Chapter 22
Fuzzy Logic in Healthcare

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ABSTRACT

The medical decision-making process is fuzzy in its nature. The physician handles linguistic concepts in deciding the diagnosis and prognosis. The conversion from this fuzzy nature into crisp real world outcome causes the loss of precision. Fuzzy logic is a suitable way to provide the physician with the support he needs in handling linguistic concepts and get rid of the loss of precision. Fuzzy logic technologies are applied to each area of medicine, and they have been proven to be successful. The literature shows that the medical area has a great compatibility with fuzzy logic technology. Fuzzy cognitive maps, fuzzy expert systems, fuzzy medical image processing, fuzzy applications in information retrieval from medical databases, fuzzy medical data mining, and hybrid fuzzy applications are the common and most known fuzzy logic usage areas in the medical field. This chapter is a descriptive study that examines and explains the common fuzzy logic applications in the medical field after an introduction to fuzzy logic.

INTRODUCTION

Barro & Marín (2002) used the notion of "softness of real world" in their book, meaning the computer applications are "hard" and real world is "soft". "Hardness" means stringency, precision and unexceptional validity of the natural laws through mathematical formulation; "Hardness" use empirical, experimental and quantifiable data, it is targeted on exactness and objectivity, "Softness" is based on conjectures and it relies on qualitative data and analysis (Seising & González, 2012).

Softness means the world is not composed of white and black. There are multi tones of gray in between. Barro & Marín (2002) state that, modelling real world applications in "hard" manner will lead to losing valuable information in the knowledge. Translation from a continuous space into a two-edged Boolean logic causes loss of precision.

The "hammer principle" of Zadeh is a very illustrative example to describe the situation. He says "when the only tool you have is a hammer, everything looks like a nail" (Seising & González, 2012).

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The saying clearly announces you need a tool box to handle different situations. The thing to do is not only to "nail". We have a wide array of context-depending situations to handle, so hard computing is not able to meet all the requirements.

A good example to this "soft real world" application is medical reasoning and decision making. A physician decides on diagnosis or prognosis, in very tough circumstances. In every case, there exist a multitude of possibilities and the information for that process is not sufficient, it is vague and noisy in most of the time. In all conditions, the resultant judgement is subjective and intuitive. Although computers are fast and have a very high capacity in memory, speed etc. compared to a human being, this kind of decision making process is not suitable for computers. It is very clear that computers and computer supported decision making process operate in zero-one, either-or, black-white, cold-hot, available-not available … etc. boolean logic, there is no value or concept in between. This kind of Boolean logic is not suitable for Medical Decision Making process. It has to consider and take into account many values and concepts in between these edge values.

Consider the medical statement "If the back pain is severe, and the patient is old, then apply acupuncture to certain point for a long time". To process this statement in a computer system, we need more than programming skills. All terms we need to model like 'severe', 'old', 'certain point', 'long time', are vague and fuzzy. These states, severe, old, etc., change according to the situation and case. A symptom or a test value may point a severe condition; the same indications may stand for a non-severe or less severe condition in another case, depending on the parameters. As the computer staff forces the medical staff to generalize the concepts into a computer readable and processable form, the resistance of the medical users rise and the success of the computer application falls. This situation arises from the Boolean logic of the computer assistance in decision making process.

Pathologic evaluation is another good example of this stalemate. It is neither a measurement nor a statistical calculation. Pathologic examination has the basic variables: Size, shape, color, borders, crowding of things, spatial relationship of different components etc. These variables are not expressed as numerical values during morphologic interpretation. For example, size as a variable, is expressed like "very small", "small", "medium-sized", "large", "extremely large", "monstrous".

Another point of soft computing requirement in the medical domain is the characteristics of the medical concepts. Medical concepts have an ongoing expanding and evolving nature, in addition, they are highly changeable and imprecise (Kwiatkowska, Michalik, & Kielan, 2012).

The examples of the problems impossible to solve using Boolean logic in medicine can be augmented in number. The solution to this dead end is found by the concept of fuzzy logic. The methods of fuzzy logic are suitable to this kind of endeavour and can lead to algorithms that mirror the non-explicit nature of clinical decision making (Hanson & Marshall, 2001; Steimann, 2001; Helgason & Jobe, 1999).

Healthcare computer applications employ fuzzy logic because of its ability to extend the classical Boolean logic of the computer applications. It connects symbols and concepts, to deal with the semantics of the related domain, it compares, constraints, extends, particularizes etc. concepts, as humans do in reasoning (Barro & Marín, 2002).

Simons & Parker (1995) state that although, most diagnostic clinical reasoning has been modelled on Bayesian analysis, Fuzzy reasoning, provides a much more intuitive way of handling imprecise data, and modelling diagnostic reasoning using fuzzy reasoning may provide a much closer approximation of clinical reality.

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