Research interests
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1 Automatic Model Simplification for Continuous and Discontinuous Systems

My major research topic is “Automatic model simplification techniques for continuous and discontinuous systems,” which is also the title of my dissertation. The aim of this research is twofold. On one side, methodologies and automatic techniques are devised to cope with the model complexity frequently encountered in engineering studies, in order to simplify and streamline the model analysis and simulation tasks. On the other side, the focus is set on how to integrate the devised solutions in the toolchain of state-of-the-art modelling and simulation tools [4], focusing particularly – yet in principle not exclusively – on object-oriented ones, in a view to demonstrating the viability and practical usefulness of the mentioned methodological results. Within this research topic, I developed an automatic technique for the structural analysis of complex nonlinear systems [2, 3, 5], so as to provide information to the modeler for a possible partition, aimed at improving simulation efficiency, or for cosimulation techniques [6]. In addition, extension to some model order reduction techniques to the case of switched affine systems are devised, adopting a scenario-based approximation, and proposing novel reset maps providing better quality performance than the ones presented in the literature [1].

References


2 Generation of human walking paths

This research investigates how to identify the way humans plan their trajectory in a goal-directed motion. This research investigates the way humans plan their paths in a goal-directed motion. The
person is viewed as an optimal controller that plans the path minimizing a certain (unknown) cost function. Taking this viewpoint, the problem has been formulated as an inverse optimal control one. The obtained results compared to a set of collected trajectories of human walking, were evaluated with different methodologies, providing a threefold contribution [1]. First, a novel cost function and kinematic model have been proposed. Second, the methodology for the solution of the inverse optimal control has been improved with respect to previous approaches. Last, the performance evaluation has been conducted using a distance different from the typical euclidean one, i.e., the Fréchet distance, providing more accurate results.

References


3 Control-based operating system design

This research topic deals with the application of system- and control-theoretical methods to the design of computer operating system components. It argues that computer operating system components should not be first “designed” and then “endowed with control,” but rather conceived from the outset as controllers, synthesised and assessed in the system-theoretical world of dynamic models, and then realised as control algorithms [4, 2]. Doing so is certainly a significant perspective shift with respect to current practices in operating system design, but the payoff is significant too. In some sense, adopting the suggested attitude means viewing computing systems as cyber-physical ones, where the operating system plays the computational role, the physical elements are the managed resources [5, 3], and the various (control) functionalities to be realised, interact and co-operate as a network. The book [1] includes both a theoretical treatment of the usefulness of the approach, and the description of a complete implementation in the form of Miosix, a microcontroller kernel made available as free software.

References


4 Event-based control

I am also working on event-based control, jointly with my advisor Prof. Alberto Leva, developing a framework for tuning PID controllers in the case of event-based realization of the control system. The strength of the approach is that, by suitably constraining in a coordinated manner the controller discretization and the event triggering rule, stability of the closed loop system can be ensured. Such a sufficient condition, simple to enforce in practice, allows to take standard tuning rules, conceived for continuous-time controllers, and apply them to event-based realizations in a straightforward manner [1].

References


5 Other research topics

5.1 Evolutionary game theory

In the second year I worked on evolutionary game theory, especially dealing with voluntary public goods games, proving that even with milder punishing mechanisms it is possible to achieve qualitatively the same asymptotic behaviors [1].

5.2 Autotuning techniques

In model-based PI/PID tuning regulators, the same set of I/O data and the same tuning rule can produce very different results, depending just on the procedure used to parametrise the process model. The problem is seldom addressed, but extremely relevant for the acceptability of model-based autotuners in the applications. This research investigates methodologies to treat the model parametrisation and regulator tuning phases jointly, so as to circumvent said problem with affordable process stimulation and computational effort [6, 7].

5.3 Control education

I am also interested in different aspects in control education, particularly in the introduction of technological solutions to improve teaching of basic and advanced control theory in academic courses [2, 3].

5.4 Recommender systems

I also worked on recommender systems, i.e., algorithms which goal is to filter information contained in large databases and to recommend to users only the items that are likely of interest to them. In particular, I was involved in the analysis of different algorithms comparing the obtained results with both user-centered performance evaluation indices and statistical ones [4, 5].

References


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