A METHOD OF LEARNING RULES FROM UNCERTAIN DATA APPLIED TO THE COMPUTER VISION PROBLEM

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ABSTRACT

The construction of knowledge-based systems of a size large enough to be useful has led to problems of knowledge acquisition. A way of solving this is to enable the computer to automatically generate its own knowledge from sets of sample data. This becomes further complicated when the sample data may have errors or noise in it.

This paper describes a system that generates knowledge in the form of rules from uncertain data, in the domain of computer vision. The way in which the uncertainty arises and is processed is discussed, and some sample results are presented.

KEYWORDS: machine learning, fuzzy sets, computer vision.

INTRODUCTION

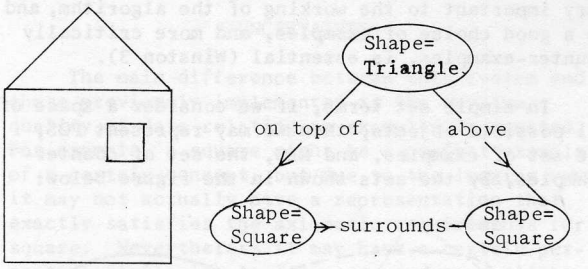
The construction of knowledge-based systems of a size large enough to be useful has led to problems of data acquisition. Expert systems have relied on the interaction between a knowledge engineer and a domain expert to produce a set of rules that capture the expert's knowledge on a particular topic. This process is very time-consuming, and as the size of the knowledge base increases it becomes a limiting factor. In computer vision, this method has the additional problem that the language necessary to represent the rules is not well-defined. The information given to any vision system is usually in the form of pixels, but formulating rules in terms of pixels is computationally expensive and would be difficult for a programmer to understand. A higher-level representation language is required in order to bring down the computation cost and to aid comprehension.

This paper addresses the subject of 'machine learning from examples', or equivalently of automatically generating rules to describe a concept from examples and counter-examples of that concept. Desirable properties of such a generation process are ease of inclusion of additional problem-specific knowledge, and ease of comprehension by a user or programmer. The representation of the examples and rules is hence of primary importance, since to a large extent this will determine the range of situations that can be expressed, and the manipulations it is possible to perform.

The problem of interpreting uncertain data has received considerable attention from people building expert systems, e.g. MYCIN (Shortliffe Buchanan 1), but the problem of learning rules to describe uncertain data has been studied less. In computer vision there is uncertainty due to imperfect image processing and noise. Here this has been modelled by the technique of fuzzy sets.

EXAMPLES AND COUNTER-EXAMPLES

Objects are made up of sub-objects called 'primitives'. The primitives have properties that are called 'attributes', and there are connections between the primitives which are expressed as relations. For the purposes of computer vision, these primitives are the regions, and the attributes may be properties such as shape, size and colour; the relations are 2-D spatial relationships such as 'above' or 'surrounds'. This representation corresponds to a semantic net or graph.



Here shape, size and height are the unary descriptors used and these take values of, for example, shape=triangle, size=medium and height=6. This illustrates the use of two types of unary descriptors:

- nominal descriptors, where the values have names.
- linear descriptors, where the values are numbers.

The two types of unary descriptor are treated in different ways. More restrictions are placed on linear descriptors since it is assumed that