PRESENT APPLICATIONS OF ARTIFICIAL INTELLIGENCE TO ENERGY SYSTEMS

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Contents

Summary

In this chapter, we describe in a general way the existing applications of AI techniques in the field of Energy Systems. After a brief description of the possible applications, of which an analytical list is provided, five areas in which a sizeable number of implemented codes exist are discussed at length, and the individual merits and pitfalls of each class of application are reported on the basis of industry reports. In Section 4, we then suggest some possible future applications, which we deem feasible at the present state of the art of AI techniques.

1. Introduction

The general vision behind the subject of the present chapter is the same that underlies the entire Topic *Artificial Intelligence and Expert Systems in Energy Systems Analysis*: at the present state of technology, designers and energy planners alike have realized that the real possibility exists of freeing technical workers (blue- and white collars alike) from what is perceived as the "drudgery of labor". There is common agreement on the fact that the concrete possibility exists of building machines that perform "human-like" tasks, mimicked and organized after the physical and intellectual activities a human worker would perform on his/her own. Such a vision has of course been widely publicized in science fiction books and movies: what we attempt to describe here is obviously not fiction, but real applied science. The enormous advances in AI techniques and applications in the latest years have been supported and indeed made possible by the ever accelerating pace of the development of modern computational facilities (in this context meant as both hardware and software), which have allowed the allocation of hitherto unforeseen amounts of computer resources (in terms of both CPU and computational speed) to industrial users: this has been the fall-out of a previous scientific work, witnessed by the almost incredible number of high-level publications in theoretical and applied AI work. We are reaching a level at which scientists begin to ask questions like “how intelligent can machines be?”, whereas only few years ago the problem was still open whether “machines could think”. Obviously, there are well-defined limits to the intrinsic ability of a man-made “machine” to “think”, and some of the basic problems are discussed in *Artificial Intelligence and Energy Systems: Scope and Definition*: what is now clear is that some of the analytical qualities of human thinking can be captured by suitable artificial systems. Obviously, machines can (and are expected to) do only specifically defined and highly specialized work, perhaps complex, but definitely limited in scope: the fact is, the complexity of the tasks AI codes can perform is ever increasing, and the limits of their applications are being continuously shifted to “higher” levels. At the same time, the “intelligence” these codes possess is now recognized as a mere mirror and application of its human counterpart: even the most “intelligent” programs are, in fact, only as intelligent as their creators can (and want!) to make them. After an initial euphoric state of affairs, which led to an attitude that “machines can perform all tasks humans can perform”, a more sober view is now gaining ground. The relatively disappointing high number of unfulfilled promises and the inherent difficulties encountered in the transition from “paper paradigms” to “machine shop tools” has led to a present state of affairs in which man has recognized that, while there is in effect no theoretical limit to the amount of knowledge an artificial system may possess, its ability to successfully perform even relatively simple tasks with the flexibility, the non-linearity and the inherent complexity of human mind is substantially limited by a series of factors that include reliability, transparency, ease of access and feedback-control of the outcome. The field is still, if not in its infancy, at least in its adolescence, and some of the excesses and failures of these systems are strikingly similar to the “mistakes” an adolescent makes while learning new and more complex tasks. Our goal here is to report on present applications and outline their merits and limits, and to stimulate researchers and users to “think ahead” and to look for possibilities of enhancing the breadth and the depth of practical applications, with the final goal of improving the resource effectiveness of industrial systems and, in the present context, specifically of energy systems.

2. Possible Applications

In line of principle, there are very few activities in the Engineering field that cannot be performed by an “automated” tool working under the paradigms of Artificial Intelligence (for a better definition both of the meaning of AI and of its tools, see *Artificial Intelligence and Energy Systems: Scope and Definition).* In the specific area of Energy Systems, possible AI applications can be classified as follows:

a) Process Monitoring & Control

- Low level control: intelligent mass- and power control; temperature, pressure and phase composition control;
- Fault detection and alarming; sensors diagnostics;

- Process Diagnosis: implementation of complex control decisions based on flexible, non-deterministic strategies.
- High-level control: access and clarification of information about process parameters;
- Analysis of crucial events;
- On-line decision support; training.

b) Scheduling and Planning

- Production planning, cost accounting (via material and energy accounting); high-level reasoning about process dynamics; handling of conflicting constraints.

c) Fault Diagnostics and Maintenance

- Systematic analysis of equipment- and process status; proper handling of process response to faults; systematic analysis of equipment failures; optimal dynamic load scheduling.

d) Design

- Generation of alternative designs; integration of existing process configurations; comparative analysis of alternative configurations; process optimization.

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Biographical Sketch

Roberto Melli is a Researcher at the Department of Mechanical and Aeronautical Engineering of the University of Roma 1 “La Sapienza” (UDR1), Roma, Italy.

He received a Master in Mechanical Engineering from UDR1 in 1974. From 1974 to 75, he was a Research Assistant at the Chair of Machines in the same University.

As a faculty member he lectures on Machinery and Energy Systems Design in Nuclear Engineering Master level courses.

His research activities are equally divided in two main fields:

1) Energy Systems Simulation and Design

2) Applications of AI-related techniques and procedures to the Design, Synthesis and Optimization of Energy Systems

His publications include more than thirty journal articles (mostly on international refereed Journals in the field of Energy). He published one book on AI applications for the types of NOVA Science, USA.

Within his 24 year diverse management experience, ranging from founder and co-owner of a process engineering consulting firm as a consultant for AGIP S.p.A. and AGIP Petroli designed an all energy (electrical and mechanical) system for Agip Petroli’s new employee recreational facility at its new headquarters in Rome showcasing the effective deployment and use of solar energy. Led a 2 year, 30 person project to design and construct China’s Rural Energy Resources Training Center in Beijing and coached/mentored Chinese counterparts in designing, building and deploying systems to convert renewable energy into usable energy. Produced prototypes and simulation models for training purposes and provided much needed knowledge transfer to the Chinese Government in availability and use of various energy sources.

In recent years he developed an extensive experience in the application and use of expert systems for energy management applications.