment are included.

Chapter 21 (by D. A. Bradley, D. W. Seward) presents the developments made in the Lancaster University Computerised Intelligent Excavator (LUCIE) project giving details of the machine kinematics, the real time control and the design implications.

Chapter 22 (by P. A. M. Renton and H. A. Elmaraghy, M. Greenspan and H. Zghal) proposes a sensor-based (Plan-N-Scan) technique for collision-free autonomous exploration, gaze planning and workspace mapping using a wrist-mounted laser range camera. It demonstrates that the Plan-N-Scan system is capable of incrementally acquiring range information and successfully scanning both targets and workspace volumes.

Finally, *Chapter 23* (by S. -N. Huang, S. C. Chan and W. Ren) presents a mixed traffic control strategy that allows automatically controlled and manually controlled vehicles to co-exist in a highway. An intelligent vehicle driving system (IVDS) and a manual driver model that mimics the human driver are developed. Results from large scale simulation with many vehicles running on a highway simulator are included.

In overall, the book examines many important elements of modern IAS and provides techniques and tools that are readily applicable in real practice. The book is suitable for the researcher, practitioner and senior student in the field. The editor expresses his thanks to all contributors for their acceptance to offer some of their experience and for their work in preparing comprehensive essays. Special thanks are also due to Kluwer's (Dordrecht) editorial members, especially to Dr. Karel Nederveen and Ms. Catherine Murphy for their assistance throughout the lengthy editorial process.

Spyros G. Tzafestas
August 1998

CONTRIBUTORS

AGOSTINI Y.	<i>LASC, Metz Univ. , Iledu Saulcy, France</i>
BOLMSJO G.	<i>PME Dept., Lund Univ., Lund , Sweden</i>
BORGES SOUSA J.	<i>Eng. Fac., Porto Univ., Porto Portugal</i>
BOURHIS G.	<i>LASC, Metz Univ., Iledu Saulcy, France</i>
BRADLEY D.A.	<i>SEECs, Wales Univ., Bangor, U.K.</i>
BRINK K.	<i>PME Dept., Lund Univ., Lund, Sweden</i>
CHAN S.C.	<i>California Univ., Berkley , U.S.A</i>
DISTANTE A.	<i>IESI, Natl. Res. Council , Bari, Italy</i>
DREISEITL S.	<i>Johannes Kepler Univ., Linz, Austria</i>
ELMARAGHY H.A.	<i>Windsor Univ., Windsor, Canada</i>
FLOREANO D.	<i>EPFL., Lausanne , Switzerland</i>
FUKUDA T.	<i>Nagoya Univ. , Nagoya, Japan</i>
GODJEVAC J.	<i>EPFL., Lausanne , Switzerland</i>
GONZALEZ DE SANTOS P.	<i>Inst. Autom. Ind. (CSIC) , Madrid, Spain</i>
GREENSPAN M.	<i>NRC of Canada, Ottawa, Canada</i>
HOHM K.	<i>Darmstadt Univ. Tech., Germany</i>
HUANG S.-N.	<i>California Univ. , Berkley, U.S.A.</i>
JACAK W.	<i>Johannes Kepler Univ., Linz, Austria</i>
JARVIS R.	<i>IRRC, Monash Univ., Clayton, Australia</i>
JIMENEZ M.A.	<i>Inst. Autom. Ind. (CSIC) , Madrid, Spain</i>
KLEINMANN K.	<i>Darmstadt Univ. Tech., Germany</i>
KLINGSPOR V.	<i>Informatik, Dortmund Univ., Germany</i>
KRIKOHORITIS T.E.	<i>IRAL, Natl. Tech. Univ. of Athens, Greece</i>
KYRIAKOPOULOS K.J.	<i>Natl. Tech. Univ. of Athens, Greece</i>
LOBO PEREIRA F.	<i>Engrg. Fac., Porto Univ., Portugal</i>
MARTINOLI A.	<i>EPFL., Lausanne , Switzerland</i>
MATIA F.	<i>DISAM, Univ. Polit. Madrid , Spain</i>
MIGADIS G.	<i>Natl. Tech. Univ. of Athens, Greece</i>
MONDADA F.	<i>EPFL, Lausanne , Switzerland</i>
NEBOT E.M.	<i>Sydney Univ., Sydney, Australia</i>
NICOUD J. -D.	<i>EPFL, Lausanne , Switzerland</i>
OLSSON M.	<i>PME Dept., Lund Univ., Lund , Sweden</i>
PEREIRA DA SILVA E.	<i>Inst. Sup. Eng. do Porto, Porto , Portugal</i>
PUENTE E.A.	<i>DISAM, Univ. Polit. Madrid , Spain</i>
REEVE R.E.	<i>AI Dept., Edinburgh Univ., U.K.</i>
REN W.	<i>California Univ., Berkeley, U.S.A</i>
RENTON P.A.M.	<i>McMaster Univ., Hamilton, Canada</i>
RIGATOS G.G.	<i>IRAL, Natl. Tech. Univ. of Athens, Greece</i>
SANZ R.	<i>DISAM, Univ. Polit. Madrid , Spain</i>

SARRIGEORGIDES K.

Natl. Tech. Univ. of Athens, Greece

SEITZ M.

Darmstadt Univ. Tech., Germany

SEWARD D.W.

Eng. Dept. , Lancaster Univ., U.K.

SHIRAISHI Y.

ME Dept., Saga Univ., Saga , Japan

STELLA E.

IESI, Natl. Res. Council, Bari, Italy

TABERA J.

Inst. Autom. Ind. (CSIC), Madrid , Spain

TANG J.

Yamaguchi Univ., Tokiwadai, Japan

TZAFESTAS C.S.

IRAL, Natl. Tech. Univ. of Athens, Greece

TZAFESTAS E.S.

IRAL, Natl. Tech. Univ. of Athens, Greece

TZAFESTAS S.G.

IRAL, Natl. Tech. Univ. of Athens, Greece

TZAMTZI M.P.

IRAL, Natl. Tech. Univ. of Athens, Greece

WATANABE K.

ME Dept., Saga Univ., Saga , Japan

WEIGL A.

Darmstadt Univ. Tech., Germany

ZGHAL H.

IMS Centre, Windsor Univ., Canada

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