Chapter 4
Challenges in the Design of Adoptive, Intelligent and Cognitive Systems

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ABSTRACT

Numerous attempts are being made to develop machines that could act not only autonomously, but also in an increasingly intelligent and cognitive manner. Such cognitive machines ought to be aware of their environments which include not only other machines, but also human beings. Such machines ought to understand the meaning of information in more human-like ways by grounding knowledge in the physical world and in the machines' own goals. The motivation for developing such machines range from self-evidenced practical reasons such as the expense of computer maintenance, to wearable computing in health care, and gaining a better understanding of the cognitive capabilities of the human brain. To achieve such an ambitious goal requires solutions to many problems, ranging from human perception, attention, concept creation, cognition, consciousness, executive processes guided by emotions and value, and symbiotic conversational human-machine interactions. This paper discusses some of the challenges emerging from this new design paradigm, including systemic problems, design issues, teaching the subjects to undergraduate students in electrical and computer engineering programs, research related to design.

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INTRODUCTION

Engineers cause change through their knowledge, skills and professional activities (Koen, 2003; p.11; Eder & Hosnedl, 2008). One of the major roles of engineers is to design, build and test new physical or logical systems that have not existed before. A system is a deliberate arrangement of parts (such as hardware and software components, functional units, subsystems, procedures, or people and facilities) required to achieve a desired goal and specific objectives (e.g., Hollnager & Woods, 2005). Following the scientific method, with its physical and mathematical principles augmented by ergonomics and aesthetics, a system is first specified, then simulated and emulated if necessary, and its different parts (subsystems) are built and put together, tested and installed in an environment for which it was intended. Finally, field testing and operational observations provide feedback for improvements and modifications of the system.

If the system is simple (i.e., linear, with few static non-interacting components), many well-established design techniques can be used. If the system is complex (nonlinear, with interacting components), the design techniques must be much more involved including many heuristics. When the system must involve human operators (not users), even more complex design techniques must be considered. This article describes some of the design challenges brought about by the emerging dynamical systems, as well as intelligent and cognitive machines and systems (Kinsner, 2007a; Kinsner, 2007b). These developments require profound changes to the design process as dictated by the new scientific and engineering principles involved.

ENGINEERING DESIGN

An Engineer

The American College Dictionary and other dictionaries define an engineer as a person who is not only versed in the design, construction and use of machines, but also is capable of employing the innovative and methodological application of scientific knowledge and technology to produce a device, or a system, or a process, all intended to satisfy human needs, subject to technological, economic and environmental constraints.

Similar definitions are provided by the engineering accreditation bodies such as the Canadian Engineering Accreditation Board (CEAB) of Engineers Canada (formerly the Canadian Council of Professional Engineers, CCEP) (CEAB, 2006), and the ABET Engineering Accreditation Commission (formerly the Accreditation Board of Engineering and Technology) in the USA (ABET, 2006).

The definitions stress design and implementation through innovative and methodological application of knowledge (not just of information, or even worse, data). As we shall see, innovation and creativity are of particular importance to the design of intelligent systems. We shall also see that the design process of such systems requires a well synchronized team of engineers and other professional from non-engineering disciplines, rather than an ensemble of isolated individuals. In fact, a concept of the world-class engineer has been developed at academics and industry (Leonhard, 1995, December).

The Engineering Design Process (EDP)

What is an engineering design process (EDP)? The process of developing a product is based on a design philosophy (Koen, 2003) and involves a number of steps that guide the designer from the concept to the implementation and testing in