



ISNM
International Series of
Numerical Mathematics
Vol. 121

Managing Editors:
K.-H. Hoffmann, München
D. Mittelmann, Tempe

Associate Editors:
R.E. Bank, La Jolla
H. Kawarada, Chiba
R.J. LeVeque, Seattle
C. Verdi, Milano

Honorary Editor:
J. Todd, Pasadena

Stability Theory

**Hurwitz Centenary Conference
Centro Stefano Franscini, Ascona, 1995**

Edited by

**R. Jeltsch
M. Mansour**

**Birkhäuser Verlag
Basel · Boston · Berlin**

Editors:

Rolf Jeltsch
Seminar for Applied Mathematics
ETH Zentrum
8092 Zürich
Switzerland

Mohamed Mansour
Automatic Control Laboratory
ETH Zentrum
8092 Zürich
Switzerland

A CIP catalogue record for this book is available from the Library of Congress, Washington D.C., USA

Deutsche Bibliothek Cataloging-in-Publication Data

Stability theory / Hurwitz Centenary Conference, Centro

Stefano Francini, Ascona, 1995. Ed. by Rolf Jeltsch ;

Mohamed Mansour. - Basel ; Boston ; Berlin : Birkhäuser, 1996

(International series of numerical mathematics ; Vol. 121)

ISBN-13:978-3-0348-9945-1 e-ISBN-13:978-3-0348-9208-7

DOI: 10.1007/978-3-0348-9208-7

NE: Jeltsch, Rolf [Hrsg.]; Hurwitz Centenary Conference <1995,

Ascona>; Centro Stefano Francini; GT

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in other ways, and storage in data banks. For any kind of use the permission of the copyright owner must be obtained.

© 1996 Birkhäuser Verlag, P.O. Box 133, CH-4010 Basel, Switzerland

Printed on acid-free paper produced from chlorine-free pulp. TCF ∞

Cover design: Heinz Hiltbrunner, Basel

ISBN 3-7643-5474-7

ISBN 0-8176-5474-7

9 8 7 6 5 4 3 2 1

Contents

Preface	VII
Stability theory	
<i>A. Beghi, A. Lepschy and U. Viaro</i>	
The Hurwitz Matrix and the Computation of Second-Order Information Indices	1
<i>B. Bernhardsson, A. Rantzer and L. Qiu</i>	
A Summary on the Real Stability Radius and Real Perturbation Values	11
<i>J. Garloff and B. Srinivasan</i>	
The Hadamard Factorization of Hurwitz and Schur Stable Polynomials	19
<i>Y.V. Genin</i>	
On the Cauchy Index of a Real Rational Function and the Index Theory of Pseudo-Lossless Rational Functions	23
<i>H. Górecki, M. Szymkat and M. Zaczek</i>	
A Generalization of the Orlando Formula-Symbolic Manipulation Approach	33
<i>L. Atanassova, D. Hinrichsen and V.L. Kharitonov</i>	
On Convex Stability Directions for Real Quasipolynomials	43
<i>E.I. Jury</i>	
From J.J. Sylvester to Adolf Hurwitz: A Historical Review	53
<i>F.J. Kraus, M. Mansour and M. Sebek</i>	
Hurwitz Matrix for Polynomial Matrices	67
<i>H.C. Reddy, P.K. Rojan and G.S. Moschytz</i>	
Two-Dimensional Hurwitz Polynomials	75
<i>E.D. Sontag and H.J. Sussmann</i>	
General Classes of Control-Lyapunov Functions	87
<i>R. Strietzel</i>	
Towards the Stability of Fuzzy Control Systems	97
<i>M. Vidyasagar</i>	
Discrete Optimization Using Analog Neural Networks with Discontinuous Dynamics	107

Robust Stability*B.D.O. Anderson and S. Dasgupta*Multiplier Theory and Operator Square Roots: Application to
Robust and Time-Varying Stability 113*R. Lozano and D.A. Suárez*Adaptive Control of Non-Minimum Phase Systems Subject to
Unknown Bounded Disturbances 125*M. Mansour and B.D.O. Anderson*

On the Robust Stability of Time-Varying Linear Systems 135

W. Sienel

On the Computation of Stability Profiles 151

*Q.H. Wu and M. Mansour*Robust Stability of Family of Polynomials with 1-Norm-Bounded
Parameter Uncertainties 163*E. Zeheb*On the Characterization and Formation of Local Convex Directions
for Hurwitz Stability 173**Numerics***G.E. Collins*Application of Quantifier Elimination to Solotareff's
Approximation Problem 181*R. Jeltsch*Stability of Time Discretization, Hurwitz Determinants
and Order Stars 191*R. Liska and S. Steinberg*

Solving Stability Problems Using Quantifier Elimination 205

M.R. Trummer

Stability of Numerical Methods for Solving Differential Equations 211

J. Sreedhar, P. Van Dooren and A.L. Tits

A Fast Algorithm to Compute the Real Structured Stability Radius 219

Some Open Problems 231**Appendix: Original Article by A. Hurwitz***A. Hurwitz*Über die Bedingungen, unter welchen eine Gleichung nur
Wurzeln mit negativen reellen Theilen besitzt 239

Preface

This book contains the historical development of the seminal paper of Adolf Hurwitz, professor in mathematics at ETH (1892–1919), and its impact on other fields. The major emphasis, however, is on modern results in stability theory and its application in the theory of control and numerics. In particular, stability of the following problems is treated: linear, nonlinear and time-dependent systems, discretizations of ordinary and partial differential equations, systems with time delay on multidimensional systems. In addition robust stability, pole placement and problems related to the stability radius are treated.

The book is an outgrowth of the international conference “Centennial Hurwitz on Stability Theory” which was held to honor Adolf Hurwitz, whose article on the location of roots of a polynomial was published one hundred years ago. The conference took place at the Centro Stefano Franscini, Monte Verità, Ascona, Switzerland, on May 21–26, 1995. This book contains a collection of the papers and open problems discussed on that occasion. Leading researchers from all over the world working on stability theory and its application were invited to present their recent results. In one paper the historic development initiated by Hurwitz’s article was discussed.

The interaction between the two major groups of participants, researchers in control theory and mathematics, as well as the excellent setting of the Monte Verità strongly contributed to the success of the meeting. We thank the Centro Stefano Franscini of the Swiss Federal Institute of Technology (ETH) in Zürich and the Swiss National Science Foundation for financial support. Our thanks go also to the publisher Springer which allowed us to reproduce the original article by Adolf Hurwitz in this volume. We also thank the members of the Seminar for Applied Mathematics (ETH) for their help in the successful organization of the meeting, in particular Ms M. Krämer and M. Pfister. In addition we thank the secretaries of the Centro Stefano Franscini, Ms K. Bastianelli and F. Tewelde, for their support.

We express our deep gratitude to the staff of Birkhäuser Verlag for their excellent cooperation in producing this volume. Our biggest thanks go to our secretaries, Ms. M. Krämer and M. Pfister, as well as to our systems people, Ms. E. Copeland and Dr. P. Scherbel, who all went to great effort to produce the excellent electronic version of this book.

We hope that this volume will be helpful to engineers and mathematicians working in the area of control theory and numerics.

Rolf Jeltsch
Mohamed Mansour
Zürich, Switzerland
October 1995