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H_∞ Control and Filtering of Two-dimensional Systems

With 32 Figures

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Preface

Two-dimensional(2-D) signals and systems have vast applications in process control, image and signal processing. The study of 2-D systems has attracted tremendous interest from researchers and practitioners in recent years. Many techniques have been developed for the analysis and synthesis of 2-D systems. This monograph presents research work on H_∞ control and filtering for 2-D discrete systems. We first establish several versions of 2-D Bounded Real Lemma in terms of solution of certain 2-D Riccati difference inequality or equation. Based on the derived Bounded Real Lemma, we consider the H_∞ control and filtering problem of 2-D discrete systems described in state space. Solutions are obtained in terms of algebraic Riccati inequalities (ARIs) or linear matrix inequalities (LMIs). Also, the problem of output feedback stabilization of uncertain 2-D discrete systems is considered and the link between the robust stabilization and H_∞ control for 2-D systems is established. Furthermore, the H_∞ model reduction and deconvolution of 2-D digital systems are approached. The applications of the developed H_∞ control and filtering techniques in signal processing, image processing and process control are demonstrated throughout the monograph.

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Lihua Xie
Chunling Du

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Symbols and Acronyms

2-D:	two-dimensional.
1-D:	one-dimensional.
LMI:	linear matrix inequality.
ARI:	algebraic Riccati inequality.
RDI:	Riccati difference inequality.
RDE:	Riccati difference equation.
$\mathcal{Z}$:	set of interger numbers.
i, j:	integer-valued vertical and horizontal coordinates.
$\mathcal{R}^n$:	n-dimensional real Euclidean space.
$\mathcal{R}^{n\times m}$:	set of $n \times m$ real matrices.
I_n:	$n \times n$ identity matrix.
$\text{diag}\{A_1, A_2, \cdots, A_n\}$:	block diagonal matrix with A_j(not necessarily square) on the diagonal.
X^T:	transpose of matrix X.
$X^{1/2}$:	a symmetric square root of a matrix $X = X^T \geq 0$, i.e., $X^{1/2}X^{1/2} = X$.
$P \geq 0$:	symmetric positive semidefinite matrix $P \in \mathcal{R}^{n\times n}$.
$P > 0$:	symmetric positive definite matrix $P \in \mathcal{R}^{n\times n}$.

$P \geq Q$:	$P - Q \geq 0$ for symmetric $P, Q \in \mathcal{R}^{n\times n}$.
$P > Q$:	$P - Q > 0$ for symmetric $P, Q \in \mathcal{R}^{n\times n}$.
$\sigma_{\max}(X)$:	maximum singular value of matrix X.
$Ker(X)$ or $\mathcal{N}(X)$:	null space of linear operator X.
$\mathcal{R}(X)$:	range space of linear operator X.
$X^{\perp}$:	matrix satisfying $\mathcal{N}(X^{\perp}) = \mathcal{R}(X)$ and $X^{\perp}X^{\perp T} > 0$.
$\\|\cdot\\|$:	Euclidean vector norm.
$\\|w\\|_2$:	ℓ_2-norm of a 2-D discrete-time signal $\{w(i,j)\}$, i.e., $\sqrt{\sum_{i=0}^{\infty}\sum_{j=0}^{\infty}\\|w(i,j)\\|^2}$.
$\ell_2\{[0,\infty),[0,\infty)\}$:	space of square summable sequences on $\{[0,\infty),[0,\infty)\}$ with values on $\mathcal{R}^n$.
$z_i(i = 1, 2)$:	2-D z-transform variables.