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An overview of soft computing

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Abstract

Soft computing, as opposed to traditional computing, deals with approximate models and gives solutions to complex real-life problems. Unlike hard computing, soft computing is tolerant of imprecision, uncertainty, partial truth, and approximations. In effect, the role model for soft computing is the human mind. Soft computing is based on techniques such as fuzzy logic, genetic algorithms, artificial neural networks, machine learning, and expert systems. Although soft computing theory and techniques were first introduced in 1980s, it has now become a major research and study area in automatic control engineering. The techniques of soft computing are nowadays being used successfully in many domestic, commercial, and industrial applications. With the advent of the low-cost and very high performance digital processors and the reduction of the cost of memory chips it is clear that the techniques and application areas of soft computing will continue to expand. This paper gives an overview of the current state of soft computing techniques and describes the advantages and disadvantages of soft computing compared to traditional hard computing techniques.

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Keywords: Soft computing; fuzzy logic; genetic algorithms; neural networks; expert system.

1. Introduction

One of the problems in traditional control systems is that complex plants cannot be accurately described by mathematical models, and are therefore difficult to control using such existing methods. Soft computing on the other hand deals with partial truth, uncertainty, and approximation to solve complex problems. Dr Zadeh[1] who is the pioneer of fuzzy logic quoted that “the guiding principle of soft computing is to exploit the tolerance for imprecision, uncertainty, and partial truth to achieve tractability, robustness, low solution cost, better rapport with

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reality". Because of its features such as intelligent control, nonlinear programming, optimization, and decision making support, soft computing has become popular and has drawn research interest from people with different backgrounds, Jang et al[2].

It is becoming difficult to control the growing complexity of modern machinery using traditional control systems techniques. For example, many nonlinear and time-variant plants with large time delays cannot easily be controlled and stabilized using traditional techniques. One of the reasons for this difficulty is the lack of an accurate model that describes the plant. Soft computing is proving to be an efficient way of controlling such complex plants.

Zadeh[3] pointed out that soft computing is not a single method, but instead it is a combination of several methods, such as fuzzy logic, neural networks, and genetic algorithms. All these methods are not competitive, but are complimentary to each other and can be used together to solve a given problem[4]. It can be said that soft computing aims to solve complex problems by exploiting the imprecision and uncertainty in decision making processes.

Fig. 1 shows the conventional and soft computing based problem solution principle as suggested by Gupta and Kulkarni[5]. The left diagram shows the traditional hard computing approach where an exact model of the plant under investigation is available and traditional mathematical methods are used to solve the problem. The right diagram shows soft computing approach where only an approximate model of the plant may be available, and the solution depends upon approximate reasoning techniques.

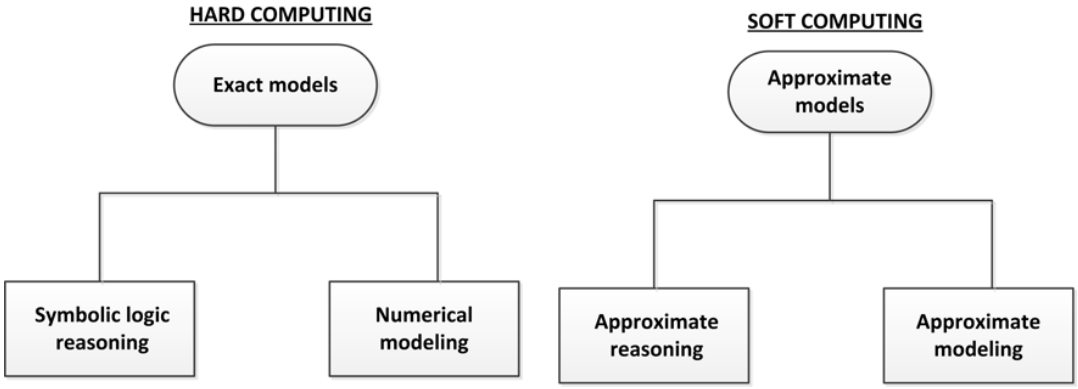

Fig. 1 Problem-solving approach

Fuzzy control has been in use for over two decades to solve complex control problems, Driankov et al[6]. In addition, many instrumentation problems are being solved using fuzzy logic principles as reported by Russo[7].

Neural networks, although a newer concept, have also been used by many people to solve complex automatic control problems, including the demanding servo problems[8].

In addition to solving automatic control problems, soft computing has also been used in diverse applications such as in intelligent speech recognition[9], communications[10], fields of signal processing[11], heavy current systems[12], design and manufacturing[13], pattern recognition[14], and many more applications.

This paper is an overview of soft computing techniques and describes some of the commonly used techniques to solve complex problems with soft computing methods, such as fuzzy logic, neural networks, genetic algorithms, and expert systems.

2. Fuzzy logic

The concept of fuzz logic was introduced by Zadeh[3] as a method for representing human knowledge that is imprecise by nature. Fig. 2 shows the basic configuration of a fuzzy logic system.

The fuzzification interface transforms the crisp input value into a fuzzy linguistic value. The fuzzification is always necessary in a fuzzy logic system since the input values from existing sensors are always crisp numerical values. The inference engine takes the fuzzy input and the fuzzy rule base and generates fuzzy outputs. The fuzzy rule base is in the form of "IF-THEN" rules involving linguistic variables. The last processing element of a fuzzy logic system is the defuzzification which has the task of producing crisp output actions.