Worsted spinning process parameters inversion based on a mixed population genetic-ANN algorithm

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Abstract. Demand diversity and individuation, make the textile production process is complicated. To solve the problem of worsted spinning process parameters inversion accuracy, the hybrid population genetic neural network algorithm is presented in this paper(mixed population based - artificial neural network, MPG - ANN), MPG - ANN's advantage lies in three distinct advantages. First, itimprove the premature problem of traditional genetic algorithm.Second, predict generalization performance is enhanced and the inversion model. Third, the results of the calculation of stability was improved. Based on the quality index of yarn CV value of worsted spinning the key process parameters for inversion in the process of production, and compared with traditional genetic algorithm is applied to the inversion results, verify the feasibility and effectiveness of MPG - ANN algorithm, the inversion accuracy of 97%, the method not only has an important guiding role in the textile production process quality control, but also has a very good reference for enterprises rapid process development of new product design decision.

Introduction

Textile production is a complex multi-stage process, in order to effectively and reasonably for machining quality prediction and control, many experts and scholars uses intelligent algorithms to build modelsand achieved good results[1-4]. Production quality prediction is obtains the machining quality of the products by raw material and equipment process parameters in advance to ensure product quality and shorten the production cycle. Relative to the predicted, the so-called inverse problem, is to consider the quality of processed products, for selected raw materials and main technological parameters have a preliminary selection and design to enhance process development of targeted, reducing production cost.

Forward modeling of textile production process can be expressed as a nonlinear function of the model parameters, thus the inversion can also be classified as non-linear optimization problems. Thorough search is the most simple and direct method among all nonlinear inversionmethods [5], The advantage of this method is that as long as there are to meet the conditions of the solution, then we will be able to search the solutions, but in fact in the calculation in order to achieve the complete search is not possible, the work of computer cannot be completed, therefore it is necessary to find an effective algorithm for inversion. In recent years, GA algorithm, BP artificial neural network algorithm for global optimization has become a research hotspot in the field of domestic and foreign inversion [6-9]. The literature of [10] with direct approximation method, combining remote sensing and cotton model, established the remote sensing - cotton inversion model, with the initial data and parameters to the inversion model of cotton required, experimental verification of the model is feasible. The literature of [11] by genetic algorithm (GA) of the artificial neural network (ANN) prediction and inversion model weights and threshold optimization, set up fine wool textile virtual machining system, to achieve the regulation of quality prediction and control of process parameters, the dynamic process in the production process.

Traditional parameter inversion algorithm convergence and stability is not ideal, the inversion problems such as low precision and computing speed slow (16-19), and the standard genetic algorithmshortcomings such as premature convergence, this paper proposes a mixed population

based algorithmto optimize the BP neural network weights and threshold to forward genetic neural network model is established, and on this basis, according to the yarn CV value to establish the mixed population genetic algorithm inversion model, used for inversion of production process input parameters. The results show that the use of mixed populations combined genetic algorithm and neural network algorithm, in the textile process parameters inversion problem has obvious superiority, makes the forecast model and the inversion model of stability and convergence rate remained at a high level, to provide reliable theoretical basis for textile process parameters adjustment.

Worsted spinning inversion algorithm design

Basic steps inversion algorithm

(1) based on discrete coefficient of fiber diameter (discrete coefficient), wool top oil content, roving twist factor, tops of moisture regain, fiber length (hao specialty degree LH), spindle speed, spinning draft) (average diameter, yarn, fiber diameter wire coil weight, fiber quality irregularity conditions. Combined with hybrid population genetic algorithm neural network algorithm to establish the prediction model for initial yarn CV value.

(2) according to establish a good initial spun yarn CV value prediction of prediction model, calculate the root mean square error of the actual data and calculated data, whether it meets the good accuracy requirement, if meet the accuracy requirements the iteration is terminated, or iteration until accuracy meets the requirements.

(3) based on the current forward model, through the mixed population genetic algorithm to construct the inversion model, reach the iteration calculation of inverse problem.

(4) to CV value measured data and forecast data of the poor as objective function, the new model on the basis of the performance parameters you need.

(5) for all eligible inversion data, calculate the CV value according to the forward model data, the objective function value is obtained, and then selected the best inversion parameters.

MPG algorithm inversion

The gene encoding the mechanical parameters

Coding method not only influences chromosomal arrangement, also decided the individual from the search space of genotype to phenotype transformation decoding solution space. For the problem of textile parameters inversion such, real code simply cannot be discrete coding sequence and continuous particle position corresponding up, in order to facilitate the parameter inversion description and genetic operation, this paper proposes to use a binary number with the real combination method to encode the particle.

Particle code consists of two parts, as shown in Figure 3, the left part of the A, B, C, ⋯ by composition between total n, whose number is equal to the inversion parameters, the numerical representation parameters inversion position. The right part of the Gray mode coding, A, B, C..... Composed of random number 0 or 1, every parameter inversion from the binary encoded eight bit representation, let M= [A, B, C,⋯], length (M) =8*n.

$$\underbrace{a, b, c, \cdots\cdots}_{n}, \underbrace{A, B, C, \cdots\cdots}_{8*m}$$

Figure 3 particle coding structure

The generation of mixed population

In the mixed population initialization process, the chromosomes of each population on the left part determined by the actual parameters of the inversion, a = 2, if any, b = 5, said need to inversion of wool top resurgence and the fiber length, once established, populations. A, b value will not change in the process of iteration;The right part number varies with the inversion parameters, if the number is 2, the mechanical parameters are randomly generated within a certain scope 1 row 16 columns of 0, 1, numerical matrix to initialize the population.

Selection

Undertake choosing according to the calculated results for the fitness of individual operations. First calculate each all the individuals in the population fitness value, then each individual in the

population according to the fitness from big to small, Assume that each individual fitness is $f_k(k = 1,2,\cdots l)$, the total population fitness for the $\sum_i^1 f_k$, will be the proportion of $f_k/\sum_i^1 f_k$.as the k individual choice probability. Through the choice of operation makes the individual fitness values are close to the optimal solution.

Crossover and mutation

Crossover and mutation is an effective method to form a new individual, its advantage is to avoid the loss of part information, the maximum guarantee the effectiveness of the genetic algorithm. Inversion algorithm of using crossover and mutation operators are algorithm part of the same operation, the difference in chromosome encoding.

Examples of application

To a company in the worsted wool top oil content and inversion of spinning draft as an example to demonstrate the implementation of this algorithm. First yarn yarn CV value of the forward model is established, in which input parameters for discrete coefficient of fiber diameter (discrete coefficient), wool top oil content, fiber quality irregularity, roving twist factor, tops of moisture regain, fiber length (hao specialty degree LH), spindle speed, weight, yarn spinning draft traveller, fiber diameter (average diameter). The output parameter for yarn CV value, a company known spun yarn production data as shown in table 1, selection of sample number 1 ~ 60 as the training data set, sample no. 61 ~ 65 as forecast model testing data set. The remaining 10 groups as inversion test data set.

Yarn CV value prediction model training

Using Matlab software to write programs, the neural network predictive model algorithm parameters setting: m = 10, input neurons and output neurons number n = 1, the number of hidden layer neurons according to the type (1) set to 7, steeped training function, function tansig hidden layer and output layer function purelin, hybrid population genetic algorithm related parameter is set to: populations MP = 20, each species contains the number of individual ID = 40, evolution algebra maxgen = 100. The first use of ` has given data samples of MPG - ANN prediction model training, the fitness function iteration curve is shown in figure 1. To compare the MPG - ANN prediction model has better prediction performance, and the fitness function value iteration of SGA curve. As shown in figure 2.

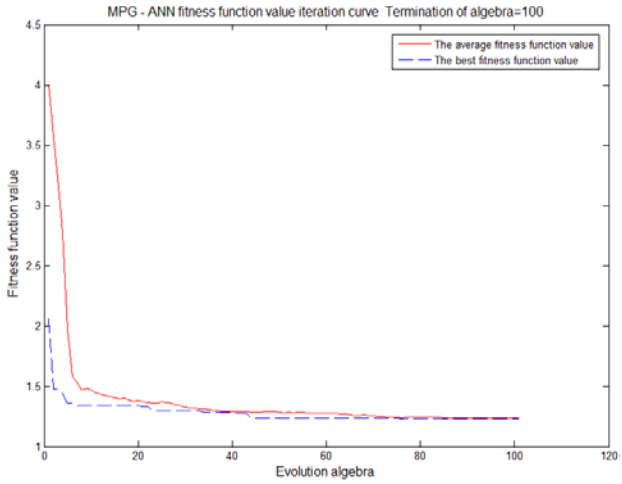

Fig. 1 MPG - ANN fitness function value iteration curve

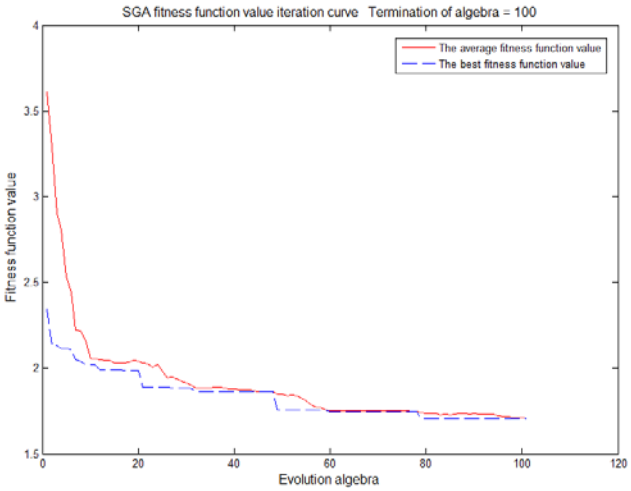

Fig. 2 SGA fitness function value iteration curve

When evolution algebra can be seen from the figure 6, 70 after generation, the fitness function value of the prediction is test set (i.e., mean absolute error) gradually stabilized, about 1.2, this time with the best fitness value is close to the average fitness value, show that every individual in a near optimal solution. The figure 2, you can see that SGA fitness function value from 60 generations gradually stabilized at about 1.7 and curve of stability to difference in MPG - ANN, explain MPG - ANN in predicting yarn CV value better than SGA on the precision of the model.

Worsted spinning parameters inversion result analysis

Neural network prediction model is trained well, by now the no. 66-75 sample data in table 1, through the establishment of MPG - ANN inversion model inversion wool top oil and spinning draft two parameters. MPG - ANN inversion model set the main parameters as: populations MP = 30 the number of individuals, each species contains ID = 40, evolution algebra maxgen = 100. The crossover probability and mutation probability of each population within a certain range of random generation. To compare the MPG - ANN inversion model inversion effect, at the same time give SGA model optimal inversion results and the corresponding yarn CV value predicted results for comparison, the specific results such as table 2 and table 3, shown in table 4.

Table 2 Parameter inversion results of wool top oil

Sample number	The measured values	MPG - ANN inversion model		SGA inversion model	
		The inversion values	The relative error /%	The inversion values	The relative error /%
66	1.3	1.3262	2.0136	1.3712	5.4760
67	1.1	1.1378	3.4364	1.1931	8.4617
68	1.3	1.3519	3.9923	1.2604	3.0497
69	1.4	1.4300	2.1423	1.3526	3.3890
70	1.3	1.3642	4.9384	1.1730	9.7698
71	1.2	1.1824	1.4641	1.2906	7.5503
72	1.4	1.4306	2.1857	1.4692	4.9426
73	0.8	0.8216	2.7000	0.9024	12.8052
74	1.5	1.4540	3.0700	1.3857	7.6200
75	1.1	1.1307	2.7909	1.1716	6.5090
The average relative error/%			2.8734		6.9573

Table 3Parameter inversion results of spinning draft

Sample number	The measured values	MPG - ANN inversion model		SGA inversion model	
		The inversion values	The relative error /%	The inversion values	The relative error /%
66	19.2	19.3773	0.9233	18.1151	5.6504
67	20.5	19.9780	2.5463	21.7881	6.2834
68	19.3	19.7001	2.0730	18.3979	4.6741
69	21.5	21.1215	1.7605	20.3698	5.2567
70	21	20.1708	3.9486	22.1323	5.3921
71	18.5	17.8617	3.4502	17.5638	5.0604
72	21.5	21.1222	1.7572	19.7680	8.0558
73	21.3	22.1467	3.9751	20.0914	5.6744
74	16.8	17.2421	2.6318	18.1859	8.2494
75	22.8	21.8579	4.1320	21.2965	6.5942
The average relative error/%			2.7198		6.0891

Two models of wool top oil and spinning draft corresponding forecast parameters inversion result and inversion results such as table 2, as shown in table 3

(1) from the parameter inversion accuracy, wool top oil of SGA model inversion of ten sets of results of the average relative error is 6.9573%, the average relative error of spinning draft is 6.0891%, and MPG - ANN model inversion, the average relative error is 2.8734% and 2.7198% respectively compared to the SGA algorithm is reduced by 4.0839% and 3.3693% respectively, thus the MPG - ANN model on worsted spinning parameters inversion accuracy than SGA model.

(2) from the perspective of the results on the stability of unified parameter inversion, MPG - ANN model of the tops of the biggest oil parameters inversion relative error is 4.9384%, the minimum relative error is 1.4641%, the fluctuation of the biggest is 3.4743%;The biggest inversion sand draft relative error is 4.1320%, the minimum relative error is 0.9233%, as the biggest fluctuation 3.2087%;Again, can be concluded from table 2 and table 3, two parameters of SGA model inversion results the biggest swings are 9.7555% and 3.5753% respectively, therefore, MPG - ANN in worsted spinning parameters on the stability of the inversion results of model is superior to SGA.

Conclusion

Parts for the textile process parameter is not easy to get and important influence on the processing technology, with mixed population genetic algorithm to optimize the BP neural network weights and threshold in the forward model is set up, make network prediction accuracy is greatly increased. On this basis, through the mixed population genetic algorithm is used for inversion parameters, and a instance is given to demonstrate the feasibility and effectiveness of the proposed algorithm, the improved technology development company, to reduce the cost of production has a certain reference.

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