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EDITORIAL
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Editorial: Linear Parameter Varying Systems Modeling, Identification and Control

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Editorial on the Research Topic

Linear Parameter Varying Systems Modelling, Identification and Control

This Research Topic comprises five articles submitted and selected within "*Linear Parameter Varying Systems Modelling, Identification and Control*." Linear parameter varying (LPV) systems are linear systems whose parameters are functions of a scheduling signal. The scheduling signal may be external or internal. LPV systems with internal scheduling signals are known as quasi-LPV systems.

The LPV concept is derived from the gain scheduling approach to control nonlinear systems. Presently, it is widely used to design control systems for nonlinear systems. Its main advantage is to allow the use of well-known linear control design techniques. Nevertheless, the control design is based on LPV models. LPV modeling may be done by analytical methods, based on the availability of reliable nonlinear equations for the dynamics of the plant, or by experimental methods, entirely based on identification. Thus, LPV system identification emerged with the LPV paradigm. Many real systems in areas such as aeronautics, space, automotive, mechanics, mechatronics, robotics, bioengineering, process control, semiconductor manufacturing, and computing systems, to name a few, can be reasonably described by LPV models. However, despite the theoretical results with great potential produced by intense research activity in recent years, there are still few applications in the real world.

The research on LPV systems covers applications to mechatronics, automotive, aerospace, robotics, advanced manufacturing, chemical processes, biological systems, (renewable) energy systems, and network systems, among others, some discussed in this Research Topic. Both control and estimation problems are addressed.

The article *An Improved Integral Inequality for Delay-Dependent Gain-Scheduled LPV Control* by Tasoujian et al. focused on the design of gain-scheduling controllers for linear parameter varying (LPV) time-delay systems where the delays are also parameter dependent. A Lyapunov–Krasovskii functional (LKF) approach is used to derive delay-dependent LPV control synthesis conditions for LPV systems with arbitrarily varying parameter-dependent time delays. This approach uses intermediary values of delay instead of assuming the worst-case delay value. Hence, fewer conservative conditions were assumed to synthesize delay-dependent dynamic output-feedback controllers for LPV time-delay systems with large and fast-varying time delays. The proposed control guarantees closed-loop stability and induced L2-norm performance measure. The reduced conservatism and improved performance of the proposed approach have been assessed and compared with prior results in the literature through a numerical example and were successfully implemented in a real-world application, consisting of an automated mean arterial blood pressure

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(MAP) control and regulation in hypotensive critical emergency-care situations. The LPV approach made it possible to consider a more comprehensive model of the complex MAP response dynamics. Simulations based on collected animal experiment data and using a nonlinear patient model demonstrate the superiority and effectiveness of the proposed LPV control in achieving desired MAP reference tracking, transient response performance, disturbance rejection, and noise attenuation.

The article *Linear Parameter Varying Path Tracking Control for Over-Actuated Electric Vehicles* by Gimondi et al. proposed a multi-layer LPV path tracking controller for autonomous full electric vehicles with four-wheel drive. The LPV formulation allows the incorporation of tire characteristics, increasing the robustness of the regulator. On the contrary, the multi-layer structure separately manages the steering wheel and the electric motors, permits the exploitation of pre-existing control systems, and maintains a straightforward tuning process. The proposed strategy is compared with a benchmark controller that manages all the actuators in a simulated example. The multi-layer controller performed better. It guaranteed stability and excellent tracking, with small errors on high and low grips, respectively.

The article *Cascade Descriptor Observers: Application to Understanding Sitting Control of Persons Living With Spinal Cord Injury* by Srihi et al. investigated the estimation of non-measurable (unknown) input variables from high-sized nonlinear models and applied them to people living with Spinal Cord Injury (SCI). The unknown variables are the joint torques generated by the exercises designed to teach the SCI patients new motor patterns to stabilize the upper part of the trunk, only through movements of the head and upper limbs. A model called S3S-2D (Seated-3-Segment) has been built to describe the system. This is a planar triple inverted pendulum, represented in the sagittal plane (2D) defined by the trunk, upper arm, and forearm segments. In order to obtain feasible performant solutions, the S3S-2D is decomposed into interconnected systems described by quasi-LPV descriptor forms from where descriptor quasi-LPV observers were derived, whose designs involve much more simplified Linear Matrix Inequalities (LMI) constraints problems. Simulation and real-time experiments compared with the global 2D-S3S observer show the relevance of the proposed approach.

The article *Observer-Based Control of LPV Systems with Input Delay and Saturation and Matched Disturbances via a Generalized Sector Condition* by Salavati et al. studied the problem of the induced L_2-norm control design for input-delay LPV systems with saturation constraints and matched input disturbances. An observer is designed to estimate the input disturbance, and simultaneously, the output-feedback controller is designed to cancel input disturbances and stabilize the input-delay LPV system with saturation. Results are provided in an LMI framework. Then, the problem of blood pressure regulation in patients under hypotension conditions is considered, and the results are implemented to control a simulated patient in the loop.

The article *Conversion from Unstructured LTI Controllers to Observer-Structured Ones for LPV Systems* by Sato and Sebe considered the conversion problem from unstructured Linear Time-Invariant (LTI) controllers to observer-structured LTI controllers, whose structure is similar to but not exactly the same as the so-called Luenberger observer-based controllers, for LPV plant systems. In contrast to Luenberger observer-based controllers, observer-structured LTI controllers can be defined and constructed even if the plant systems are given as LPV systems. Several simulated examples illustrate the effectiveness and usefulness of observer-structured LTI controllers and the proposed conversion parametrization.

Finally, we would like to thank all the authors that contributed to this Research Topic. We trust that the results presented here provide a significant and stimulating overview of the current LPV Research Topics.

AUTHOR CONTRIBUTIONS

PL, FF and JR wrote the Editorial; TA and OS proof read the text.

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