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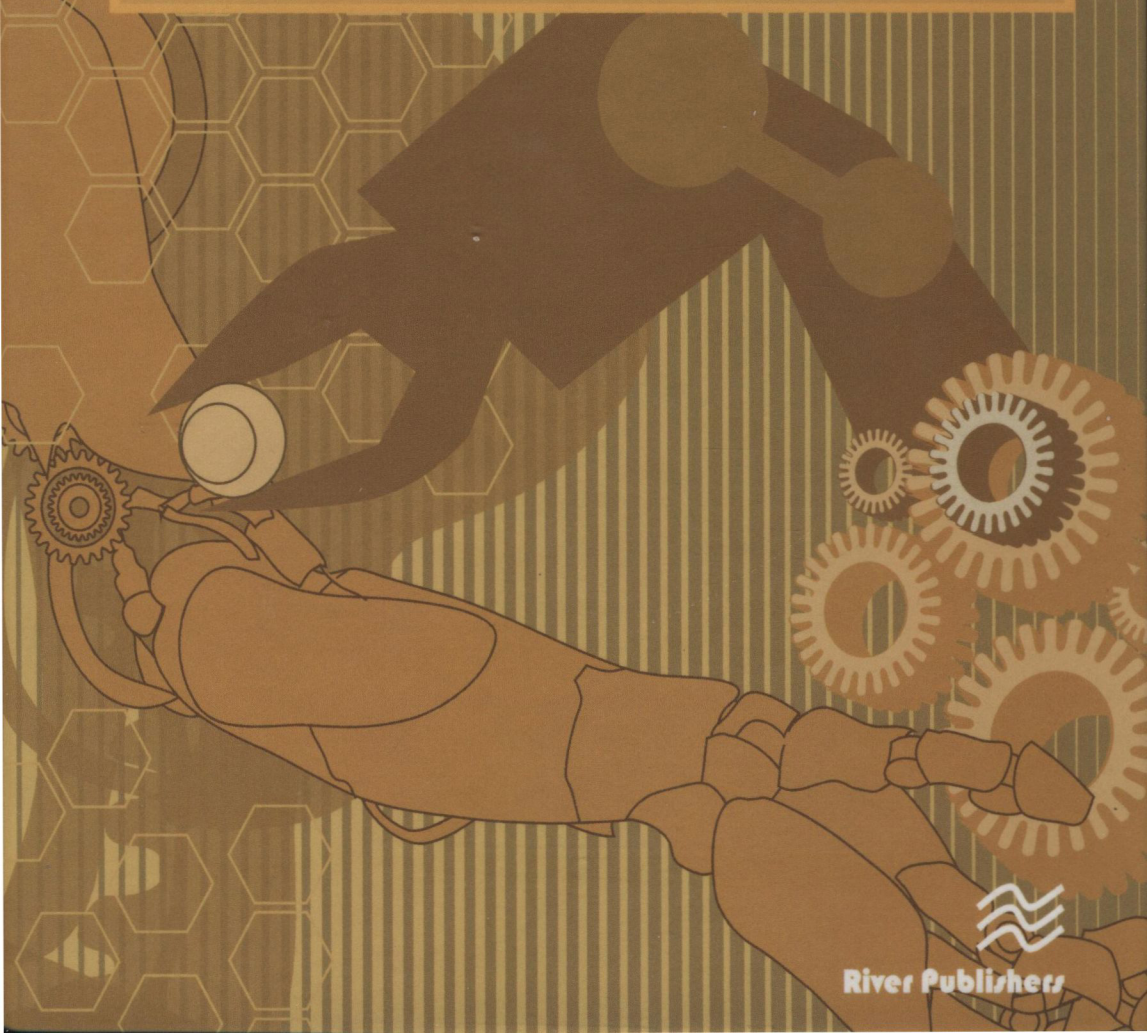
Advances in Intelligent Robotics and Collaborative Automation

Yuriy P. Kondratenko and Richard J. Duro (Editors)



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Volume 1

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The "River Publishers Series in Automation, Control and Robotics" is a series of comprehensive academic and professional books which focus on the theory and applications of automation, control and robotics. The series focuses on topics ranging from the theory and use of control systems, automation engineering, robotics and intelligent machines.

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Preface

This book provides an overview of a series of advanced trends in robotics as well as of design and development methodologies for intelligent robots and their intelligent components.

All the contributionswere discussed at the International IEEE Conference IDAACS-2013 (Berlin, Germany, 12–14 June, 2013). The IDAACS workshop series is established as a forum for high quality reports on state-of-the-art theory, technology and applications of intelligent data acquisition and advanced computer systems. All of these techniques and applications have experienced a rapid expansion in the last few years that has resulted in more intelligent, sensitive, and accurate methods for the acquisition of data and its processing applied to manufacturing process control and inspection, environmental and medical monitoring and diagnostics. One of the most interesting paradigms that encompass much of the research presented at IDAACs is Intelligent Robotic Systems, and this is the area this book concentrates on.

The success of IDAACS arises not only from the importance of the topics it focuses on, but also because of its nature as a unique forum for establishing scientific contacts between research teams and scientists from different countries. This purpose has become one of the main reasons for the rapid success of IDAACS, as it turns out to be one of the few events in this area of research where Western and former Eastern European scientists can discuss and exchange ideas and information, allowing them to characterize common and articulated research activities and creating the environment for establishing joint research collaborations. It provides an opportunity for all the participants to discuss topics with colleagues from different spheres such as academia, industry, and public and private research institutions. Even though this book concentrates on providing insights into what is being done in the area of robotics and intelligent systems, the papers that were selected reflect the variety of research presented during the workshop as well as the very diverse fields that may benefit from these techniques.

In terms of structure, the 13 chapters of the book are grouped into four sections: Robots, Control and Intelligence, Sensing and Collaborative

Automation. The chapters have been thought out to provide an easy to follow introduction to the topics that are addressed, including the most relevant references, so that anyone interested in them can start their introduction to the topic through these references. At the same time, all of them correspond to different aspects of work in progress being carried out in various laboratories throughout the world and, therefore, provide information on the state of the art of some of these topics.

The first part, "Robots", includes three contributions:

"A Modular Architecture for Developing Robots for Industrial Applications", by A. Faíña, F. Orjales, D. Souto, F. Bellas and R. J. Duro, considers ways to make feasible the use of robots in many sectors characterized by dynamic and unstructured environments. The authors propose a new approach, based on modular robotics, to allow the fast deployment of robots to solve specific tasks. In this approach, the authors start by defining the industrial settings the architecture is aimed at and then extract the main features that would be required from a modular robotic architecture to operate successfully in this context. Finally, a particular heterogeneous modular robotic architecture is designed from these requirements and a laboratory implementation of it is built in order to test its capabilities and show its versatility using a set of different configurations including manipulators, climbers and walkers.

S. Osadchy, V. Zozulya and A. Timoshenko, in "The Dynamic Characteristics of a Manipulator with Parallel Kinematic Structure Based on Experimental Data", studies two identification techniques which the authors found most useful in examining the dynamic characteristics of a manipulator with a parallel kinematic structure as an object of control. These techniques emphasize a frequency domain approach. If all input/output signals of an object can be measured then the first one of such techniques may be used for identification. In the case when all disturbances cannot be measured the second identification technique may be used.

In "An Autonomous Scale Ship Model for Parametric Rolling Towing Tank Testing", M. Míguez González, A. Deibe, F. Orjales, B. Priego and F. López Peña analyze a special kind of robotic system model, in particular, a self-propelled scale ship model for model testing, with the main characteristic of not having any material link to a towing device to carry out the tests. This model has been fully instrumented in order to acquire all the significant raw data, process them onboard and communicate with an inshore station.

The second part "Control and Intelligence" includes four contributions: In "Autonomous Knowledge Discovery Based on Artificial Curiosity Driven Learning by Interaction", K. Madani, D. M. Ramik and C. Sabourin investigate

the development of a real-time intelligent system allowing a robot to discover its surrounding world and to learn autonomously new knowledge about it by semantically interacting with humans. The learning is performed by observation and by interaction with a human. The authors provide experimental results both using simulated environments and implementing the approach on a humanoid robot in a real-world environment including everyday objects. The proposed approach allows a humanoid robot to learn without negative input and from a small number of samples.

F. Kulakov and S. Chernakova, in "Information Technology for Interactive Robot Task Training through Demonstration of Movement", consider the problem of remote robot control, which includes the solution of the following routine problems: surveillance of the remote working area, remote operation of the robot situated in the remote working area, as well as pre-training of the robot. Authors propose a new technique for robot control using intelligent multimodal human-machine interfaces (HMI). The application of the new training technology is very promising for space robots as well as for modern assembly plants, including the use of micro-and nanorobots.

In "A Multi-Agent Reinforcement Learning Approach for the Efficient Control of Mobile Robots", U. Dziomin, A. Kabysh, R. Stetter and V. Golovko present a multi-agent control architecture for the efficient control of a multi-wheeled mobile platform. The proposed control architecture is based on the decomposition of a platform into a holonic, homogenous, multi-agent system. The multi-agent system incorporates multiple Q-learning agents, which permits them to effectively control every wheel relative to other wheels. The learning process consists module positioning—where the agents learn to minimize the error of orientation, and cooperative movement—where the agents learn to adjust the desired velocity in order to conform to the desired position in formation. Experiments with a simulation model and the real robot are discussed in details.

D. Oskin, A. Dyda, S. Longhi and A. Monteriù, in "Underwater Robot Intelligent Control Based on Multilayer Neural Network", analyse the design of an intelligent neural network based control system for underwater robots. A new algorithm for intelligent controller learning is derived using the speed gradient method. The proposed systems provide robot dynamics close to the reference ones. Simulation results of neural network control systems for underwater robot dynamics with parameter and partial structural uncertainty have confirmed the perspectives and effectiveness of the developed approach.

The third part "Sensing" includes four contributions:

"Advanced Trends in Design of Slip Displacement Sensors for Intelligent Robots", by Y. Kondratenko and V. Kondratenko, discusses advanced trends in the design of modern tactile sensors andsensor systems for intelligent robots. The detection of slip displacement signals provides information on three approaches for using slip displacement signals, in particular, for the correction of the clamping force, the identification of manipulated object mass and the correction of the robot control algorithm.The chapter presents the analysis of different methods for the detectionof slip displacement signals, as well as new sensor schemes, mathematical models and correction methods.

T. Happek, U. Lang, T. Bockmeier, D. Neubauer and A. Kuznietsov, in "Distributed Data Acquisition and Control Systems for a Sized Autonomous Vehicle", present an autonomous car with distributed data processing. The car is controlled by a multitude of independent sensors. For lane detection, a camera is used, which detects the lane marks using a Hough transformation. Once the camera detects these, one of them is selected to be followed by the car. This lane is verified by the other sensors of the car. These sensors check the route for obstructions or allow the car to scan a parking space and to park on the roadside if the gap is large enough.

In "Polymetric Sensing in Intelligent Systems", Yu. Zhukov, B. Gordeev, A. Zivenko and A. Nakonechniy examine the up-to-date relationship between the theory of polymetric measurements and the state of the art in intelligent system sensing. The chapter discusses concepts of polymetric measurements, corresponding to monitoring information systems used in different technologies and some prospects for polymetric sensing in intelligent systems and robots. The application of the described concepts in technological processes ready to be controlled by intelligent systems is illustrated.

D. Popescu, G. Stamatescu, A. Maciuca and M. Strutu, in "Design and Implementation of Wireless SensorNetwork Based on Multilevel Femtocells for Home Monitoring", propose an intelligent femtocell-based sensor network for home monitoring of elderly or people with chronic diseases. The femtocell is defined as a small sensor network which is placed into the patient's house and consists of both mobile and fixed sensors disposed on three layers. The first layer contains body sensors attached to the patient that monitor different health parameters, patient location, position and possible falls. The second layer is dedicated for ambient sensors and routing inside the cell. The third layer contains emergency ambient sensors that cover burglary events or toxic gas concentration, distributed by necessities. Cell implementation is based on The IRIS family of motes running the embedded software for resource constrained

devices, TinyOS. Experimental results within the system architecture are presented for a detailed analysis and validation.

The fourth part "Collaborative automation" includes two contributions:

In "Common Framework Model for Multi-purpose Underwater Data Collection Devices Deployed with Remotely Operated Vehicles", M. Caraivan, V. Dache and V. Sgarciu presents a common framework model for multi-purpose underwater sensors used for offshore exploration. The development of real-time applications for marine operations focusing on modern modeling and simulation methods are discussed with addressing deployment challenges of underwater sensor networks "Safe-Nets" by using Remotely Operated Vehicles.

Finally, S. Gansemer, J. Sell, U. Grossmann, E. Eren, B. Horster, T. Horster-Möller and C. Rusch, in "M2M in Agriculture - Business Models and Security Issues" consider the machine-to-machine communication (M2M) as one of the major ICT innovations. A concept for process optimization in agricultural business using M2M technologies is presented using three application scenarios. Within that concept standardization and communication as well as security aspects are discussed.

The papers selected for this book are extended and improved versions of those presented at the workshop and as such are significantly expanded with respect to the original ones presented at the workshop. Obviously, this set of papers are just a sample of the dozens of presentations and results that were seen at IDAACS 2011, but we do believe that they provide an overview of some of the problems in the area of robotics systems and intelligent automation and the approaches and techniques that relevant research groups within this area are employing to try to solve them. We would like to express our appreciation to all authors for their contributions as well as to reviewers for their timely and interesting comments and suggestions. We certainly look forward to working with you again.

Yuriy Kondratenko
Richard Duro

List of Abbreviations

ABS	Acrylonitrile butadiene styrene
ABS	American Bureau of Shipping
ADC	analog to digital converter
AES	Advanced Encryption Standard
AI	Artificial Intelligence
ANN	Artificial Neural Network
AquaRET	Aquatic Renewable Energy Technologies
ASN	Ambient sensor network
AUV	Autonomous Underwater Vehicle
AWS	Archimedes Waveswing
BCU	Behavior Control Unit
BOP	Blow-Out Preventer
BSN	Body sensor network
CAN	Controller Area Network
CCD	charge-coupled device
CCF	Conscious Cognitive Functions
CCMP	Counter Mode/CBC-MAC Protocol
CCSDBS	computer-aided floating dock ballasting process control and monitoring system
CMF	continuous max-flow algorithm
CO	Carbon monoxide
CO_2	Carbon dioxide
COIL	Columbia Object Image Library
CP	characteristic points
CRL	Certficate Revocation List
CS(SC)	system of coordinates
CSMA/CA	Carrier sense multiple access/collision avoidance
CU	Communication Unit
DB	database
DC	Direct Current
DHCP	Dynamic Host Configuration Protocol
DHSS	Direct hopping spread spectrum
DMA	decision-making agency
DMP	decision-making person

DNS	Domain Name System
ECG	Electrocardiogram
EE	external environment
ESC	Electronic Speed Control
ESN	Emergency sensor network
EU	European Union
FHSS	Frequency hopping spread spectrum
FIM	Fisher Information Matrix
FMN	Femtocell management node
FPSO	Floating production storage and offloading
FSM	frame-structured model
GIS	geographic information systems
GM	graphical model
GM	Ship Metacentric Height
GND	Ground
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
H^2MAS	holonic homogenous multi-agent system
HLAU	High-level Knowledge Acquisition Unit
HMI	human-machine interfaces
HTPS	hand position tracking system
HTTPS	Secure Hypertext Transfer Protocol
ICT	Information and Communication Technology
IE	internal environment
IEEE	Institute of electrical and electronics engineers
IMI	intelligent multimodal interface
IMM	intellectual multy modal system
IMU	Inertial Measurement Unit
INE	information environment agency
IP	Internet Protocol
IRR	ideal rational robot
IS	International System (Measuring)
ISM	Industrial Scientific Medical
ISO	International Standardization Organization
ITTC	International Towing Tank Conference
JRE	Java Runtime Environment
KB	knowledge base
LASCOS	loading and safety control system
LHP	left half-plane
LKAU	Low-level Knowledge Acquisition Unit
LNG	liquefied natural gas

LPG	liquefied petroleum gas
M2M	Machine To Machine
MAS	multi-agent system
MEE	combination of the EE
MEMS	Microelectromechanical Systems
MFM	motion shape models
MIE	particular IE
MIT	Massachusetts Institute of Technology
MiWi	Wireless protocol designed by Microchip Technology
MM	mathematical model
MMI	man-machine interface
MOE	model of the OE
MP	Multilayer Perceptron
MPNN	Multilayer Perceptron Neural Network
NEM	navigation environment monitoring
NN	Neural Network
NU	Navigation Unit
OCSP	Online Certificate Status Protocol
ODA	Operations Data Aquisition
OE	objects of the environment
OpenCV	Open Computer Vision
OPI	operator interface agency
OWC	OscillatingWater Column
PC	Personal computer
PCB	printed circuit board
PCBs	Printed Circuit Boards
PID	Proportional-Integral-Derivative
PPA	polymetric perceptive agency
PT	Process Transparency
RADIUS	Remote Authentication Dias-in User Service
RC	Radio Control
RCS	robot control system
RF	Radio Frequency
RHP	right half-plane
RMS	Root Mean Square
ROV	Remotely (Underwater) Operated Vehicle
RSN	Robust Secure Network
RSU	Remote Software Update
SADCO	systems for automated distant (remote) control
SDS	slip displacement sensor
SIFT	Scale-invariant feature transform
SIM	Subscriber Identity Module

SMA	sensory monitoring agency
SNR	Signal to Noise Ratio
SPM	ship state parameters monitoring
SSM	sea state monitoring
Tbps	Terrabytes per second
TDR	time domain reflectometry
THM	tracking the head motion
TMS	Tether Management System
TSHP	system for tracking hand movements
TSP	telesensor programming
UART	Universal Asynchronous Receiver Transmitter
UAV	Unmanned Aerial Vehicle
UCF	Unconscious Cognitive Functions
UMTS	Universal Mobile Telecommunications System
UPEC	University Paris-Est Creteil
UR	Underwater Robot
USART	Universal Synchronous/Asynchronous Receiver Transmitter
USB	Universal Serial Bus
USD	United States Dollars
UUV	Unmanned Underwater Vehicle
VB.NET	Visual Basic .NET
VSM	virtual ship model
WCM	weather conditions model
WCS	Windows Color System
WIFI	Wireless Fidelity
WLAN	Wireless Local Area Network

Contents