( 1 )

# Frequency-Weighted Discrete-Time LPV Model Reduction Using Structurally Balanced Truncation

Hossam Seddik Abbas and Herbert Werner

## Abstract:

This paper proposes a method for frequency weighted discrete-time linear parameter-varying (LPV) model reduction with bounded rate of parameter variation, using structurally balanced truncation with a priori (nontight) upper error bounds for each fixed parameter. For systems with both input and output weighting filters, guaranteed stability of the reduced-order model is proved as well as the existence of solutions, provided that the full-order model is stable. A technique based on cone complementarity linearization is proposed to solve the associated linear matrix inequality (LMI) problem. Application to the model of a gantry robot illustrates the effectiveness of the approach. Moreover, a method is proposed to make the reduced order model suitable for practical LPV controller synthesis.

## Keywords:

cone complementarity problem, Discrete-Time LPV System gantry robots, LMI, Structurally balanced Truncation

## Published In:

IEEE Transactions on Control System Technology , Vol. 19, No. 1 , PP. 140-147

( 2 )

# Microcontroller Implementation for DC Motor Speed and Position Control

Mohamed A. Darwish, Hossam S. Abbas, Awad I. Saleh, and Mohamed M. M. Hassan.

## Abstract:

This paper presents the design and experimental implementation of a Fuzzy logic controller (FLC) for a DC servomotor speed and position control. The motivation to utilize the FLC is its robustness against model's parameters inaccuracy and uncertainty. The implementation of the FLC algorithm is carried out by a low cost 8-bit microcontroller instead of using expensive general purpose microprocessors which are commonly employed in practice. This leads to a reasonable hardware cost for such applications. The experimental results in terms of reference tracking and disturbance rejection show high performance with the FLC approach in comparison with PI and PD controllers designed for the same purposes.

## Keywords:

DC motor control, Fuzzy logic controller, Mamdani Type Fuzzy Controller, Microcontroller

## Published In:

Journal of Engineering Sciences, Assiut University , Vol 39 -No 2 , pp 405-423

( 3 )

# Low-complexitylinearparameter-varyingmodelingandcontrol of aroboticmanipulator

Seyed MahdiHashemi , HossamSeddikAbbas , HerbertWerner

## Abstract:

In thispaper,apracticalprocedureforlinearparameter-varying(LPV)modelingandidentificationof a roboticmanipulatorispresented,whichleadstoasuccessfulexperimentalimplementationofan LPV gain-scheduledcontroller.Anonlineardynamicmodelofatwo-degrees-of-freedommanipulator containingallimportanttermsisobtainedandunknownparameterswhicharerequiredtoconstructan LPV modelareidentified.Animportanttoolforobtainingamodelofcomplexitylowenoughtobe suitableforcontrollersynthesisistheprinciple-component-analysis-basedtechniqueofparameterset mapping.Sincetheresultingquasi-LPVmodelhasalargenumberofaffineschedulingparametersanda large overbounding,parametersetmappingisusedtoreduceconservatismandcomplexityin controllerdesignbyfindingtighterparameterregionswithfewerschedulingparameters.Asufficient a posteriori condition isderivedtoassessthestabilityoftheresultingclosed-loopsystem.Toevaluate the applicabilityandefficiencyoftheapproximatedmodel,apolytopicLPVgain-scheduledcontrolleris synthesizedandimplementedexperimentallyonanindustrialrobotforatrajectorytrackingtask.The experimentalresultsillustratethatthedesignedLPVcontrolleroutperformsanindependentjointPD controllerintermsoftrackingperformanceandachievesaslightlybetteraccuracythanamodel-based inverse dynamicscontroller,whilehavingasimplerstructure.Moreover,itisshownthattheLPV controllerismorerobustagainstdynamicparameteruncertainty.

## Keywords:

LPV modeling Parameter setmapping Parameter reduction Gain-scheduled control Robotic manipulator

## Published In:

Control EngineeringPractice , , PP.248-257

( 4 )

# On the State-Space Realization of LPV Input-Output Models: Practical Approaches

Roland Tóth, Hossam Seddik Abbas, and Herbert Werner

## Abstract:

A common problem in the context of linear parameter- varying (LPV) systems is how input-output (IO) models can be efficiently realized in terms of state-space (SS) representations. The problem originates from the fact that in the LPV literature discrete-time identification and modeling of LPV systems is often accomplished via IO model structures. However, to utilize these LPV-IO models for control synthesis, commonly it is required to transform them into an equivalent SS form. In general, such a transformation is complicated due to the phenomenon of dynamic dependence (dependence of the resulting representation on time-shifted versions of the scheduling signal). This conversion problem is revisited and practically applicable approaches are suggested which result in discrete-time SS representations that have only static dependence (dependence on the instantaneous value of the scheduling signal). To circumvent complexity, a criterion is also established to decide when an linear-time invariant (LTI)-type of realization approach can be used without introducing significant approximation error. To reduce the order of the resulting SS realization, an LPV Ho-Kalman-type of model reduction approach is introduced, which, besides its simplicity, is capable of reducing even non-stable plants. The proposed approaches are illustrated by application oriented examples.

## Keywords:

Dynamic dependence, input-output (IO) representation, linear parameter-varying (LPV) systems, model reduction, realization, state-space (SS) representation.

## Published In:

IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY , VOL. 20, NO. 1 , PP.139-153

( 5 )

# DC Motor Position Control Using Discrete-Time Fixed-Order H Controllers

Mohamed A. Darwish, Hossam S. Abbas

## Abstract:

This paper describes the design and experimental implementation of a discrete-time fixed-order H controller for a DC motor position control. Based on grey box modeling, a model of the DC motor is identified. An extension of HIFOO toolbox to discrete-time controller design developed recently is used to synthesize the controller. The performance of the designed controller in comparison with various control strategies is demonstrated. The paper aims at demonstrating simple modeling and control synthesis techniques with the help of available software tools to design low-complexity controllers in terms of design and implementation. Consequently, cheap hardware can be utilized for several applications.

## Keywords:

Discrete-Time H Control, DC Motor Position Control, DC Motor Speed Control, Fixed-Order Controllers, Microcontroller

## Published In:

1st International Conference on Innovative Engineering Systems , ,

( 6 )

# DC Motor Speed and Position Control Using Discrete-Time Fixed-Order H Controllers

Mohamed A. Darwish, Hossam S. Abbas

## Abstract:

This paper describes the design and experimental implementation of a discrete-time fixed-order H controller for a DC motor speed and position control. To provide a model for the DC motor, two system identification techniques are employed. In the first one a model for DC motor speed control is identified in open-loop based on black box modeling whereas in the other one a model for position control is identified in closed-loop based on grey box modeling. An extension of HIFOO toolbox to discrete-time controller design developed recently is used to synthesize the controller. The performance of the designed controller in comparison with various control strategies is demonstrated. The paper aims at demonstrating simple modeling and control synthesis techniques with the help of available software tools to design low-complexity controllers in terms of design and implementation. Consequently, cheap hardware can be utilized for several applications.

## Published In:

IJIM: International Journal on Information Management , Vol. 1, No. 1 , pp. 1 ~ 13

( 7 )

# LPVIOID- A LPV IDENTIFICATION TOOLBOX FOR MATLAB: RECENT AND NOVEL TECHNIQUES

Mustafa Rabeei, Hossam S. Abbas and Mohamed M. Hassan

## Abstract:

In this paper a system identification toolbox for MATLAB is introduced, including a user friendly graphical user interface. The toolbox is appropriate for the identification of systems in discrete-time linear parameter varying (LPV) form. Using LPVIOID1 it is possible to identify input-output models in open-loop and closed-loop settings based on experimental data. It comprises several recent LPV identification techniques. Furthermore, a novel method for identifying unstable plants in closed-loop is proposed. The toolbox is equipped with several tools for model validation. Examples for illustration are included.

## Keywords:

Linear parameter varying systems, system identification, non-linear modelling.

## Published In:

Journal of Engineering Sciences, Assiut University, Faculty of Engineering , 41- 4 , 1637 - 1659

( 8 )

# LPV state-feedback control of acontrol moment gyroscope

Hossam Seddik Abba, Ahsan Ali , Seyed Mahdi Hashemi , Herbert Werner

## Abstract:

This paperpresentsthedesignandsuccessfulexperimentalvalidationofalinearparameter-varying (LPV) controlstrategyforafour-degrees-of-freedomcontrolmomentgyroscope(CMG).TheMIMOplant is highlycoupledandnonlinear.First,alinearizedmodelwithmovingoperatingpointisusedto construct anLPVmodel.Then,agridding-basedLPVstate-feedbackcontrolisdesignedthatclearly outperforms lineartime-invariant(LTI)controllers.Moreover,awayisproposedtoselectpre-filter gains for referenceinputsthatcanbegeneralizedtoalargeclassofmechanicalsystems.Overall,thestrategy allowsasimpleimplementationinreal-timeandmaybeofinterestforapplicationssuchasattitude control ofasatellite.Themethodisappliedtoalaboratoryscale CMG,andexperimentalresultsillustrate that theproposedLPVcontrollerachievesindeedabetterperformanceinamuchwiderrangeof operation thanlinearcontrollersreportedintheliterature

## Keywords:

Gyroscopes Control momentgyroscope Attitude gyros Linear parameter-varyingsystems Linearization H control Gain-scheduled control

## Published In:

Control Engineering Practice , Vol.24 , PP.129137

( 9 )

# Synthesis of LPV Controllers With Low Implementation Complexity Based on a Reduced Parameter Set

Christian Hoffmann, Seyed Mahdi Hashemi, Hossam S. Abbas, and Herbert Werner

## Abstract:

A major difficulty encountered in the application of linear parameter-varying (LPV) control is the complexity of synthesis and implementation when the number of scheduling parameters is large. Often heuristic solutions involve neglecting individual scheduling parameters, such that standard LPV controller synthesis methods become applicable. However, stability and performance guarantees are rendered void, if controller designs based on an approximate model are implemented on the original plant. In this brief, a synthesis method for LPV controllers that achieves reduced implementation complexity is proposed. The method is comprised of first synthesizing an initial controller based on a reduced parameter set. Then closed-loop stability and performance guarantees are recovered with respect to the original plant, which is considered to be accurately modeled. Iteratively solving a nonconvex bilinear matrix inequality may further improve performance. A two-degrees-of-freedom (2-DOF) and three-degrees-of-freedom robotic manipulator is considered as an illustrative example, for which experimental results indicate a good performance for controllers of reduced scheduling order. Furthermore, in the 2-DOF case, controller performance has been significantly improved.

## Keywords:

Terms—Linear fractional transformation (LFT), linear-parameter varying (LPV) control, nonlinear control, parameter-dependent Lyapunov functions, reduced parameter set.

## Published In:

IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY , VOL.22, NO.6 ,

( 10 )

# LPV model development and control of asolution copolymerization reactor

Sandy Rahme, Hossam S. Abbas, Nader Meskin, Roland Tóth, Javad Mohammadpour

## Abstract:

In this paper, linear parameter-varying (LPV) control is considered for a solution copolymerization reactor, which takes into account the time-varying nature of the parameters of the process. The nonlinear model of the process is first converted to an exact LPV model representation in the state-space form that has a large number of scheduling variables and hence is not appropriate for control design purposes due to the complexity of the LPV control synthesis problem. To reduce such complexity, two approaches are proposed in this paper. First, an approximate LPV representation with only one scheduling variable is obtained by means of a parameter set mapping (PSM). The second approach is based on reformulating the nonlinear model so that it provides an LPV model with a fewer number of scheduling parameters but preserves the same input-output behavior. Moreover, in the implementation of the LPV controllers synthesized with the derived models, the unmeasurable scheduling variables are estimated by an extended Kalman filter. Simulation results using the nonlinear model of the copolymerization reactor are provided in order to illustrate the performance of the proposed controllers in reducing the convergence time and the control effort.

## Keywords:

Copolymerization reactor; Linear parameter-varying systems; Parameter set mapping; LPV control; Extended Kalman filter.

## Published In:

Control Engineering Practice , 48 , 98-110

( 11 )

# Model Predictive Control of a Wind Turbine Based on Linear Parameter-Varying Models

Abdelrahman Morsi Hossam S. Abbas Abdelfatah M. Mohamed

## Abstract:

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## Keywords:

NULL

## Published In:

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( 12 )

# CONTROL OF A WIND TURBINE USING MODEL-BASED PREDICTIVE CONTROL

Abdelrahman Morsi Hossam S. Abbas Abdelfatah M. Mohamed

## Abstract:

This paper presents as application of discrete-time model predictive control (MPC) to control a utility scale wind turbine based on linearized models. The main objective of the controller is to allow the wind turbine to extract from the wind a prespecified desired amount of power according to the wind speed during the whole range of operation. A nonlinear model of a 225 kW wind turbine is considered; at each sampling instant, a linearized model of the corresponding operating point is computed and used to obtain the optimal control input by solving an infinite horizon MPC problem. The procedure is repeated in the subsequent samples to control the nonlinear model. This MPC scheme can guarantee the stability of the closed-loop system at the operating point and its neaighborhood and it demonstrates high control performance.

## Keywords:

NULL

## Published In:

The International Conference of Engineering Sciences and Applications , NULL , 262-267

( 13 )

# A Robust MPC for Input-Output LPV Models

Hossam S. Abbas, Roland Toth, Nader Meskin, Javad Mohammadpour and Jurre Hanema

## Abstract:

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## Keywords:

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## Published In:

IEEE Transactions in Automatic Control , Vol. 61, No. 12 , 4183-4188

( 14 )

# Fixed-Structure LPV-IO Controllers: An Implicit Representation Based Approach

Simon Wollnack, Hossam Seddik Abbas, Roland Toth and Herbert Werner

## Abstract:

In this note, novel linear matrix inequality (LMI) analysis conditions for the stability of linear parameter-varying (LPV) systems in input-output (IO) representation form are proposed together with bilinear matrix inequality (BMI) conditions for fixed-structure LPV-IO controller synthesis. Both the LPV-IO plant model and the controller are assumed to depend affinely and statically on the scheduling variables. By using an implicit representation of the plant and the controller interaction, an exact representation of the closed-loop behavior with affine dependence on the scheduling variables is achieved. This representation allows to apply Finsler's Lemma for deriving exact stability as well as exact quadratic performance conditions. A DK-iteration based solution is carried out to synthesize the controller. The main results are illustrated by a numerical example.

## Keywords:

Linear Parameter-Varying; Fixed-Structure; Input-Output.

## Published In:

Automatica , 83 , 282-289

( 15 )

# Wind turbine control based on a modified model predictive control scheme for linear parameter-varying systems

Abdelrahman Morsi , Hossam S. Abbas, Abdelfatah M. Mohamed

## Abstract:

This study presents a successful application of a model predictive control (MPC) design approach based on linear parameter-varying (LPV) models subject to input/output constraints to control a utility-scale wind turbine. The control objectives are to allow the wind turbine to extract from the wind the rated power taking into account the wind speed variation, to reduce mechanical loads and power fluctuations and to guarantee the stability of the system for the whole range of operation. A modified min□max MPC-LPV scheme is proposed to compute online the optimal control input at each sampling instant by solving an optimisation problem subject to linear matrix inequality constraints. To reduce the conservatism of the original MPC scheme due to the overbounding associated with affine parameter-dependence, the full block S-procedure with a linear fractional transformation formulation is used. The performance and the efficiency of the proposed MPC-LPV algorithm is validated via simulation and compared with the original scheme and other conventional controllers.

## Keywords:

NULL

## Published In:

IET Control Theory & Applications , vol. 11, No. 17 , 3056-3068

( 16 )

# Model Predictive Control of a Wind Turbine Based on Linear Parameter-Varying Models

Abdelrahman Morsi, Hossam S. Abbas, Abdelfatah M. Mohamed

## Abstract:

This paper demonstrates the application of a low conservative model predictive control (MPC) scheme based on linear parameter-varying (LPV) models to control a utility scale wind turbine. The main objective of the controller is to allow the wind turbine to extract from the wind a prespecified desired amount of power according to the wind speed and to guarantee the stability of the closed-loop system during the whole range of operation. An LPV representation for a nonlinear model of a 225 KW wind turbine is developed using the Jacobian linearization based technique. A tight parameter set is considered to reduce the conservatism of the LPV model. Then a quasi min-max MPC-LPV algorithm is used to compute online the optimal control input at each sampling instant. The performance and the efficiency of the MPCLPV scheme is validated via simulation and it is compared with another MPC scheme based on linearized models of the system.

## Keywords:

NULL

## Published In:

2015 IEEE Conference on Control Applications (CCA) Part of 2015 IEEE Multi-Conference on Systems and Control , NULL , 318-323



# Fixed-structure LPV-IO controllers: An implicit representation based approach

Wollnack, Simon; Abbas, Hossam Seddik; Tóth, Roland; Werner, Herbert

## Abstract:

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## Keywords:

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## Published In:

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( 18 )

# -Distributed model predictive control of constrained spatially invariant interconnected systems in input-output form

Liu, Qin; Abbas, Hossam S.; Mohammadpour, Javad; Wollnack, Simon; Werner, Herbert

## Abstract:

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## Keywords:

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## Published In:

Proceedings of the American Control Conference , v 2016-July , p 3600-3605



# Linear parameter-varying control of a copolymerization reactor

Abbas, Hossam S.; Rahme, Sandy; Meskin, Nader; Hoffmann, Christian; Tóth, Roland; Mohammadpour, Javad

## Abstract:

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## Keywords:

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## Published In:

IFAC-PapersOnLine , v 48, n 26 , p 200-206



# An LMI-based approach to distributed model predictive control design for spatially-interconnected systems

Liu, Qin; Abbas, Hossam Seddik; Mohammadpour Velni, Javad

## Abstract:

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## Keywords:

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## Published In:

Automatica , v 95 , p 481-487



# Reduced LPV model development and control of a solution copolymerization reactor

Rahme, Sandy; Abbas, Hossam S.; Meskin, Nader; Toth, Roland; Mohammadpour, Javad

## Abstract:

NULL

## Keywords:

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## Published In:

2015 IEEE Conference on Control and Applications, CCA 2015 - Proceedings , NULL , p 1044-1050

( 22 )

# An improved robust model predictive control for linear parameter-varying input-output models

Abbas, H.S.; Hanema, J.; Tóth, R.; Mohammadpour, J.; Meskin, N.

## Abstract:

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## Keywords:

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## Published In:

International Journal of Robust and Nonlinear Control , v 28, n 3 , p 859-880



# Electrical Energy Consumption Forecasting Using Gaussian Process Regression

Morad, Mohammed; Abbas, Hossam S.; Nayel, Mohamed; Elbaset, Adel A.; Galal, A.I.A.

## Abstract:

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## Keywords:

NULL

## Published In:

2018 20th International Middle East Power Systems Conference, MEPCON 2018 - Proceedings , NULL , p 292-297