



## Compression of Monochromatic and Multicolored Image with Neural Network

Ragmi Mustafa<sup>1</sup>, Basri Ahmedi<sup>1</sup> and Kujtim Mustafa<sup>2\*</sup>

<sup>1</sup>Public University "Kadri Zeka" Gjilan, Kosovo.

<sup>2</sup>South East European University, Macedonia.

### Authors' contributions

*This work was carried out in collaboration among all authors. The first draft of the manuscript was written by author BA, he also wrote the protocol. Author RM designed the study and performed the statistical analysis. Authors RM and KM managed the analyses of the study. Author BA managed the literature searches. All authors read and approved the final manuscript.*

### Article Information

DOI: 10.9734/AJRCOS/2021/v9i130213

#### Editor(s):

(1) Dr. Shivanand S. Gornale, Rani Channamma University, India.

#### Reviewers:

(1) Ghizlane Orhanou, Mohammed V University in Rabat, Morocco.

(2) Kansab Samah, University of Hassiba BenBouali Chlef, Algeria.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/68647>

Original Research Article

Received 15 March 2021

Accepted 21 May 2021

Published 24 May 2021

### ABSTRACT

Nowadays we have so much images provided by different types of machines, while we need to store them or transfer to other devices or via internet, we need to compress them because the images usually have large amount of size. Compressing them reduces time for transferring files. The compression can be done with different methods and software in order to reduce their capacity expressed in megabytes as much as tens of hundreds of gigabytes for more files. It is well known that the speed of information transmission depends mainly on its quantity or the capacity of the information package. Image compression is a very important task for data transfer and data storage, especially nowadays because of the development of many image acquisition devices. If there is no compression technique used on these data, they may occupy immense space of memory, or render difficult data transmission. Artificial Neural Networks (ANN) have demonstrated good capacities for lossy image compression. The ANN algorithm we investigate is BEP-SOFM, which uses a Backward Error Propagation algorithm to quickly obtain the initial weights, and then these weights are used to speed up the training time required by the Self-Organizing Feature Map algorithm. In order to obtain these initial weights with the BEP algorithm, we analyze the hierarchical approach, which consists in preparing the image to compress using the quadtree data

\*Corresponding author: E-mail: km26915@seeu.edu.mk;

structure by segmenting the image into blocks of different sizes. Small blocks are used to represent image areas with large-scale details, while the larger ones represent the areas that have a small number of observed details. Tests demonstrate that the approach of quadtree segmentation quickly leads to the initial weights using the BEP algorithm.

*Keywords: Photo compression; neural network, BEP-SOFM; frame segmentation; vector quantization; color spectrum.*

## 1. INTRODUCTION

There are many advantages of neural models learned through standard techniques “with a teacher” is the skill of associating facts [1]. This enables associations to be made for the input data networks based on patterns learned in the past [2,3]. The optimization of neural radial weights found in these networks is carried out through a “non-model” technique. One frequently used method uses the SOFM (Self-Organizing Feature Map) models proposed by Tuevo Kohonena [4]. An interesting feature of auto-association neural models of the SOFM type is their ability to classify objects even though the previously classified models were not known [5-7].

## 2. MONOCHROMATIC IMAGE [8]

Monochromatic image in Fig. 1 usually has the meaning of black and white or grayscale image. In computers, monochromatic has two meanings:

In a monochromatic bitMap image each pixel is stored as a single bit (0 or 1). In this regard a monochromatic image with a resolution of 640 x 480 pixels requires not less than 37.5 [kB] of memory. A monochromatic image looks like the following Fig. 1.



**Fig. 1. Monochromatic image 24-bit color photos [8]**

In 24-color images in Fig. 2, the graphic image is displayed and stored (especially in computer processing) in a very large number of colors and shades with very high quality photographic images or complex graphics. By definition, these images are colored with at least 256 shades of red, green and blue, so in total with 16 777 216 color variations. This 24-bit color image definition is important for computer graphics, where colors are represented by numbers, and each number is equivalent to the color to be represented. An example of 24-bit color photography is shown in Fig. 2.



**Fig. 2. Example of 24-bit color image**

Data compression is a very important task for data transfer and storage. It is the modification process of the information recording method in order to reduce redundancy (and hence the information volume) without changing the transmitted or stored information [9]. Nowadays the transmission of information through images plays an important role because of the development of many image acquisition devices [10]. A large number of image compression techniques have been developed, in order to make the process of image storage and transmission more economical [11]. Artificial Neural Networks (ANN) have demonstrated good capacities for problems that deal with noisy or incomplete data [12]. In the literature different approaches of image compression have been presented. One of these is BEP-SOFM algorithm [13] which uses a Backward Error Propagation algorithm to obtain quickly the initial weights, and then these weights are used to speed up the training time required by Self-Organizing Feature

Maps algorithm. The image is divided into same-size blocks. The pixel gray level values within the block are reshaped into a column vector and inputted to the neural network through the input nodes.

The purpose of this work is to present an analysis of the BEP-SOFM algorithm for network learning, but instead of dividing the image into same-size blocks, we use the quadtree segmentation. This procedure is based on segmenting the image into variable blocks size, depending on its level of activity [14, 15]. We developed a software application for building the SOFM and BEP-SOFM algorithms (with same-size blocks and quadtree segmentation), for compressing and decompressing the images, and displaying the compression ratio statistics. Simulation results are presented, together with algorithms comparisons.

### 3. IMAGE PRE-PROCESSING

We used the gray scale images. The pixel can take values from 0 to 255. In order to change the colour image into gray scale image, we summarize 30% of the red component, 59% of the green and 11% of the blue component. The image is subject to this process before compression.

#### 3.1 Image Fragmentation Into Blocks

The easiest technique of preparing the image for compression is its same-sized blocks fragmentation [16, 17, 8]. Fig. 3 presents the image of size 64 x 64 divided into blocks of 8 x 8.

#### 3.2 Quadtree Segmentation

In most images, we can distinguish regions containing more or less details [10]. In this technique, the image is divided into blocks of

different sizes that contain similar levels of gray colour [5]. The small blocks represent the parts of the image with many details, while the bigger ones represent the regions with less detail. The image is divided into smaller blocks, if the contrast of gray level on the block is larger than a specified threshold. Here the contrast is the difference of the pixels in the examined block with the average pixels value in this block. The block size is  $2^n$  pixels ( $n$  – natural number) [18]. By using these techniques a tree structure is formed as shown in Fig. 4. First the image is divided into blocks and for each of them the difference of the contrast is checked. If this contrast is less than the predetermined threshold, then it means that the block has no detail (or just a few). Otherwise the block is divided into 4 smaller blocks of size 2 times smaller (L1). This procedure is repeated for each of the newly formed blocks (creation of the L2, L3, ...). This operation of dividing the image into smaller blocks continues until reaching the minimum block size. An example of this procedure is shown in the Fig. 5.

The average pixel value in the block is calculated and then for each pixel the inequality is checked by:

$$|x_{ij} - x_m| \leq R \tag{1}$$

Where  $x_m$  is the average pixel value for block  $m$ ;  $R$  is a constant that helps to determine the number  $L$  of pixels that do not meet the condition (1). If this condition is true for all pixels in the block, then the block is not divided further. Otherwise the decision for further division depends on the value of parameter  $L$ . This procedure continues until the minimum block size is reached and the pixel block values are set to the average pixels value [18,14].

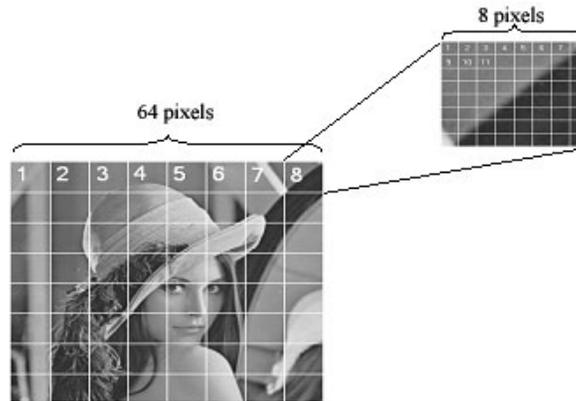


Fig. 3. Image fragmentation into blocks

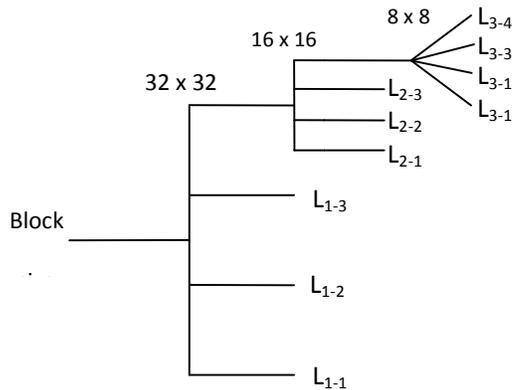


Fig. 4. Tree structure



Fig. 5. Example of quadtree segmentation

All the actions realized during the quadtree segmentation are stored in the segmentation map in order to achieve the process of reconstruction of the compressed image. This requires the use of a bilinear interpolation.

#### 4. BEP-SOFM ALGORITHM FOR NEURAL NETWORK

Kohonen proposed an unsupervised learning algorithm SOFM for the vector quantization [16], where the main disadvantage is the long time required to calculate the code book. This delay is due to the use of random initial values for the SOFM algorithm. Panchanathan [13] proposed a new schema of image compression, which was a combination of BEP and SOFM algorithms. Linking BEP-SOFM accelerates the execution of vector quantization. The initial values of weights for the SOFM algorithm are quickly obtained from the BEP algorithm.

Before compression, the image is divided into frames using quadtree segmentation. Each frame represents an input vector. The network architecture (Fig. 6) is a three-layer network with  $N$  input nodes,  $N$  output neurons, and  $M$  hidden neurons.  $N$  and  $M$  are respectively the input vector size and the codebook length.  $W_{k,j}^{(1)}$  is the weight connection between  $k$ -th input node and  $j$ -th hidden neuron, where  $1 \leq k \leq N$  and  $1 \leq j \leq M$ . Similarly,  $W_{j,k}^{(2)}$  is the weight connection between  $j$ -th hidden neuron and  $k$ -th output neuron. In the SOFM algorithm weights  $W_{k,j}^{(1)}$  are randomly initialized. To accelerate the generation of code books, it is important that the SOFM algorithm begins the calculation with the appropriate initial weight values.

BEP-type learning algorithm [17, 19] can be used for effective network learning, in order to generate the required weights when the image pattern is presented in the network input.

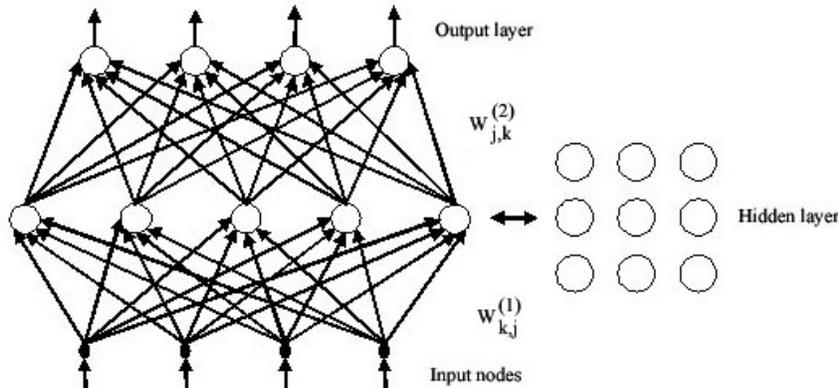


Fig. 6. Network scheme for BEP-SOFM algorithm

It is expected that the required output (response) during the learning process should be identical to the input vector. Then the hidden neurons will decode the input vector. That's why the neuron in the hidden layer may be sensitive only for a certain group of similar vectors and can be used as a representative of the input signal characteristics. Therefore, the weights at the end of the BEP learning algorithm are well calculated as initial weights for the SOFM algorithm.

## 5. THE EXPERIMENTAL RESULTS AND DISCUSSION

We analysed the impact of image size on the compression process for BEP-SOFM algorithm, and compared the results obtained from the SOFM algorithm, the BEP-SOFM with same-size segmentation and the BEP-SOFM with quadtree segmentation. These results are presented in terms of mean square error (MSE) and peak signal to noise ratio (PSNR).

### 5.1 Image Size

Image compression with the BEP-SOFM algorithm is tested on different image sizes. The network architecture is as follow: input nodes 64; hidden neurons (equal to the code book length) 256; output neurons 64; frame size 8 x 8; The Fig. 7. represents the results for an image of 512 x 512.

Image 512 x 512  
MSE = .002947 PSNR = 4989918



Fig. 7 a. Original image

For other images

Image 256 x 256  
MSE = .0038510 PSNR = 48.73810

Image 128 x 128  
MSE = .0053690 PSNR = 47.29497

For the 512 x 512 image, we have the highest PSNR ratio value. This is because the 8 x 8 frame size in a small image contains more details, a fact that is significant in an image of these sizes. Meanwhile in a bigger image, the frame contains just a few details and that is why the PSNR ratio has higher values.

### 5.2 Comparison of Algorithms

We compared the BEP-SOFM algorithm with SOFM algorithm, and the influence of the quadtree segmentation on the image compression process. The graphic (Fig. 8) shows the error values for these scenarios.

The use of BEP algorithm to obtain quickly the initial weights value for the SOFM algorithm provides clearly better results. On the other hand, the use of quadtree segmentation for the BEP-SOFM algorithm also provides better error results, but from the test we noted that the image quality for small images is not or is slightly improved. The difference is noted for bigger images. (Fig. 9)



Fig. 7 b. Image after decompression

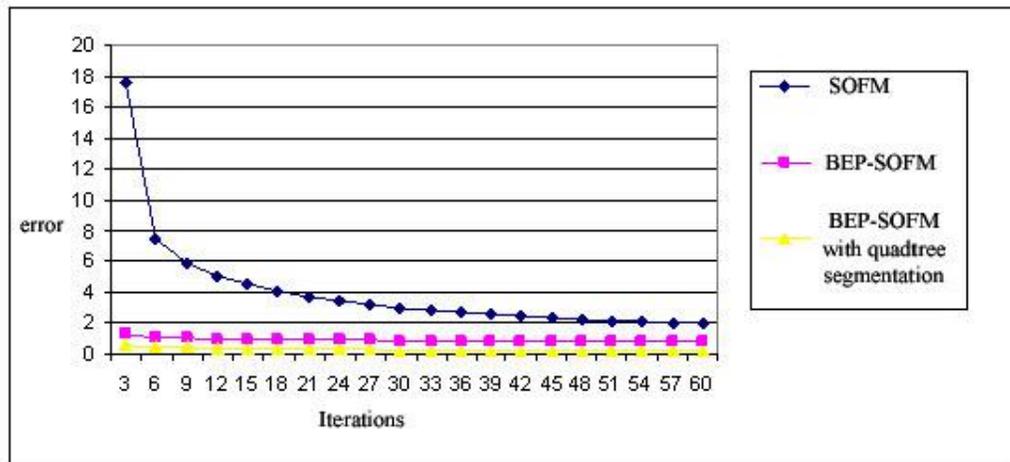
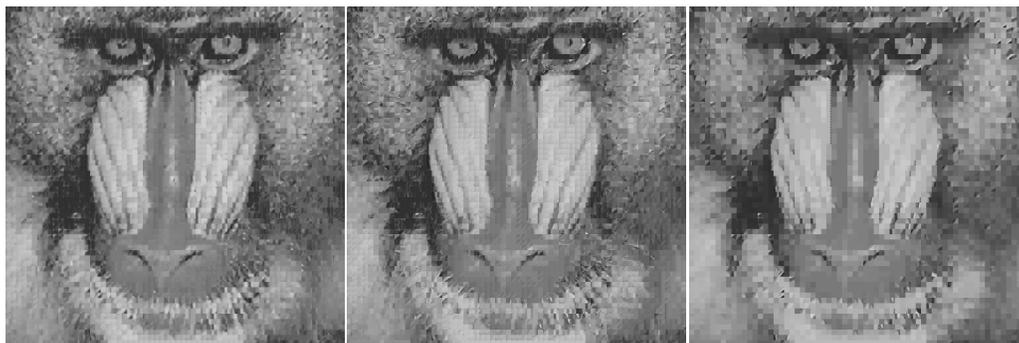


Fig. 8. Error results graphic for SOFM, BEP-SOFM and BEP-SOFM with quadtree segmentation



**SOFM algorithm**  
PSNR=44,77; MSE=0,0096

**BEP-SOFM algorithm**  
PSNR=44,86; MSE=0,0094

**BEP-SOFM algorithm with quadtree segmentation**  
PSNR=44,88; MSE=.0093

Fig. 9. BEP-SOFM algorithm image

## 6. CONCLUSIONS

The presented work is about the issue of image compression using neural network. We analyzed the BEP-SOFM algorithm, which uses Backward Error Propagation algorithm to quickly obtain initial values of the weights for Self-Organizing Feature Maps algorithm. The image to compress was prepared by dividing it into same-size blocks and by using the quadtree segmentation. The tests showed that using quad tree segmentation for the BEP-SOFM algorithm provides better error results than dividing the image into same-size blocks. An important feature for the image compression process is the image size. Quadtree segmentation for small images did not, or slightly improved the image quality comparing with the results obtained from the simple dividing method. But, for bigger images the quality is improved evidently.

This is because, dividing the training image into smaller blocks by changing the pixels value to the average value, the input vector components have the same value. This means that on the decompressing process, the blocks will have the same color value. But for a bigger image, these blocks do not have many details in them [10].

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Boniecki P, Nowakowski K, Tomczak RŁ. Neural networks type MLP in the process of identification chosen varieties of maize. 3rd International Conference on

2. Digital Image Processing (ICDIP 2011), Proceedings of SPIE. 2011;8009, Article Number: 800908, DOI: 10.1117/12.896184
2. Boniecki P, Dach J, Nowakowski K, Jakubek A. Neural image analysis of maturity stage during composting of sewage sludge. International Conference on Digital Image Processing (ICDIP 2009), Proceedings. 2009;200-203. DOI: 10.1109/ICDIP.2009.85.
3. Nowakowski K, Boniecki P, Dach J. The identification of mechanical damages of corn kernels basis on neural image analysis. International Conference on Digital Image Processing (ICDIP 2009), Proceedings. 2009;412-415. DOI: 10.1109/ICDIP.2009.78.
4. Kohonen T. Self-organized formation of topologically correct feature maps. Biological Cybernetics. 1982;43:59-69.
5. Janczak D, Lewicki A, Mazur R, Boniecki P, Dach J, Przybył J, Pawlak M, Pilarski K., Czekala W. The selected examples of the application of computer image analysis in the assessment of environmental quality. 5<sup>th</sup> International Conference on Digital Image Processing. Proceedings of SPIE. 2013;8878:Article Number: 88783R. DOI: 10.1117/12.2031069.
6. Kozłowska M, Jaskulska M, Łacka A, Kozłowski RJ. Analysis of studies of the effectiveness of a biological method of protection for organic crops. Biometrical Letters. 2014;51(1):45-56. DOI: 10.2478/bile-2014-0004.
7. Kujawa S, Nowakowski K, Tomczak RJ, Dach J, Boniecki P, Weres J, Mueller W, Raba B, Piechota T, Rodríguez Carmona PC. Neural image analysis for maturity classification of sewage sludge composted with maize straw. Computers and Electronics in Agriculture. 2014;109:302-310. DOI:10.1016/j.compag.2014.08.014
8. Dragan Cvetkovic. Racunarska Grafika. Beograd; 2006.
9. Asuquo DE, Nwachukwu EO, Ekong NJ. Application of run-length technique in data compression. Journal of Applied Sciences Research, INSInet Publication; 2010.
10. Rafael C. Gonzales, Richard E. Woods. Digital Image Processing” 2nd edition. Prentice-Hall; 2002.
11. Snehal O. Mundhada, Vijaja K. Shandilya. Image compression and its various techniques. International Journal of Computer Information Systems. 2011;2(3).
12. Yahya M Masalmah, Jorge Ortiz. Image compression using neural networks. Electrical and Computer Engineering Department University of Puerto Rico; 2003.
13. Panchanathan S. i in. : Artificial neural networks for image compression. SPIE. 1992;1709.
14. Osowski S. Sieci neuronowe do przetwarzania informacji. Ofic. Wyd. PW; 2000.
15. Yuen H, Hanzo L. Multimedia image coding using lossless quadtree segmented block-based two-dimensional differential coding. University of Southampton, Research Journal; 1996.
16. Christophe Amerijckx et al. Image compression by Self-Organized Kohonen maps. IEEE Trans on Neural Networks. 1998 May;9(3).
17. Rama Prasad V Vaddella, Kurupati Rama. Artificial neural network for compression of digital images: a review”. International Journal of Reviews in Computing; 2010.
18. Osowski S. Sieci neuronowe w ujęciu algorytmicznych. WTN; 1996.
19. Kulkarni S, Verma B, Blumenstein M. Image compression using a direct solution method based neural network. in Proceedings of the Tenth Australian Joint Conference on Artificial Intelligence, Perth, Australia. 1997;114-119.

© 2021 Mustafa et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*  
*The peer review history for this paper can be accessed here:*  
<http://www.sdiarticle4.com/review-history/68647>