Classification of Wooden Boards by Neural Networks and Fuzzy Rules.

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Abstract
Fuzzy-Neural system has been applied to many engineering tasks. Fuzzy neurons in pattern classification are extremely useful because they provide a degree of membership information instead of numerical critic values such as "0" (bad) or "1" (good). This paper shows a neural network application for automatic classification of wooden boards. The basic processing unit consists of two types of generic OR and AND neurons structured in a four layer topology.

1 - Introduction
A conventional pattern recognition system deals with crisp inputs. The pattern is classified (or not) if the features are present (or not). In many applications, these systems do not allow correct pattern recognition. This occurs because the features can be partially present.

For a system to tackle real-life situations in a human-like way, one may incorporate the concept of fuzzy sets into the neural networks [1]. The utility of fuzzy sets lies in their ability to model the uncertain or ambiguous data so often encountered in real life [1].

In a productive process, as pencil manufacture, wooden boards are visually inspected. Workers are properly trained take into account the visual homogeneity for each one. Visual Homogeneity is the wooden fiber distribution, or knots in the board surface, and it results directly the board quality [2][3]. This distribution is visually appraised for manual classification. This feature is used in this work for the automatic classification of wooden boards.

The aim of this paper is to describe a visual inspection system that classifies in an automatic way wooden boards used for the manufacture of pencils using neural networks and fuzzy logic.

2 - Neural networks and fuzzy logic
2.1 - Fuzzy logic
Fuzzy logic allows implementing classification systems with results lying in the range [0, 1], instead of binary results (yes, no). Let X be a space of points with a generic element of X denoted by x. A fuzzy set A in X is defined as:

\[ A = \{ (x, \mu_A(x)) / x \in X \} \]

Where \( \mu_A(x) \) is called the membership function of x in A. The membership function maps each element of X with a continuous membership value between 0 and 1.

2.2 - Fuzzy neurons
I) Maximum Fuzzy Neuron: It realizes the union of two sets A and B [4]. It is called AND neuron, too. This neuron aggregates input signals (membership values) of \( X = [x_1, x_2, \ldots, x_n] \), by first combining them individually with the
By choosing the input features, it was possible to get 87% of right results for A-boards, 53% for C-boards and 91.6% for S-boards. In the productive process these results can be considered sufficient. For pencil production, S-boards are rejected, while A-boards and C-boards are accepted:

<table>
<thead>
<tr>
<th>Boards</th>
<th>right results</th>
<th>wrong results</th>
<th>% right</th>
<th>% errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>A and C</td>
<td>108</td>
<td>14</td>
<td>88.5</td>
<td>11.6</td>
</tr>
<tr>
<td>S</td>
<td>55</td>
<td>5</td>
<td>91.6</td>
<td>8.4</td>
</tr>
<tr>
<td>Total</td>
<td>163</td>
<td>19</td>
<td>89.5</td>
<td>10.5</td>
</tr>
</tbody>
</table>

Table I - Classification result.

The time spent for each board classification was about 0.39 seconds that enables the system to classify 153 (one hundred fifty-three) boards in 1 (one) minute. On our classification system prototype, the performance was limited by the mechanical system.

Nevertheless, on the industrial line production, the system performance is satisfactory.

7 - References