Switching of Wavelet Transforms by Neural Network for Image Compression

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ABSTRACT

Nowadays, digital images compression requires more and more significant attention of researchers. Even when high data rates are available, image compression is necessary in order to reduce the memory used, as well the transmission cost. An ideal image compression system must yield high-quality compressed image with high compression ratio. In this article, a neural network is implemented for image compression using the feature of wavelet transform. The idea is that a back-propagation neural network can be trained to relate the image contents to its ideal compression method between two different wavelet transforms: orthogonal (Haar) and biorthogonal (bior4.4).

KEYWORDS
Back-Propagation Algorithm, Biorthogonal Wavelet, Haar Wavelet, Image Compression, Neural Network, Scaled Conjugate Gradient

1. INTRODUCTION

In the past few years, there has been a fast development of the computer applications which caused a big increase of the use of digital data mainly in the domain of multimedia, medical imagery, satellite transmission, games, etc., and this data need in some point to be compressed in order to reduce the storage space and the transmission cost, consequently many techniques of compression such wavelet transforms are been rapidly developed to handle and store data in efficient way (Ahmadi, Javaid & Salari, 2015; Rabbani & Jones, 1991).

Wavelet transforms are lossy powerful methods that compress images at higher compression ratio; they are a time-frequency representation that takes account both the time and the frequency of the signal to analyze (Rabbani & Jones, 1991). They have been used with great success in a wide range of applications. For many years, a number of researchers have been interested in the three important processing stages of the wavelet compression technology: pixels transform, vector quantization and entropy coding (Krishnanaik, Someswar, Purushotham & Rajaiah, 2013) and the majority of the articles they published have shown the efficiency of the technique in compressing images at high compression ratios with low image distortion (Antonini, Barlaud, Mathieu & Daubechies, 1992; Said & Pearlman, 1996). As a result of all this research, several wavelet families have emerged (Gandhi, Panigrahi & Anand, 2011) and all these techniques have the same purpose which is to yield high compression ratio while maintaining high-quality images.

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The implementation of artificial neural networks in image processing application has increased since they have been introduced in the signal processing few years ago (Zang & Beneveniste, 1992; Jiang, 1999). Moreover, a lot of research has focused on the combination of image compression techniques and the use of the neural network with great success. This combination has proved to be a valuable tool for image processing (Dimililer, 2013; Dimililer & Khashman, 2008; Alexandridis & Zapranis, 2013).

Despite the fact that the wavelet library contains a large number of wavelets, many researchers have proved that the choice of the best wavelet has significant impact on the quality of compression (Gandhi, Panigrahi & Anand, 2011). Therefore, the work presented in this paper deals with the selection of the most suitable wavelet function for compressing a particular image between two wavelets transforms Haar and Bior4.4 by training a back-propagation neural network to relate a grayscale image to its ideal compression system just by learning the nonlinear relationship between the pixel intensities of the image.

This paper is organized as follow: section 2 is shared in three parts: the first part presents a brief theory of the wavelet transform process, the second part focuses on the theoretical concept of the feed-forward artificial neural network the last part presents the back-propagation based on the scale conjugate gradient algorithm. In section 3, the methodology of the experiment is presented followed by the results and discussions in the section 4. Finally, section 5 demonstrates conclusion and directions for future works.

2. THEORETICAL BACKGROUND

2.1. Wavelet

For image compression, wavelets have recently emerged as a powerful tool that provides good visual quality with fewer bits to represent digital images (Gandhi, Panigrahi & Anand, 2011). The wavelet decomposition of function f(t) consists of a sum of functions obtained from simple dilation and translation operations done on a main admissible function called “mother wavelet” (Gandhi, Panigrahi & Anand, 2011; BenAmar & Jemai, 2007):

\[
\text{Tr}(a, b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{+\infty} f(t) \hat{\psi}(a, b) dt
\]

(1)

Where

\[
\hat{\psi}(a, b) = \frac{1}{\sqrt{a}} \hat{\psi} \left( \frac{t - b}{a} \right)
\]

is the waves family (2)

a and b are, respectively, the dilation and translation parameters.

\(\psi(t)\) is the “mother wavelet” which must have a compact support and must satisfy the properties of oscillation, translation and dilatation so other wavelets will be generated.

As the Fourier transform, wavelet transform is applicable to both continuous as well as discrete signals like digital images. The discrete wavelet transform (DWT) decomposes the digital image into sub-band in the horizontal and vertical directions. A low and high pass filters are applied to the image along rows and columns separately from this emerge three detailed sub-images: horizontal high-pass sub-image, vertical high-pass sub-image and diagonal high-pass sub-image and one approximate low-pass sub-image (Ahmadi, Javaid & Salari, 2015; Mallat, 1989). The decomposition process is
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