

Representation of information using Kohonen's SOM (Self-Organizing Maps)

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Resumen

En este artículo se presenta una demostración de los mapas auto organizados de Kohonen's también llamados SOM. Así mismo es realizado un estudio del funcionamiento de los mapas de kohonen en una y dos dimensiones y las características de este tipo de redes que trabajan de forma similar al cerebro humano. Finalmente, son detalladas las características necesarias para realizar el entrenamiento de las redes y la forma como son utilizados sus resultados, con la finalidad de descubrir características de la información de entrada, como por ejemplo, la distribución, la densidad y la forma de la información.

Palabras Claves: Algoritmo de Kohonen, Redes Neuronales no Supervisadas, Entrenamiento Competitivo.

Abstract

In this paper is presented a demonstration of Kohonen's self-organizing maps, also known as SOM. Likewise is prepared a study of the functioning of Kohonen's maps in one and two dimensions and the most important characteristics of this type of network that works in similar way that the human brain. Finally, this paper details the characteristics necessary for the network's training and how is possible use the results of the neural networks to discover the characteristics of the information input for instance, how is your distribution, the density and shape.

Keywords: Kohonen, Algorithm, Unsupervised neural networks, Competitive Training.

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1 Introduction

The information is a set of data organized that integrate a message about a particular entity or phenomenon. At present the large quantities of information makes more complex their analysis and interpretation. For this reason is important the collaboration of tools that make more easy the information, for instance, the visualization of information, that allows information about their distribution, these tools can be used to detect errors and improve the take of decisions [1].

This paper presents a demonstration of Kohonen's maps [2], which is based on unsupervised neural networks, in order to debug the data or the information. This debug allows the representation of the pattern of information with Kohonen's maps and a smaller amount of data, but including all characteristics of the input data. The Kohonen's maps can be structures of information of one dimension, two dimensions or three dimension and each map there are zones with different density that is proportional to the repetition of data, for instance the zone with more information repetitive has more density than the information with less repetitive data.

2 Kohonen's maps

Kohonen's maps are incorporated into an algorithm of neural networks that can create cluster of data for a training process. This group creates the projection of these data on a map distributed the features gradually. Kohonen's maps have different applications such as [3],[4] :

- **Clustering:** Can be created groups of inputs data by different criteria.
- **View [5]:** These groups were done in orderly manner allowing see and discover new features or relations that weren't referred.
- **Classification [6] :** Done a Kohonen map, you can label and separated the data in different groups.
- **Interpolation function:** Providing numerical values to each node of the Kohonen network can avail these values in the vectors of the input.
- **Vector quantization [7]:** is used for obtain any vector or the vector close to a data set previously knew

2.1 Architecture of Kohonen's maps

The Kohonen's maps have architecture divided on layers:

- Input layer.

- Competition layer.

In the Kohonen's maps each neuron of the input layer is connected to all neurons in the layer of competition (Fig. 1).

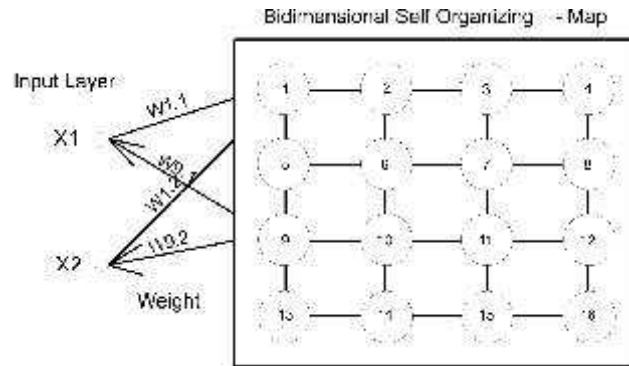


Fig. 1. Architecture of Kohonen maps

The difference with other types of networks [8], the neurons of Kohonen's maps are distributed throughout the input space, so when there are data in the input, it activates the neuron more close to the input data in the distribution area.

The important characteristic of these maps is the capacity to self organize as part of the learning process. When one neuron is active for one data, the neuron is developed in the space going to the point in the hyperspace of the input data. In this movement change the active neuron and his neighboring have a small displacement to organize the mesh created. The neurons can be moved through the space to the entrance remain grouped, forming a mesh in areas of the input space, which correspond to the input data.

For this the Kohonen's maps can detect relations between the data and common characteristics or also can be used for data compression and optimization.

3 Definition of type of neighborhood

The definition of the type of neighborhood [9] allows identify the neurons that learn when one neuron is active. For each neuron can be define one type of neighborhood, and each neuron can have 2 neighbors (Fig. 2), 6 neighbors (Fig. 3) or 8 neighbors (Fig. 4). The configuration

most used is the square configuration but the hexagonal configuration has the best theory base.

The neighborhood has another important factor is the shape of the function that changes the values of the vectors that she has. A Gaussian type function does that change the values decrease with distance. A function type circular change in the same way all vectors are in the neighborhood

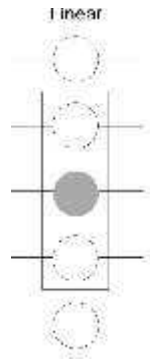


Fig. 2. Linear architecture of the neighborhood.

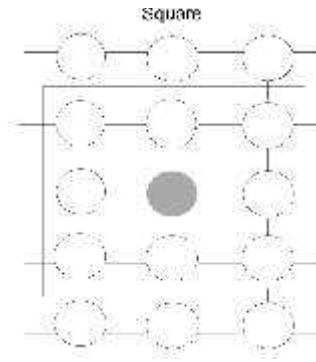


Fig. 3. Square architecture of the neighborhood

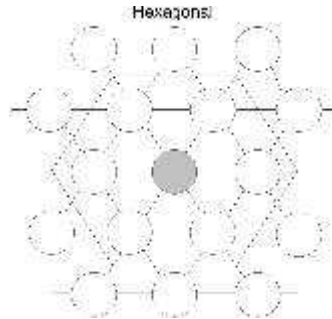


Fig. 4. Hexagonal architecture of neighborhood.

4 Training of Kohonen's maps

For the training in the Kohonen's maps should follow the next steps [10]: (i) organizes a data set that is the input in the network, (ii) is realized the scale of the data input, (iii) training the network, where presenting each one of the data on the network that moves the neuron that is close to the input data, and (iv) the training cycle is repetitive until the variation of the Kohonen map is low.

4.1 Initialization of variables.

The initialization of variables can be randomly within a range of variation and distribution determined (uniform, Gaussian, random distribution with small values)

4.2 Scale the inputs.

Sometimes the sets have different scales, so it should be do (before to training) a pre-processing of data in order that the variables have approximate the same range and standard deviation [11], guaranteeing that the input of the network are always on the same range. So should apply some methods, for example, the scale of the input variables is a statistic scale that has the following characteristics:

- Zero mean.
- The most values in the range $(-1, +1)$.
- By the scale between $(-1, +1)$ will be the 95% of the input data.

The scale of the variable is do for:

$$x_i = \frac{1}{2\sigma_{x_i}} (X_i - \mu_{x_i}) \quad (1)$$

Where,

X_i = Original variable.

x_i = Scale variable.

σ_{x_i} = Standard deviation of the original variable.

μ_{x_i} = mean of the input data.

4.3 Network Training

The main steps for the training of the network are shown in the diagram Figure 5 and described as follows:

- (i) Initialization of the weights in random form,

$$U_i = [u_{i,1}, u_{i,2} \dots u_{i,n}]$$

- (ii) Its show a vector of data for training,

$$E = [e_1, e_2 \dots e_n]$$

- (iii) Calculate the distance between the input and each of the output neurons j ,

$$d_j = \sum_{i=0}^{N-1} (X_i(t) - W_{i,j}(t))^2 \quad (2)$$

Where $X_i(t)$ is the i th input in the time t and $W_{ij}(t)$ is the neuron weight i to the neuron of output j .

- (iv) Selection of the neuron with the shortest distance j^* that is the winner neuron.
- (v) Update the weights of winner neuron j^* and the weights of the neighbours according of the type of the neighbourhood.

$$W_{i,j}(t+1) = W_{i,j}(t) + \alpha(t)(X_i(t) - W_{i,j}(t)) \quad (3)$$

Where $\alpha(t)$ ($0 < \alpha(t) < 1$) is the rate of learn and decreases in the time.

- (vi) Modifying the parameters of the neural network [12]: learning and the neighbourhood that are reduces when the number of iterations increases. The learning rate is calculated by equation (4).

$$\alpha_t = \alpha_0 \left(1 - \frac{t}{T}\right) \quad (4)$$

Where T is the number of iterations and α_0 is the initial value of α . The value of the neighbourhood is calculated with:

$$\Omega_t = \Omega_0 \left(1 - \frac{t}{T}\right) \quad (5)$$

Where, $\Omega_0 \cup \frac{1}{2}n^o$ neurons in the layer.

All the process of the neural network training is presented in the diagram block in the Fig. 5, in this diagram there are all the steps that were presented.

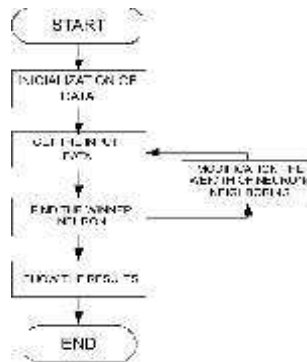


Fig. 5. Sequence for the application of neural network

4.4 Scale of the network.

In the finish of the training and testing process, the output signal shows the values that are within the range of $(-1, +1)$. It is necessary that the output back in the same proportion as were the entries. For this is necessary doing the scaling in the output signal. To return the input data in the initial range applies equation (8) which is to take equation (1) and isolate the variable X_i ,

$$X_i = 2\sigma_{X_i} \langle x_i + \mu_{X_i} \rangle \quad (6)$$

5 Evaluation of training's network

To do the test algorithm training is developed a program in Matlab, in order to do the variation of the sets of input data in the system (Fig. 6). Likewise, it makes the selection of the size of the representation of the input data that will be used for make the Kohonen's maps.

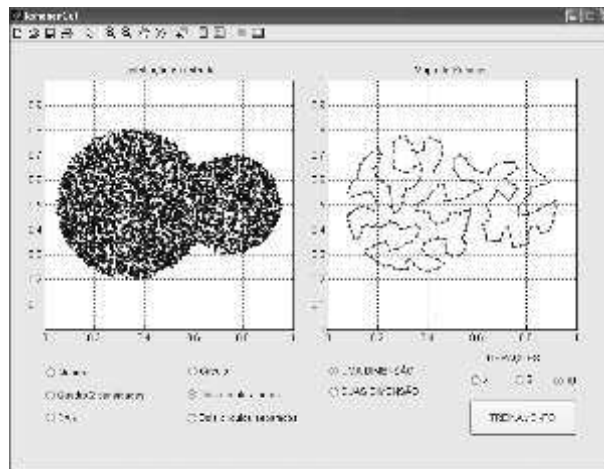


Fig. 6. Graphical interface.

After are created many sets of data for the test, in this set are modified in the density and distribution of input data and seeks to observe the variation of network behaviour to represent the input data.

Four different sets of data are testing with the Kohonen's maps:

- A square with uniform distribution of data.
 - A square where one half has a higher density than the other.
 - Half cross with uniform distribution of data.
- Two rounds with a separation between them.

5.1 Results

The following results were obtained with a mesh of 216 neurons and trained with a learning rate of 0.4. The input data in each of the sets have a ratio of 20 input data for each of the neurons of the mesh.

TEST 1: A square with the data uniformly distributed (Fig. 7 and Fig. 8).

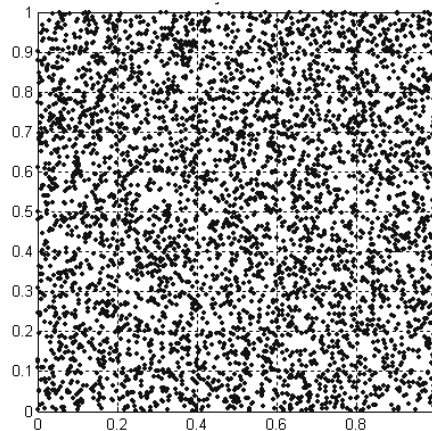


Fig. 7. Input square with uniform distribution

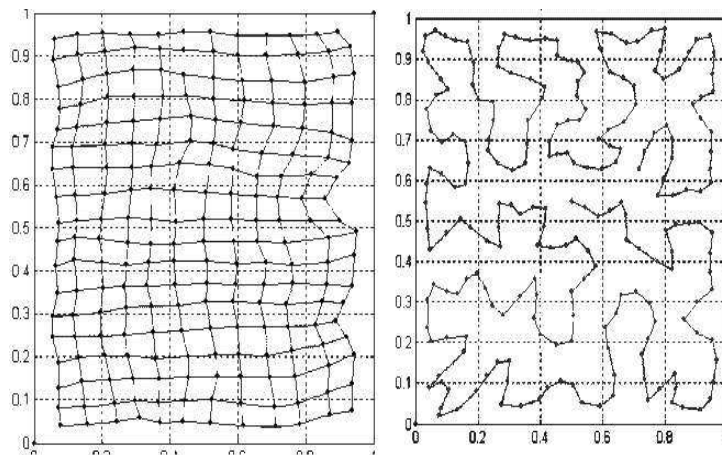


Fig. 8. Kohonen's maps for test 1 in one and two dimensions.

TEST 2: A square where one half has a higher density than the other (Fig. 9 and Fig. 10)

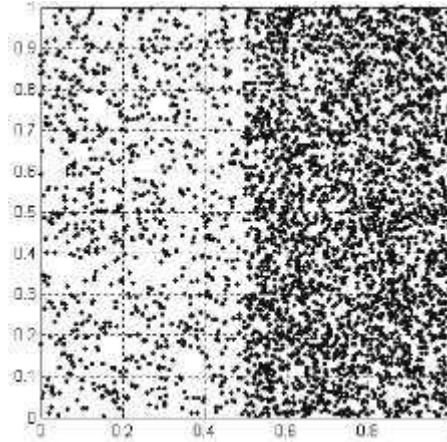


Fig. 9. Input square halves of different density.

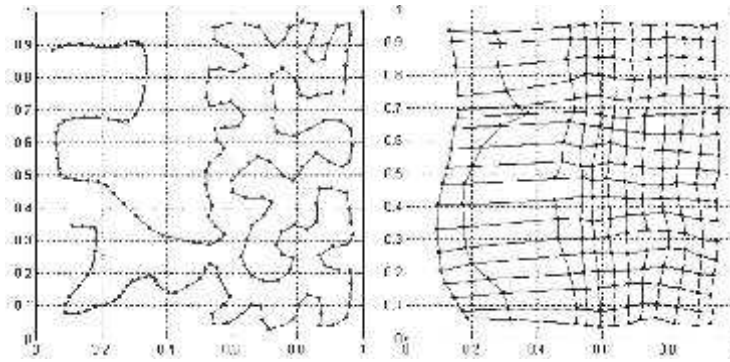


Fig 10. Kohonen's maps for test 2 in one and two dimensions.

TEST 3: Half cross with uniform distribution of data (Fig. 11 and Fig. 12).

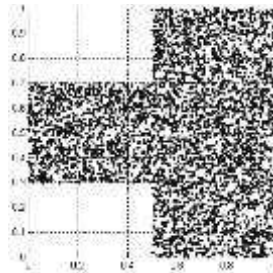


Fig. 11. Input half cross with uniform distribution

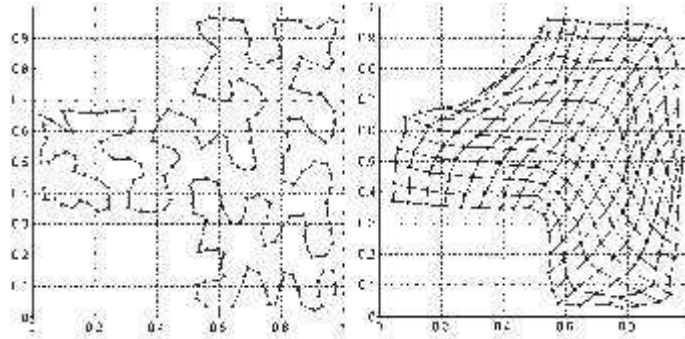


Fig.12 . Kohonen's maps for test 3 one and two dimensions.

TEST 4: Two circles that have a separation between them (Fig. 13 and Fig. 14)

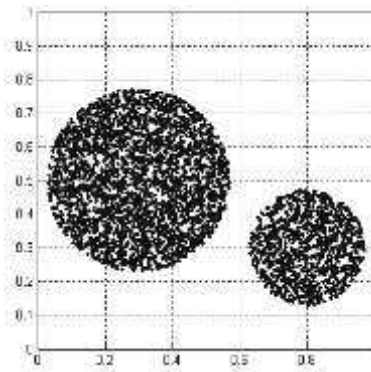


Fig. 13. Input data of two separate circles

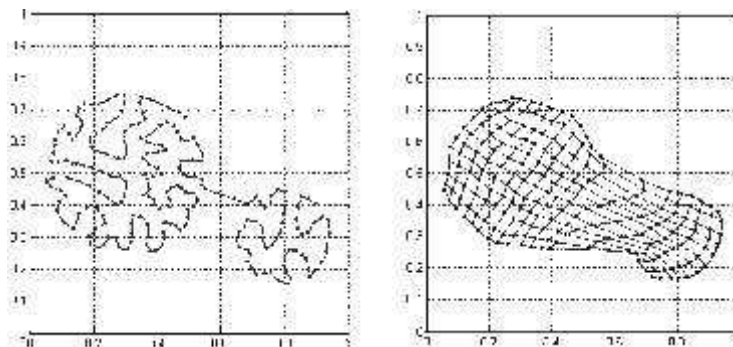


Fig. 14 . Kohonen's maps for test 4 one and two dimensions.

6 Conclusions

The Kohonen's maps are very used when do not have knowledge of the information, the results obtained with the kononen's maps not are better than the result of an analysis of a case where we have the knowledge of the characteristics of information. Therefore, is recommend working with this type of unsupervised procedures when nobody has knowledge of information

The density in the mesh of Kohonen's maps is an important characteristic that determines the absence of information in one range when the mesh in the neural network is sparse or otherwise when the presence of information with similar characteristics there are Kohonen's map with nodes very close between them.

In this article we can see the importance of the implementation of Kohonen maps in information processing, since it can have a representation of the distribution of input data allows to obtain a better knowledge of data input in a process for make decisions.

7 Acknowledge

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