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KEYNOTE ADDRESS

Towards Autonomous Intelligent Control Systems

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Abstract

Autonomous intelligent control systems are designed to perform well under significant uncertainties in the system and environment for extended periods of time, and they must be able to compensate for system failures without external intervention. Such control systems evolve from conventional control systems by adding intelligent components, and their development requires interdisciplinary research.

In the design of controllers for complex dynamical systems there are needs today that cannot be successfully addressed with the existing conventional control theory. They mainly pertain to the area of uncertainty. Heuristic methods may be needed to tune the parameters of an adaptive control law. New control laws to perform novel control functions should be designed while the system is in operation. Learning from past experience and planning control actions may be necessary. Failure detection and identification is needed. These functions have been performed in the past by human operators. To increase the speed of response, to relieve the operators from mundane tasks, to protect them from hazards, autonomy is desired.

There are several *degrees of autonomy*. A fully autonomous controller should perhaps have the ability to even perform hardware repair, if one of its components fails. Note that conventional fixed feedback controllers can be considered to have a low degree of autonomy since they can only tolerate a restricted class of plant parameter variations and disturbances. A controller with high degree of autonomy can deal with unexpected situations, new control tasks, and failures within limits; it can be considered to be an *enhanced adaptive controller* as it significantly increases the useful *operating range* of the system. To achieve this, high level decision making techniques for reasoning under uncertainty and taking actions must be utilized. These techniques, if used by humans, may be attributed to *intelligent* behavior. Hence, one way to achieve autonomy is to utilize high level decision making techniques, "intelligent" methods, in the autonomous controller. *Autonomy is the objective, and "intelligent" controllers are one way to achieve it.* The field of Artificial Intelligence and Operations Research offer some of the tools to add the higher level decision making abilities.

After some discussion of the history, methods and concepts of conventional Control Systems Theory, certain important issues in Autonomous Intelligent Control Systems modelling, analysis and design will be presented, with emphasis on mathematical modelling. Some recent results in relevant research areas will be summarized.

This Keynote Address is based on several ideas which have appeared and discussed in a number of papers, some of which are listed below. For further information, please consult these and the references therein.

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