Neural Network based Soft Computing Technique for Image Compression and Decompression

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Abstract--- Image compression is the technique used to minimize memory space and decrease bandwidth (reduce high data rate) for transmission without deteriorating image quality. The various methods and standards for image and video like JPEG, Wavelet, M-JPEG, H.26x etc. have been proposed by researchers. Even though, Increase in mass-storage density, speed of processor, and digital communication system performance, demand for data storage capacity and data-transmission bandwidth continues to outrage the capabilities of available technologies.

Apart from the above mentioned existing technology on image & video compression, a method of image compression using soft computing have been proposed. Two layer Feed forward neural network will be considered and will be trained off-line using Levenberg Marquardt algorithm. The weights of trained network of hidden and output layers are used for image compression and decompression respectively for any test image. MATLAB will be used as software tool to carry out for training neural network, image compression and image decompression. The performance parameters like compression efficiency, complexity of algorithm and quality, for image compression & decompressions will be analyzed.

*Keywords:*Data Compression, Image Compression, Feed Forward Neural Networks, Compression Techniques, Levenberg Marquardt algorithm.

I. INTRODUCTION

Direct transmission of the video data requires a high-bit-rate (Bandwidth) channel. When such a high bandwidth channel is unavailable or not economical, compression techniques have to be used to reduce the bit rate and ideally maintain the same visual quality. Similar arguments can be applied to storage media in which the concern is memory space. Video sequence contain significant amount of redundancy within and between frames. It is this redundancy that allows video sequences to be compressed. Within each individual frame, the values of neighboring pixels are usually close to one another. This spatial redundancy can be removed from the image without corrupting the picture quality using "Intra frame" techniques.

A. Principles of Image Compression

The principles of image compression are based on information theory. The amount of information that a source produce is the Entropy. The amount of information one receives from a source is equivalent to the amount of the uncertainty that is removed.

A source produces a sequence of variables from a given symbol set. For each symbol, there is a product of the symbol probability and its logarithm. The entropy is a negative summation of the products of all the symbols in a given symbol set.

Compression algorithms are methods that reduce the number of symbols used to represent source information, therefore reducing the amount of space needed to store the source information or the amount of time necessary to transmit it for a given channel capacity. The mapping from the source symbols into less target symbols is referred to as Compression and Vice-versa Decompression.

Image compression refers to the task of reducing the amount of data required to store or transmit an image. At the system input, the image is encoded into its compressed from by the image coder. The compressed image may be subjected to further digital processing, such as error control coding, encryption or multiplexing with other data sources, before being used to modulate the analog signal that is actually transmitted through the channel or stored in a storage medium. At the system output, the image is processed step by the step to undo each of the operations that were performed on it at the system input. At the final step, the image is decoded into its original uncompressed form by the image decoder. If the reconstructed image is identical to the original image the compression is said to be lossless, otherwise, it is lossy.

B. Performance measurement of image Compression

There are three basic measurements for the IC algorithm.

1) Compression Efficiency:-
It is measured by compression ratio, which is defined as the ratio of the size (number of Bits) of the original image data over the size of the compressed image data

2) Complexity:
The number of data operations required performing bit encoding and decoding processes measures complexity of an image compression algorithm. The data operations include additions, subtractions, multiplications, division and shift operations.

3) Distortion measurement (DM):
For a lossy compression algorithm, DM is used to measure how much information has been lost when a reconstructed version of a digital image is produced from the compressed data. The common distortion measure is the Mean-Square-Error of the original data and the compressed data. The Signal-to-Noise ratio is also used to measure the performance of lossy compression algorithm.

4) Image compression techniques
Still images are simple and easy to send. However it is difficult to obtain single images from a compressed video signal. The video signal uses a lesser data to send or store a

video image and it is not possible to reduce the frame rate using video compression. Sending single images is easier when using a modem connection or anyway with a narrow bandwidth.

Main compression standard for still image	Main compression standards for video signal
JPEG	M-JPEG (Motion.JPED)
Wavelet	H.261,263etc.
JPEG 2000	MPEG1
GIF	MPEG2
	MPEG3
	MPEG4

Table 1: compression standards

C. JPEG (Joint Photographic Expert Group)

The JPEG (Joint Photographic Experts Group) standard has been around for some time and is the only standard for lossy still image compression. There are quite a lot of interesting techniques used in the JPEG standard .JPEG comes from the committee name that introduced this standard. This is a lossy type of image compression. It is effectively used on still images.

JPEG is called lossy because the reconstructed image on the receiver side is not the same as the transmitter side. The advantage is that one can achieve much higher compression with this standard but at the cost of some data. The small difference in color is invisible to human eye and JPEG standard works on that concept. If detail analysis of the image pixel-by-pixel is done, it would be realized that the amount of data being lost is high. Although the data is lost, it can be controlled by setting parameters.

One can keep decreasing size of the file, by reducing the number of bits until it is not affecting the quality of image. The image should be recognized well on the receiver side. There is one mode called progressive mode, which handles real time image transmission. In multiple scans, DCT co-efficient are sent. Depending on each scan, we can get more compressed image. This mode is a hierarchical mode, which is used for an image at multi resolution. Images with resolution like 1024x1024 and 2048x2048, are stored as a difference with next small size images. There were many extensions introduced to JPEG. Quantization is one of them. This method i s most popular these days for image compression. It is easy to separate most important and less important parts of the image with this method. To code them, it is necessary to pay high attention to important part and less attention to less important parts.

D. Wavelet

Wavelets are functions used in representing data or other functions. They analyse the signal at different frequencies with different resolutions. Optimized standard for images with amount of data with sharp discontinuities. Wavelet compression transforms the entire image differently from JPEG and is more natural as if follows the shape of the objects in the picture. It is necessary to use special software for viewing, being this a non-standardized compression method.[21]

E. JPEG2000

While there is a modest increase in compression performance of JPEG 2000 compared to JPEG, the main advantage offered by JPEG 2000 is the significant flexibility of the code stream. The code stream obtained after compression of an image with JPEG2000 is scalable in nature, meaning that it can be decoded in a number of ways; for instance, by truncating the code stream at any point, one may obtain a representation of the image at a lower resolution, or signal-to-noise ratio – see scalable compression. By ordering the code stream in various ways, applications can achieve significant performance increases. However, as a consequence of this flexibility, JPEG 2000 requires encoders/decoders that are complex and computationally demanding. Another difference, in comparison with JPEG, is in terms of visual artifacts: JPEG 2000 produces ringing artifacts, manifested as blur and rings near edges in the image, while JPEG produces ringing artifacts and 'blocking' artifacts, due to its 8×8 blocks.JPEG 2000 has been published as an ISO standard, ISO/IEC 15444. As of 2013, JPEG 2000 is not widely supported in web browsers, and hence is not generally used on the Internet.

F. GIF (Graphic Interchange Format).

Graphic format used widely with Web images. It is limited to 256 colors and is a good standard for images which are not too complex. It is not recommended for network cameras being the compression ratio too limited.[21]

G. M-JPEG (Motion –JPEG)

This is a not a separate. Standard but rather a rapid flow of JPEG image that can be viewed at a rate sufficient to give the illusion of motion. Each frame within the video is stored as a complete image in JPEG format. Singel image do not interact along with the self. Images are then displayed sequentially at a high frame rate. This method produces a high quality video, but at a cost of large files.[15]

H. H.261, H.263 etc.

Standards approved by ITU (International Telecommunications Union). They are designed for videoconference applications and produce images with a high quality.[15]

II. IMAGE COMPRESSION WITH NEURAL NETWORKS

Apart from the existing technology on image compression represented by series of JPEG, MPEG, and H.26x standards, new technology such as neural networks and genetic algorithms are being developed to search the future of image coding. Successful applications of neural networks to vector quantization have now become well established, and other aspects of neural network concern in this area are stepping up to play significant roles in supporting with those usual compression techniques. Existing research can be summarized as follows:

1. Back-Propagation image Compression;
2. Wavelate based image compression
3. Adaptive Back-Propagation Neural Network
4. Hebbian Learning Based Image Compression
5. Vector Quantization Neural Networks;

6. Predictive Coding Neural Networks.

A. Introduction to Neural Network

It can be defined as a "massively parallel distributed architecture" for storing experimental knowledge and making it available for use. It refers to a computational paradigm in which a large number of simple computational units are interconnected to form a network, performing complex computational tasks. A neural network is a system of interconnecting neurons in a network working together to produce an output function. The output of a neural network relies on the cooperation of the individual neurons within the network to operate. Processing of information by neural networks is often done in parallel rather than in series (or sequentially). Since it relies on its member neurons collectively to perform its function, a unique property of a neural network is that it can still perform its overall function even if some of the neurons are not functioning. That is, they are very robust to error or failure (i.e., fault tolerant). There are three major learning paradigms, each corresponding to a particular abstract learning task. These are supervised learning, unsupervised learning and reinforcement learning. Neural networks can accept a vast array of input at once and process it quickly, so they are useful in image compression.

III. Back propagation neural network

Backpropagation is a systematic method of training Multilayer Artificial Neural Networks. The Backpropagation derives from the fact that computations are passed forward from the input to the output layer. The Feed forward Backpropagation Network is a very popular model in Neural Networks. In Multilayer Feed forward Networks, the processing elements in adjacent layers are connected. This is represented by the following figure2. Some inherent features of back propagation network image data compression schemes are:

1) The network structure is massively parallel.
2) The network is adaptive.
3) The network examines the compressed features of the original image in a self organizing manner during the training stage.
4) The intrinsic generalization property of the structure enables it to process images outside the training set (novel images) effectively.

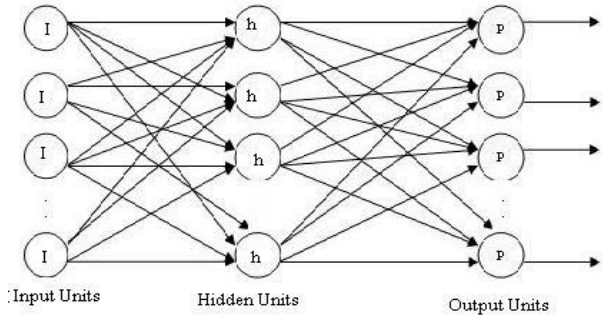

Fig. 1: Multi-layer Feed Forward Back propagation neural network

The Feed forward process involves presenting an input pattern to input layer neurons that pass the input values onto the hidden layer. The hidden layer nodes compute a weighted sum of its inputs and present the result to the output layer.

IV Wavelet networks for image compression

Our purpose is to use an artificial neural network and more especially a wavelet network by means of describing the network architecture specialized for the problem of image compression. This architecture includes a layer of input neurons, a hidden neuron layer and a layer of output neurons. Both of input and output layers are fully connected to the hidden layer. The feed-forward propagation algorithm is used to adjust the weights of this network.

Wavelet Transform

Wavelet transform (WT) of an image represents image as a sum of wavelets on multi-resolution levels. In wavelet transforms any one-dimensional function is transformed into a two-dimensional space, where it is approximated by coefficients that depend on time (determined by the translation parameter) and on scale,(determined by the dilation parameter). The zoom phenomena of the WT offer hightemporal localization for high frequencies while offering good frequency resolution for low frequencies. Hence, the wavelet transform is well suited to image compression.

IV. Vector Quantization Neural Network for Image Compression

The most powerful and quantization technique used for the image compression is vector quantization(VQ).The vector quantization algorithms for reducing the transmission bit rate or storage have been extensively investigated for speech and image signals. Image vector quantization (VQ) includes four stages: vector formation, Training set selection, codebook generation and quantization. The first step is to divide the input image into set of vectors. The Subset of vectors in the set is later chosen as a training sequence. The codebook of code-words is obtained by an iterative clustering algorithm. Finally, in quantizing an input vector, closest code-words in the codebook is determined and corresponding label of this code word is transmitted. In this process, data compression is achieved because address transmission requires fewer bits than transmitting vector itself. The concept of data quantization is extended from scalar to vector data of arbitrary dimension. Instead of output levels, vector quantization employs a set of representation vectors (for one dimensional case) or matrices (for two dimensional cases). Set is defined as "codebook" and entries as "code words". Vector quantization has been found to be an efficient coding technique due to its inherent ability to exploit the high correlation between the neighboring pixels.

V. Challenges in Image Compression

Advancement of technology have produced many applications of digital imaging such as photovideotex, desktop publishing ,graphics arts ,colour facsimile, newspaper wire-photo transmission, medical imaging. For many other contemporary applications (such as distributed

multimedia systems) rapid transmission of image is necessary. Research challenges include

1) Developing real time compression algorithm
2) Guaranteed quality of service in case of multimedia applications
3) Cost minimization, because cost and time cost of transmission and storage tend to be directly proportional to the volume of data.

A. Future video/image compression demands

1) Improved low bit-rate compression performance
2) Improved lossless and lossy compression
3) Improved continuous-tone and bi-level compression
4) Be able to compress large images
5) Use single decompression architecture
6) Transmission in noisy environments
7) Robustness to bit-errors
8) Progressive transmission by pixel accuracy and resolution
9) Protective image security

VI. PROPOSED METHOD USED FOR IMAGE COMPRESSION WITH NEURAL NETWORK

Two layer Feed forward neural network will be considered and will be trained off-line using Levenberg Marquardt algorithm. The weights of trained network of hidden and output layers are used for image compression and decompression respectively for any test image. MATLAB will be used as software tool to carry out for training neural network, image compression and image decompression. The performance parameters like compression efficiency, complexity of algorithm and quality, for image compression & decompressions will be analyzed.

VII. LEVENBERG MARQUARDT ALGORITHM

The Levenberg-Marquardt (LM) algorithm is an iterative technique that locatesthe minimum of a multivariate function that is expressed as the sum of squaresof non-linear real-valued functions .It has become a standard technique for non-linear least-squares problems, widely adopted in a broad spectrum ofdisciplines. LM can be thought of as a combination of steepest descent and the Gauss-Newton method. When the current solution is far from the correct one,the algorithm behaves like a steepest descent method: slow, but guaranteed to converge. When the current solution is close to the correct solution, it becomes aGauss-Newton method. Next, a short description of the LM algorithm based onthe material in issupplied.Note, however, that a detailed analysis of the LM algorithm is beyond the scope of this reportand the interested reader is referred tofor more comprehensive treatments.

VIII. CONCLUSION

The Various methods of image compressions and decompressions like Wavelet based, DCT and various standard like JPEG, GIF have been studied in detail. A novel method for image compression and decompression using soft computing technique.ANN (artificial neuron network) is proposed to carry out future work.

This paper takes a detailed analysis on the most significant means of doing image compression. Image compression technique is used to reduce the number of bits required in representing image, which helps to reduce the storage space and transmission cost. We work on bit area and maintain the information of the bits. The implementation of feed forward neural network trained off using LM algorithm on image compression system with good performance has been demonstrated. It has been observed that the convergence time for the training of Feed Forward neural network is very faster.

REFERENCES

[1] Anuj Gupta, Deepak Goel , Dr.Pankaj Gupta, et al. "An Improved Adaptive Down-Sampling Approach for Low Bit-Rate Image Compression", IJMRS‟s International Journal of Engineering Sciences, Vol. 01, Issue 03, September 2012.
[2] Rekha, Sangeeta Yogi, Geeta, et al. "A Segmented Wavelet Inspired Neural Network Approach To Compress Images", International Journal of Latest Trends in Engineering and Technology (IJLTET), Vol. 1 Issue 1 May 2012.
[3] Diffuse (2002). Guide to image compression, Retrieved October 23, 2003, from http://www.diffuse.org/compress.html
[4] Grgic, S. Mrak, M., & Grgic, M. (2001) Comparison of JPEG image coders. Retrieved October 23, 2003, from http://www.vcl.fer.hr/dtv/sgrgic_vip2001.pdf
[5] Welsh, T.: A technique for high-performance data compression IEEE Computer. Mag. 17, 8–19 (1984).
[6] Compression Using Fractional Fourier Transform "A Thesis Submitted in the partial fulfillment of requirement for the award of the degree of Master of Engineering In Electronics and Communication. By Parvinder Kaur.
[7] Stephen A. Martucci and Iraj Sodagar, 1996. Zerotree Entropy Coding of Wavelet Coefficients For Very Low Bit Rate Vide, IEEE, PP 533-536.
[10] Scott E. Umbaugh, "Computer Vision and Image processing", PHI international (1998).
[11] Shalkoff R.J. John wiley and sons, New York, "Digital Image Processing and computer vision" (1989).
[12] Stewan W.Smit," Scientist and Engineers Guide to Digital Image processing", Second Edition, (1999).
[13] www.mathworks.com

