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Research on Stage Lighting Console Based on BP Neural Network Handwriting Recognition

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Abstract: With the development of the stage lighting industry and pattern recognition, the stage lighting console can learn from the algorithms in the field of pattern recognition to make it more powerful and more flexible. In this paper, the BP neural network is summarized as a carrier, and the BP neural network is summarized. The application of BP neural network algorithm in handwriting recognition is analyzed in detail, and the trained handwriting recognition model is applied to the stage lighting console. The user can determine the character number by handwriting recognition. At the same time, the console according to the lighthouse file in the level of the lamp, the vertical channel information, using the proposed beam track of the grid coding algorithm, the DMX encoded information output, the corresponding lamps can be based on horizontal, vertical channel position Information ran out of handwriting character movement trajectory effect. In this paper, the recognition rate of BP neural network is 96%, and the grid coding method proposed in this paper is simple and effective to control the light track.

1. Introduction

Stage lighting console through the network decoder outputs DMX signal to control lamps, transforming out different modes, color, pattern, Logo and other gorgeous lights rely on the built-in effect with console program[1]. And the current stage of the stage lighting console are rely on the lighting through the console button or putter for lamp programming, some built-in effects need to spend a lot of time to prepare well, especially the stage effects of temporary changes. However, the usage of BP neural network's function about training handwriting recognition, the lighting division only needs to write a character on the touch screen, you can control the level of the lamp and vertical channel out of the character trajectory, saving the time about lighting division of a certain programming[2].

2. BP neural network overview

The BP neural network consists of an input layer, an output layer and an implicit layer, where the hidden layer can be a layer can be multi-layer. As shown in Fig. 1, the neurons of the three layers of BP neural network are connected by weight W, but the neurons located in the same layer are not connected[3, 4].

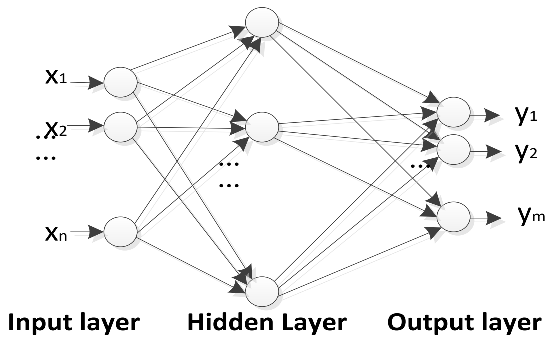


Fig 1 The BP neural network

BP neural network belongs to multi-layer forward network, so it has the characteristics of forward network. The input data is propagated layer by layer, there are input layer to the hidden layer (which can be multi-layer), and finally output from the output layer, adjacent two layers of neurons all connected to each other, but in the same layer of neurons no connection[5]. In addition, the implicit layer of BP neural network can be multi-layer, which is the difference with the structure of linear neural network. To overcome the linear neural network, BP neural network must solve the problem of linear separable problems, processing with the ability to be linearly indistinguishable[6]. And the BP neural network can realize all non-linear mapping from input to output by changing the network topology (the number of layers of the network, the number of neurons in each layer network) and the weight threshold of the network.

BP algorithm is based on the square error of the neural network as the objective function, according to the gradient descent method to achieve the objective function, also achieving the minimum value of the algorithm. BP training process is divided into two stages: the signal forward propagation and error back propagation. The forward propagation of the signal refers to the actual output value obtained by calculating the input layer through the input layer and the network output layer through the input layer[7]. The error back propagation is the error between the actual output value of the network and the expected output. Error back propagation, to adjusting the weights and thresholds of the nodes layer by layer to reduce the error. It is forwards propagation and reverse propagation process shown in Fig 2.

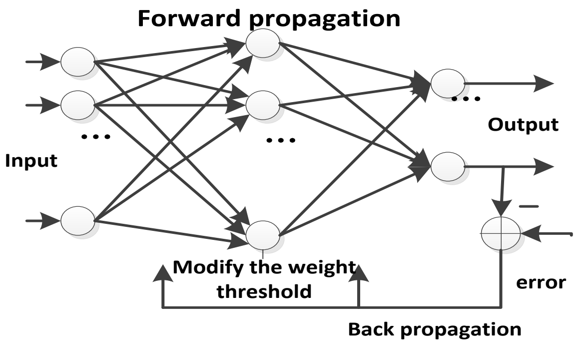


Fig 2 The forward propagation and reverse propagation process

In the above BP network, assuming that the number of neurons in the input layer is M, the number of neurons in the hidden layer is N, and the number of neurons in the output layer is P. The m-th neurons of the input layer are denoted as X_m, the n-th neurons of the hidden layer are denoted as Z_n, and the P-th neurons in the output layer are denoted as Y_n. The connection weight from X_m to Zn is W_{mn}, and the connection weight from Zn to Y_p is W_{np}. The transfer function of the hidden layer is f1, and the transfer function of the output layer is f2. The network accepts a vector of length M as input, and finally outputs a vector of length P.

3. Handwriting recognition

Data set uses MNIST data set, MNIST data set concludes a total of 60,000 character images, from 0 to 9, the data set is divided into two parts: part of the 50000 picture training neural network, and a separated 10,000 images are used as validation sets. The machine gradient is reduced by randomly selecting a small number of m training inputs to work. Marking these random training inputs $X_1, X_2, \ldots \ldots X_{\mathrm{m}}$, which called them a small batch of data. Assuming that the number of samples m is large enough, we expect that the average of ∇C_x is approximately equal to the average of the entire ∇C_{X_j}, ie $\nabla C \approx \frac{1}{\mathrm{m}} \sum_{j=1}^{m} \nabla C_{X_j}$, so you can simply calculate the gradient of the small batch data randomly to estimate the overall gradient[8, 9].

In the BP neural network, the first layer is the input layer. Since each picture is composed of 28 * 28 pixels, and each pixel is input as a neuron, there are 784 neurons in the input layer. The third output layer has a total of 10 neurons, each neuron as the output of the code y = {0, 1}, any one neuron output is 1, it represents the corresponding value [6]. For example: the third layer of neuron outputs 0000000010 representing the interpretation of the characters to 2. As for the hidden layer we tested the number of different neurons by finding the accuracy shown in Table 1:

Table 1 The number of different neurons by finding the accuracy

Number of hidden neurons	Accuracy
20	94.02%
40	95.46%
60	86.55%
80	96.38%
100	87.37%
120	96.54%
140	96.69%
160	78.31%
180	57.73%

Found that the number of hidden neurons set is around 140 or so when the accuracy can reach 96.69%. And the number of iterations is 30, performance shown in Fig 3:

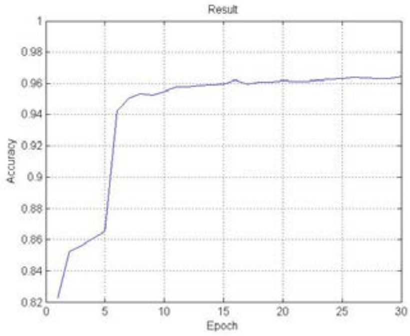


Fig 3 The number of iterations is 30 performance shown the line chart

In the iterative cycle of 10 times, BP neural network test accuracy has stabilized.

4. Grid coding algorithm

Stage lighting industry, different manufacturers of different lamps produced by the function will be different, manufacturers produced lamps and lanterns will be based on the function of different lamps prepared by the lamp library software. Therefore, all the properties of the console control fixture are based on the lighthouse file. In the lighthouse file, there are two channels for controlling the movement of the fixtures[10, 11], namely Pan (horizontal) and Tilt (vertical) channels, and the DMX range of both channels is 0-65536.In the horizontal channel, the console's encoder from 0% to 100% and from 100% to 0%, the beam at the level of movement as shown in Fig 4

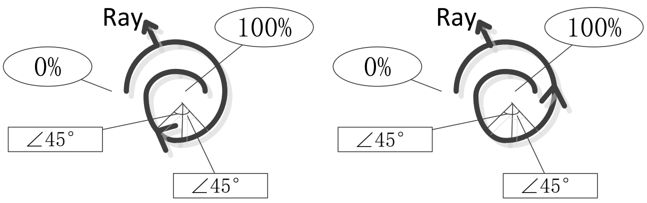


Fig 4 Horizontal position beam track

In Fig 4, the fixture holder center is centered, the DMX code starts from 0 to 65536, and the fixture starts to rotate in the horizontal direction, as indicated by the arrow on the circle in Figure 4. And the beam is perpendicular to the surface as shown in Ray, the lamp has a total angle of ∠540°, where we set the angle from ∠225°to ∠315°, and the vertical ground as the center is divided into two ∠45°, this is set to We are the horizontal active area of the beam motion trajectory, which is also the most active range of the horizontal position of the beam. The percentage of rotation of the corresponding console runner is:

$$\varphi = \frac{D}{D_T} \,, \tag{1}$$

In Eq 1, D is the horizontal angle and D_T is the total rotation angle in the horizontal direction, where D_T = ∠540°. Therefore, the percentage of the starting angle φ_s = 41.67%, the termination angle percentage φ_e = 58.33%.

In the vertical channel, the console's encoder from 0% to 100% and from 100% to 0%, the beam in the vertical movement as shown in Fig 5

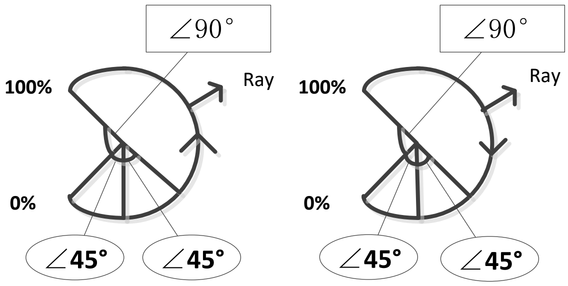


Fig 5 Vertical position beam track

In Fig. 5, the beam trajectory is perpendicular to the paper and is perpendicular to the circle in the figure. We are here to expand it into a flat circle analysis, when the console wheel is from 0% to 100%, the lamp has a total angle of ∠270°. Where we set the angle from ∠0°to ∠90°, and the vertical ground as the center is divided into two ∠45°, this is set to our beam motion trajectory of the horizontal activity area, which is the vertical position of the beam the most active range. The percentage of rotation of the corresponding console runner is:

$$\phi = \frac{H}{H_T} \ , \tag{2}$$

In Eq 1,2, H is the vertical direction angle, and H_T is the total rotation angle in the vertical direction, where H_T = ∠270°. Therefore, the percentage of the starting angle ϕ_s = 0%, the percentage of the stop angle ϕ_e= 33.33%.

Therefore, we will character into the ground beam projection grid shown in Fig 6

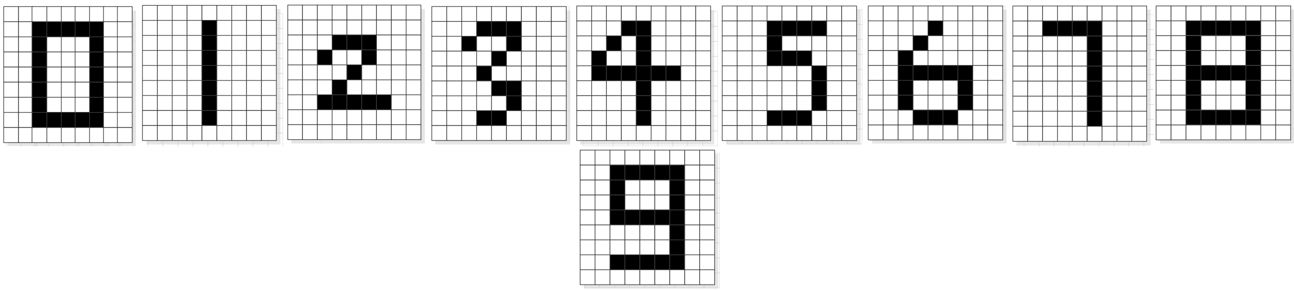


Fig.6 Character ground projection

Through the preparation of the program to form a 9 × 9 grid, and then we in the 9 × 9 grid in accordance with the order of writing characters in order to fill the grid in black, the program will automatically record the order of filling the grid position and write the file. For example, the contents of the character '0' in the file shown in Table 2

Table 2 Grid coordinate position

Ste	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Pan	2	3	4	5	6	7	8	8	8	8	8	7	6	5	4	3	2	2	2	2
Titl	3	3	3	3	3	3	3	4	5	6	7	7	7	7	7	7	7	6	5	4

In Fig 6, the abscissa position corresponds to Pan in Table 2, and the ordinate position corresponds to Tilt. The grid pattern in Fig 6 can be drawn by filling the grid in Fig 6 in the order of the position in Table 1, that is, the beam can exit the pattern of the character.

The console controls the fixture through the DMX encoding output, so we convert the grid to the DMX signal by the following formula.

$$P_i = \varphi_s \times W + \frac{\varphi_e \times T - \varphi_s \times T}{N} \times i \ , \quad (3)$$

For Tilt channels:

$$T_i = \phi_s \times W + \frac{\phi_e \times T - \phi_s \times T}{N} \times i \ , \quad (4)$$

In Eq 3, φ_s is the starting percentage of the grid horizontal position, φ_e is the percentage of grid termination, W is the maximum DMX output for the Pan channel is 65535, i is the position of the abscissa grid, and N is the number of lattice. Similarly, in Equation 4, ϕ_s is the percentage of the vertical position of the grid, ϕ_e is the percentage of grid termination, and W is the maximum DMX output of 65535 for the Tilt channel. With Eq 3, 4, we can get the character beam trajectory to move to the horizontal, vertical position of the DMX output.

5. Handwriting recognition applied to the stage lighting console

Through the transplantation of the algorithm, the BP neural network trained Model transplant to the stage lighting console users can write characters through the touch screen, and then identify the corresponding characters. Handwritten characters are shown in Fig 7:

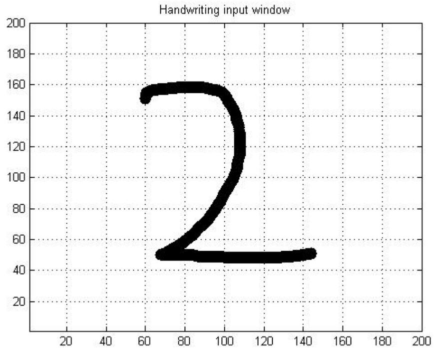


Fig 7 Handwritten characters

It will be identified by the handwritten characters to the processor program as shown in Fig 8

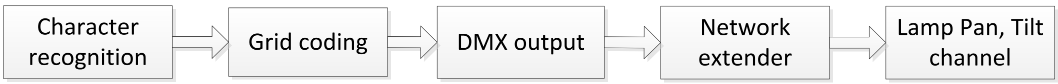


Fig 8 The handwritten characters to the processor program

Using our proposed grid coding algorithm, the recognition of the handwritten digital conversion to the corresponding location of the DMX code, the console processor to obtain DMX coding after this output, through the network expander to Pan, Tilt channel information decoding, and then send Command to the corresponding lamp Pan, Tilt channel, you can control the lamp running out of the corresponding handwritten light beam trajectory.

In this way, the lighting division without the need for each step character trajectory to carry out visual programming can be achieved quickly built-in character chase setting, easy to light on the stage of the temporary changes in the programming of the lamp.

6. The test results

We changed the DMX data on the Pan, Tilt channel as shown in Fig 9 by touching the handwritten numeric character '2' on the console and after the grid encoding algorithm

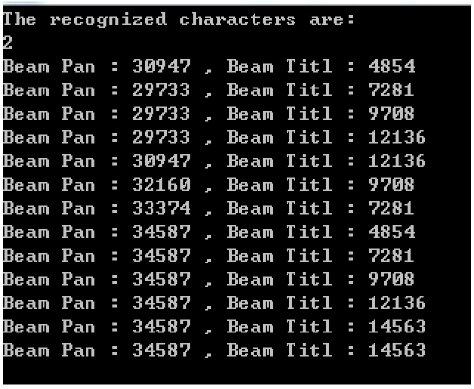
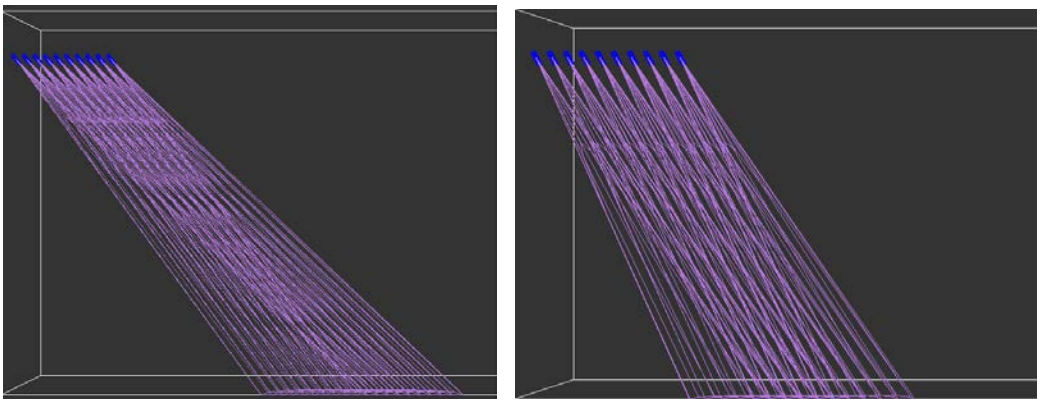


Fig 9 DMX output

In Fig. 9, the beam Pan corresponds to the DMX coding of the horizontal position in the grid, and Titl is the DMX code in the vertical position of the grid. The console moves the trajectory of the control beam by sending a coded command to both channels, and moves out of the trajectory of the handwritten numeral '2'. Test platform is ‘Visualiser’ software developed by the British Avolites company, this software can simulate the support light library files of all the lamps, the processor only need to correspond to the fixture chase code sent to the ‘Visualiser’ software, the software can see the corresponding changes in the lamp.



a b

Fig 10 The light beam from the horizontal position from far to change (a) far and (b) near.

If you write a horizontal 1 on the touch screen, you can see the light beam from the horizontal position from far to change, out of the corresponding character trajectory shown in Fig 10.

7. Conclusion

Through the BP neural network algorithm, achieving the training of handwritten digital character Model, and through the test set implicit layer of the number of neurons set to 100, the recognition rate can reach 96%. It has a strong practical value that the Model ported to the processor, the lighting division can be through the touch screen handwritten digital characters directly programmed to control the lamp track to walk. The method of trellis coded DMX is simple and effective. Making the operation more simple and flexible, in the case of emergency changes in the field can be flexible. But Model has limitations, only for digital character. If the data set to expand to the alphabetic characters will make the console built-in effect more abundant.

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