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Comparison study for Image Classification using supervised and unsupervised Neuronal Networks

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***Abstract*— Image classification is a very common step in image analysis process. It is a low-level processing that precedes the step of measuring, understanding and decision. Its aim is image partitioning into related and homogeneous regions in the sense of a homogeneity criterion.**

This paper presents a new approach to image clustering based on neuronal networks. It involves performance evaluation of two different algorithms for classification of grayscale images: Supervised and Unsupervised neuronal networks.

***Keywords*— Image classification, Neuronal networks, Unsupervised, Supervised learning.**

I. Introduction

Classification is a basic step in the image processing. This operation aims to separate different homogeneous regions of an image to organize objects into clusters whose members have various properties in common (intensity, color, texture, etc.).

The classification can be performed in two ways: Unsupervised classification which aims to automatically split the image into natural clusters, i.e. without any prior knowledge of the classes; and supervised classification which operates from the knowledge of each of the classes defined by a probabilistic approach.

The Most common problems in image classification are; mixed pixel problem, lack of normality of the training data, and Hughes phenomenon. For these constraints, non-parametric classifiers such as neural network, decision tree classifier, and knowledge-based classification have increasingly become important approaches for multisource data classification [1].

Many algorithms have been proposed which are effective for classification implementation, and made huge progress in such aspects as image texture segmentation, remote-sensing image segmentation and edge detection, neural network provides one of them [2, 3, 4, 5], and there are several possibilities of neural network design.

The tool used in this work for the classification process in gray-scale image is the neuronal networks theory, or more precisely, the multi-layer perceptron and Kohonen algorithms, which are among the most effective methods applied in the image classification.

This paper is structured as follows; Firstly, we describe neuronal networks and its most common types in section 2. Then, we build theory in Section 3 which allows a suitable classification and we explain the principle of our approach. We show experimentally the difference between the two methods in Section 4 and conclude in Section 5.

II. Neuronal Networks

Neural networks perform a variety tasks, such as prediction and function approximation, pattern classification, they are also capable of complex data and signal classification task and many other using.

There exist two learning types; supervised and unsupervised.

A. Supervised Learning

It is a guided mode of learning. For each input, we provides the network with a desired output, used to measure the error committed at the output, in order to change network's behaviour to reduce this error.

The most common supervised learning algorithm is back-propagation as gradient descent for multi-layer perceptron.

- *Multi-layer perceptron with back-propagation*

The back-propagation algorithm can be used very generally to train neural networks; it is most famous for applications to layered feed-forward networks, or multilayer perceptron.

This algorithm is gradient descent on the squared cost function between the desired and actual outputs, which is defined as:

$$E = \frac{1}{2}\sum_{i=1}^{k}\left(Yi - di\right)^2 \tag{1}$$

Where yi is the activity level of the ith unit in the top layer and di is the desired output of the ith unit.

B. Un-supervised Learning

For an unsupervised learning rule, the training sets consist of input training patterns only. Therefore, the network is trained without benefit of any teacher. The network learns to adapt based on the experiences collected through the previous training patterns.

- *Kohonen Neuronal Networks*

Kohonen competitive neural network (CNN) provides one method of classification of image segments into a given number of classes using segments features [6].

The objective of a Kohonen network is to map input vectors (patterns) of arbitrary dimension N onto a discrete map with 1 or 2 dimensions. Patterns close to one another in the input space should be close to one another in the map: they should be topologically ordered. A Kohonen network is composed of a grid of output units and N input units. The input pattern is fed to each output unit. The input lines to each output unit are weighted. These weights are initialised to small random numbers.

The learning algorithm for Kohonen networks is the following:

start: Then-dimensional weight vectors w1,w2, . . . ,wm of the m computing units are selected at random. An initial radius r, a learning constant η, and a neighborhood function Φ are selected.

step 1 : Select an input vector ξ using the desired probability distribution over the input space.

step 2 : The unit k with the maximum excitation is selected (that is, for which the distance between wi and ξ is minimal, i = 1, . . .,m).

step 3 : The weight vectors are updated using the neighborhood function and the update rule

$$wi \leftarrow wi + \eta\Phi(i,k)(\xi - wi) \qquad for\ \ i = 1,\ldots\ldots m. \qquad (2)$$

step 4 : Stop if the maximum number of iterations has been reached; otherwise modify η and Φ as scheduled and continue with step 1.

The winning output unit is simply the unit with the weight vector that has the smallest Euclidean distance to the input pattern. The neighbourhood of a unit is defined as all units within some distance of that unit on the map (not in weight space).

III. Image Clustering

A suitable classification system and a sufficient number of training samples are prerequisites for successful classification.

A sufficient number of training samples and their representativeness are critical for image classifications [7, 8, 9, 10]. Selecting suitable variables is a critical step for successfully implementing an image classification.

The use of too many variables in a classification procedure may decrease classification accuracy [11].

So, it is important to select only the variables that are most useful for separating classes such as homogeneous areas, textures, edges and low intensities.

1) Supervised clustering method

Supervised classification enables us to have sufficient known pixels to generate representative parameters for each class of interest.
Development of the algorithm including supervised neural networks is done in three phases. The first phase is learning. Wherein, the network is driven from features vectors containing 64 samples extracted from each sliding window sized (3×3) belonging to various image areas (texture, edge, ect…). The second phase is the test; it is initiated when the network has finished learning. The third is an evaluation phase of our method which is the classification by value optimized using the neural network.

The best network architecture that has been tested in our experiments composed by 35 neurons in the first entrees layer and only one neuron in the output layer.

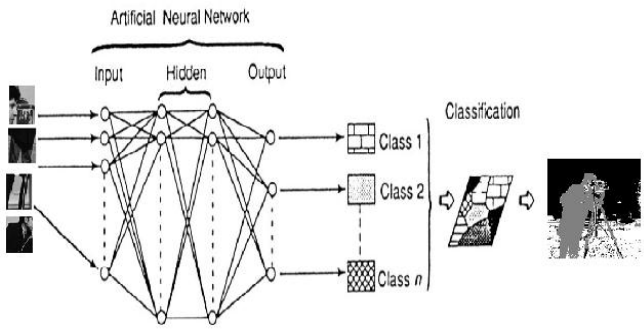


Fig. 3 Supervised clustering's architecture

2) Unsupervised clustering method

In an unsupervised classification pre-hand knowledge of classes is not required. Unsupervised clustering is motivated by the need to find interesting patterns or groupings in a given set of data.

Development of this algorithm requires only the inclusion of input vector with same samples used previously for supervised learning, and to indicate number of classes.

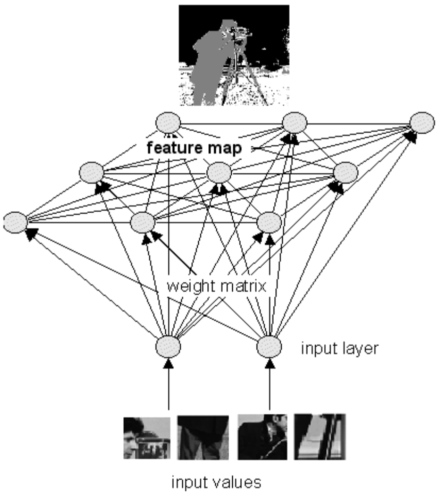


Fig. 4 unsupervised clustering's architecture

IV. Experiments

For assessing the performance of our approach, we use Segmentation by thresholding that is simple and effective segmentation method for images with different intensities. The technique basically attempts for finding a threshold value, which enables the classification of pixels into different categories.

The simulation results have been obtained using a lot of synthetic and other images that have various characteristics, low & high contrast, different sizes, with many or few objects in them, different grades of blurring, etc., so, permitting to justify that the method of classification by Kohonen neuronal networks is sufficiently robust

So the obtained results of classification and segmentation are respectively reported in the following figures.

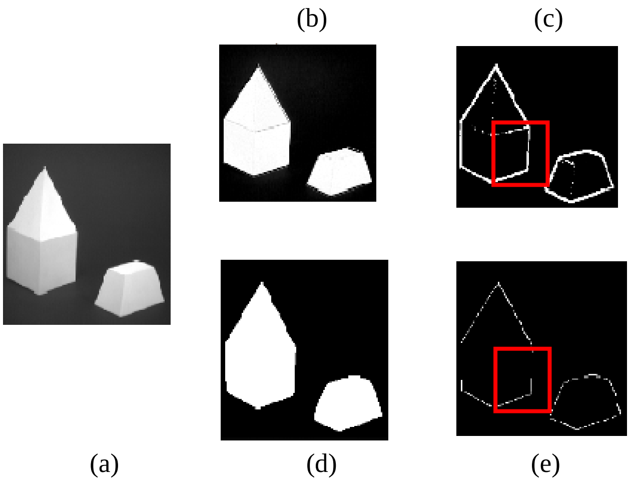


Fig.5.Classification results of supervised and unsupervised neuronal networks :(a) Original image, (b) Image classified using FF, (c) Segmented Image, (d) Image classified using kohonen , (e) Segmented image

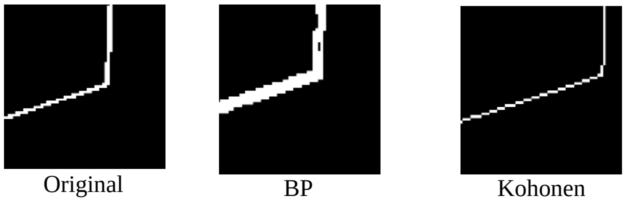


Fig.6. zoomed window of a segmented image

In order to clarify the difference between both methods of classification, the figures above represent a zoom in several areas of the segmented image.

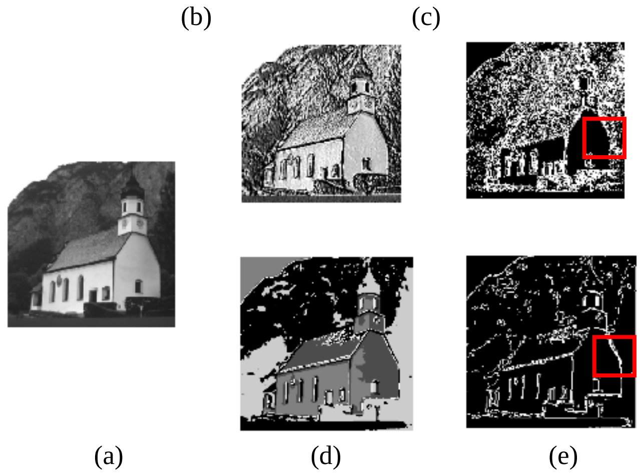


Fig.7.Classification results of supervised and unsupervised neuronal networks :(a) Original image, (b) Image classified using FF, (c) Segmented Image, (d) Image classified using kohonen , (e) Segmented image

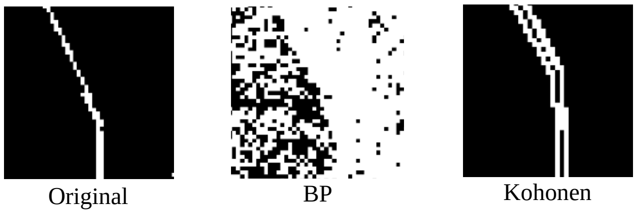
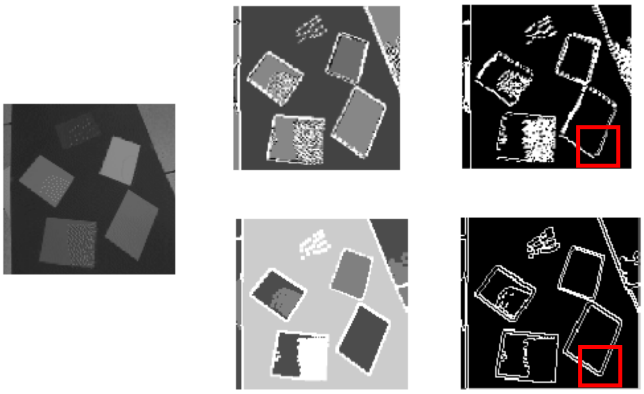


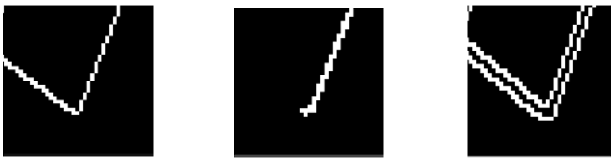
Fig.8.zoomed window of a segmented image

(b) (c)



(a) (d) (e)

Fig.9.Classification results of supervised and unsupervised neuronal networks :(a) Original image, (b) Image classified using FF, (c) Segmented Image, (d) Image classified using kohonen , (e) Segmented image



Original BP Kohonen

Fig.10. zoomed window of a segmented image

These simulation results show that the unsupervised image classification method can produce more accurate classified images when compared to supervised method; Classes and edges are more precise.

To prove the efficiency of Kohonen algorithm, we compute the entropy, as well as, the energy of each image. The results of comparing Kohonen algorithm with back-propagation algorithm are list in Table1.

TABLE I: ENTROPY AND ENERGY RATE

	Kohonen		BP	
	Entropy	**Energy**	**Entropy**	**Energy**
Original binary image	0,2377	1,32E+03	0,2377	1,32E+03
Classified binary image	0,32	1,35E+03	0,3357	3,31E+03
Original gray-scale image	0,3381	3847703	0,3381	3847703
Classified gray-scale image	0,7773	1,10E+04	0,9314	4,76E+04
original synthetic image	0,6263	1,79E+03	0,6263	1,79E+03
Classified synthetic image	0,7979	1,94E+03	0,7121	2,30E+03

Analyzing the result in Table1, it can be found that the Kohonen algorithm generates better results in classification than the back-propagation algorithm.

V. CONCLUSION

In this paper, primary studies of image classification by using competitive and supervised neural networks are presented, and we have made an analysis about the performance of these two different methods.

Based on current results, the Kohnen method seems to be more suitable tool for image classification than supervised neuronal networks.

Future work entails applying this two kind of classification for color image and retrieval and evaluating the performance by comparing with alternative clustering techniques.

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