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Editorial

Special Issue "Model Predictive Control: Algorithms and Applications": Foreword by the Guest Editor

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1. Introduction

Model Predictive Control (MPC) is an advanced control method that makes it possible to effectively control Multiple-Input Multiple-Output (MIMO) processes subject to different types of constraints [1–3]. MPC is not only an active area of research, but also has a great number of applications in different fields, including process control industrial systems, e.g., chemical reactors and distillation towers, and fast embedded systems, e.g., automotive applications and drones. Typically, relatively uncomplicated MPC methods based on linear models are implemented in practice [1,2] but nonlinear MPC approaches that utilise nonlinear process description are increasingly popular [4,5].

The aim of this special issue is to present different aspects of MPC algorithms, in particular new computational schemes, formulation of the underlying MPC optimisation tasks, important algorithms' properties, control quality assessment tools and applications. We hope the published articles will be interesting for researchers and industry practitioners who implement MPC methods.

2. Special Issue

The article *Numerically Efficient Fuzzy MPC Algorithm with Advanced Generation of Prediction—Application to a Chemical Reactor* [6] was written by P.M. Marusak. This contribution stresses that the classical MPC algorithms in which linear models are utilised for prediction may give insufficient control quality for nonlinear processes. Conversely, when a nonlinear model is used, we obtain a nonlinear optimisation task that must be solved online at each sampling instant. A fuzzy MPC algorithm with an advanced computation of the predicted trajectory is proposed in the article. A significant advantage of the algorithm is the fact that the algorithm requires solving relatively simple quadratic optimisation tasks. The same author also authored the second article, *Advanced Construction of the Dynamic Matrix in Numerically Efficient Fuzzy MPC Algorithms* [7]. This work describes a sophisticated approach to the online calculation of the so-called dynamic matrix, which is next used for prediction at each sampling instant. The described approach is utilised in a fuzzy MPC algorithm relying on online model linearisation. In addition, in this case, a quadratic optimisation task is derived. In the two works authored by P.M. Marusak, the proposed MPC solutions give very good control quality, close to that possible in computationally demanding MPC using nonlinear online optimisation. The efficiency of the presented approaches is shown for a chemical reactor with a van de Vusse reaction.

The article *Tuning of Multivariable Model Predictive Control for Industrial Tasks* [8] was written by R. Nebeluk and M. Ławryńczuk. This work presents an approach to tuning parameters of MPC algorithms applied to MIMO dynamical systems. The MPC algorithm has the typical industrial objective, i.e., disturbance compensation. The described tuning procedure is quite simple yet effective. Firstly, the consecutive parameters are found separately and a multicriteria assessment is utilised as a few control quality indicators are taken into account. The effectiveness of the tuning method is demonstrated for a

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multivariable distillation column. The authors consider perfect and imperfect model cases. The obtained results lead to better control quality than the typical approach in which all tuning parameters are constant.

The article *A New Click-Through Rates Prediction Model Based on Deep&Cross Network* [9] was written by G. Huang et al. The authors note that with the development of e-commerce, online advertising thrives and has gradually developed into a new business model. The Click-Through Rates (CTR) prediction is an essential methodology in these conditions. It allows to predict the users' click probability of an online advertisement action. This work is concerned with using deep neural networks in CTR prediction. The authors describe a new prediction methodology based on the Deep&Cross Network (DCN) model. To demonstrate the advantages of their approach, the iPinYou datasets are used. The described model outperforms other state-of-the-art solutions, particularly in terms of generalisation.

The article *The Model Order Reduction Method as an Effective Way to Implement GPC Controller for Multidimensional Objects* [10] was written by S. Plamowski and R.W. Kephart. This work is concerned with implementing the Generalized Predictive Control (GPC) algorithms for MIMO dynamical systems. It is necessary to stress that in the MIMO case, an identification procedure may frequently find a high-order model. Because of that property and the way the model is used in the GPC algorithm, numerical problems are possible. They result from limitations of double-precision floating-point representation. Numerical problems result in poor control quality. The authors describe a practical approach to solve the issue achieved by reducing the model order. For MIMO processes, the article demonstrates and discusses the considered problem and shows the proposed solution's efficiency.

The survey article *Performance Assessment of Predictive Control—A Survey* [11] was written by P.D. Domański. This work starts with a short characterisation of MPC and general control performance assessment approaches, including experiment-based, model-based and data-driven methods. The author brings attention to the fact that assessing MPC control quality requires a suitable, often specific, methodology and comparative indicators. Next, control performance assessment methods designed specifically for MPC are reviewed. In particular, non-Gaussian and fractal methods are emphasised because they are robust against industrial disturbances, allow us to measure control quality and detect wrong MPC tuning or configuration. In addition to providing a rich list of references accompanying the article, the author also points out several important issues collected during many years of industrial practice concerned with advanced process control system design.

The article *Comparison and Interpretation Methods for Predictive Control of Mechanics* [12] was written by T. Sands. This contribution reminds us that the Michel Chasles's theorem allows us to invoke Newton and Euler's equations to fully describe the six degrees of freedom of mechanical motion. For a double-integrator benchmark process, the effectiveness of the following different control strategies are thoroughly compared: the open-loop optimum controller, continuous-time and discrete-time MPC optimum controllers, the Proportional and Derivative (PD) controller derived from an optimisation problem, the feedforward-feedback PD controller and the two-Degrees-of-Freedom (2DOF) controller which consists of the optimal control strategy augmented with feedback errors calculated with optimal states. The controllers are assessed in terms of many indicators, including tracking error and robustness, evaluated using Monte Carlo analysis. Noise and modeling errors are taken into account. The optimal controller achieves the lowest cost (with very poor robustness), while the classical controllers achieve low mean errors and deviations (at the highest cost). Both continuous-time and discrete-time MPC schemes perform well, while the 2DOF controller performs better.

The article *Freeway Traffic Congestion Reduction and Environment Regulation via Model Predictive Control* [13] was written by J. Chen et al. This contribution describes an MPC-based approach based on dynamic multi-objective optimisation for reducing freeway congestion and relieving environment impact. For MPC optimisation, a new dynamic multi-objective optimisation algorithm based on clustering and prediction is introduced. The minimised cost-function measures the time spent, the travel distance, the emissions and the resulting fuel consumption. The optimal solution is used from the Pareto front computed by the optimisation algorithm. To verify the algorithm's performance, simulations of the freeway network in Shanghai are considered. The obtained results indicate that it can effectively alleviate traffic congestion and reduce emissions and fuel consumption compared to the fixed speed limit strategy and the classical MPC approach based on a single optimisation method.

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Short Biography of Authors

Maciej Ławryńczuk was born in Warsaw, Poland, in 1972. He obtained his MSc in 1998, PhD in 2003 and DSc in 2013, in automatic control, from Warsaw University of Technology, Faculty of Electronics and Information Technology. Currently, he is employed at the same university at the Institute of Control and Computation Engineering as a professor (full). He is the author or a co-author of 7 books and more than 190 other publications, including more than 70 journal articles. His research interests include advanced control algorithms, particularly Model Predictive Control (MPC) algorithms, set-point optimisation algorithms, soft computing methods, particularly neural networks, modelling and simulation. Currently, Maciej Ławryńczuk is an associate editor of ISA Transactions (Elsevier), a member of the editorial board of International Journal of Applied Mathematics and Computer Science (De Gruyter), an academic editor of Electronics (MDPI) and Computational Intelligence and Neuroscience (Hindawi) journals.