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Emerging Control Technologies: What does the Future Hold?

Keynote address

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SUMMARY

There is increasing emphasis today on higher autonomy and intelligence in control systems that is driven by ever more demanding control requirements and fueled primarily by recent significant advances in sensor, actuator, computer and computer network technologies. Distributed control methodologies and coordination of interacting intelligent systems over networks will bring sophisticated control and decision methodologies where the needs are. We are at the dawn of a new era in control and decision systems which has the potential to significantly benefit agriculture. Highly demanding control requirements in production and processing of agricultural products coupled with the complexity and uncertainty of the models require the use of sophisticated control methods. Areas that stand to benefit from the use of advanced methods include the control and management of greenhouses, water resources, energy etc as well as all areas of processing and distributing agricultural products.

Inteligent Autonomous Control Systems: To meet highly demanding control specifications in complex systems a number of methods have been developed that are collectively known as intelligent control methodologies. They enhance and extend traditional control methods. An alternative term used is intelligent autonomous control, which emphasizes the fact that an intelligent controller typically aims to attain higher degrees of autonomy in accomplishing and even setting control goals, rather than stressing the (intelligent) methodology that achieves those goals. Intelligent autonomous controllers are envisioned emulating human mental faculties such as adaptation and learning, planning under large uncertainty, coping with large amounts of data etc in order to effectively control complex processes; and this is the justification for the use of the term intelligent, since these mental faculties are considered to be important attributes of human intelligence; see for example [1-5] and the references therein.

Hybrid Control Systems: The needs of our society are imposing ever increasing demands for efficient intelligent methodologies in control and automation. To rise to the challenge, significant progress in the area of hybrid systems is needed. Hybrid systems arise from the interaction of discrete planning algorithms and continuous processes, and as such, they provide the basic framework and methodology for the analysis and synthesis of autonomous and intelligent systems. Hybrid systems contain two distinct types of

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components, subsystems with continuous dynamics and subsystems with discrete event dynamics, that interact with each other. Such systems are important in a variety of contexts: Hybrid systems frequently arise from computer aided control of continuous processes in manufacturing, communication networks, autopilot design, computer synchronization, traffic control, and industrial process control, for example. Another important way in which hybrid systems arise is from the hierarchical organization of complex control systems. In these systems, a hierarchical organization helps manage complexity and higher levels in the hierarchy require less detailed models (discrete abstractions) of the functioning of the lower levels, necessitating the interaction of discrete and continuous components. Examples of such systems include flexible manufacturing and chemical process control systems, interconnected power systems, intelligent vehicle highway systems, air traffic management systems, computer communication networks. The study of hybrid control systems is essential in designing sequential supervisory controllers for continuous systems, and it is central in designing intelligent control systems with a high degree of autonomy. The investigation of hybrid systems is creating a new and fascinating discipline bridging control engineering, mathematics and computer science; see for example [6-14] and the references therein.

DES and Petri nets: Discrete event systems are of great interest as they are an integral part of intelligent autonomous controllers, but also in their own right as they are important in describing discrete dynamical processes in manufacturing, process control, computer and communication networks, to mention but a few. Approaches to supervisory controller synthesis based on finite automata have existed since the early 1980's. Recently a novel, computationally efficient approach for the design of supervisory controllers has been developed that uses ordinary Petri nets, and their place invariants. Details of the approach may be found in [14-17].

Concluding Remarks: There is significant progress and excitement in the Control and Automation area. Discrete event approaches are increasingly being used, together with conventional controllers, to control more complex systems, better. Hybrid control systems that take fully into consideration the hybrid dynamics are emerging. Advances in hardware and software offer for the first time the ability to implement very ambitious control methodologies. Agricultural production and processing issues present considerable challenges. We hope to address these needs using these merging technologies that aim to introduce higher autonomy and intelligence in systems.

Note: The above summary briefly highlights the main points of the keynote address and provides some references, and so details and the specifics regarding possible application of these methodologies to agriculture are omitted. The ideas presented here are rather new and show a lot of promise. It is hoped that this talk will raise enough interest and motivate researchers to find out more and evaluate these new approaches with respect to their specific problems. Note that there is an extensive list of publications in Intelligent, Hybrid and DES control and the references given here should not be considered as an exhaustive list by any means, as they only represent the primary sources used in the preparation of this keynote address.

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