A Predicted Model Established Method for Spinning Yarn Quality in Cotton Mill

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ABSTRACT

Many factors such as production environment, production process and raw material quality have certain influence on various yarn quality indicators. It is very difficult to control and predict accurate of yarn quality indicators. This paper proposed a multi-mode fuzzy inference system method. All the influencing factors parameters used as the input, and the yarn quality indicators as the output that to establish a relationship model between them. If the predicted data can’t satisfy the production requirements, the model needs to be calibrated. Compared this model with the existing methods, the data predicted by this model has some advantages, such as smaller error, higher precision, comprehension, and faster speed.¹

KEYWORDS

Fuzzy Speculation; Model Establishment; Evaluation Model; Calibration Model.

INTRODUCTION

In recent years, people's requirements for quality of life have continued to increase with the advancement of technologies [1][2]. Traditional cotton yarn textile technology can no longer satisfy people's requirements. The production process of cotton yarn textile is complicated and the quality of the product is more influential [3][4]. How to improve product quality in the case of many influencing factors was an urgent problem for all textile enterprises [5][6].

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In the middle of the last century, experts from abroad began to study the relationship between cotton yarn influencing factors and cotton yarn quality. The French A. Babay [7] constructed a cotton yarn hairiness prediction model based on BP neural network, which has higher prediction accuracy. But the input and output parameters were not comprehensive. In 2010, Oguz and Erdem [8] of Turkey constructed a single hidden layer BP neural network model, which has higher prediction accuracy. Haitao Hao [9] used regression analysis and neural networks to predict cotton yarn quality, but the magnitude of the error was uncertain and the algorithm was single. Huijun Li [10] uses the micronaire value of raw cotton as an input parameter to predict the hairiness. The experimental results show that the relative error of the measured values was small but they considered the influencing factors less. Xiang Li [11] uses BP (back-propagation) and RBF (radial basis function) to establish a cotton yarn prediction model, and compared the prediction performance with high accuracy.

DATA PROCESSING

Data processing is first performed to remove data that does not satisfy production requirements. Units of various types of data are not uniform and are normalized for this purpose. Processing the data between [0-1] eliminates the effects of the original indicator units. Normalized formula such as formula (1)

\[ x_i = \frac{x - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}} \]  

Where \( x_i \) represents normalized data; \( x \) represents unprocessed data; \( x_{\text{min}} \) represents the minimum value of unprocessed data; and \( x_{\text{max}} \) represents the maximum value of unprocessed data.

MODELESTABLISHMENT

In this paper, a mapping relationship \( R_T \) from \( U \) to \( V \) can be determined by transforming \( T \) from input vector \( U \) to output vector \( V \). Input \( U = \{u_1, u_2, ..., u_n\} \). Output \( V = \{v_1, v_2, ..., v_m\} \). Then given a mapping matrix \( R_T \) of \( U \) to \( V \). Therefore, a function transformation can be determined as shown as formula (2)

\[ R_T = U \circ V \]  

(2)
Where: \( \circ \) represents the synthesis operator, \( u_i (i = 1, 2, \ldots, n) \) represents the value of each input parameter and \( v_j (j = 1, 2, \ldots, m) \) represents the output.

**EVALUATE MODEL**

Assume \( U = \{u_1, u_2, \ldots, u_n\} \) has \( n \) influencing factors. \( V = \{v_1, v_2, \ldots, v_m\} \) has \( m \) kinds of evaluation results. An assessment made separately \( f(u_i) \) be seen as a model map \( f \) from \( U \) to \( V \) for each factor \( u_i \). A model relationship \( R_f \) of \( U \) to \( V \) can be induced by \( f \). A model linear transformation \( R_t = U \circ V \) from \( U \) to \( V \) can be induced by \( R_f \). The above is the model evaluate. The process as follows:

1. **Evaluation model matrix**: the model establishes a single factor assessment \( \{r_{i1}, r_{i2}, \ldots, r_{in}\} \) for each factor \( u_i \). The model obtains a single factor evaluation matrix \( R = (r_{ij})_{m \times n} \).

2. **Evaluation model**: \( b_j = \sum (a_i r_{ij}) \) \((1 \leq i \leq n, j = 1, 2, \ldots, m)\) is a weighted average model. Model balances all factors. Assume \( c_{ij} (i = 1, 2, \ldots, n; j = 1, 2, \ldots, m) \) represents the value of the \( y \) th output indicator and the \( x \) th input factor. The model evaluation matrix \( R = (r_{ij})_{m \times n} \) is obtained by the formula (3)

\[
    r_{ij} = \frac{c_{ij}}{\sum_{j=1}^{s} c_{ij}}
\]

(3)

3. **Method for determining weight**: the method of determining the weight can be used the frequency statistics method to determine the weight of each factor.

**CALIBRATION MODEL**

Finding the model relationship \( R_f \) from \( U \) to \( V \) induced by the \( T \), the fuzzy relation model established according to the mapping relationship can be obtained by

\[
    \begin{pmatrix}
        \omega_{x1} & \omega_{x2} & \cdots & \omega_{xn} \\
        \vdots & \vdots & \ddots & \vdots \\
        \omega_{x1} & \omega_{x2} & \cdots & \omega_{xn}
    \end{pmatrix}
    \begin{pmatrix}
        r_{1i} & r_{2i} & \cdots & r_{ni} \\
        \vdots & \vdots & \ddots & \vdots \\
        r_{1i} & r_{2i} & \cdots & r_{ni}
    \end{pmatrix}
    =
    \begin{pmatrix}
        y_{11} & y_{12} & \cdots & y_{1m} \\
        \vdots & \vdots & \ddots & \vdots \\
        y_{11} & y_{12} & \cdots & y_{1m}
    \end{pmatrix}
\]

(4)
RESULT ANALYSIS

Figure 1-4 shows the actual value and predicted value of single strength, hairiness, neps and mightiness. The error is within a certain range. The predicted value satisfied the production required of the company. According to the production test of the textile group, the cost is reduced by 25% and the benefit is increased by 20% and the productivity of the enterprise is greatly improved.

CONCLUSIONS

Multi-mode fuzzy inference system model offers a new solution for improving yarn quality and reducing production costs. It has the advantages of small error, high precision, comprehensive consideration, and high speed. It improves the quality and productivity of textile products and reduced the cost of production and enhances the competitiveness of the company's textile products in the international market.
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