Image Feature Extraction Based on Differential Evolution Neural Network

Qingzhao Li

School of Foreign Languages, Suzhou University,
Suzhou 234000, Anhui, China

Abstract
Image feature extraction result determines the analysis and understanding of the final image, and plays an important role in image engineering. Based on image feature extraction as the research object, this paper processes the image by using the good generalization ability, robustness and numerical approximation ability of the neural network to form the input data of BP neural network, then adopts the differential evolution (DE) algorithm to improve the BP neural network, which make it realize the faster convergence during the sample training, thus, the image feature extraction effect is increased and the time complexity is reduced, and in this way, the feature extraction result is guaranteed to not be distorted to the maximum. That the algorithm in this paper has better performance in the image feature extraction is testified by experimental simulation analysis and comparison.
Key words: IMAGE FEATURE EXTRACTION, DIFFERENTIAL EVOLUTION ALGORITHM, ARTIFICIAL NEURAL NETWORK

Introduction

As one most challenging task in the low level vision among the computer vision field, the image feature extraction completes the extraction in features such as the area and boundary. Image feature extraction mainly detects and measure interested objects in the image in order to obtain the objective information and then to establish a description of image and the objective, which is a process from the image to the data[1]. The understanding and research of the nature of each object andtheir connectioncan improve the identification accuracy, reduce the computational complexity and improve the operating speed and so on, thus the original image is transformed into a more compact form to make higher image understanding possible. In practical problems, the feature extraction could be interfered by the noise such as the background, perspective, the illumination and size, and then how to extract the feature parameters that have good characteristic performance with smaller noise interference is an important problem of the applied study[2,3].

In the process of the development of the image feature extraction technology, a lot of kinds of methods have been put forward by the researchers. The recent research hot spot is the extraction method combining specific theory, and the specific theory includes intelligent algorithm and the artificial neural network etc[4]. The successive proposal of new methods broadens the application scope of image feature extraction and improve the extraction precision. However, the existing algorithm remains face the deficiency that the extraction results are easy to be distorted to cause the low precision and larger time overhead of the algorithm, which is not suitable for the large-scale data processing. Artificial Neural

Network (ANN) is one algorithm mathematical model imitating the animal neural network behavior characteristics and conducting the distributed parallel information processing. This network depends on the complexity of the system and adjusts the internal relations between a large number of nodes connected, so as to achieve the purpose of processing information[5]. Artificial neural network has the self learning and adaptive ability, and can analyze and master potential laws between the input and output data based on a batch of beforehand provided input and output data to finally calculate the output result with new input data according to these laws, and this study analysis process is known as "training"[6]. DE algorithm has strong convergence ability and is suitable to solve complex optimization problems. DE is a randomized parallel direct search algorithm and it can minimize the nonlinear and non-differentiable continuous space function, and embraces success in several fields with its usability, robustness and strong global optimization ability. This paper conducts the image feature extraction by combining the the differential evolution algorithm and artificial neural network, which can effectively deal with numerical value information, and the parallel computing mode is of great help to reduce the time complexity of the algorithm[7,8].

The basic idea of this paper is to optimize the BP neural network structure by using differential evolution algorithm, and the neural network is trained by the training sample set to determine the connection weights and threshold value between nodes, and then the newly input image data is processed with a trained neural network. DE algorithm can quickly and efficiently calculate the complex nonlinear multidimensional data space, and it not only can get the global optimal value, but also greatly shorten the calculation time.This paper first expounds the DE algorithm and neural network theory, and on this basis, put forwards the implementation process the DE algorithm optimizing BP neural network, and at last, the experimental simulation and analysis is described.

Differential Evolution Algorithm

Differential evolution algorithm is a new evolution algorithm based on population parallel random search. This algorithm starts from the original population to derive new populations through mutation, hybridization, and by choosing several operating methods, and the global optimal solution search will be realized through iteration step by step[9,10]. Here are DE algorithm implementation steps:

(1) Population initialization

Randomly produce the initial population $u(0)=\{u_1^0,u_2^0,...,u_{NP}^0\}$ in the problem solution space, in which, $u_i^0=\{u_{i,1}^0,u_{i,2}^0,...,u_{i,D}^0\}$ is used to represent the individual solution of number i individual. Each vector of the individual can be generated according to the following formula:

$$u_{i,j}^0 = u_{j,\min} + rand(u_{j,\max} - u_{j,\min}) \quad (1)$$

In which, $u_{j,\max}$ and $u_{j,\min}$ are respectively the upper and lower bound of the number j dimension of the solution space.

(2) Mutation

For each objective vector $u_i^t(i=1,2,...,NP)$, the mutation vector is generated as follows:

$$v_i^{t+1} = u_{r1}^t + F\cdot(u_{r2}^t - u_{r3}^t) \quad (2)$$

In which, the randomly selected serial number r_1, r_2 and r_3 are different from each other, and r_1, r_2 and r_3 are different from the objective vector serial number i. The mutation operator $F\in[0,2]$ is a real constant.

(3) Crossover

For the objective vector x_i^t of the group, the crossover is operated with the mutation vector v_i^{t+1} to generate the test individual u_i^{t+1}. The crossover operation equation is:

$$u_{ij}^{t+1} = \begin{cases} v_{ij}^{t+1}, & rand(j)\le CR \ or \ j = randn(i) \\ x_{ij}^t, & rand(j) > CR \ and \ j \ne randn(i) \end{cases} \quad (3)$$

$rand(j)\in[0,1]$ in formula (3) is the equally distributed random number. j represents number j variable, CR is the crossover probability constant and its value scope is $[0,1]$, and its value shall be determined in advance. $rand(i)\in[1,2,...,D]$ is the randomly selected dimensional variable index. At least one one-dimension variable of the test vector shall be guaranteed to be contributed by the mutation vector, or the test vector may be same with the objective vector and new individual thus cannot be generated[11].

(4) Selection

DE algorithm adopts the “greedy” selection strategy, i.e. select one individual with best fitness value as the individual u_i^{t+1} of the next generation from the parental individual u_i^t and the test individual x_i^t, and the selection operation is:

$$u_i^{t+1} = \begin{cases} u_i^t & \text{if } \ \text{fitness}\ (u_i^t) < \text{fitness}(x_i^t) \\ x_i^t & \text{otherwise} \end{cases} \quad (4)$$

In which, $fitness(\cdot)$ is the fitness function. Generally, the objective function to be optimized shall be taken as the fitness function.

Compared with other evolution algorithm, differential evolution algorithm mainly has the following features: the algorithm searches not from a single point, but one group; the algorithm principle is simple and easy to implement; the group search ability is strong and has the ability to memorize the individual optimal solution; the probability transfer rule is adopted without deterministic rules[12,13].

BP Neural Network Model and Its Basic Principle

Artificial neural network is the complex network systemcomposed of widely interconnected simple processing units similar to the neurons. It reflects some of the characteristics of the human brain, and has adaptive, self-organizing and self-learning ability, and which is the simplification, abstraction and simulation of the nervous system.It shows the learning, induction and classification characteristics similar to the human brain through the adjustment of the connection strength. The network composed of neurons with threshold value has better performance, and can improve the fault tolerance and storage capacity. Therefore, the fundamental purpose to research the neural network is to explore the human brain mechanism to process, store and search information. There are not only all kinds of change in terms of the information processed by the neural network, but also the nonlinear dynamic system itself is also changing when the information is processed[14].

BP Network Basic Principle

BP neural network is short for the bias back propagation neural network, which consists of an input layer, one or more hidden layer and one output layer, and is composed by a certain number of neurons each time.These neurons are associated with each other as the human nerve cells. Basic BP algorithm includes two aspects: signal forward propagation and bias back propagation[15]. Namely, start from the input to the output direction when the actual output is calculated, while, the correction of the weight and threshold value is conducted from output to the input direction. its structure is shown in Figure 1.

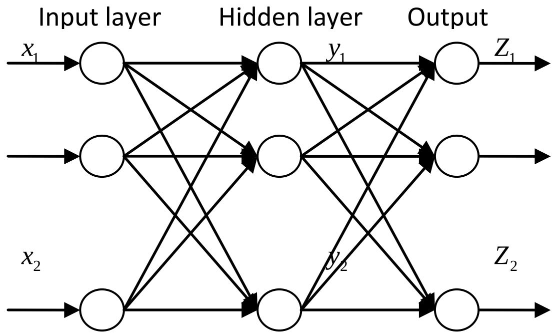


Figure 1. BP Neural network structure

Transfer Function of BP Network

Figure 2 is several transfer function of BP neural network. There are many types of transfer function of the BP network, the transfer function of BP neuron model adopts the differentiable monotone increasing function, such aslogsig of sigmoid, tansig function, and linear function-pureline.The input value of logsig type functionmay take any value, and the output value is between 0 and 1; the input value of tansig type transfer function may take any value, and the output value is between -1 and +1; the input and output value of purelin linear transfer function may take any value. The character of the neuron in last layer of the BP network determines the output characteristics of the entire network.When the neuron of the last layeradopts sigmoid type function, the output of the entire neuron will be confined to a smaller range, while, if the neuron of the last layer adopts purelin type function, the output of the entire network can be any value [16].

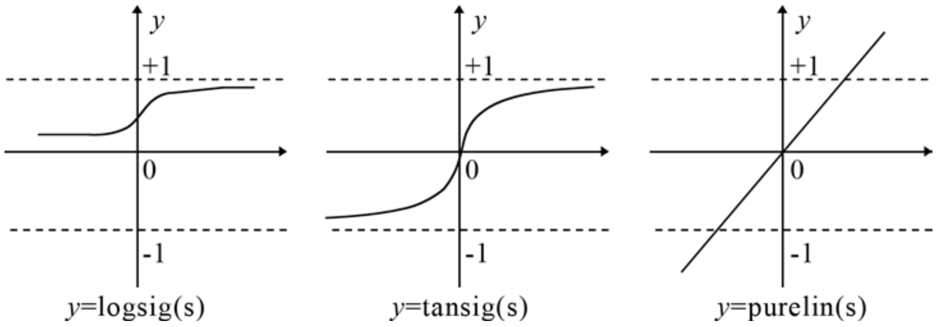


Figure 2. Widely used transfer function of BP neural network

Application of Image Feature Extraction in the DE Neural Network

Optimization of DE Algorithm in the BP Neural Network

Optimizing the BP neural network through the differential evolution algorithm, which is to optimize the link weight and threshold value of the BP neural network through the differential evolution algorithm for the neural network with identified structure, that is to use the differential evolution algorithm to determine the continuous weights and the threshold value[17,18].

(1) Determine BP neural network structure, including the structure layer number n, the number of input variables m, the element number hidden layer I, the number of output variables; determine the population size of the differential evolution algorithm M, crossover probability P_c, mutation probability P_n.

(2) Initialize all neurons states value.

$$x_P^l(0) = 1/L + \varepsilon \quad (5)$$

In which, ε has 0 mean value of random disturbance.

(3) For each layer which contains a nonzero neuron, according to the following equation to calculate the class center gray value.

$$G(l) = \frac{1}{\sum_{i=1}^{M_b}\sum_{j=1}^{M_b}\Psi(x_P^l)}\sum_{i=1}^{M_b}\sum_{j=1}^{M_b}\Psi(x_P^l)g(i,j),(p=(i-1)M_b+j)$$
(6)

$\Psi(\cdot)$ is a hard limiting function.

$$\Psi(x) = \begin{cases} 1, & x>0 \\ 0, & else \end{cases} \quad (7)$$

(4) The individual with high fitness function value, it will directly transmitted to future generations, then after the selection, crossover and mutation operation, new species is produced, and the number of iterations increases 1.

(5) When the differential evolution algorithm is completed, the result is the individual with the highest fitness value. Therefore, determine the initial connection weights and the threshold of BP neural network value.

(6) For each pixel $P(i,j)$, get the gray value into the class center gray value.

$$g(i,j) = \sum_{i=1}^{L}(G(l)\Psi(x_P^l)),(p=(i-1)M_b+j) \quad (8)$$

(7) Train the BP neural network, and at the same time, through the global bias of the forward transmitting the output calculation results, determine whether the results achieve the given precision, if it reaches the precision, then put an end to the training.

Procedure of DE Neural Network Extracting Image Feature

Based on the DE neural network, the image feature extraction basically has the following steps, and Fig.3 is the flowchart of DE neural network extracting image feature[19,20].

(1) Input the image, obtain the image pixel matrix, reduce the matrix dimension and get the input vector. Extract the gray value of each pixel, to calculate fitness $f_0(x_{ij})$ and $f_B(x_{ij})$ of the sets objective S_o and background S_B by using the pixel points (i,j) in the calculating matrix of the fitness function, set the input vector and the objective vector.

(2) Initialize the DE neural network, and set the sample vector training rate. Then input the sample and start training until the network bias reaches the set point or times of training reaches the maximum. At last, save the weights and threshold value.

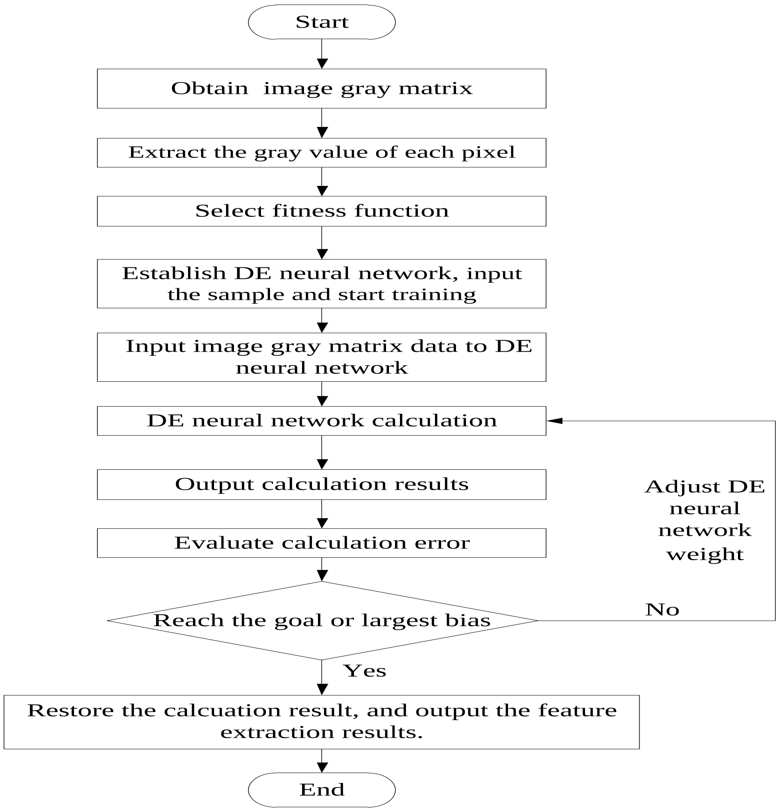


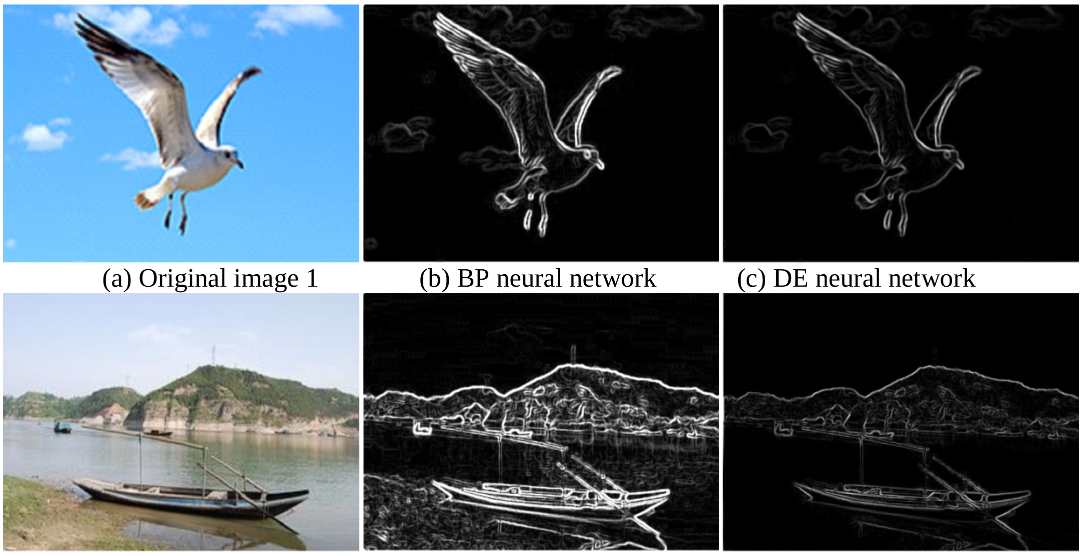
Figure 3. Flowchart of DE neural network extracting image feature

(3) Choose the image which feature is to be extracted, and use the trained DE neural network to train the input vector, and at last the final output vector is the classification of the images[21].

(4) Restore the result from the vector form into image gray matrix, and output the feature extraction results.

Simulation Experiment and Analysis

To use 300 images chosen from the image library to train the BP neural network, and choose images to test the image feature extraction, at the same time to show the image feature extraction results made through the BP neural network and the DE neural network. The experiment result is illustrated by the following Figure 4.



(a) Original image 1 (b) BP neural network (c) DE neural network

(d) Original image 2 (e) BP neural network (f) DE neural network

Figure 4. Differential evolution algorithm optimizing BP neural network

Through the comparison mentioned above, the images feature extraction through the method of BP neural network are not fine enough. In the images, the results made by using the BP neural network feature extraction shows merely the outline of the objective, some characteristics in the area cannot be completely extracted. While the images made by using the DE neural network have much more precise result than the former which shows more details, then it is concluded that the improved algorithm proposed in this paper has much better performance in the objective outline and details in the area. Therefore, the improved algorithm proposed in this paper has much better effects.

Conclusion

This paper has put forward the DE neural network image feature extraction method which has drawn lessons from the traditional BP neural network in the field of the image feature extraction. This paper at first has analyzed the basic model of the DE neural network and the BP neural network and their training process. Aiming at the shortcomings of the BP neural network, such as the long training time, slow convergence etc, This paper has used DE algorithm to improve the transmission function, learning rate, network training method, and the experimental simulation results have proved that the image feature extraction of the algorithm proposed in the paper have better effect.

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