minimax approaches to robust model predictive control johan lofberg

Minimax Approaches to Robust Model Predictive Control Johan Lofberg

minimax approaches to robust model predictive control johan lofberg have become a vital topic of interest in the control engineering community. As systems grow more complex and uncertainties become harder to predict, the need for control strategies that can guarantee performance despite disturbances and model inaccuracies is paramount. Johan Löfberg, a notable researcher in this field, has contributed significantly to the theory and application of robust model predictive control (MPC), particularly through minimax formulations. In this article, we will explore the essence of minimax approaches to robust MPC, highlighting Johan Löfberg’s contributions while unpacking the theoretical underpinnings and practical implications of these methods.

Understanding Robust Model Predictive Control

Before diving into minimax strategies, it’s important to grasp the basics of model predictive control and its robust variations. MPC is a control technique that uses a model of the system to predict future behavior and optimize control inputs over a finite horizon. At each control step, it solves an optimization problem to find the best action, then implements the first input and repeats the process.

However, real-world systems often face uncertainties—such as unknown disturbances, measurement noise, or parameter variations—that can degrade the performance of a nominal MPC controller. Robust MPC aims to account for these uncertainties explicitly, ensuring that the control actions remain effective even in worst-case scenarios. This is where minimax approaches come into play.

What Are Minimax Approaches in Robust MPC?

The term “minimax” refers to a strategy that minimizes the maximum possible loss. In the context of robust MPC, a minimax approach formulates the control problem as a game between the controller and “nature,” where nature tries to maximize the cost by choosing the worst possible disturbance or uncertainty realization, and the controller tries to minimize this worst-case cost.

This leads to an optimization problem of the form:

$$
\min_{u} \max_{w \in \mathcal{W}} J(u, w)
$$

where u is the control input, w represents uncertainties or disturbances within a set $\mathcal{W}$, and J is the cost function evaluating the system’s performance.

By solving this game, the controller guarantees that even under the worst disturbance, performance will not drop below a certain threshold. Minimax robust MPC thus provides a very conservative but safe control policy, which is especially valuable in safety-critical applications.

Johan Löfberg’s Contributions to Minimax Robust MPC

Johan Löfberg is widely recognized for his work in optimization and control, particularly in leveraging convex optimization tools for solving robust control problems. His research has bridged the gap between theoretical robustness guarantees and computationally efficient implementations.

One of his key insights involves the use of semidefinite programming (SDP) and convex relaxations to reformulate minimax robust MPC problems into tractable optimization problems. This approach allows robust MPC to be solved efficiently in real time, even for complex systems with high-dimensional uncertainty.

Löfberg’s work also emphasizes the integration of polytopic uncertainty sets and structured disturbances in the minimax framework, providing tighter robustness guarantees without overly conservative designs. His software contributions, notably the development of robust control toolboxes compatible with MATLAB, have empowered practitioners and researchers to implement these advanced control strategies more easily.

Key Concepts in Minimax Robust MPC

1. Uncertainty Modeling

A fundamental step in robust MPC is defining the uncertainty set $\mathcal{W}$. This can include:

- **Bounded disturbances:** Known limits on noise or external inputs.
- **Parametric uncertainties:** Variations in system parameters modeled by convex sets.
- **Polytopic or ellipsoidal uncertainty sets:** Geometric representations enabling tractable optimization.

Johan Löfberg’s methods often leverage polytopic uncertainty, enabling efficient characterization of worst-case disturbances.

2. Optimization Formulation

The minimax problem is inherently a bilevel optimization, which can be challenging to solve directly. Löfberg’s approach reformulates the problem using convex optimization techniques, often transforming it into a semidefinite program or a quadratic program that can be solved efficiently.

3. Trade-off Between Conservatism and Performance

One challenge in minimax robust MPC is balancing conservatism (overly cautious control) with performance. Too conservative a controller may waste resources or reduce system responsiveness, while too optimistic a controller can fail under disturbances.

Löfberg’s frameworks enable tuning this trade-off by adjusting uncertainty sets or cost function weights, allowing practitioners to tailor robustness to specific applications.

Practical Applications of Minimax Robust MPC

Minimax approaches to robust MPC are particularly useful in domains where safety and reliability are critical, such as:

- **Aerospace:** Flight control systems must handle turbulence and parameter variations.
- **Automotive:** Autonomous vehicles require robust decision-making under uncertain sensor data.
- **Process control:** Chemical plants need to maintain operation despite fluctuating inputs.

By applying these methods, engineers can design controllers that ensure stability and performance even in the presence of unforeseen disruptions.

Tips for Implementing Minimax Robust MPC Inspired by Johan Löfberg

If you’re considering adopting minimax robust MPC in your control projects, here are some practical tips inspired by Johan Löfberg’s work:

1. **Leverage Convex Optimization Toolboxes:** Use tools like YALMIP and robust control toolboxes that Löfberg helped develop to model and solve your minimax MPC problems efficiently.

2. **Carefully Define Uncertainty Sets:** Avoid overly conservative uncertainty descriptions. Use data-driven approaches or system identification techniques to shape realistic bounds.

3. **Test on Simplified Models First:** Begin by applying robust MPC on reduced-order models to gain insights into tuning parameters before scaling up.

4. **Explore Scenario-Based Approaches:** When exact uncertainty sets are unknown, scenario optimization can approximate minimax behavior effectively.

5. **Balance Performance and Safety:** Tune the cost function and constraints to avoid unnecessarily conservative controls that may degrade system efficiency.

Advanced Topics in Minimax Robust MPC

For those interested in diving deeper, recent research inspired by Löfberg’s principles explores:

- **Tube-based MPC:** Separates nominal trajectories from disturbance tubes, enhancing computational efficiency in minimax formulations.
- **Probabilistic robustness:** Combining worst-case minimax strategies with chance constraints to allow for probabilistic guarantees.
- **Distributed robust MPC:** Applying minimax control in networked or multi-agent systems where uncertainties can propagate.

These extensions continue to push the boundaries of what robust MPC can achieve in complex, uncertain environments.

The Future of Robust MPC and Johan Löfberg’s Role

As control systems become increasingly embedded in autonomous technologies and critical infrastructures, the need for robust, reliable control will only grow. Johan Löfberg’s pioneering work in minimax approaches to robust MPC lays a solid foundation for future innovations.

Emerging trends, including machine learning integration and adaptive control, are likely to benefit from robust optimization techniques that Löfberg helped popularize. By continuing to blend rigorous mathematical formulations with practical computational methods, the control community can develop controllers that are not only robust but also intelligent and adaptive.

In summary, the minimax approaches to robust model predictive control, championed by researchers like Johan Löfberg, represent a powerful paradigm for managing uncertainty in control systems. By framing control as a game against worst-case disturbances and leveraging advanced optimization tools, these methods provide reliable and safe control policies for a wide range of applications. Whether you are a researcher, practitioner, or student, exploring these techniques offers valuable insights into the future of robust, predictive control design.

Frequently Asked Questions

What is the main focus of Johan Lofberg's work on minimax approaches to robust model predictive control?

Johan Lofberg's work primarily focuses on developing minimax optimization strategies to enhance the robustness and reliability of model predictive control (MPC) systems under uncertainty and disturbances.

How do minimax approaches improve robust model predictive control?

Minimax approaches improve robust MPC by optimizing control actions against the worst-case scenarios, thereby ensuring system performance and stability despite uncertainties and disturbances in the model or environment.

What are the key advantages of using minimax strategies in robust MPC according to Johan Lofberg?

Key advantages include enhanced robustness to model uncertainties, guaranteed constraint satisfaction under worst-case disturbances, and improved closed-loop stability and performance in uncertain environments.

What types of uncertainties are considered in Johan Lofberg's minimax robust MPC framework?

The framework typically considers bounded disturbances, model parameter uncertainties, and measurement noise to ensure that the control policy remains effective under all admissible uncertainty realizations.

How does Johan Lofberg's minimax approach relate to computational complexity in MPC?

While minimax approaches can increase computational complexity due to nested optimization problems, Johan Lofberg explores efficient solution techniques and approximations to make the approach tractable for real-time control applications.

Are there specific application areas where Johan Lofberg's minimax robust MPC methods have been successfully applied?

Yes, these methods have been applied in areas such as aerospace, automotive systems, process control, and robotics, where handling uncertainties robustly is critical for safe and reliable operation.

What mathematical tools does Johan Lofberg use in formulating minimax robust MPC problems?

He employs convex optimization, linear matrix inequalities (LMIs), and game-theoretic formulations to express and solve the minimax robust MPC problems effectively.

How does Johan Lofberg's research contribute to the field of control theory and practice?

His research provides systematic and computationally feasible methods for designing robust MPC controllers that can handle worst-case uncertainties, thereby advancing both theoretical understanding and practical implementation of robust control systems.

Additional Resources

Minimax Approaches to Robust Model Predictive Control Johan Lofberg

minimax approaches to robust model predictive control johan lofberg represent a significant advancement in the field of control systems engineering, particularly within the domain of robust optimization for dynamic systems. Johan Lofberg, a prominent researcher and expert in control theory and optimization, has contributed extensively to the development and application of minimax strategies in robust model predictive control (MPC). This article delves into the theoretical underpinnings, practical implementations, and ongoing challenges associated with these minimax methodologies, highlighting their relevance in enhancing the performance and reliability of predictive control systems under uncertainty.

Robust model predictive control aims to maintain system performance despite the presence of disturbances, model inaccuracies, and parameter variations. Traditional MPC frameworks often assume nominal models, which can lead to suboptimal or even unstable behavior when confronted with real-world uncertainties. Minimax approaches to robust MPC, as explored by Lofberg and his contemporaries, formulate the control problem as a zero-sum game between the controller and nature—where the controller minimizes the worst-case cost inflicted by uncertainties. This strategic viewpoint ensures performance guarantees across all admissible uncertainties, making it particularly attractive in safety-critical applications and environments with high levels of unpredictability.

Foundations of Minimax Robust Model Predictive Control

At its core, minimax robust MPC tackles the challenge of uncertainty by embedding worst-case optimization directly into the predictive control algorithm. Instead of merely optimizing expected performance, the controller anticipates the most adverse disturbance scenario and designs control actions to mitigate its impact.

Johan Lofberg’s work often leverages convex optimization techniques and semidefinite programming to solve these complex minimax problems efficiently. By framing the robust MPC problem as a convex-concave saddle-point problem, Lofberg’s approaches facilitate tractable solutions even for high-dimensional systems with intricate uncertainty structures.

Mathematical Formulation and Algorithmic Advances

The minimax robust MPC formulation typically involves an objective function of the form:

$$
\min_{u(\cdot)} \max_{w(\cdot) \in \mathcal{W}} J(x_0, u(\cdot), w(\cdot))
$$

where $u(\cdot)$ denotes the control input sequence, $w(\cdot)$ represents the disturbance or uncertainty sequence constrained within a known set $\mathcal{W}$, and J is a cost function reflecting control objectives such as regulation, tracking, or energy consumption.

Lofberg’s contributions include approaches that:

- Use polytopic or ellipsoidal uncertainty descriptions to model disturbances.
- Employ dualization techniques to convert the inner maximization into a tractable form.
- Incorporate constraints robustly by ensuring feasibility across all disturbances.
- Apply semidefinite programming and sum-of-squares optimization to handle nonlinearities and nonconvexities.

These innovations enable robust MPC schemes that are both computationally efficient and theoretically sound, making them suitable for real-time industrial applications.

Comparative Perspectives on Robust MPC Strategies

While minimax approaches to robust MPC have gained traction, they compete with alternative robust control methodologies such as tube-based MPC, stochastic MPC, and adaptive control. Understanding the comparative advantages of minimax formulations is essential for practitioners and researchers.

Advantages of Minimax Approaches

- **Worst-case guarantees:** By explicitly optimizing against the worst disturbance, minimax MPC ensures robust constraint satisfaction and stability.
- **Systematic uncertainty handling:** The framework naturally incorporates bounded uncertainty sets without relying on probabilistic assumptions.
- **Flexibility:** Capable of handling various uncertainty structures, including parametric and additive disturbances.

Challenges and Limitations

- **Computational complexity:** Despite advances, minimax robust MPC can be computationally intensive, especially for nonlinear or large-scale systems.

- **Conservatism:** Worst-case optimization may lead to overly cautious control actions, sacrificing nominal performance.
- **Uncertainty set specification:** The effectiveness hinges on accurately defining the uncertainty set $\mathcal{W}$, which can be difficult in practice.

Johan Lofberg's research addresses some of these limitations by proposing scalable optimization algorithms and less conservative uncertainty descriptions, striking a balance between robustness and performance.

Applications and Impact of Lofberg's Minimax Robust MPC

The practical relevance of minimax approaches to robust model predictive control, as developed by Johan Lofberg, spans numerous industries and technological domains. From autonomous vehicles navigating uncertain environments to energy systems dealing with fluctuating demands and renewable integration, minimax robust MPC frameworks enhance decision-making under uncertainty.

Industrial Automation and Process Control

In chemical and manufacturing processes, disturbances such as fluctuating feedstock quality or equipment degradation can jeopardize operational safety and efficiency. Lofberg's robust MPC formulations enable controllers to maintain optimal performance by preemptively counteracting these disturbances, reducing downtime and improving yield.

Robotics and Autonomous Systems

Autonomous systems must operate reliably in dynamic, unpredictable settings. The minimax robust MPC paradigm provides a foundation for safe trajectory planning and control by ensuring system constraints are respected even in worst-case scenarios, critical for collision avoidance and stability.

Energy Systems and Smart Grids

Energy management involves uncertainties from renewable generation variability and consumption patterns. By applying Lofberg's minimax robust MPC methods, grid operators can optimize resource allocation and maintain system stability, facilitating the transition to more sustainable energy infrastructures.

Future Directions and Research Opportunities

The evolving landscape of robust control continues to inspire new directions in minimax approaches. Emerging research seeks to integrate data-driven techniques, such as machine learning, with robust MPC to reduce conservatism and enhance adaptability. Johan Lofberg's ongoing work explores hybrid methodologies that blend scenario-based optimization with minimax frameworks, aiming to improve computational efficiency and robustness simultaneously.

Moreover, extending minimax robust MPC to nonlinear, distributed, and hybrid systems remains an active area of investigation. Addressing the curse of dimensionality and real-time applicability will be crucial for broader adoption in complex cyber-physical systems.

The exploration of minimax approaches to robust model predictive control Johan Lofberg has championed marks a pivotal step toward resilient, reliable control systems capable of thriving amid uncertainty. By merging rigorous mathematical frameworks with practical optimization tools, these methodologies continue to shape the future of advanced control engineering.

Minimax Approaches To Robust Model Predictive Control Johan Lofberg

minimax approaches to robust model predictive control johan lofberg: *Minimax Approaches to Robust Model Predictive Control* Johan Löfberg, 2003-04-11 Controlling a system with control and state constraints is one of the most important problems in control theory, but also one of the most challenging. Another important but just as demanding topic is robustness against uncertainties in a controlled system. One of the most successful approaches, both in theory and practice, to control constrained systems is model predictive control (MPC). The basic idea in MPC is to repeatedly solve optimization problems on-line to find an optimal input to the controlled system. In recent years, much effort has been spent to incorporate the robustness problem into this framework. The main part of the thesis revolves around minimax formulations of MPC for uncertain constrained linear discrete-time systems. A minimax strategy in MPC means that worst-case performance with respect to uncertainties is optimized. Unfortunately, many minimax MPC formulations yield intractable optimization problems with exponential complexity. Minimax algorithms for a number of uncertainty models are derived in the thesis. These include systems with bounded external additive disturbances, systems with uncertain gain, and systems described with linear fractional transformations. The central theme in the different algorithms is semidefinite relaxations. This means that the minimax problems are written as uncertain semidefinite programs, and then conservatively approximated using robust optimization theory. The result is an optimization problem with polynomial complexity. The use of semidefinite relaxations enables a framework that allows extensions of the basic algorithms, such as joint minimax control and estimation, and approximation of closed-loop minimax MPC using a convex programming framework. Additional topics include development of an efficient optimization algorithm to solve the resulting semidefinite programs and connections between deterministic minimax MPC and stochastic risk-sensitive control. The remaining part of the thesis is devoted to stability issues in MPC for continuous-time nonlinear unconstrained systems. While stability of MPC for un-constrained linear systems essentially is solved with the linear quadratic controller, no such simple solution exists in the nonlinear case. It is shown how tools from modern nonlinear control theory can be used to synthesize finite horizon MPC controllers with guaranteed stability, and more importantly, how some of the tech- nical assumptions in the literature can be dispensed with by using a slightly more complex controller.

minimax approaches to robust model predictive control johan lofberg: Investigation on Robust Codesign Methods for Networked Control Systems Sanad Al-Areqi, 2015-12-31 The problem of jointly designing a robust controller and an intelligent scheduler for networked control systems (NCSs) is addressed in this thesis. NCSs composing of multiple plants that share a single channel communication network with uncertain time-varying transmission times are modeled as switched polytopic systems with additive norm-bounded uncertainty. Switching is deployed to represent scheduling, the polytopic uncertainty to overapproximatively describe the uncertain time-varying transmission times. Based on the resulting NCS model and a state feedback control law, the control and scheduling codesign problem is then introduced and formulated as a robust (minimax) optimization problem with the objective of minimizing the worst-case value of an associated infinite time-horizon quadratic cost function. Five robust codesign strategies are investigated for tackling the introduced optimization problem, namely: Periodic control and scheduling (PCS), Receding-horizon control and scheduling (RHCS), Implementation-aware control and scheduling (IACS), Event-based control and scheduling (EBCS), Prediction-based control and scheduling (PBCS). All these codesign strategies are determined from LMI optimization problems based on the Lyapunov theory. The properties of each are evaluated and compared in terms of computational complexity and control performance based on simulation and experimental study, showing their effectiveness in improving the performance while utilizing the limited communication resources very efficiently.

minimax approaches to robust model predictive control johan lofberg: Fighter Aircraft Maneuver Limiting Using MPC: Theory and Application Daniel Simon, 2017-09-12 Flight control design for modern fighter aircraft is a challenging task. Aircraft are dynamical systems, which naturally contain a variety of constraints and nonlinearities such as, e.g., maximum permissible load factor, angle of attack and control surface deflections. Taking these limitations into account in the design of control systems is becoming increasingly important as the performance and complexity of the aircraft is constantly increasing. The aeronautical industry has traditionally applied feedforward, anti-windup or similar techniques and different ad hoc engineering solutions to handle constraints on the aircraft. However these approaches often rely on engineering experience and insight rather than a theoretical foundation, and can often require a tremendous amount of time to tune. In this thesis we investigate model predictive control as an alternative design tool to handle the constraints that arises in the flight control design. We derive a simple reference tracking MPC algorithm for linear systems that build on the dual mode formulation with guaranteed stability and low complexity suitable for implementation in real time safety critical systems. To reduce the computational burden of nonlinear model predictive control we propose a method to handle the nonlinear constraints, using a set of dynamically generated local inner polytopic approximations. The main benefit of the proposed method is that while computationally cheap it still can guarantee recursive feasibility and convergence. An alternative to deriving MPC algorithms with guaranteed stability properties is to analyze the closed loop stability, post design. Here we focus on deriving a tool based on Mixed Integer Linear Programming for analysis of the closed loop stability and robust stability of linear systems controlled with MPC controllers. To test the performance of model predictive control for a real world example we design and implement a standard MPC controller in the development simulator for the JAS 39 Gripen aircraft at Saab Aeronautics. This part of the thesis focuses on practical and tuning aspects of designing MPC controllers for fighter aircraft. Finally we have compared the MPC design with an alternative approach to maneuver limiting using a command governor.

minimax approaches to robust model predictive control johan lofberg: Accelerating Monte Carlo methods for Bayesian inference in dynamical models Johan Dahlin, 2016-03-22 Making decisions and predictions from noisy observations are two important and challenging problems in many areas of society. Some examples of applications are recommendation systems for online shopping and streaming services, connecting genes with certain diseases and modelling climate change. In this thesis, we make use of Bayesian statistics to construct probabilistic models given prior information and historical data, which can be used for decision support and predictions. The main obstacle with this approach is that it often results in mathematical problems lacking analytical solutions. To cope with this, we make use of statistical simulation algorithms known as Monte Carlo methods to approximate the intractable solution. These methods enjoy well-understood statistical properties but are often computational prohibitive to employ. The main contribution of this thesis is the exploration of different strategies for accelerating inference methods based on sequential Monte Carlo (SMC) and Markov chain Monte Carlo (MCMC). That is, strategies for reducing the computational effort while keeping or improving the accuracy. A major part of the thesis is devoted to proposing such strategies for the MCMC method known as the particle Metropolis-Hastings (PMH) algorithm. We investigate two strategies: (i) introducing estimates of the gradient and Hessian of the target to better tailor the algorithm to the problem and (ii) introducing a positive correlation between the point-wise estimates of the target. Furthermore, we propose an algorithm based on the combination of SMC and Gaussian process optimisation, which can provide reasonable estimates of the posterior but with a significant decrease in computational effort compared with PMH. Moreover, we explore the use of sparseness priors for approximate inference in over-parametrised mixed effects models and autoregressive processes. This can potentially be a practical strategy for inference in the big data era. Finally, we propose a general method for increasing the accuracy of the parameter estimates in non-linear state space models by applying a designed input signal. Borde Riksbanken höja eller sänka reporäntan vid sitt nästa möte för att nå inflationsmålet? Vilka gener är förknippade med en viss sjukdom? Hur kan Netflix och Spotify veta vilka filmer och vilken musik som jag vill lyssna på härnäst? Dessa tre problem är exempel på frågor där statistiska modeller kan vara användbara för att ge hjälp och underlag för beslut. Statistiska modeller kombinerar teoretisk kunskap om exempelvis det svenska ekonomiska systemet med historisk data för att ge prognoser av framtida skeenden. Dessa prognoser kan sedan användas för att utvärdera exempelvis vad som skulle hända med inflationen i Sverige om arbetslösheten sjunker eller hur värdet på mitt pensionssparande förändras när Stockholmsbörsen rasar. Tillämpningar som dessa och många andra gör statistiska modeller viktiga för många delar av samhället. Ett sätt att ta fram statistiska modeller bygger på att kontinuerligt uppdatera en modell allteftersom mer information samlas in. Detta angreppssätt kallas för Bayesiansk statistik och är särskilt användbart när man sedan tidigare har bra insikter i modellen eller tillgång till endast lite historisk data för att bygga modellen. En nackdel med Bayesiansk statistik är att de beräkningar som krävs för att uppdatera modellen med den nya informationen ofta är mycket komplicerade. I sådana situationer kan man istället simulera utfallet från miljontals varianter av modellen och sedan jämföra dessa mot de historiska observationerna som finns till hands. Man kan sedan medelvärdesbilda över de varianter som gav bäst resultat för att på så sätt ta fram en slutlig modell. Det kan därför ibland ta dagar eller veckor för att ta fram en modell. Problemet blir särskilt stort när man använder mer avancerade modeller som skulle kunna ge bättre prognoser men som tar för lång tid för att bygga. I denna avhandling använder vi ett antal olika strategier för att underlätta eller förbättra dessa simuleringar. Vi föreslår exempelvis att ta hänsyn till fler insikter om systemet och därmed minska antalet varianter av modellen som behöver undersökas. Vi kan således redan utesluta vissa modeller eftersom vi har en bra uppfattning om ungefär hur en bra modell ska se ut. Vi kan också förändra simuleringen så att den enklare rör sig mellan olika typer av modeller. På detta sätt utforskas rymden av alla möjliga modeller på ett mer effektivt sätt. Vi föreslår ett antal olika kombinationer och förändringar av befintliga metoder för att snabba upp anpassningen av modellen till observationerna. Vi visar att beräkningstiden i vissa fall kan minska ifrån några dagar till någon timme. Förhoppningsvis kommer detta i framtiden leda till att man i praktiken kan använda mer avancerade modeller som i sin tur resulterar i bättre prognoser och beslut.

minimax approaches to robust model predictive control johan lofberg:

Frequenzselektive Aktivfilterung von Stromoberschwingungen mit einer erweiterten modellbasierten Prädiktivregelung Martin Pieschel, 2010 Modellpradiktive Regelungen waren bisher aufgrund der erforderlichen hohen Rechenleistung in ihrem Anwendungsbereich auf Regelstrecken mit niedrigen Abtastraten beschrankt. Durch die Verfugbarkeit schneller Rechenhardware wurde bereits ein Verfahren dieser Klasse von Reglern erfolgreich bei der feldorientierten Regelung von Asynchronmaschienen erprobt. In dieser Arbeit wird der Einsatz einer modellbasierten Pradiktivregelung zur frequenzselektiven Aktivfilterung von Stromoberschwingungen untersucht. Hierzu wird ein Wechsel von der bisher ublichen Regelung von Gleichgrossen zu einer Regelung mehrerer uberlagerter Sinusschwingungen durch Hinzufugen von dynamischen Modellen der Fuhrungsgrosse zu einer Pradiktivregelung mit einer Zustandsraumdarstellung durchgefuhrt. Nach der erfolgreichen simulativen Untersuchung des Kompensationsverhaltens wurde zur Verifikation des Verfahrens im Labormassstab ein mehrstufiger Umrichter aus einer Reihenschaltung von zehn H-Brucken mit Spannungszwischenkreis als Stellglied fur die Regelung aufgebaut. Der Umrichter wurde uber einen schwach gedampften Saugkreis parallel zu verschiedenen Stromoberschwingungsquellen angeschlossen und bewies die Funktionstuchtigkeit der entwicketen Regelung.

minimax approaches to robust model predictive control johan lofberg: Robust Model Predictive Control Rainer Manuel Schaich, 2017

minimax approaches to robust model predictive control johan lofberg: A Convex Relaxation of a Minimax MPC Controller , 2001

minimax approaches to robust model predictive control johan lofberg: *Robust Model Predictive Control* E. F. Camacho, Frank Allgöwer, 2000

minimax approaches to robust model predictive control johan lofberg: Robust Model Predictive Control , 2013

minimax approaches to robust model predictive control johan lofberg: *Minimax Approaches to Robust Control* Paul Milliken, 1999

minimax approaches to robust model predictive control johan lofberg: Performance and Constraint Satisfaction in Robust Economic Model Predictive Control Florian A. Bayer , 2017 In this thesis, we develop a novel framework for model predictive control (MPC) which combines the concepts of robust MPC and economic MPC. The goal of this thesis is to develop and analyze MPC schemes for nonlinear discrete-time systems which explicitly consider the influence of disturbances on arbitrary performance criteria. Instead of regarding the two aspects separately, we propose robust economic MPC approaches that integrate information which is available about the disturbance directly into the economic framework. In more detail, we develop three concepts which differ in which information about the disturbance is used and how this information is taken into account. Furthermore, we provide a thorough theoretical analysis for each of the three approaches. To this end, we present results on the asymptotic average performance as well as on optimal operating regimes. Optimal operating regimes are closely related to the notion of dissipativity, which is therefore analyzed for the presented concepts. Under suitable assumptions, results on necessity and sufficiency of dissipativity for optimal steady-state operation are established for all three robust economic MPC concepts. A detailed discussion is provided which compares the different performance statements derived for the approaches as well as the respective notions of dissipativity.

minimax approaches to robust model predictive control johan lofberg: Explicit Robust Model Predictive Control and Its Applications Danlei Chu, 2006

minimax approaches to robust model predictive control johan lofberg: Robust & Stochastic Model Predictive Control Qifeng Cheng, 2012 In the thesis, two different model predictive control (MPC) strategies are investigated for linear systems with uncertainty in the presence of constraints: namely robust MPC and stochastic MPC. Firstly, a Youla Parameter is integrated into an efficient robust MPC algorithm. It is demonstrated that even in the constrained cases, the use of the Youla Parameter can desensitize the costs to the effect of uncertainty while not affecting the nominal performance, and hence it strengthens the robustness of the MPC strategy. Since the controller u =

KLQX + c can offer many advantages and is used across the thesis, the work provides two solutions to the problem when the unconstrained nominal LQ-optimal feedback KLQ cannot stabilise the whole class of system models. The work develops two stochastic tube approaches to account for probabilistic constraints. By using a semi closed-loop paradigm, the nominal and the error dynamics are analyzed separately, and this makes it possible to compute the tube scalings offline. First, ellipsoidal tubes are considered. The evolution for the tube scalings is simplified to be affine and using Markov Chain model, the probabilistic tube scalings can be calculated to tighten the constraints on the nominal. The on- line algorithm can be formulated into a quadratic programming (QP) problem and the MPC strategy is closed-loop stable. Following that, a direct way to compute the tube scalings is studied. It makes use of the information on the distribution of the uncertainty explicitly. The tubes do not take a particular shape but are defined implicitly by tightened constraints. This stochastic MPC strategy leads to a non-conservative performance in the sense that the probability of constraint violation can be as large as is allowed. It also ensures the recursive feasibility and closed-loop stability, and is extended to the output feedback case.

minimax approaches to robust model predictive control johan lofberg: Robust Model Predictive Control for Cross-directional Processes Tapio Mäenpää, 2006 Tiivistelmä: Robusti malliprediktiivinen paperiradan poikkisuuntainen säätö.

minimax approaches to robust model predictive control johan lofberg: Strategies in Robust and Stochastic Model Predictive Control Diego Muñoz-Carpintero, 2014

minimax approaches to robust model predictive control johan lofberg: Robustness Aspects of Model Predictive Control David Megías Jiménez, 2000

minimax approaches to robust model predictive control johan lofberg: Model Predictive Control mit MATLAB und Simulink Rainer Dittmar, 2019-12-04 Modellbasierte prädiktive Regelungen dienen der Lösung anspruchsvoller Aufgaben der Mehrgrößenregelung mit Beschränkungen der Stell- und Regelgrößen. Sie werden in der Industrie in vielen Bereichen erfolgreich eingesetzt. Mit der MPC ToolboxTM des Programmsystems MATLAB®/Simulink® steht ein Werkzeug zur Verfügung, das sowohl in der industriellen Praxis als auch an Universitäten und Hochschulen verwendet wird. Das vorliegende Buch gibt eine Übersicht über die Grundideen und Anwendungsvorteile des MPC-Konzepts. Es zeigt, wie mit Hilfe der Toolbox MPC-Regelungen entworfen, eingestellt und simuliert werden können. Ausgewählte Beispiele aus dem Bereich der Verfahrenstechnik demonstrieren mögliche Vorgehensweisen und vertiefen das Verständnis. Das Buch richtet sich an in der Industrie tätige Ingenieure, die MPC-Regelungen planen, entwickeln und betreiben, aber auch an Studierende technischer Fachdisziplinen, die in das Arbeitsgebiet MPC einsteigen wollen. Model Predictive Control (MPC) is used to solve challenging multivariable-constrained control problems. MPC systems are successfully applied in many different branches of industry. The MPC ToolboxTM of MATLAB®/Simulink® provides powerful tools for industrial MPC application, but also for education and research at technical universities. This book gives an overview of the basic ideas and advantages of the MPC concept. It shows how MPC systems can be designed, tuned, and simulated using the MPC Toolbox. Selected process engineering benchmark examples are used to demonstrate typical design approaches and help deepen the understanding of MPC technologies. The book is aimed at engineers in industry interested in the development and application of MPC systems, as well as students of different technical disciplines seeking an introduction into this field.This book gives an overview of the basic ideas and advantages of the MPC concept. It shows how MPC systems can be designed, tuned, and simulated using the MPC Toolbox. Selected process engineering benchmark examples are used to demonstrate typical design approaches and help deepen the understanding of MPC technologies. The book is aimed at engineers in industry interested in the development and application of MPC systems, as well as students of different technical disciplines seeking an introduction into this field.

minimax approaches to robust model predictive control johan lofberg: Learning-based Approximate Model Predictive Control with Guarantees Julian Nubert, 2020

minimax approaches to robust model predictive control johan lofberg: Model Predictive

Control Eduardo F. Camacho, Carlos Bordons, José M. Maestre, 2025-08-10 Model Predictive Control (MPC), the classic textbook for students and practitioners seeking deep understanding of advanced control systems, is now revised, updated and reorganized in a streamlined third edition. The authors, renowned researchers in the field, cover an extensive range of topics that embraces the basic and the advanced, the theoretical and the applied. The book offers advanced undergraduate and graduate students an accessible, step-by-step approach that enables them progressively to grasp and apply the concepts they are studying. For instructors, this is an invaluable curriculum resource packed with examples and case studies. The text features material on: commercial MPC: convolution models, transfer functions, state-space models, and constraints; advanced topics: robust and stochastic MPC and MPC for nonlinear, hybrid, large-scale, and distributed systems; and applications: a series of case studies in solar energy generation, hospital stock control, copper mining and aviation; along with exercises to help readers assess their progress, many with full or partial solutions in a solutions manual downloadable by adopting instructiors. MATLAB® programs to assist with the design aspects of the book and with reproducing some of the examples are included. Model Predictive Control (third edition)'s distinctive strength is its real-world relevance. It is an essential tool for future engineers; its focus on practical implementation, bridging the gap between academic theory and industrial practice and supplemented by exploration of optimization- and algorithm-related aspects of MPC, ensures a holistic treatment of the subject.

minimax approaches to robust model predictive control johan lofberg: Robustness and Stability Analysis of Model Predictive Control Guang Li, Dr Supervisor Lennox, University of Manchester. School of Electric & Electronic Engineering, 2006

Related to minimax approaches to robust model predictive control johan lofberg

Minimax Ustvarjen za podjetnika in računovodjo Minimax je najbolj priljubljen poslovno računovodski program

Podjetniki | Seyfor - Minimax Minimax se lahko poveže z aplikacijami za spletno trgovino, blagajno (POS), fakturiranje in drugimi. Tako ni ročnega prenašanja in imate vedno usklajene podatke

Računovodje | Seyfor - Minimax Minimax vam glede na datum obračuna predlaga prave zneske dnevnic, kilometrine, dohodnine, olajšav, minimalne in povprečne plače Namesto vas poknjiži vse poslovne dogodke v glavno

Minimax podpora | Minimax SI Baza znanja in dogodki Minimax poletna šola BLOG: Od julija 2025 obvezne dodatne DDV evidence E-PRIROČNIK: Kriteriji za odmero letnega dopusta in njegova izraba

Predstavitev | Seyfor - Minimax Brezplačna predstavitev programa Minimax V posnetku boste spoznali prednosti Minimaxa za vaše podjetje ali računovodski servis. Za več informacij nas pokličite na 080 14 50 ali nam pišite

Cenik | Seyfor - Minimax V paketih z izdanimi računi je vključenih 300 računov na organizacijo mesečno. Od 301. računa dalje se vsak račun zaračuna po 0,04 EUR + DDV. V paketih z obračunom plač je vključenih

Kontakt | Seyfor - Minimax Močna podpora Na vsakem koraku vam ob strani stoji zanesljiva podporna ekipa, ki Minimax odlično pozna

Podpora | Seyfor - Minimax Ste razvijalec? Minimax lahko povežete z drugimi programi za izmenjavo podatkov o strankah, artiklih, naročilih, računih, zalogah in drugem

Demo | Seyfor - Minimax DA, Minimax nam ustreza. Prijavite se v Minimax in na vrhu kliknete Naroči program. Podatke iz preizkusnega obdobja lahko ohranite ali izbrišete. Pakete pa po želji spreminjate tudi kasneje

Funkcionalnosti | Seyfor - Minimax Brezplačni preizkus brez obveznosti S hitro registracijo lahko Minimax 30 dni uporabljate povsem brez obveznosti. Preizkusite in se sami prepričajte o njegovi

enostavni uporabi
Minimax Ustvarjen za podjetnika in računovodjo Minimax je najbolj priljubljen poslovno računovodski program
Podjetniki | Seyfor - Minimax Minimax se lahko poveže z aplikacijami za spletno trgovino, blagajno (POS), fakturiranje in drugimi. Tako ni ročnega prenašanja in imate vedno usklajene podatke
Računovodje | Seyfor - Minimax Minimax vam glede na datum obračuna predlaga prave zneske dnevnic, kilometrine, dohodnine, olajšav, minimalne in povprečne plače Namesto vas poknjiži vse poslovne dogodke v glavno
Minimax podpora | Minimax SI Baza znanja in dogodki Minimax poletna šola BLOG: Od julija 2025 obvezne dodatne DDV evidence E-PRIROČNIK: Kriteriji za odmero letnega dopusta in njegova izraba
Predstavitev | Seyfor - Minimax Brezplačna predstavitev programa Minimax V posnetku boste spoznali prednosti Minimaxa za vaše podjetje ali računovodski servis. Za več informacij nas pokličite na 080 14 50 ali nam pišite
Cenik | Seyfor - Minimax V paketih z izdanimi računi je vključenih 300 računov na organizacijo mesečno. Od 301. računa dalje se vsak račun zaračuna po 0,04 EUR + DDV. V paketih z obračunom plač je vključenih
Kontakt | Seyfor - Minimax Močna podpora Na vsakem koraku vam ob strani stoji zanesljiva podporna ekipa, ki Minimax odlično pozna
Podpora | Seyfor - Minimax Ste razvijalec? Minimax lahko povežete z drugimi programi za izmenjavo podatkov o strankah, artiklih, naročilih, računih, zalogah in drugem
Demo | Seyfor - Minimax DA, Minimax nam ustreza. Prijavite se v Minimax in na vrhu kliknete Naroči program. Podatke iz preizkusnega obdobja lahko ohranite ali izbrišete. Pakete pa po želji spreminjate tudi kasneje
Funkcionalnosti | Seyfor - Minimax Brezplačni preizkus brez obveznosti S hitro registracijo lahko Minimax 30 dni uporabljate povsem brez obveznosti. Preizkusite in se sami prepričajte o njegovi enostavni uporabi

Related Articles

- o holy night piano sheet
- skeletal system worksheet with answers
- anne of green gables movie series in order

Back to Home