Prediction and research of bending rebound based on neural network

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There is a common problem about rebound in the process of bending forming. It has a significant effect on Dimensional accuracy and productivity of parts. In this paper, the rebound prediction and research mainly through the BP neural network nonlinear characteristics. But the BP network is easy to fall into local minimum, and the genetic algorithm has good global search capability, so you can use the genetic algorithm to optimize its weights and thresholds to achieve a perfect bending rebound prediction and research.

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It's bound to causing rebound after bending and drawing the sheet, the degree of rebound has a direct effect on the Geometric accuracy of Material during the development of science and technology, the industry is developing rapidly, the bending is one of the important skills in industrial production. With the good versatility, simple process, wide range of and other advantages, it is widely applied to electrical machines, household appliances, machinery, construction and other manufacturing industries. Bend is also ubiquitous in industry. Accuracy is becoming more and more important for industrial production, and the metallic materials have the plastic and elastic features, so the bending process inevitably produces rebound, thus affecting the accuracy of material processing, so the research and prediction on rebound is very important. The rebound problem has become a hot issue in the field of sheet metal forming. Because neural network not only can approximate any nonlinear mapping, but also can describe the regular pattern about input and output, so it play an important role in the precision prediction of process parameters, organizational performance, precision molding.

Back-propagation (BP) neural network can approximate nonlinear functions with arbitrary precision, the process has been widely used to solve nonlinear characteristics and structure of the unknown control problems, it is currently the most widely used neural network and it use genetic algorithm to optimize their weights and thresholds, that it can avoid local minimum. It compensate for the lack of BP neural network through using genetic algorithm and BP neural network. The research that I did was on the basis of experiments, then training and testing the experimental data to make the prediction within the range of error allowed.

1. Experiment and data analysis

Many factors affect the bending rebound (such as the mechanical properties of the material, the relative bending radius r / t, the central angle of bending, etc. But the impact varies, orthogonal test analysis results of the four main factors [1-2] that influence resilience punch radius (r) on the basis of experiments, the thickness (t), yield strength (σ), elastic modulus (E).

From the 200 set of experiments, through data analysis, 68 groups as shown in studies to retain data in the following table, these data as a sample library BP network training.

Sample number	r (mm)	R (mm)	t (mm)	σ/E
S1	25	26.32	6	0.0039
S2	60	66.51	9	0.0048
S3	193	215.52	7	0.0012
S4	60	68.1	6	0.0039
S5	142	155.41	6	0.0012
S6	70	77.44	8	0.0036
S7	193	290.37	8	0.0046
S8	50	54.68	7	0.0039
S9	70	73.17	6	0.0012
S10	100	131.82	6	0.0048
S11	60	65.41	8	0.0036
S12	193	310.81	6	0.0039
S13	25	26.01	8	0.0036
S14	193	280.15	9	0.0048

S15	70	78.98	9	0.0048
S16	25	25.33	9	0.0012
S17	70	81.24	6	0.0039
S18	142	191.28	8	0.0048
S19	70	78.62	7	0.0036
S20	193	349.08	6	0.0046
S21	100	104.76	8	0.0012
S22	25	25.41	7	0.0012
S23	50	53.31	9	0.0036
S24	70	79.77	8	0.0046
S25	142	181.95	9	0.0046
S26	70	72.38	8	0.0012
S27	193	211.58	8	0.0012
S28	50	55.07	8	0.0048
S29	70	81.38	7	0.0046
S30	142	182.27	7	0.0036
S31	60	67.06	8	0.0046
S32	70	72.12	9	0.0012
S33	25	26.6	6	0.0046
S34	142	179.62	8	0.0039
S35	193	321.58	7	0.0048
S36	60	68.2	7	0.0046
S37	25	26.21	8	0.0046
S38	193	251.77	9	0.0036
S39	142	196.97	6	0.0039
S40	100	124.85	7	0.0046
S41	50	56.94	6	0.0048
S42	100	113.78	9	0.0036
S43	25	26.11	9	0.0046
S44	70	77.15	9	0.0039
S45	142	211.64	6	0.0046
S46	193	269.7	8	0.0039
S47	50	54.27	9	0.0046
S48	70	84.34	6	0.0048
S49	142	201.24	7	0.0048
S50	193	218.56	6	0.0012
S51	100	106.5	6	0.0012
S52	142	151.85	8	0.0012
S53	50	51.24	8	0.0012
S54	142	150.7	9	0.0012
S55	50	51.56	6	0.0012
S56	100	118.33	9	0.0046
S57	142	171.5	9	0.0036
S58	193	209.35	9	0.0012
S59	60	62.01	7	0.0012
S60	100	118.43	7	0.0036
S61	25	26.11	7	0.0036
S62	60	70.26	6	0.0048
S63	142	153.36	7	0.0012
S64	60	61.57	9	0.0012
S65	100	117.27	8	0.0039
S66	70	72.72	7	0.0012
S67	50	55.59	7	0.0046
S68	193	275.71	7	0.0036

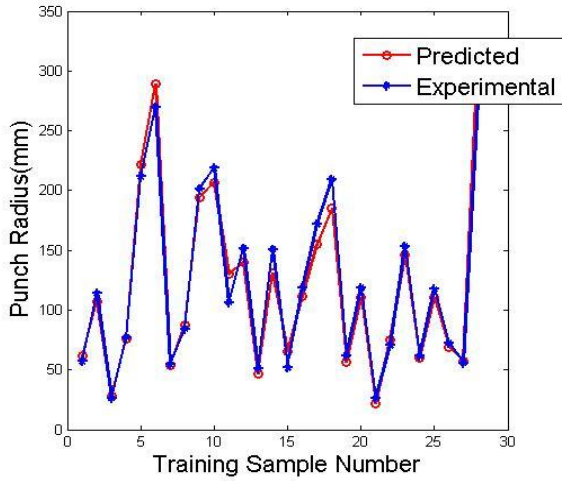
2. The Neural network modeling and predicting

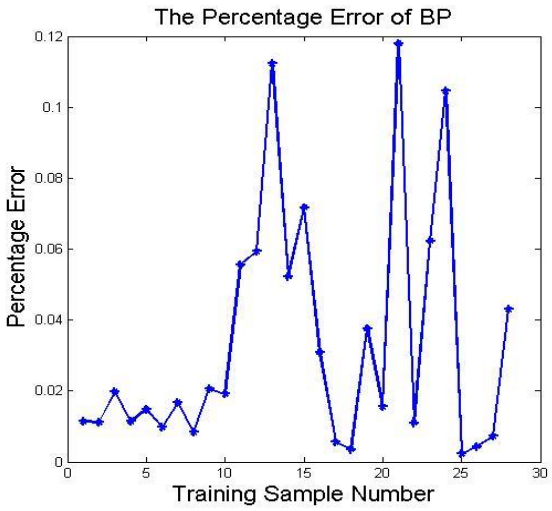
BP neural network can approximate any nonlinear function of the accuracy. There are some literatures using BP neural network monitor tool wear, form process optimization, predict parameters and so on [3-5]. Using a neural network learning function, nonlinear neural network model can be established between the forming process parameters and the rebound value [6]. The first step of the BP network model design is to determine the network layers. Layer neural network modeling can solve many practical problems, three-layer neural network can approximate any continuous function, and four-layer neural networks can describe discontinuous functions. Layer can be added to increase the processing capability of artificial neural networks, but it will make the training complex, causing the number of training samples and the training time increases. So this paper, three-layer BP network model is used.

Input layer nodes is 3, the output layer nodes is 1. According to the Komogorov theorem, for any continuous function can use three layer networks to accurately achieve it. There are m units in the first layer and 2m+1 units in the intermediate layer, n units in the third layer. According to the Formula there are seven nodes the layers. Based on it, increasing the number of nodes in the layer network, and we can know 8 hidden layer is best. Network model is the 3-8-1. Learning process for BP network: network input value from the input layer after layer of weighted incoming implied, get the value of the hidden layer output function operation after hidden layer, hidden layer output value weighted spread through the output layer, after computing the function to get the output value of the output layer.

After determining the above parameters, the hidden layer using tansig function, the output layer using purelin function, learning rate use 0.1, and the termination of iterations is 100, the network expected error is 0.0001, weights and thresholds automatically assigned by the network, the training network. The comparison of the data

behind the 24 samples as predicted, after BP network forecasting results obtained with the actual values in the following figure:





From the above table can be clearly seen, BP network prediction error is obvious. Thus introducing genetic algorithm to optimize the weights and thresholds of BP network is very important.

3. BP-GA analysis and predicted

The optimization and improvement of genetic algorithm are about in two main areas [7].The first is the optimization settings of network structure, than form more efficiently network structure. The other is the optimization of weights and thresholds. This paper studies the latter.

(1) Genetic Code. Coding is a combination of the neural network weights by a certain way to get the algorithm of individual genetic algorithm. The weights' learning of neural network is a very complex process of optimization system parameters. Huge weights, so utilize a real number coding. The neural network structure of prediction rebound radius is 3-8-1, network weight is 3*8 +8*1 = 32, threshold is 8 +1 = 9, and the length of individuals is 32 +9 = 41. Adoption the MATLAB rand function to initialize the network weights and thresholds, and normalized into [-1, 1] within.

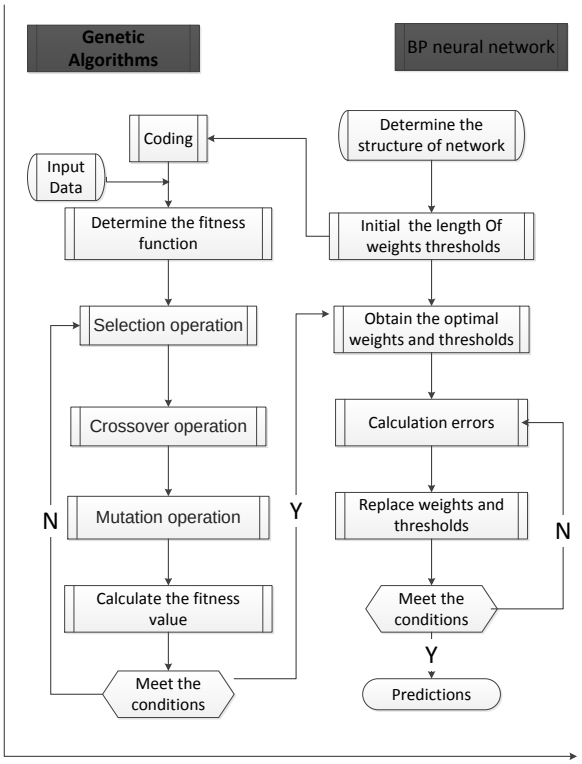
(2) The Initialization of populations. In the parameter selection of genetic algorithms, population size is a very important parameter, population size affect the efficiency of genetic algorithms and the final result. According to the relationship between the number of decision variables(n) size and population studies by Xiaoxia Liu, based on the experimental typical optimization problems, select the size of the population should be between 4n to 6n.The population size of this paper selected 18.

(3) Selecting of fitness function. The fitness Used to evaluate level of the individual. Conversely the smaller fitness is the poorer individual could be. Depending on the size of the fitness to select the individual, in order to ensure good performance individual have more opportunities to breed, so that fine features can be inherited. In this paper, the fitness function F chose the deviation of expectations and predictive value [4].

(4) Genetic Manipulation. The task of genetic manipulation is applying a certain operation in a contrast of the adaptation to the environment of individuals in order to achieve survival of the fittest evolutionary process .From the perspective of optimizing search, genetic manipulation allows solution of the problem, from generation to generation optimization, and presses in the optimal solution. Genetic manipulation including selection, crossover and mutation.

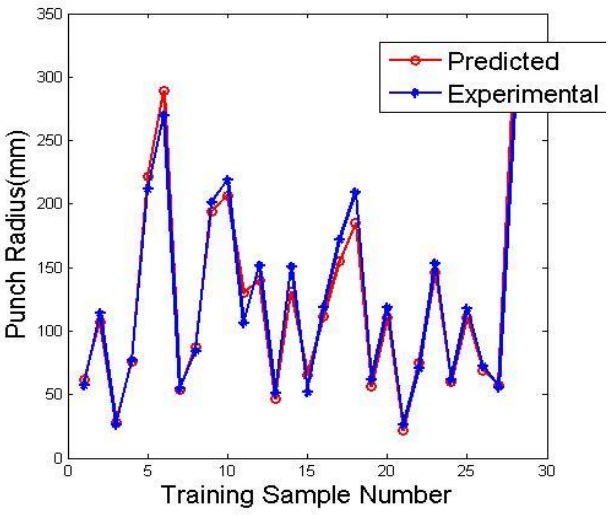
The purpose of the selection operation is selecting the best individual from the current population (a set of network weights and thresholds), so that they have a chance to reproduce as the next generation. While the best individual of the genetic combinations can transplant directly from generation as a next generation network group members. This article takes a selection probability PS as 0.08. Crossover operation is selected by a certain probability of individual, then according to a certain probability Pc to exchange gene form new individuals. This paper takes the crossover probability PC as 0.8. Mutation operation is based on a certain probability Pm randomly changing the value of an individual's genes, in order to maintain the diversity of population, then genetic algorithm has the ability to make local search. This paper takes the mutation probability Pm as 0.01.

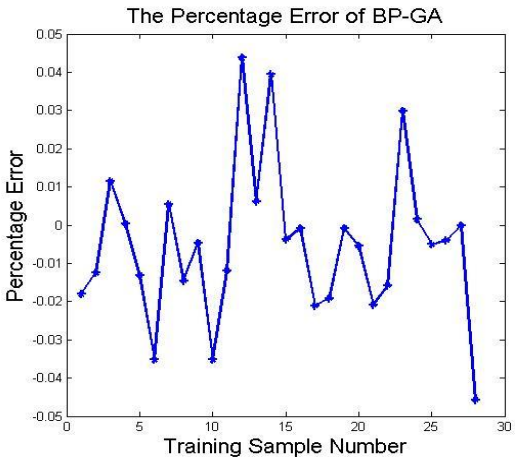
After these operations, the optimal individual of population is assigned to BP neural network used for further prediction. The whole process of the article is in the following chart:



4. Data analysis

The results of GA-BPNN running is in the following figure:





You can clearly see that the prediction accuracy of BP after a genetic algorithm to optimize weights and thresholds obtained much higher in the figure is closed to the measured value.

In this figure, you can see clearly that the curve of GA-BP neural network training data is closed to the actual data curve, while there is a great discrepancy between the curve of BP neural network training and he actual data curve. Compared to BP Neural Network prediction, the predicted after optimization weights and thresholds of neural network with genetic algorithm more accurate.

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