Workshop on Networks and Control – Abstracts

M. Vidyasagar **University of Texas at Dallas**

A new look at an old problem: Partial realization via compressed sensing

The partial realization problem is to determine, from a set of observed samples of the unit pulse response of an unknown system, a model of minimal dynamical order that fits the data. This problem can be formulated as one of minimizing the rank of a Hankel matrix where only some entries are specified, by judiciously choosing the rest. During the past decade, there have been substantial advances made in "compressed sensing," where the central problem is to reconstruct a "low complexity" object from a limited number of measurements. One instance of compressed sensing is the so-called "matrix completion" problem, in which a small fraction of the elements of a low-rank matrix are measured, and these are used to infer the remaining elements. I will formulate the partial realization problem as a matrix completion problem, but with the additional constraint that the unknown matrix has a Hankel structure. Then I will derive necessary and sufficient conditions for a matrix to solve this problem, and conclude by presenting some numerical computations. The theory is still incomplete however, and offers a great deal of scope for control theorists to tackle this old problem using new methods.

Shinji Hara **Chuo University, Japan**

Hierarchically Cooperative Control Towards "Wa" (Harmony)

Harmony is one important new notion to realize smart cities to solve many worldwide crucial social issues such as environment, energy, and transportation. IFAC Japan NMO proposed "Wa (Harmony)" as the theme of IFAC 2023 World Congress to be held in Yokohama, Japan. After a brief explanation of the idea of "Wa", a unified theoretical framework for controlling large-scale networked dynamical systems is introduced. The key is hierarchically cooperative control, where the local agent is controlled in a decentralized way by a proper coordination by the global controller. Several systematic design methods are provided with applications to electric vehicle control to show the effectiveness of the theoretical results.

Timothy Hughes **University of Cambridge**

A generating set for the class of series-parallel minimally reactive bicubic impedances

A thought experiment into the mechanical realization of a general passive suspension behaviour led to the invention of the inerter. Over a decade of research into the "minimal" realization problem has revealed a far more challenging subject than initially anticipated. In this time, considerable progress has been made by Malcolm Smith and co-workers towards a complete understanding of the realization problem for biquadratic impedances. With some notable exceptions, results for bicubic and higher order impedances remain elusive.

In this talk, we consider the class of bicubic impedances realized by series-parallel networks containing 3 reactive elements. We present a set of networks which collectively realize the entire class. Each of the networks contains at most 4 resistors (the least possible number). The implications for the design of passive mechanical networks will be discussed. Finally, we provide a perspective on the challenges involved in extending the results to the minimal realization of higher order impedances.

Yutaka Yamamoto **University of Kyoto**

Tracking beyond the Nyquist frequency in sampled-data systems

Since the advent of the celebrated Shannon theory for signal reconstruction, it has been commonly believed that signal manipulation or control is possible only below the so-called Nyquist frequency. On the other hand, modern sampled-data control made it possible to control intersample behavior with a proper choice of weighting functions. This talk shows that tracking beyond the Nyquist frequency is indeed possible with the multirate technique along with a proper choice of a weighting function. An application to control of hard disk drives is indicated.

Jason Jiang **University of Bristol**

Positive-real functions: regularity, essential regularity, and a structure-immittance format

Interest in classical circuit synthesis has been revived due to the introduction of an ideal mechanical element, the inerter, and its deployment in the racing industry. Since then, research on the potential advantages of inerter-based vibration suppression systems have been growing rapidly. For mechanical structures, minimising the complexity of vibration suppression systems is critically important due to space and weight constraints. This makes it important to synthesize positive-real functions in the most efficient way. The concept of regular and essential-regular positive-real functions were introduced, and have contributed to the minimum realisation of biquadratic and certain class of bicubic functions. Using network synthesis, a wide range of candidate layouts can be analysed systematically. However, there is no control over complexity, topology or element sizes. To this end, a new immittance format, namely the structural immittance, is introduced. This talk will review the concepts of regularity, essential regularity, as well as the structure-immittance format. Their applications in the design of vibration suppression devices will also be demonstrated.

Patrick Dewilde **Technical University of Munich**

Emergent Behavior (an attempt at synthesis between chaos theory and philosophy)

In an attempt to reconcile ideas in system theory, biology and philosophy, the talk presents an approach to philosophy in which chaos and the derived emergent behavior play a central role, together with appropriate elements of logic (based on Gdels incompleteness theorem), semantics seen as emergent with respect to the underlying syntactical structures, evolution and the role intelligence plays in it, again as emergent behavior, and the role the brain plays as receptacle of presumed ‘laws of nature. An argument will be made for the necessity of relativistic ethics to guide the world in its process of continuous evolutionary creation. Selected opposing viewpoints will be briefly discussed as well.

Anders Rantzer **University of Lund**

Adaptive control - What can we learn?

More than thirty years have now passed since the work of Kreisselmeier and Smith on "Stable Adaptive Regulation of Arbitrary nth-Order Plants". We will revisit the topic in the light of recent progress on concentration bounds for random variables.

Michael Chen **Nanjing University of Science and Technology**

Recent advances in inerter and its applications

Inerter, proposed by Professor Malcolm Smith, is a mechanical element genuinely corresponding to a capacitor in the force-current analogy. In his pioneering paper in 2002, Professor Smith proposed three possible applications of inerter, including vehicle suspensions, vibration absorption, and simulated mass, regarding the unique properties of inerter. After 15 years of development, inerter has been applied to various mechanical systems, including vehicle suspensions, train suspensions, dynamic vibration absorbers, buildings, motorcycles, bridges, robots, etc. In this presentation, some representative applications of inerter will be reviewed, in honor of Professor Smiths 60th birthday.

Dick Glover **McLaren**

Three Control Topics at McLaren

Control is a core discipline at McLaren across our Racing, Automotive and Applied Technologies businesses. Three examples are given to highlight the range of problems that we address and the range of solutions that are applied. 1) the evolution of Formula One control systems since the standard ECU was introduced in 2008 and how the technology platform enables fast development of new control laws and fast tuning of the controller; 2) the McLaren driving simulator uses a high bandwidth motion platform which delivers optimised cueing enabling racing drivers to control the car to the limit of performance; and 3) the recently launched McLaren 720S supercar has adaptive suspension with a brand new controller developed in collaboration with Cambridge University.

Glenn Vinnicombe **University of Cambridge**

Engineering robust oscillations in the cell

Cellular processes are dominated by noise, due to small numbers, with precise regulation requiring the integration of many random steps. For example, and under mild assumptions, halving the variance in the population of any species requires increasing the rate of production of intermediate signalling molecules by a factor of sixteen (ie that factor of two, raised to the fourth power). Similar principles constrain the ability of oscillators to keep time. In this talk we will see how, by embracing these principles, it was possible to reengineer the "repressilator", one of the earliest synthetic biology constructs, to achieve oscillations of previously unattainable precision.

Tryphon Georgiou **University of California, Irvine**

Malcolm C. Smith, a third of a century in Systems, Control & Circuits: personal reminiscences and more

Malcolm's leadership in the field of Systems, Control & Circuits extends over a third of a century. His technical contributions include fundamental results on the stabilizability of dynamical systems, the well-posedness of system-models, robustness and optimal control, realizability, and many more, along with the invention of the mechanical capacitor, aka inerter. The talk will revolve around personal reminiscences and is aimed to highlight Malcolm's influence on the speaker and on the field.