Presentation of Medical Knowledge by Arden Syntax with Extensions Based on Fuzzy Set Theory

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ABSTRACT

The Arden Syntax for Medical Logic Systems (Arden) is an approach to present medical knowledge by defining rules that include crisp decision logic. Clinical rules based on natural language usually contain uncertainty by way of vagueness which cannot be handled by Arden. Uncertain knowledge can be presented by extending Arden to include concepts of fuzzy set theory.

INTRODUCTION

An Arden knowledge base consists of a set of single Medical Logic Modules (MLMs). The present syntax includes programming language elements such as comparison operators and if-then statements to be used to define the decision logic of an MLM [1].

In contrast to decision rules based on a crisp decision logic, rules based on natural language usually contain vagueness associated with terms such as 'increased', 'sometimes', etc. This linguistic uncertainty can be handled mathematically by applying concepts of fuzzy set theory [2].

METHODS

The Arden Syntax provides basic comparison operators such as 'is equal to', 'is less than', or 'is greater than'. Such comparisons can be described by compatibility functions, which define the relationship between a value and a linguistic term as a degree of compatibility—whether the result of the comparison is false (0) or true (1). An example is shown in Fig. 1 (left): the term 'diastolic blood pressure is increased' can be represented by a crisp comparison $x > x_0$, where x is the diastolic blood pressure and x_0 the threshold, which indicates increased diastolic blood pressure.

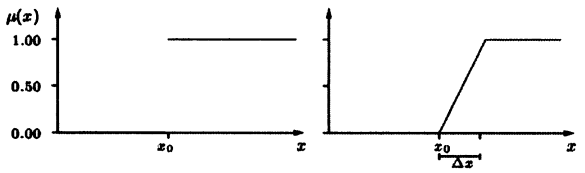

Fig. 1: Comparison 'greater than' based on a crisp definition (left) and on a fuzzy definition (right)

The crisp definition causes an abrupt change in the output value from false to true if the input exceeds the threshold—even by an infinitesimally small amount of x.

To avoid this abrupt change we redefined these operators as fuzzy operators. As shown in Fig. 1 (right), we defined a gradual transition between 'false' and 'true' using one additional parameter, namely Δx. The result of such a fuzzy comparison is closer to intuitive human reasoning than is a crisp comparison.

In addition, the extension can be used to stretch the range of selected data. More complex Arden operations may profit from this stretched range.

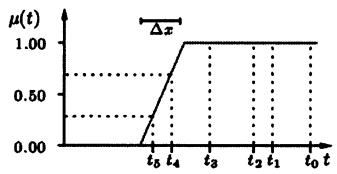

Fig. 2: Selection of data by time

The example in Fig. 2 shows the compatibility of test results obtained at time $t_1,\ldots,t_5$ with a temporal selection criterion anchored at time t_0 (e.g., in the last two weeks). The result of the selection is a set of five values. Two of them are within the stretched range and would not have been considered by a crisp Arden selection, but might now influence the result of the rule. In this case, the result might have a reduced total degree of compatibility, i.e., a reduced degree of truth.

RESULTS

The possible extension of the Arden Syntax by fuzzy theoretic concepts was discussed with the HL7 'Clinical Decision Support' technical committee and was found to be useful. Further steps toward Fuzzy Arden have been initiated. Technically, the necessary syntax extensions, the programming of a Fuzzy Arden compiler, and a new rules engine are under way.

REFERENCES

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1067—5027/01/$5.00