Dynamical Systems, Control, Coding, Computer Vision New Trends, Interfaces and Interplay

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Systems, networks and control theory circumscribe a vast and varied field of science, within which one may find theoretical work of a mathematical nature involving a broad spectrum of techniques. These techniques are linear algebra, function theory, ordinary and partial differential equations, functional analysis, differential geometry, algebraic geometry, stochastic analysis, and combinatorics. Apart from these particular tools, the heart of the field is still formed by the concepts of feedback, stability, optimal control, and recursive filtering.

This book contains a collection of essays written by top experts in the field, presented at the Mathematical Theory of Networks and Systems Symposium (MTNS-98), held in Padova, Italy, on July 6-10, 1998.

The goal of the Symposium, which this book proposes to align to, was to reflect new research directions and connections in coding and computer vision.

Still there are articles of which orientation and approach are within the scope of classical mathematics.

"The Role of the Hamiltonian in the Solution of Algebraic Riccati Equations", by P. Lancaster, is an expository article, studying two forms of algebraic Riccati equations. At the beginning of the article, the author pays homage to Count Jacopo Riccati, who, in 1723, was wondering about the following problem: how, given the equation

$$x'(t)=c(t)-d(t)x^2(t), \qquad (1)$$

with $d(t)=t^{-n}$ and $c(t)=-nt^{n+m-1}$, to choose the numbers n and m so that solutions are expressed as finite expressions of elementary functions of t. In modern time, a matrix equation of the form $X'(t)=C(t)-X(t)A(t)-A^*(t)X(t)-X(t)D(t)X(t)$ is named a Riccati equation. But this nonlinear matrix equation has a corresponding linear first -order system of equations. The notion of Hamiltonian and the invariant subspaces are used to define solutions to the equations.

A topic related to Lancaster's is that dealt with by P.Benner, R. Byers, V. Mehrmann and H. Xu, in their essay ***"Numerical Methods for Linear Quadratic and H_∞ Control Problems"***. The emphasis is put on numerical methods and on how to preserve the special algebraic structures of the matrix pencils in the deflating subspaces.

The Riccati equations are again brought to light, this time in connection with a network theory approach made by B. D. O. Anderson: ***"Riccati Equations, Network Theory and Brune Synthesis: Old Solutions for Contemporary Problems"***.

In ***"Nonlinear Feedback Stabilization Revisited"***, E. Sontag shows that the problem of existence of a regular stabilizing feedback is equivalent to the existence of a differentiable control-Lyapunov function. Then the author enters into more detail to talk about the discontinuous feedback and the sensitivity to small measurement errors. Rigorous proofs are given in the Appendices.

A. Isidori makes a contribution of the same importance as Sontag's when writing on ***"Stabilization of Nonlinear Systems Using Output Feedback"***. Much attention is paid to the stabilization with or without a separation principle.

D. Z. Arov deepens, in ***"Passive Linear Systems and Scattering Theory"***, the theory of passive linear time-invariant systems, with emphasis on the scattering theory.

P. A. Fuhrmann focuses his study titled: ***"On Canonical Wiener-Hopf Factorizations"*** on the connections between the Wiener-Hopf factorizations and geometric control theory.

The modeling and analysis of two human movement systems (the human ocular system and the locomotory-control system) are mathematically described and graphically illustrated by C. Martin and L. Schovanec in ***"The Control and Mechanics of Human Movement Systems"***.

Some of the essays are dealing with the connections between system theory and coding theory.

G. D. Forney, Jr. shows some properties of "***Group Codes and Behaviors***", using, among others, a fundamental State Space theorem.

In her ***"The Berlekamp-Massey Algorithm, Error-correction, Keystreams and Modeling"***, Margreet Kuijper presents a general decoding algorithm, extending the Berlekamp -Massey algorithm.

Further, J. Rosenthal discusses ***"An Algebraic Decoding Algorithm for Convolutional Codes"***.

Another important aspect is the area of computer vision.

As J. Malik and P. Perona point out in ***"Introduction to Mathematical Aspects of Computer Vision"***, the vision tasks may be organized in four broad categories: **reconstruction** of images, control (e.g. visually guided control of vehicle navigation), **grouping/tracking** and **recognition**.

Two more articles, ***"The Structure and Motion of Surfaces"***, by R. Cipolla and P. R. S. Mendonça, and ***"Shape from Texture and Shading with Wavelets"***, by M. Clerc and S. Mallat, are both combining mathematical representations with image examples.

The number of essays in the book amounts to more than those in our presentation. The diversity of subjects and the current work done in the field all over the world, make one's selection a hazardous solution it needs to operate. We took this responsibility.

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