A Fuzzy Classifier Based on Correlation Matrix Memories

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Abstract: - This paper describes a binary neural network classifier that is able to make decisions based on fuzzy relational rule sets. Rule sets are extracted from a training data set and stored in a Correlation Matrix Memory (CMM). Such a classifier has many advantages including suitability for hardware implementations, fast matching, handling of missing or erroneous data and online learning. The main purpose of this paper is to demonstrate the suitability of the AURA library for building CMMs that perform fuzzy operations.

Key-Words: - Fuzzy Classification, Neural Networks, Correlation Matrix Memory, AURA

1 Introduction

Applications that use neural networks for fuzzy classification are well known. Most of these methods use neural networks separately, in order to adjust membership function shapes [1], [2]. There are also some methods that propose artificial neuron designs that are capable of processing fuzzy values [3], [4]. Designs based on classical neural network architectures that perform classification tasks have some disadvantages and limitations. Passing values among layers of processing units can be time consuming during classification, the systems may not be able to represent missing values, and it can be hard to add new relations after the training process is finished.

There have been many methods proposed for learning fuzzy relations from training data sets composed of crisp values [5], [6]. We use two methods for this purpose and compare their effects on the performance of our CMM architecture. The first method was proposed by Jain & Abraham [7]. It uses the mean and standard deviation values of samples of each class. Each new sample is assigned a membership degree to each class based on its similarity to common properties of corresponding classes. This approach allows creation of only one rule per class. The other method we use for generating fuzzy rules is to use NEFCLASS [8].

Our design uses CMM for storing and recalling fuzzy relations. CMM is a single layered neural network that uses binary weights for pattern association. We use the AURA C++ library [9] which provides functions and classes that can be used to implement CMM based applications.

Section 2 describes AURA and the CMM that lies at the heart of our design. Section 3 explains the fuzzy rule extraction methods and more precisely how they are used in our project. Section 4 focuses on the design we propose to be used for fuzzy classification. Section 5 shows results of some parameter tests and provides a comparison with the well known C4.5 decision tree generation algorithm.

2 The Advanced Uncertain Reasoning Architecture

AURA belongs to a group of neural networks that are called Random Access Memory (RAM) based neural networks. A detailed description of RAM based neural networks can be seen in [10]. They are also called weightless neural networks since they do not use real valued weights like most of the classical models. Weights are either 1 or 0, indicating the presence or non-presence of a connection.

AURA has been previously used for reasoning with crisp rules as a rule matcher, which matched crisp antecedent values with crisp consequent values [11]. This architecture required separate CMMs for rules with different arities.

2.1 The Correlation Matrix Memory

A CMM is a single layered network that implements pattern association. Input and output vectors are used to form a matrix, as explained below, and they are associated by setting the weights at corresponding intersection points to 1. This structure provides fast recall because there are no multiple layers of individual processing units. Furthermore time performance is independent of the previous information stored in the CMM, unlike
Table 1: Experimental results and comparisons with the C4.5 method. Results for each method show both the classification success when the same training data is used as test data (shown as Train) and the classification success when the separate test data set is used as test data (Shown as Test).

<table>
<thead>
<tr>
<th>Data Set</th>
<th>Attr. #</th>
<th>Class #</th>
<th>Missing Values</th>
<th>Sample # (Test / Train)</th>
<th>JA Method Test</th>
<th>JA Method Train</th>
<th>NEFCLASS Test</th>
<th>NEFCLASS Train</th>
<th>C4.5 Test</th>
<th>C4.5 Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iris</td>
<td>4</td>
<td>3</td>
<td>No</td>
<td>50 / 100</td>
<td>78%</td>
<td>80%</td>
<td>86%</td>
<td>96%</td>
<td>90%</td>
<td>98%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>8</td>
<td>2</td>
<td>No</td>
<td>200 / 568</td>
<td>64%</td>
<td>68.13%</td>
<td>67%</td>
<td>74.47%</td>
<td>75.0%</td>
<td>79%</td>
</tr>
<tr>
<td>Breast Cancer</td>
<td>9</td>
<td>2</td>
<td>Yes</td>
<td>149 / 550</td>
<td>91.28%</td>
<td>88.36%</td>
<td>92.61%</td>
<td>92.73%</td>
<td>93.3%</td>
<td>98.7%</td>
</tr>
</tbody>
</table>

6 Conclusion

We propose a fuzzy classifier model that uses the AURA model for storing fuzzy relations. We demonstrate that the AURA model can be used successfully for fuzzy inference applications. The architecture shows a promising potential if it is used with a suitable rule learning method. The matching mechanism is also suitable to be used for a fuzzy controller. The learning algorithm needs to be optimized in order to reduce the load of the learning process. Reducing the number of bins to be processed can lead to faster learning.

References:


