Knowledge-based Systems for Industrial Control*

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This book is a compilation of texts presented by a large number of British authors at an IEE Vacation School for engineers from industry and academia held at the University of Strathclyde, U.K. in September 1990.

Artificial intelligence techniques are expected to hold much potential for industrial control systems in the years to come. This is a fascinating and emerging area in which people from many disciplines (control engineering, artificial intelligence, software engineering, knowledge engineering) work together. Various successful applications have already been reported and persons using, and vending, control systems for practical applications in the process industry are interested and attracted by these new techniques. This is mainly because these methods seem to correspond to the daily practice and experience of process engineers and operators.

The attention, though, being paid to these methods by the control theory community is astonishingly low, although the methods seem to be able to solve some of the most difficult problems in control engineering (highly nonlinear systems, systems with large delay times, partly unknown systems).

Until now, the official IFAC Journal Automatica has also given little attention to knowledge-based systems, although various workshops and symposia related to these subjects have been organized.

Therefore, a book such as this, contributing to the field of knowledge-based systems should be very welcome in the control engineering community. What, then, is the reason for the fast proliferation and growing interest in artificial intelligence methods in control engineering?

A number of factors have influenced this:

- Existing control theory methods do match very well to well-defined, preferably linear systems, but have serious limitations for partly unknown and highly nonlinear systems. The introduction of adaptive and robust control methods has enlarged the field of application, but these are still not able to solve some existing control problems and have not narrowed the gap between theory and day-to-day practice which plant engineers and process operators are confronted with.
- The AI community is no longer seeking ultimate solutions for solving general problems, but is now promoting useful products and methods aimed at solving problems arising in narrow fields of application.
- In the process industry, an evolution is occurring towards versatile production facilities, which should be able to react dynamically to changing economical situations by the fast adaptation of product throughput and mix.
- Distributed digital process control systems are becoming part of hierarchical multilayered information systems. Plantwide control solutions are therefore advocated— including many levels of decisions to be taken on tactical, managerial, scheduling, planning, optimization, monitoring and control. The result of this amalgamation of decisions and information is that the system has to cope with many types of information and knowledge. These decisions are based on, for example:
  - First principle physical/chemical models.
  - Elaborated black box models yielded by identification and parameter estimation techniques.
  - Heuristics of various origins gained by experiments.
  - Expertise gained by experienced operators and process engineers.

It is clear that in order to tackle these problems, there is a growing need for new methods and approaches and these should be founded upon existing methods based on system and control theory, and planning and scheduling methods—all of which are mainly based on large statical models.

It seems that, in applying AI techniques in control engineering at present, we have a situation which is similar to that when the first adaptive controllers were introduced in practice without much theoretical background. After many years of research, and a growing number of practical applications, the use of such methods could be justified theoretically.

However, one should not exaggerate the extent of the possible applications of knowledge-based systems and one should not introduce these techniques in cases for which there is no justification—has occurred many times with the introduction of sophisticated control algorithms to problems which could be solved relatively simply by well-known conventional controllers.

With this as a background, we return to the review of the book. This consists of four parts, with 18 individual contributions, referred to as “chapters”. The division is somewhat artificial and, moreover, the editors did not contribute much to make this book more than a compilation of individual contributions. There are contributions which present a survey, others that concentrate on case studies or have a highly commercial content. Some of the contributions are even out of scope.

It is the reviewer’s opinion that the editors should have added a comprehensive introduction, putting the contributions in relationship with each other and some of the authors should have been asked to polish their contributions, and bring uniformity into the definitions.

Moreover, it would have been desirable to start the book with an introductory chapter, giving an overview of the possible applications of AI techniques in control engineering, as suggested below:

- Direct implementation of AI techniques as part of closed-loop control systems. The reviewer refers to this as direct knowledge-based control. Applications can be found using expert systems, fuzzy controllers and neural networks. Relatively little attention is paid to these types of applications in this book.
- Supervisory control. Expert systems or fuzzy control are being used to supervise simple PID-like controllers or more sophisticated controllers, like adaptive or predictive ones. To this class of applications also belong structure and strategy switching, in which the supervisory level determines the structure of a control algorithm, or parameter estimator, or decides which control strategy out