Preface

Intelligent Control is presently a well established field within the discipline of Control Systems. It represents a generalization of the concept of control, to include autonomous anthropomorphic interactions of a machine with the environment. It has been successfully represented by a Technical Committee of the EEE Control Systems Society, and the technical results of many researchers in the area are regularly reported in many of the annual conferences in the USA and around the world. The recent appearance in the technical literature of monographs on the subject matter is a strong indication that the area has entered a period of maturity.

However, it was only in 1971, that Saridis made the first attempts to analytically investigate control systems with cognitive capabilities, that could successfully interact with the environment, and Albus presented his Cerebellar Model Articulation Controller, resembling a human behavioral control system. Since then, Intelligent Control, was postulated by Saridis, as the process of autonomous decision making in structured or unstructured environments, based on the interaction of the disciplines of Artificial Intelligence, Operations Research, and Automatic Controls.

The name Intelligent Control was coined by K.S. Fu in 1971, when he was asked to define the area beyond Adaptive and Learning Control. The presentation was part of debate at the time, about the evolution of the Theory of Control Systems. Tracking the chronological development one may go back to the 1940's and 50's where Classical Control was formulated, using frequency domain techniques. In the 1960's, with the discovery of Pontryagin's Maximum Principle, Optimal Control Theoly flourished. Stochastic Optimal Control, was a by-product of this theory, introducing the concept of uncertainty in the design process. In the late 1960's, when structural uncertainties were accepted as part of the systems to be controlled, Adaptive Control was introduced as the methodology to manage systems of higher sophistication. They were using implicit or explicit system identification to provide optimal decision making for the best performance. In the meanwhile considerable progress was made in the behavioral sciences, regarding the collection and use of information about the environment for decision making by humans. It was then only natural to apply behavioral techniques to Control System Theory to improve the performance of a system operating in an uncertain environment. The approach was called Learning Control, and it utilized methods considered as predecessors of the modern Neural Net Theory. Self-Organizing Controls were formalized in the same period, to handle cases of autonomous management of uncertain processes in unfamiliar environments.

The evolution of Control System Theory, followed a trend of increasing autonomy, as was recognized by Antsaklis and Passino in many of their publications. Therefore, a more general definition of control is imperative in order to handle more sophisticated processes which interact with the environment. Here is one such definition: Control is driving a process to attain a prespecified goal.

Intelligent Controls, follow the above definition, in order to manage complex processes in uncertain environments in an anthropomorphic manner, by using cognitive engineering systems and the tremendous power of modern computer technology. Typical examples are modern

Intelligent Robotic Systems. They are usually stratified in three levels with possible multiple substates in each level. Saridis has proposed an analytic formulation of such a system, based on a Principle of Increasing Precision with Decreasing Intelligence. Such a machine is structured in three levels; the Organization level, the Coordinatio)l level, and the Execution level. They follow a hierarchical order of decrease of machine intelligence with an increase of complexity, for most efficient operation. Neural Net, Petri Net, and Optimal Control technologies have been utilized in these three levels, with Entropy as the common measure of performance. Albus et al., developed NASREM, which represents another successful Hierarchical Intelligent Control System that uses a behavioral approach. Several other Intelligent Control methods that are also described in this volume, have various applications, especially to autonomous Robotic Systems.

The present volume is a collection of representative publications on the state of the art of Intelligent, Knowledge-based, Learning and Hierarchical Control Systems, demonstrating a high level of autonomy. It may serve as a reference to the researcher as well as the practitioner who wants to design highly sophisticated control systems that operate in remote, hazardous and unfamiliar environments. The material may be grouped into several categories according to their approach. In the category of Hierarchical or Model-based Architectures one may include the chapters by Antsaklis and Passino, Albus, Zeigler and Chi, and Meystel. In the category of Distributed Intelligence belong the chapters by Acar and Ozguner, and Levis while the chapters by Astrom and Arzen, Passino and Antsaklis, Berenji, Nguyen and Stephanou, Belkin and Stengel, Seetharaman and Valavanis, and Prasad and Davis deal with Knowledge-based Control Systems and their applications. Finally, the chapters by Farrell and Baker, Kokar, and Grant treat the subject of Learning Controls. It is interesting to notice that these chapters cover the whole spectrum from theory to design and applications of Intelligent and Autonomous Control Systems.

Finally, I believe that the editors should be congratulated for their thorough effort of collecting and publishing a comprehensive volume of major contributions in the field of Intelligent Control Systems, an area which is fast growing and is finding many applications in industry, medicine, and space exploration. One looks forward to new additions to the technical literature of the same caliber.

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