Chapter 7.32
Fuzzy Logic in Medicine

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ABSTRACT

This article explores the use of fuzzy logic in the medical field. While giving a comparison of classic and fuzzy logic we present the various uses of the applications made possible by fuzzy logic, focusing on diagnosis and treatment. The ever evolving technology making the line between medicine and technology thinner every year, is helping to make the treatment of disease and the mending of injury easier for medical professionals. We also propose several questions that arise from, and may by answered by, fuzzy logic and its applications.

INTRODUCTION

In order to understand the intricacies of fuzzy logic one must build from a thorough understanding of classical logic. A basic component of classic logic is the proposition that a statement can be characterized as either true or false. An example of a proposition is "The country of France contains the Eiffel tower" or "The Eiffel tower is closed on Sundays." In classical logic, propositions are said to be either true or false. Propositions are typically connected using AND, OR, and NOT. On occasion, one might use other connections, but they can all be derived from a combination of these three. The notation used to describe classic logic is called propositional calculus. In most computer programming languages it is common to assign numerical values to the correctness of a proposition where 1 = true and 0 = false. A proposition can either be true or it can be false. It cannot be both at the same time, nor can it simultaneously be neither. Collections of propositions can be transformed to prove truths that might not necessarily be evident on their own. The basic rules of mathematics have been transcribed into propositional calculus and as a result computers are now able to transform a series of propositions into mathematical proofs. Computers are now able to solve proofs in ways never previously conceived.

Fuzzy logic is similar to classical logic in the search for truthfulness of a proposition. Sometimes truth is subjective ill defined. As an example, it is difficult to assign a true or false value to the proposition "Andy is tall" or "Shell is old." How tall does one have to be before being categorized as "tall"? Likewise, how old does one have to be before being considered "old"? Most would agree that 100 years is old for a person but young for a planet. Like many real-world propositions, the concept of age is relative to its usage. To solve these problems there was a need to develop a more robust system of logic. Rather than assigning a proposition as either 0 or 1 the idea of variable truth was added. The variable is measured over the interval of [0, 1]. Fuzzy logic rose from this concept. One major focus of this discipline is in the development of computational models, which can accurately assign fractional values to the level of truthfulness.

Contrary to the name, the goal of fuzzy logic is to create computer programs that can accept input and provide the user a clear answer. The system is defined as "fuzzy" because it is not always evident, given the input parameters, what logic path the system will take to derive a solution. Fuzzy logic systems are frequently used as expert systems. This type of system attempts to emulate a field expert of a specific discipline. Ideally this software-based expert would be able to accept input, process the information, and output clear concise responses. Unfortunately, in emulating the thought processes of such an expert, the expert system must emulate human thought. Human thought is fuzzy in nature complete with uncertainties, ambiguities, and contradictions. Two experts might not place the same level of importance on the same piece of information. Additionally, they might not look at the same information the same way. Should a glass filled 50% be classified as half full or half empty?

Many techniques have been used to create fuzzy logic programs that function as an expert. The earliest systems used conditional statements with tolerance thresholds using if-then-else rules (Jackson, 1999). This approach, while seemingly simplistic, has been used successfully in a wide variety of medical applications including diagnostics and psychological bias (Shortliffe, 1976). Other less known approaches of fuzzy logic systems are association nets and frames, which have proven difficult to implement with only marginal results. The two most common implementations of fuzzy logic are rule-based and neural networks. Both fuzzy implementations have a diverse range of applications including medicine, avionics, security, and machine learning.

Unlike rule-based fuzzy logic, neural nets do not require thinking patterns to be explicitly specified. Typically two data sets are created to program a neural network. The first data set is the trainer. This set of input is passed into the neural network and processed. The processing phase consists of sorting the input values among an array of memory structures call nodes. Each node retains some information and sorts the remaining information between neighboring nodes. Once all the information has been processed it is evaluated and stored as the template for which all other datasets will be compared.

This technique can loosely be compared to the Japanese game Pachinko, also seen in the game show Price is Right as Plinko. The input values are represented by silver balls that are dropped into an arrangement of pins held by a board. Before the balls reach their final stop at the bottom of the board they make contact with many pins, which change the balls direction and velocity. This makes it almost impossible to predict where a ball will end up when dropped. In the real world, chaos prevents the same input from yielding a consistent output. In a computer model, the same input will always produce the same output. So as the computer receives input, these data are feed into a virtual pachinko machine. The first batch of input is called the trainer

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