DOWNLOAD PDF ROBUST AND H [INFINITY CONTROL

Chapter 1 : Robust Control Theory

H âˆž (i.e. "H-infinity") methods are used in control theory to synthesize controllers to achieve stabilization with guaranteed performance. To use H âˆž methods, a control designer expresses the control problem as a mathematical optimization problem and then finds the controller that solves this optimization.

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Chapter 2 : H-Infinity Synthesis - MATLAB & Simulink

Robust Control Toolboxâ„¢ commands let you apply the powerful methods of H âˆž synthesis to control design problems. You can use hinfstruct to tune fixed-structure control systems, which are control systems that have predefined architectures and controller structures.

This is an open access article distributed under the Creative Commons Attribution License , which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Abstract This paper is concerned with the problem of designing robust H-infinity output feedback controller and resilient filtering for a class of discrete-time singular piecewise-affine systems with input saturation and state constraints. Based on a singular piecewise Lyapunov function combined with S-procedure and some matrix inequality convexifying techniques, the H-infinity stabilization condition is established and the resilient H-infinity filtering error dynamic system is investigated, and, meanwhile, the domain of attraction is well estimated. Under energy bounded disturbance, the input saturation disturbance tolerance condition is proposed; then, the resilient H-infinity filter is designed in some restricted region. It is shown that the controller gains and filter design parameters can be obtained by solving a family of LMIs parameterized by one or two scalar variables. Meanwhile, by using the corresponding optimization methods, the domain of attraction and the disturbance tolerance level is maximized, and the H-infinity performance is minimized. Numerical examples are given to illustrate the effectiveness of the proposed design methods. Introduction Piecewise-affine systems offer a good modeling framework for hybrid systems involving nonlinear phenomena which have the characteristic of both continuous dynamics and discrete events with the nature of the model switching [1 â€” 5]. Piecewise-affine systems which are composed of a partition of the state space and local dynamics valid can describe a rich class of practical circuits and control systems when some nonlinear components are encountered, such as saturation, dead-zone, and relays [6 â€” 8]. In fact, many nonlinearities that appear frequently in engineering systems either are piecewise-affine or can be approximated as piecewise-affine functions, which can be used to analyze smooth nonlinear systems with arbitrary accuracy [9 , 10]. Robust stabilization problems of piecewise-affine systems with norm-bounded time-varying parameters uncertainties have been extensively studied, and various results have been obtained on the analysis and controller synthesis [11]. To mention a few, the problem of well-posedness was investigated as a basic issue for piecewise-affine systems in the literature [12]. By presenting a number of algorithms, the authors in [6] tested the controllability and observability of piecewise-affine systems. In [9 , 10], more attention was paid by constructing a piecewise-affine Lyapunov function on stability and optimal performance analysis for piecewise-affine system. By the same Lyapunov functions as in [9], controller synthesis and state estimation of piecewise-affine system were considered in [13 â€” 16]. By using a common Lyapunov function and a piecewise Lyapunov function, respectively, the authors in [17 â€” 23] investigated the analysis and control of systems that may involve multiple equilibrium points. Using a similar method to that in [10 â€” 12], some results have also been reported in [24 â€” 26] where the piecewise Lyapunov function might be discontinuous across the region boundaries. Recently, much more attention has been paid to the problem that the stabilization conditions can be determined by solving a set of linear matrix inequalities LMIs. A number of results have been reported based on the piecewise Lyapunov function [27 â€” 30], such as controller synthesis, state estimation, output regulation, and tracking of piecewise-affine system. For a filtering error dynamic system, the objective of filter designing is to estimate the unavailable state variables. During the past decades, much more filtering schemes have been investigated, such as Kalman filtering, H-infinity filtering, and reduced-order H-infinity filtering [31 â€” 34]. Then, the authors in [35] paid more attention to the problem of resilient Kalman filtering with respect to estimator gain perturbations. And the resilient H-infinity filtering was also raised. For output feedback control systems, an actuator with amplitude and rate limitations may be considered in most real-world applications that often suffer from the state constraints. For controller synthesis, ignoring these constraints may degrade the performance and may even cause the instability of closed-loop system [36 , 37] Figure 1. On the other hand, output feedback control can be easily implemented with low cost, which is particularly very useful and more realistic [38]. In the literature [39], the low gain feedback designs were investigated for linear systems with all of its open loop poles in the closed left-half plane. Based on an auxiliary feedback matrix, the authors in [40 , 41] studied the stabilization and -gain control of piecewise-linear systems with actuator saturation. Recently, the authors in [42 , 43] investigated state feedback H-infinity control and output feedback H-infinity control for piecewise-affine systems, respectively. State responses of the closed-loop system. In this paper, the H-infinity output feedback control and resilient filter design problems of singular piecewise-affine systems with input saturation and state constraints are considered. Based on a singular piecewise Lyapunov function combined with S-procedure and some matrix inequality convexifying techniques, the H-infinity stabilization condition is established and the resilient H-infinity filtering error dynamic system is investigated. The results are given in terms of solutions to a set of linear matrix inequalities. According to the existing results, the main contributions of this paper can be summarized as follows: The paper is organized as follows. In Section 2 , model description and some preliminaries are given. Sufficient conditions for designing robust H-infinity output feedback controllers are proposed in Section 3 firstly; then, a resilient H-infinity filter is given by using the analysis and synthesis methods described previously; the resulting filtering error dynamic system is admissible with the resilient H-infinity filter. Two numerical examples are presented to illustrate the effectiveness of the proposed approaches in Section 4 , which is followed by some conclusions finally. The notations used throughout the paper are standard. For real symmetric matrices and.

Chapter 3 : H-infinity loop-shaping - Wikipedia

H-infinity control theory deals with the minimization of the H-infinity-norm of the transfer matrix from an exogenous disturbance to a pertinent controlled output of a given plant. Robust and H -infinity Control examines both the theoretical and practical aspects of H -infinity control from the angle of the structural properties of linear systems.

Introduction In order to gain a perspective for robust control, it is useful to examine some basic concepts from control theory. Control theory can be broken down historically into two main areas: Conventional control covers the concepts and techniques developed up to Modern control covers the techniques from to the present. Each of these is examined in this introduction. Conventional control became interesting with the development of feedback theory. Feedback was used in order to stabilize the control system. One early use of feedback control was the development of the flyball governor for stabilizing steam engines in locomotives. Another example was the use of feedback for telephone signals in the s. The problem was the transmission of signals over long lines. There was a limit to the number of repeaters that could be added in series to a telephone line due to distortion. Harold Stephen Black proposed a feedback system that would use feedback to limit the distortion. Even though the added feedback sacrificed some gain in the repeater, it enhanced the overall performance. Refer to [Bennet96] for more historical treatment of control theory. Conventional control relies upon developing a model of the control system using differential equations. LaPlace transforms are then used to express the system equations in the frequency domain where they can be manipulated algebraically. Figure 1 shows a typical control loop. The input to the system is some reference signal, which represents the desired control value. This reference is fed through a forward transfer function G s to determine the plant output, y. The output is fed back through a feedback transfer function, H s. The feedback signal is subtracted from the reference to determine the error signal, e. Further control is based on the error signal. Therefore, the system serves to bring the output as close as possible to the desired reference input. Refer to [Oppenheim97] for an introduction to conventional control techniques. Typical Control Loop One development that was key to future developments in robust control was the root-locus method. In the frequency domain, G s and H s were expressed as ratios of polynomials in the complex frequency variable, s. Nyquist, Bode and others realized that the roots of the denominator polynomial determined the stability of the control system. These roots were referred to as "poles" of the transfer functions. The location of these poles had to be in the left half-plane of the complex frequency plot to guarantee stability. Root locus was developed as a method to graphically show the movements of poles in the frequency domain as the coefficients of the s-polynomial were changed. Movement into the right half plane meant an unstable system. Thus systems could be judged by their sensitivity to small changes in the denominator coefficients. Modern control methods were developed with a realization that control system equations could be structured in such a way that computers could efficiently solve them. It was shown that any nth order differential equation describing a control system could be reduced to n 1st order equations. These equations could be arranged in the form of matrix equations. This method is often referred to as the state variable method. The canonical form of state equations is shown below, where x is a vector representing the system "state", is a vector representing the change in "state", u is a vector of inputs, y is a vector of outputs, and A, B, C, D are constant matrices which are defined by the particular control system. Modern control methods were extremely successful because they could be efficiently implemented on computers, they could handle Multiple-Input-Multiple-Output MIMO systems, and they could be optimized. Methods to optimize the constant state matrices were developed. For instance a spacecraft control system could be optimized to reach a destination in the minimum time or to use the minimum amount of fuel or some weighted combination of the two. The ability to design for performance and cost made these modern control systems highly desirable. There are many books covering the mathematical details of modern control theory. One example is [Chen84]. A lighter overview of the key developments in modern control can be found in [Bryson96] Robust Control Definition From [Chandraseken98], "Robust control refers to the control of unknown plants with unknown dynamics subject to unknown disturbances". Clearly, the key issue with robust control systems is uncertainty and how the control system can deal with this problem. Figure 2 shows an expanded view of the simple control loop presented earlier. Uncertainty is shown entering the system in three places. There is uncertainty in the model of the plant. There are disturbances that occur in the plant system. Also there is noise which is read on the sensor inputs. Each of these uncertainties can have an additive or multiplicative component. Plant control loop with uncertainty The figure above also shows the separation of the computer control system with that of the plant. It is important to understand that the control system designer has little control of the uncertainty in the plant. The designer creates a control system that is based on a model of the plant. However, the implemented control system must interact with the actual plant, not the model of the plant. Effects of Uncertainty Control system engineers are concerned with three main topics: Observability is the ability to observe all of the parameters or state variables in the system. Controllability is the ability to move a system from any given state to any desired state. Stability is often phrased as the bounded response of the system to any bounded input. Any successful control system will have and maintain all three of these properties. Uncertainty presents a challenge to the control system engineer who tries to maintain these properties using limited information. One method to deal with uncertainty in the past is stochastic control. In stochastic control, uncertainties in the system are modeled as probability distributions. These distributions are combined to yield the control law. This method deals with the expected value of control. Abnormal situations may arise that deliver results that are not necessarily close to the expected value. This may not be acceptable for embedded control systems that have safety implications. An introduction to stochastic control can be found in [Lewis86]. Robust control methods seek to bound the uncertainty rather than express it in the form of a distribution. Given a bound on the uncertainty, the control can deliver results that meet the control system requirements in all cases. Therefore robust control theory might be stated as a worst-case analysis method rather than a typical case method. It must be recognized that some performance may be sacrificed in order to guarantee that the system meets certain requirements. However, this seems to be a common theme when dealing with safety critical embedded systems. Modeling One of the most difficult parts of designing a good control system is modeling the behavior of the plant. There are a variety of reasons for why modeling is difficult. Imperfect plant data - Often, little hard data is available about the plant. Many control systems are designed concurrently with the plant. Even if there are similar plants in existence, each plant is slightly different because of the tolerances associated with individual components. Time varying plants - The dynamics of some plants vary over time. A fixed control model may not accurately depict the plant at all times. Higher order dynamics - Some plants have a high frequency dynamic that is often neglected in the nominal plant model. For instance, vibration may cause unwanted affects at high frequencies. Sometimes this dynamic is unknown and sometimes it is deliberately ignored in order to simplify the model. Non-linearity - Most control systems are designed assuming linear time invariant systems. This is done because it greatly simplifies the analysis of the system. However, all of the systems encountered in the real world have some non-linear component. Thus the model will always be an approximation of the real world behavior. Complexity - Mechanical and electrical systems are inherently complex to model. Even a simple system with a simple requires complex differential equations to describe its behavior. Skills - Modeling requires a variety of skills. Physical phenomena such as heat transfer require physics to model behavior and in order to measure this behavior. Systems involving rigid bodies or actuators require mechanical engineers. Conversion of physical parameters into signals that can be monitored by a control system require electrical engineers. Algorithms to control the plant require applied mathematics. Implementation of control algorithms on digital systems may require computer engineers. In an embedded system, computation resources and cost are a significant issue. The issue for the control engineer is to synthesize a model that is simple enough to implement within these constraints but performs accurately enough to meet the performance requirements. The robust control engineer also wants this simple model to be insensitive to uncertainty. This simplification of the plant model is often referred to as model reduction.

Chapter 4 : Buy Robust Output Feedback H Infinity Control And Filtering For Uncertain Linear Systems

This paper is concerned with the problem of designing robust H-infinity output feedback controller and resilient filtering *for a class of discrete-time singular piecewise-affine systems with input saturation and state constraints.*

Chapter 5 : Robust H-infinity Output Feedback Control for Nonlinear Systems

The robust H-infinity control has been studied extensively in the last three decades. Typical applications for robust control include systems that have high.

Chapter 6 : H-Infinity Performance - MATLAB & Simulink

Robust control systems may successfully be designed by ~'=-optimization, in particular, by reformulating the design problem as a mixed sensitivity problem.

Chapter 7 : H-infinity methods in control theory - Wikipedia

The controllers, i.e. PSO based H-infinity, GA based H-infinity and H-infinity control based on droop characteristic were designed and their performance was investigated under various disturbances like, random wind deviation, and load demand deviation.