# **ROBUSTNESS IN IDENTIFICATION AND CONTROL**

# APPLIED INFORMATION TECHNOLOGY

Series Editor:

M. G. SINGH UMIST, Manchester, England

Editorial Board:

K. ASTROM Lund Institute of Technology, Lund, Sweden S. J. GOLDSACK Imperial College of Science and Technology, London, England M. MANSOUR ETH-Zentrum, Zurich, Switzerland G. SCHMIDT Technical University of Munich, Munich, Federal Republic of Germany S. SETHI University of Toronto, Toronto, Canada J. STREETER GEC Research Laboratories, Great Baddow, England A. TITLI LAAS, CNRS, Toulouse, France

#### INDUSTRIAL ARTIFICIAL INTELLIGENCE SYSTEMS Lucas Pun

# KNOWLEDGE BASED SYSTEM DIAGNOSIS, SUPERVISION, AND CONTROL

Edited by Spyros G. Tzafestas

PARALLEL PROCESSING TECHNIQUES FOR SIMULATION

Edited by M. G. Singh, A. Y. Allidina, and B. K. Daniels

## **ROBUSTNESS IN IDENTIFICATION AND CONTROL**

Edited by M. Milanese, R. Tempo, and A. Vicino

# **ROBUSTNESS IN IDENTIFICATION AND CONTROL**

# Edited by **M. Milanese and R. Tempo** Turin Polytechnic

Turin, Italy

and



University of Florence Florence, Italy

PLENUM PRESS • NEW YORK AND LONDON

Library of Congress Cataloging in Publication Data

International Workshop on Robustness in Identification and Control (1988: Turin, Italy) Robustness in identification and control / edited by M. Milanese and R. Tempo and A. Vicino.

p. cm.—(Applied information technology) Includes bibliographical references and index. ISBN-13: 978-1-4615-9554-0 e-ISBN-13: 978-1-4615-9552-6 DOI: 10.1007/978-1-4615-9552-6 1. System identification—Congresses. 2. Control theory—Congresses. I. Milanese, M. II. Tempo, R. III. Vicino, A. IV. Title. V. Series. QA402.I585 1988 89-16081 004.2'1—dc20 CIP



Proceedings of an International Workshop on Robustness in Identification and Control, held June 10-12, 1988, in Turin, Italy

© 1989 Plenum Press, New York Softcover reprint of the hardcover 1st edition 1989 A Division of Plenum Publishing Corporation 233 Spring Street, New York, N.Y. 10013

All rights reserved

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the Publisher

### FOREWORD

This volume collects most of the papers presented at the International Workshop on Robustness in Identification and Control, held in Torino (Italy) in 1988. The main focal point of the workshop was Unknown But Bounded uncertainty and associated robustness issues in identification and control.

Recent years have seen a growing interest in studying models which include unknown but bounded uncertainty. The motivation for dealing with such models is derived from robustness considerations. In many applications, some performance specification must be met for all admissible variations of the uncertain parameters. A second motivation for models with this type of uncertainty stems from the fact that the statistical description of uncertain variables may not be well known or even not suitable. For example, in some cases, only a small number of measurements is available and the resulting errors are due to analog-digital conversion, modelling approximation or round-off, so that a statistical description may actually be unreliable.

The interest in unknown but bounded setting is certainly not new. In fact, engineering practice demands for appropriate algorithms in dealing with finite sample properties, finite parameter variations, tolerance analysis, etc. Despite the natural need for such methods, the lack of sufficiently well assessed theoretical results and algorithms prevented a systematic use of these procedures until recent years. However, in the last few years, important advances have been made both in estimation theory and in stability analysis.

The aim of the workshop was to bring together leading researchers in these areas, in order to assess the current state of the art and to discuss future trends and new promising research directions. Researchers from different fields, including mathematics, information-based complexity, circuit theory, modelling, identification and control, attended the workshop looking for sinergy of approaches developed and used in different research areas.

The workshop was held under the auspices of Ministero della Ricerca Scientifica e Tecnologica, Regione Piemonte, Cittá di Torino and Politecnico di Torino. We are pleased to thank the financial contribution of Assessorato della Cultura della Regione Piemonte, Assessorati al Lavoro e al Turismo della Cittá di Torino, Camera di Commercio di Torino and FIAT. We would like to acknowledge the support of Dipartimento di Automatica e Informatica (Politecnico di Torino) and of Centro di Elaborazione Numerale dei Segnali (Consiglio Nazionale delle Ricerche). Finally, we are indebted to B. Ross Barmish (University of Wisconsin-Madison), Gustavo Belforte and Basilio Bona (Politecnico di Torino) who acted, together with the editors of this volume, as Scientific and Organizing Committee.

M. Milanese, R. Tempo and A. Vicino

Torino, February 1989

# CONTENTS

# 1. Robust Identification and Complexity

Estimation and prediction in the presence of unknown but bounded	
uncertainty: a survey	
M. Milanese	3
Optimal sampling design for parameter estimation and p-widths under	
stochastic and deterministic noise	
C. A. Micchelli	25
How useful is nonadaptive information for ordinary differential	
equations?	
B. Z. Kacewicz	41
Fast algorithms for the computation of fixed points	
K. Sikorski	49
Bounding techniques for model-structure selection	
J. P. Norton	59
Robust linear and nonlinear parameter estimation in the bounded-error	
context	
E. Walter, H. Piet-Lahanier	67

## 2. Robust Stability and Control

Generalized Nyquist tests for robust stability: Frequency domain
generalizations of Kharitonov's theorem
J. J. Anagnost, C. A. Desoer, R. J. Minnichelli
Extending Kharitonov's theorem to more general sets of polynomials
I. R. Petersen
Strong Kharitonov theorem for discrete systems
M. Mansour, F. J. Kraus, B. D. O. Anderson
Polytopes of polynomials with zeros in a prescribed region: new criteria
and algorithms
M. Fu
Robustness bounds for classes of structured perturbations
A. Vicino, A. Tesi
Markov's theorem of determinants and the stability of families of polynomials
C. V. Hollot
An application of state space methods to obtain explicit formulae for robustness measures of polynomials
D. Hinrichsen, A. J. Pritchard

Robust stability and stabilization of interval plants
H. Chapellat, S. P. Bhattacharyya
Shaping conditions and the stability of systems with parameter
uncertainty
T. E. Djaferis, C. V. Hollot
Structured and simultaneous Lyapunov functions for system stability problems
S. Boyd, Q. Yang
Robust stability of polynomials with multilinear parameter dependence
F. J. Kraus, M. Mansour, B. D. O. Anderson
Stability conditions for polynomials via quadratic inequalities in their
coefficients
A. T. Fam
Boundary implications for interval positive rational functions:
preliminaries
N. K. Bose, J. F. Delansky
Guaranteeing ultimate boundedness and exponential rate of convergence
for a class of uncertain systems
M. Corless, F. Garofalo, G. Leitmann
On measures of stability robustness for linear uncertain systems
R. K. Yedavalli
Robust stabilization of linear time-invariant systems via linear control
K. Wei
U-Parameter design: feedback system design with guaranteed robust stability
P. Dorato, Y. Li, H. B. Park
New criteria for robust stability
M. Corless, D. Da
Author Index
Subject Index