

3D SOM Neighborhood Algorithm

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Abstract—Neighborhood algorithm is an important part of 3D SOM algorithm. We proposed three kinds of neighborhood shape and two kinds of neighborhood decay function for three-dimensional self-organizing feature maps (3D SOM) algorithm and applied them to three-dimensional image compression coding. Experimental results show that the 3D orthogonal cross neighborhood shape and exponential function algorithm have better peak signal to noise ratio (PSNR) and subject quality than others.

Keywords—self-organizing maps; three-dimensional image coding; pattern recognition; neighborhood algorithm

I. INTRODUCTION

The self-organizing map (SOM) proposed by Kohonen is a highly intelligent information processing method that forms a topologically ordered mapping from the high-dimensional data space to a low-dimensional representation space [1]. It has already found wide applications in such areas as pattern recognition [2]-[4], data mining [5]-[8], automatic control [9]-[10] and failure detection [11]-[12] and so on.

Traditional SOM network can effectively deal with one-dimensional and two-dimensional signal, but can not deal with three-dimensional signal directly. To solve this problem, 3D SOM algorithm has been proposed in recent years. In 3D SOM theory, the neighborhood is one of the core concepts of self-organization mechanism, which reflects the interaction and mutual influence between the winning neuron and the adjacent neurons, and has important affection on the quality of learning and convergence performance of SOM algorithm. For this reason, in order to improve the performance of 3D SOM algorithm, we need to find new three-dimensional neighborhood shape and neighborhood decay function. In this paper, we propose three kinds of neighborhood shapes and two kinds of neighborhood decay functions, and compare the performance difference.

II. 3D SOM ALGORITHM

The network structure of 3D SOM algorithm is shown in Fig.1. The mapping layer neurons are arranged in a three-dimensional structure, the number of rows, columns and layers can take different values, and different three-dimensional network structure usually result in different performance. The shape of three-dimensional neighborhood can have different choice, we usually choose spherical neighborhood, square neighborhood or three-dimensional orthogonal cross

neighborhood, algorithm performance varies when selecting different three-dimensional shape of neighborhood. 3D SOM network is the same as ordinary competition network, for each input pattern, there is corresponding winning node in mapping layer, winning nodes represent the most similar pattern, the winning nodes and all nodes in its three-dimensional neighborhood adjust their own weight according to certain rules. When the input pattern changes, there will be a different pattern win through competition. In this way, the network adjusts the network weights through a large number of training samples by means of the self-organizing way. Finally the weight vector space is in accordance with the probability distribution of input patterns, namely the weight vector space can reflect the statistical characteristics of input pattern.

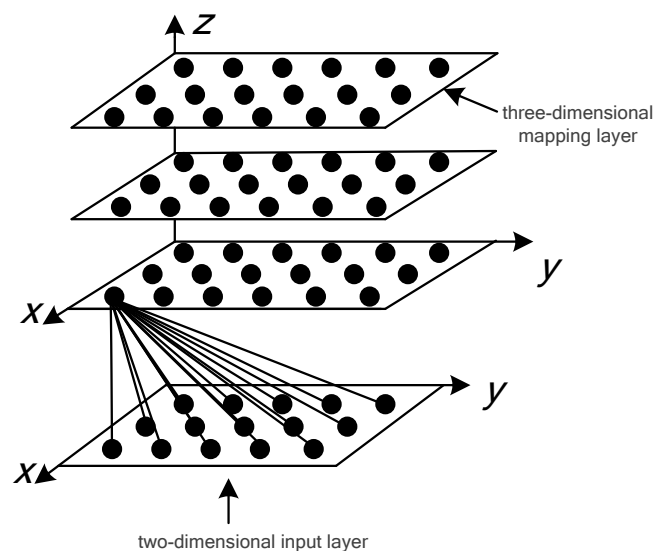


Fig.1 3D SOM network structure

III. 3D SOM NEIGHBORHOOD ALGORITHM

A. 3D Neighborhood Shape

The neighborhood shape of 3D SOM is a very important factor for the performance of the pattern library. We propose three kinds of neighborhood shapes, cube neighborhood, sphere neighborhood, 3D orthogonal cross neighborhood. Fig.2 (a) show the cube neighborhood, the length of cube side is twice the radius of neighborhood. Fig.2 (b) show the sphere neighborhood, the radius of sphere is the radius of neighborhood. Fig.2 (c) show the 3D orthogonal cross

This paper was supported by The Natural Science Foundation of China (No.61261035) and Innovation Project of GUET Graduate Education (No.GDYCSZ201451).

neighborhood, the length in each direction is the radius of neighborhood. The performance of 3D SOM algorithm is different when choosing different neighborhood shape.

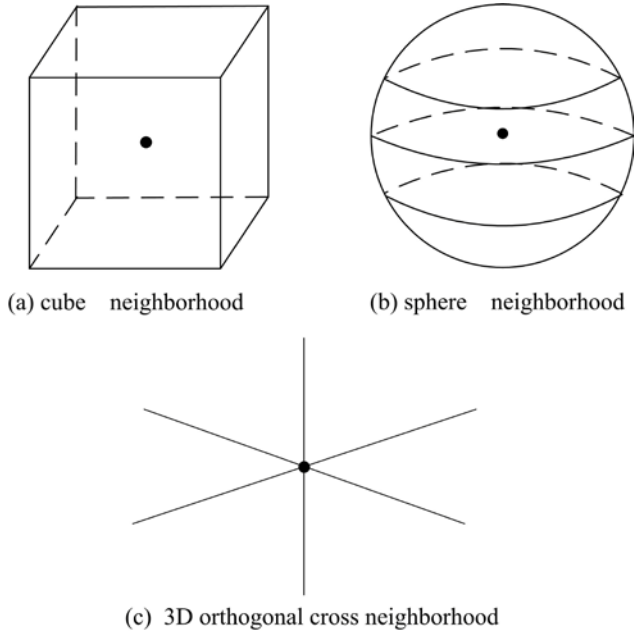


Fig.2 Three kinds of 3D neighborhood shape

B. 3D Neighborhood Decay Function

Neighborhood function $NE(t)$ decreases with time t . When t is sufficiently large, $NE(t)$ tends to a constant, the SOM network tends to stability. We proposed the linear and exponential functions as neighborhood decay function for 3D SOM algorithm.

(1) Linear function

$$NE(t) = NE_{\min} + (NE_{\max} - NE_{\min}) * (T - t) / T$$

(2) Exponential function

$$NE(t) = NE_{\min} + NE_{\max} e^{-t/T}$$

NE_{\max} and NE_{\min} are constants determining the range of the neighborhood, and T is a constant determining the decreasing rate. t is the number of iterations. When training begins, $t=0$, $NE=NE_{\max}$, as the training progresses, t increases constantly, NE tend to NE_{\min} .

IV. EXPERIMENTAL RESULTS

We use two testing grayscale stereo images to test our 3D SOM neighborhood algorithm, Tree and Plant. The reconstructed image quality is measured by PSNR, where

$$R_{\text{PSNR}} = 10 \lg \frac{255^2}{E_{\text{MSE}}} \text{dB}, \text{ and MSE is the mean square error}$$

between the original image and the reconstructed image. Ratio of image compression is calculated by $C_R = \frac{M \times B_o}{B_c}$, where

M is the dimensions of the pattern vector, B_o is bits of the original image pixels, B_c is bits of pattern vector class indexes.

In the experiment, the pattern library size is 2048

(compression ratio $C_R = \frac{64 \times 8}{11} = 46.5$). We use 3D

SOM algorithm with different neighborhood shape or neighborhood decay function to compress the disparity of the stereo image, and compare the prediction performance using PSNR between the original image and predicted image. Tab.1 shows PSNR comparison of three neighborhood shapes. It is clear that 3D orthogonal cross neighborhood achieve the best performance. Tab.2 shows PSNR comparison of two neighborhood decay functions. It is clear that exponential function has better than linear function.

TABLE I. PSNR COMPARISON OF THREE NEIGHBORHOOD SHAPES (dB)

Neighborhood shape	Cube	Spherical	3D orthogonal cross
Tree	31.61	30.43	33.39
Plant	30.43	28.93	32.69

TABLE II. PSNR COMPARISON OF TWO NEIGHBORHOOD DECAY FUNCTIONS (dB)

Neighborhood decay function	Linear function	Exponential function
Tree	29.55	33.39
Plant	27.63	32.69

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