Research on Prediction the Development Trend of Weibo Topics Based on Fuzzy Neural Network

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Abstract. The people who use the Weibo application are widely available, and Weibo has the characteristics of instant openness, strong interaction, fast transmission speed and wide influence range. Therefore, predicting the development trend of Weibo topics quickly and accurately is a topic worth studying. In this paper, the total number of posts in a Weibo topic is used as a quantitative indicator of the development the Weibo topic. Fuzzy neural network is used to predict the hot trend of Weibo topic, and the improved annealing algorithm is used to optimize the membership function of the fuzzy neural network and its quantity to improve the prediction accuracy. The superiority of the proposed method is verified by the comparison experiment of the collected Sina Weibo dataset. The method proposed in this paper effectively solves the problem that the parameters in the membership function are complex and easy to fall into the local optimum, which improves the accuracy of the development trend of Weibo public.

1. Introduction

In the new media environment, social emergencies often stimulate the emotional grievances of the Internet, thus affecting the stability of network society. For example, the Weibo app is widely used. Besides, Weibo has the characteristics of instant openness, strong interaction, fast transmission speed and wide influence range. Therefore, it is of great significance and value to predict the hot topic of Weibo public opinion.

In this paper, a fuzzy neural network based method is proposed for the Weibo public opinion trend prediction method, and the simulated annealing algorithm is used to optimize the parameters of the fuzzy neural network. The simulated annealing algorithm has a good performance in terms of global optimization and convergence speed. Fuzzy neural networks have great advantages in dealing with complex problems such as nonlinearity and fuzziness. The fuzzy neural network can effectively exert the performance of the fuzzy neural network by the fusion with the simulated annealing algorithm, and effectively solve the problem that the slow convergence rate and easy to fall into the local optimum in the Weibo public opinion prediction. Thereby, the Weibo public opinion trend can be more accurately predicted.

2. Prediction Model of Development Weibo Topic

The number of blog posts on Weibo topics can reflect the influence of various factors on topic trends, and it is also the most intuitive expression of the topic of Weibo. Therefore, the total number of blog posts on Weibo topics is set as a measure of development of the topic. The Weibo topic development trend forecasting framework is shown in the figure 1. In this paper, the annealing simulation optimization algorithm is used to optimize the parameters of fuzzy neural network, and the prediction model of Weibo topic development trend is constructed. The number of blog posts on the topic of Weibo
in the unit time period are used as the input of the fuzzy neural network to predict the trend of the Weibo topic.

![Weibo topic development trend forecasting framework](image)

**Figure 1.** Weibo topic development trend forecasting framework

2.1. **Simulated Annealing Algorithm**

In thermodynamics, the annealing phenomenon refers to the physical phenomenon that the object gradually cools down. The lower the temperature, the lower the energy state of the object; when it is low enough, the liquid begins to condense and crystallize, and in the crystalline state, the energy state of the system is the lowest. When nature cools down slowly, it can “find” the lowest energy state, i.e., crystallization. However, if the process is too fast, rapid cooling will result in an amorphous shape that is not the lowest energy state. First, the object is in an amorphous state, the solid is warmed to a sufficiently high temperature, and then allowed to cool slowly, and then annealed. Then, the internal particles of the solid become disordered with the temperature rise when it is heating, and the internal energy increases, while the particles gradually become orderly when cooling slowly, reaching an equilibrium state at each temperature. Finally, the ground state is reached at normal temperature, and the internal energy is reduced to the minimum. At this time, the object appears in a crystal form. Simulated annealing is a greedy algorithm, but its search process introduces random factors. The simulated annealing algorithm accepts a solution that is worse than the current solution with a certain probability, so it is possible to jump out of this local optimal solution to reach the global optimal solution.

The traditional simulated annealing algorithm is as follows: Set the objective function as $y = f(x)$.

1. **Step1:** Selected initial control temperature $T_0$, Markov chain length $L_0$, randomly select an initial solution $i_0$ in the feasible solution space, the Optimal solution $i = i_0$. Number of iterations $k=0$, control parameter attenuation function $T_k = h(k)$:
   - Get a new solution in the feasible solution space through random perturbation;
   - Determine whether to accept the new solution, the criterion is Metropolis:
     - (i) if $f(i) \geq f(j)$, then accept the new solution $j$, the best solution $i = j$,
     - (ii) if $f(i) < f(j)$, then accept new solutions according to probability, that is $\exp\left(\frac{f(i) - f(j)}{T_k}\right) > \text{random}[0,1]$. Then accept the new solution $j$, the best solution $i = j$. Else, reject $j$, the best solution...
\( i = i; \)

Step4: Repeat step 2 and step 3 to obtain an optimal solution under the Markov process;

Step5: Judge whether the stopping criterion is satisfied, if the optimal solution is output, the algorithm stops, otherwise step 6 is performed;

Step6: The number of iterations is \( k = k + 1 \), the optimal solution is updated to the solution obtained by step4, the temperature function becomes \( T_{k+1} \), and the length of the Markov chain becomes \( L_{k+1} \), returning to step 2.

2.2. Fuzzy Neural Network

Fuzzy Neural Network (FNN) combines fuzzy systems and neural networks. The fuzzy neural network fully considers the complementarity of them, and integrates logical reasoning, language calculation and nonlinear dynamics. It has the functions of learning, association, recognition, self-adaptation and fuzzy information processing.

The essence of FNN is to input the conventional neural network into the fuzzy input signal and the fuzzy weight. In the fuzzy neural network, the input and output nodes of the neural network are used to represent the input and output signals of the fuzzy system. The implicit nodes of the neural network are used to represent the membership function and the fuzzy rules, and the parallel processing capability of the neural network is used to make the fuzzy system The ability to reason is greatly improved. The FNN contains 5 layers, as shown in figure 2.

Layer1: Input layer, the number of nodes is the number of input variables.

Layer2: Fuzzy layer is the membership function layer of the input variable, which realizes the fuzzification of the input variables. \( c_{ij} \) and \( \sigma_{ij} \) are the center and width of the membership function. This paper uses the Gaussian membership function:

\[
\mu_i^j = e^{-[(x_i-c_{ij})/\sigma_{ij}]^2} \quad (i=1,2,\ldots,n; \ j=1,2,\ldots)
\]  

Layer3: The fuzzy inference layer, the number of nodes in the layer is the number of fuzzy rules. It is used to calculate the excitation intensity \( a_i \) of the current input for each rule, and the calculation formula is

\[
a_i = \Pi \mu_i^j
\]

Layer4: The normalization layer normalizes the excitation strength of each rule in the fuzzy rule layer, and the number of nodes is the same as the fuzzy inference layer. The normalization formula is:

\[
\bar{a}_j = a_j / \sum_{i=1}^{m} a_j
\]

Layer5: The output layer outputs the final reasoning value of the neural network model. \( P_j \) is a weight coefficient.

\[
\hat{Y} = \sum_{j=1}^{m} P_j \bar{a}_j
\]
2.3. Annealing Simulation Algorithm Optimization Fuzzy Neural Network Model

The selection of the membership function, the parameters of the membership function and the weight coefficient, which need to be optimized in the fuzzy neural network model. There are many traditional parameter optimization methods such as least squares and gradient descent. The working flow chart is shown in figure 3.

Figure 2. The structure of Fuzzy neural network
Figure 3. The SA algorithm for fuzzy neural network optimization

Initialization. The structure of the fuzzy neural network is determined by the input samples of the fuzzy neural network. Initialize the SA algorithm parameters, including initial temperature $T_0$, Markov connection length $L_0$, randomly generated initial solution $i_0$, number of iterations $k$.

After inputting the sample data into the fuzzy neural network, the MSE (mean square error) of the training result and the expected output is used as the objective function value. The formula is $\sum_{i} i_{i} i_{i}$. The new solution is generated by random perturbation of the current solution.

Update the optimal solution.

Simulated annealing operation, update temperature.

The SA algorithm is used to optimize the parameters of the fuzzy neural network, and the fuzzy neural network is evaluated. The optimized SA algorithm is substituted into the fuzzy neural network for training. The MSE (mean square error) of the fuzzy neural network is calculated to determine whether the network structure is optimal. When the MSE satisfies the condition, the optimization process is stopped. Otherwise go to process 2 to continue the iteration.

Obtain predictions. The test sample is input to complete the test based on the SA algorithm to optimize the fuzzy neural network model, and the prediction result is output.

3. Experimental Analysis

In this paper, the Matlab 2014a tool for experiments. The prediction model uses the Absolute Percentage Error (APE, also called Relative Error) as the evaluation index of the experimental results, the formula is as follows. The smaller the APE value, the more effective the model is. In this paper, the fuzzy neural network algorithm and the simulated annealing algorithm-optimized fuzzy neural network algorithm are used to predict the number of blog posts on the Weibo topic, and the effectiveness of the proposed method is verified by comparison.
3.1. Data Set
The experimental data is derived from Sina Weibo. Taking the topics of "World Cup" as an example, and collect the number of blog posts for 31 days. Taking the time series data of the total number of blog posts on the topics as experimental data, a total of 26 sets of data were used as the training set and prediction set of the model. The number of blog posts in the previous 5 days was used as the input of the fuzzy neural network. The number of blog posts on the 6th day was used as the output, and the data was arranged in a rolling manner to form an experimental data set. Taking one day as a time unit, the development trend of the total number of blog posts is shown in the figure 4.

![Figure 4: The blog post development trend of “Word Cup”](image)

3.2. Experimental Design and Parameter Setting
The data is normalized before the trend of the number of posts on the Weibo topic is predicted. According to the above theoretical basis, the network structure of this experimental prediction model is constructed. The first input layer of the fuzzy neural network model has five inputs, and the node is 5; The number of nodes in the second layer of the fuzzification layer is the sum of the number of fuzzy gradings for each variable, and is set to 9 in this paper; The number of nodes in the third layer of fuzzy layer is equal to the number of fuzzy rules, and each node sets a fuzzy rule, and the number of nodes in the layer is 9; The fourth layer of anti-fuzzification layer, the number of nodes is the same as the number of nodes of the third layer, which is 9; The fifth layer output layer has an output and the node is 1. Therefore, the fuzzy neural network topology of this paper is 5-9-9-9-1.

The simulated annealing algorithm is initialized according to the structure of the fuzzy neural network. The parameters $c_{ij}$, $\sigma_{ij}$ and $p_j$ which need to be optimized in the fuzzy neural network are used as the solution structure of the simulated annealing algorithm. According to experience, the initial temperature is set to 90, the end temperature is 1, Markov chain length is set to 800, and the maximum number of the FNN iteration is set to 2000.

3.3. Experimental Results and Analysis
Predicted samples under the topic are predicted using standard fuzzy neural network algorithm and improved fuzzy neural network algorithm respectively. Figure 5~6 is a comparison of the prediction results of different models of the topic.
Figure 5. Comparison of prediction results

According to the experimental results, it can be clearly seen that the parameter method of fuzzy neural network optimized by annealing simulation algorithm has better fitting effect than the standard fuzzy neural network. The results show that the proposed optimization method can overcome the shortcomings of the standard fuzzy neural network algorithm which is easy to fall into local optimum and result instability.

4. Summary
In this paper, the method of simulating fuzzy neural network parameters based on simulated annealing algorithm is used to construct a predictive model for the development trend of Weibo topics. Taking the number of blog that can comprehensively reflect the popularity of the Weibo topic as the model index. Selecting the number of blog posts for five consecutive days to form the time series data of the public opinion prediction model experiment, as the input of the public opinion prediction model, and the number of blog posts on the sixth day is used as the output. Experiments show that the proposed method
outperforms the standard fuzzy neural network learning method and improves the accuracy of Weibo public opinion development prediction. It has helped the relevant departments to control and guide the Weibo public opinion.

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