WORKSHOP BY THE DFG SPP 1305 ON

EVENT-BASED CONTROL AND OPTIMIZATION

∼ List of talks ∼

Formation Control: Distance Mismatch and Nonrobust Behavior

Brian D. O. Anderson (ANU)

Suppose a formation shape, in an ambient space dimension of 1,2 or 3, is being controlled through active control of a nominated set of interagent distances. Suppose further that the two agents defining any such distance both try to correct any difference between the actual distance and its desired value. Finally suppose that either there are unequal biases in the measurements of one or more distances by the associated pair of agents, or the two agents have differing views as to what the correct distance should be. It is easy to see that with two agents only, such a situation results in both agents asymptotically moving at the same constant nonzero velocity with, in the second scenario, a spacing between the views held by the two agents as to the correct distance. Much the same happens for a group of agents confined to move on a straight line. The talk will explain that result, and then go on to consider what happens in the case of formations in an ambient two-dimensional and three-dimensional space. The results challenge conventional assumptions in many algorithms based on consensus ideas.

On Event-Based Control Over a Shared Communication System

Rainer Blind (U Stuttgart)

When analyzing networked control systems, where the control loop is closed over a communication system, it is crucial to take the communication system into account. Hence, time-triggered and event-based control of an integrator system with noise over a shared communication system is analyzed. Thereby, analytical models of different communication systems are used and the analysis is focused on the effect of the communication system on the performance, as well as the interaction between control and communication.

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Rolf Findeisen (U Magdeburg)

Game Theoretic Cooperative Energy Management for Smart Microgrids

Masayuki Fujita (Tokyo Institute of Technology)

An early shift of Japanese national energy policy from nuclear power to renewables is now strongly required in Japan. In order to meet the requirement, it is necessary to develop a smart energy management system optimally operating the whole energy networks while ensuring robustness against disasters. A solution to the issue is to form a smart microgrid system, where each community forms a microgrid capable of independent management energy within the grid and the microgrids can be connected to each other via the main power line. Once the system is installed, the resulting network can be changed in real time depending on the situations. Here, we have questions on what is the optimal network formation and on how to reach the optimal network in a cooperative fashion. To answer the questions, we formulate a novel network formation problem and provide its solution based on game theoretic cooperative control techniques. Moreover, we present an energy management system linking this approach to solar radiation forecasting technology and demonstrate its effectiveness through simulation by using real data from weather satellites.

Reference: http://www.senryaku.jst.go.jp/teian/en/top/ryoiki.html#crest

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Optimal event based control of quantized systems

Lars Grüne (U Bayreuth)

In this talk we survey recent results on the numerical computation of an optimal event based feedback control based on a quantization of the state space. Starting from the basic idea of Junge and Osinga using a set oriented discretization and graph theoretic methods, we show how a successive refinement of this approach incorporating an event based control structure and past information can significantly improve stability and performance. Moreover, we sketch our recent research on applying this method to networked systems in a decentralized way and show first numerical simulations for this approach.

The talk is based on joint work with Oliver Junge, Florian Müller and Manuela Sigurani

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Distributed Event-Based Control

Karl H. Johannson (KTH)

Event-based control provides an interesting paradigm for feedback systems with constrained sensor and actuator communication. When several control loops share the same communication medium, however, it is not obvious how to generalize the existing single-input single-output event-based control schemes in the literature. In this talk, we will discuss some recent proposals on how to design distributed event-based control systems. The role played by the communication topology and the amount of shared information between the loops will be emphasized. We will highlight relations to asynchronous distributed computing and network protocols.

Ignorant Centralized Feedback for Weakly Coupled Control Problems

Péter Koltai (TUM)

In this talk we investigate an optimization-based global centralized feedback construction for a control problem with coupled systems. As an intermediate step, we consider regularity properties of the value function encoding the accumulated costs along a trajectory of the system. We seek for regularity for weakly coupled systems, and find that we can not expect to obtain it.

To enforce regularity (and hence computational tractability), the global optimal control problem is split into many coupled problems, each having a desired regularity. The corresponding controllers are "ignorant": they care less about the subsystems they are not affecting directly. Some natural event-based generalizations are discussed as well.

A Class of Distributed Optimization Methods with Event-Triggered and Local Communication

Martin Meinel (TUM)

We present a class of methods for distributed optimization with event-triggered and local communication. To this end, we extend Nesterov's first order scheme to use event-triggered communication in a networked environment. We then apply this approach to generalize the Proximal Center Algorithm (PCA) for separable convex programs by Necoara and Suykens. Our method uses dual decomposition and applies the developed event-triggered version of Nesterov's scheme to update the dual multipliers. The approach is shown to be well suited for solving the active optimal power flow (DC-OPF) problem in parallel with event-triggered and local communication. Numerical results for the IEEE 57 bus and IEEE 118 bus test cases confirm that approximate solutions can be obtained with significantly less communication while satisfying the same accuracy estimates as solutions computed without event-triggered communication.

Resource-Aware Control for Networked Control Systems

Adam Molin (TUM)

An efficient usage of available resources is a substantial requirement for the successful design of networked control systems. Recent results indicate major benefits of event-based control compared to conventional designs, when resources such as communication, energy, and computation, are sparse. This talk addresses aspects of event-triggered control for multiple loops sharing a common resource that go beyond performance issues. In particular, the ability of adaptation of event-triggered schemes is discussed. Such property can be used to implement a distributed price exchange mechanism, where event-triggers adapt their thresholds according to the resource constraints.

Stability Analysis of Interconnected Event-Based Control Loops

Christian Stöcker (U Bochum)

In this talk a new approach for decentralized event-based state-feedback control of interconnected systems is proposed where events are triggered asynchronously. A method for the stability analysis of the event-based control system is presented. A stability criterion is derived using the comparison principle. It is shown that conditions that are sufficient to prove the stability of the continuous control system imply ultimate boundedness of the event-based state feedback loop. The conservatism of the proposed stability test is evaluated for a thermofluid process.

The Bang Bang Funnel Controller

Stephan Trenn (TU Kaiserslautern)

A new controller design is presented which achieves tracking of an unknown reference signal with arbitrary prespecified error bounds for an uncertain nonlinear system with arbitrary known relative degree. These control features are in addition achieved with only two control values and a simple switching logic. In particular, the control action consists only of one bit (ON/OFF or UP/DOWN) and is therefore suitable in a digitally connected feedback loop with limited band width.

Event-Based State Estimation for Networked Control Systems

Sebastian Trimpe (ETH Zürich)

The problem of state estimation in a networked control system with multiple sensor-actuator-agents is considered. The agents are spatially distributed along a dynamic system, and they can share their sensor data over a communication bus. The objective is to maintain an estimate of the full system state on each agent while, at the same time, reducing the exchange of sensory data over the network. This work is inspired by the Balancing Cube, a cube that can balance autonomously on any of its corners through the action of six rotating arms, which constitute the agents of the control network (www.cube.ethz.ch).

An event-based approach is used to address the state estimation problem. The common bus allows each agent to run a copy of a so-called common estimator which operates only on the sensory data that has been broadcast over the network. Hence, its estimate represents the common information in the network. Each agent compares its local measurement against the common estimate of that measurement, and it transmits the measurement only if it is required to meet a certain estimation performance. Two different rules for making the transmit decision in this framework are considered: the first one is based on the difference of the actual measurement to its prediction mean, and the second one is based on the prediction variance. The two methods result in fundamentally different analysis problems.

Experimental results of applying the event-based state estimation technique for feedback control on the Balancing Cube are discussed.

Small-Gain Approaches to Decentralized Event-Triggering

Fabian Wirth (U Würzburg)
