Removal of JPEG Compression Blocking Artifacts using Artificial Neural Networks

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Abstract: JPEG compression is an image compression technique that is used for a wide range of applications these days. This paper describes a method to reduce blocking artifacts and quantisation noise through a machine learning approach. Artificial neural networks is used for this purpose. Feed –forward neural networks are used which make use of feedback and hence accuracy level is increased. Based on the number of hidden neurons and the quality of compression the regression value is obtained. Finally the DCT coefficients obtained are replaced by the actual pixel intensity values to obtain the final output image. The regression value and least mean square error values are computed and the graph is plotted for the same. The experimental results for the proposed method are also presented in this paper.

Keywords: Artifact Removal, Image Compression, Machine Learning, Artificial neural network,JPEG.

Introduction

Processing of images using mathematical operations by using any form of signal processing is Image Processing.Image Processing is a concept of processing of images by making use of mathematical operations and with the help of any signal processing techniques.Image processing takes in an image as an input and delivers an output which might be an image or set of values related to the image.Processing of images can be useful in many applications namely,Transmission,Video Processing, Pattern recognition and also in various fields such as Medicine, security etc.

Image Processing can be performed in two different ways which are Digital and Analog image processing. The Digital image processing involves in making use of digital images which are given as inputs to the system.The Analog image processing involves in taking two dimensional analog signals as inputs.Digital Image Processing serves numerous advantages compared to Analog Image Processing. One such advantage is that when the format of the image and its resolution is changed it is then ready to be used in various applications. Another advantage of Digital Image Processing is that once the image is processed the results can be viewed instantly. Since the Digital Image Compression is utilised for storage and Transmission Applications, a wide range of bandwidth is utilised. The concept of compression is introduced when the availability of the bandwidth is limited and hence the image has to be compressed in order to be transmitted.This process of compression can be lossy where the data related to the image can get lost during compression or it can be lossless where the entire data related to the image can be recovered after the image is de-compressed.The Joint Photographic Expert Group (JPEG) is proved to be reliable and trusted Image compression technique that is available.

The Image compression using JPEG involves in the process of quantisation. This quantisation is performed on the Discrete Cosine Transform(DCT) coefficients for each 8 by 8 blocks of image,which is then followed by lossless entropy encoder. The entropy encoder is used to generate Grayscale and color images. The Image Compression using JPEG involves in three sub steps which are Discrete Cosine Transform(DCT),Quantisation and Encoding or Compression.The first step of Image Compression is the DCT.It converts an input image into a numeric matrix consisting of numeric values.In the second step i.e the Quantisation process the numeric values generated by the DCT are transformed into simple numbers in order to reduce the use of bandwidth.The loss of image information happens during the Quantisation. It makes the values in the matrix compact.The process of image compression through JPEG can be diagrammatically represented as:

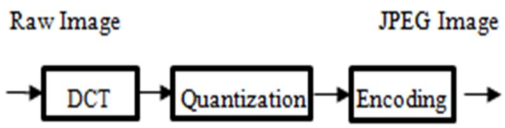

Figure 1.1: Image compression system

Compression ratios of different values can be obtained by obtaining a Quality Factor (Q) from the quantisation table.Higher values of quality factors indicates that level of noise in the image is increased on DCT coefficients. DCT coefficients when quantised can result in creating artifacts in the images.These are called Compression artifacts and they are of two types:

- Blocking Artifcats: These are the artifacts that are created when the DCT coefficients are quantised in a low frequency resulting in mosaic like looking images.
- Ringing Artifacts: These are the artifacts that are created when the DCT coefficients are quantised in a high frequency resulting in images containing noisy patterns at the edges of the image.

There are many solutions and algorithms available to reduce the compression artifacts in the compressed images, some of them are Segmentation based, Wavelet based approach, Projection Onto Convex Sets(POCS), Gaussian filtering,Image optimisation, Hybrid filtering etc.These methods remove the compression artifacts but they produce many drawbacks like the time taken for execution of the algorithms, high and less acceptable values of mean square error, low quality of the resulting images etc.

The proposed method aims in removing these compression artifacts through a Machine Learning approach which is a branch of Artificial Intelligence. The concept of Feed Forward Neural networks is used to build a neural network which can be trained explicitly according to the problem, the neural network thus gets trained on itself and can be ready when a new data is provided. Machine learning algorithms have proved to produce good results for complex images. Other advantages of machine learning is that it generally gives results with a higher accuracy.In the Artificial Network, a fitting neural network(nftool) tool is applied to create and train a custom network.The toolbox automatically decides which algorithm to use depending upon the amount of memory available in the system.The nftool toolbox usually decides among two algorithms to use which are:

- trainlm algorithm:It is a network training function which calculates the weights for each neuron in the network based on the Levenberg-Marquardt optimization.It is the fastest algorithm.
- trainscg algorithm: It is a network training function which calculates the weights based on the scaled conjugate gradient method.

Literature Survey

A survey was performed to identify various methods available to reduce the blocking artifacts in compressed images one of which is the weiner filtering method [1]. This method mainly concentrates on removing the artifacts at the boundaries. It considers each segment of the image as an individual image and hence results in different DCT coefficient values thereby making the original image and the compressed image different from each other. For this reason a weiner filter is applied to all the blocks of the image individually to determine the weiner coefficients.This method achieves the deblocking of the image in two steps.In the first step the algorithm uses the weiner filter to obtain the DCT coefficent values and in the second step quantization of the obtained values is done.

The second method for reducing the blocking artifacts is the optimization method [2]. In this method a standard formula is applied to every input image where the formula retains the structural similarity between the original image and the compressed image and also the formula obtains the smoothness at the edges of the image. The image is converted into a vector optimization formula so that the transition of the image takes place. In that process a guided filter filter is also used to make sure that the edges of the image are intact and not smoothened out. However this method is not suitable for medium sized images leading to the introduction of the sliding window which considers only a part of the image as a whole image and optimizes it to deliver better results.

The blocking artifacts are also reduced by the multiple dictionary learning method [3] where in a dictionary of different image segments is substituted with a smaller dictionary containing one value for single kind of image. Once the image is given as input it check if there is any similarity between the image block and the values in the sub directory.If there is a match then that value is chosen to substitute that block of the image. The sub dictionary is used for determining the texture of each block of the image. Another way of removing the artifacts is through hybrid filtering method[4]. In this method every input image is converted into segments and further filtered.Hybrid filtering takes place in 2 steps where in the first step is edge preserving which uses the frequency to determine the DCT coefficient values, and the second step is the low pass filtering step where it removes the block discontinuities and improves the quality of the de-compressed image.

The removal of ringing artifact through post processing method[5] involves in two steps which are domain filtering and post processing of the image so that it results resizing of the DCT blocks of the image and reduce artifacts on the individual block of image. The overshoot region's mask map is created and the reduced image is combined according to the map for generating the artifact removed image. Further this method generates better quality images compared to other methods. This method also solves the problem of producing resizable images so that this method can be applied for any application. Normally the textural images produce ringing artifacts but the normal blocking artifacts are frequently seen in natural images. Hence in this method the overshoot reduced images and the ripple reduced images are combined to result in the final artifact reduced image.

The Offset and Shift method [6] reduces the artifacts using the post processing algorithm as they improve the image quality by reducing artifacts through high compression. This technique reduces the artifacts by using the de blocking filter which has a low computational complexity. The threshold value is computed by calculating the difference between the computed and compared values. When the difference value is crossing the threshold value then it is categorized into the image block with real boundary and the pixel vector is not considered. The image is divided into three regions which are complex region and intermediate regions. Each region of the image undergoes filtering and also helps in preserving the edge quality and reduces artifacts at smooth areas. This method performs better than other methods to reduce the blocking artifacts in terms of SSIM and PSNR.

Proposed Methodology

There are various modules that are used for the efficient implementation of the proposed methodology. They are:

Main module

In this module we take the training image as an input from the user along with the quality of compression .Since the jpeg compression works only for standard size of 256X256 dimension of the image, we resize any input image to that standard size and give the image as input for compression.This process is repeated for all training images.After compressing each image their corresponding DCT coefficients and pixel intensity values are obtained and these DCT coefficients and pixel intensity values for all the images are then concatenated and formed into a single matrix. This matrix is in turn given as an input to the neural network for training. Thus a custom neural network is created and trained. Once the network is trained, a new instance or a test image is given as an input which undergoes the process of compression and by obtaining the DCT coefficient values and pixel intensity for the test image which is given as input to the neural network where the network predicts the target/output DCT coefficient values and pixel intensity values on its own with the aid of values stored during the previously trained process. These target values which are predicted are replaced in the algorithm to perform inverse DCT to bring the image back from frequency domain to image domain to display the final de-compressed image.

Image Compression

The image which is taken as input is now transform into DCT domain which undergoes quantisation to obtain a compact values in the image matrix. The quantised values are then encoded to wrap up any missing values. Once the values are encoded the de-quantisation process is performed followed by the inverse-DCT function to bring the image back from frequency domain to image domain.The image once compressed is smoothened by Gaussian filter method.

Formatting DCT inputs and targets for ANN

Every block of 8X8 matrix of the input image's DCT coefficients are transformed into 1X64 vector array. These vector array is now reshaped into a matrix and this procedure is followed for all the input images and all the matrices thus obtained are concatenated which is later given as an input to the ANN. In the matrix for every row an average value is obtained and this matrix of average values forms the target for ANN.

Formatting Pixel intensity values as inputs and targets for ANN

For each target cell in the input image its 49 cell neighbourhood cell values are considered to form vector array where this array is converted to a matrix.This procedure was repeated for all training images both horizontally and vertically and the respective matrices were concatenated and given as inputs to the ANN. The respective target cells were the targets to the network.

Build Artificial Neural Network

The inputs and targets obtained will act as arguments to the training network.Other Parameters such as number of neurons, train ,validation, test ratios are dynamically given by the user during the training to obtain the efficient result.

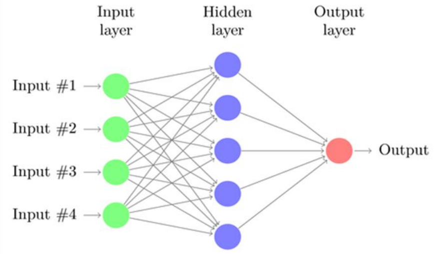

Figure 3.1: Various layers of ANN

Replacement of predicted DCT coefficients and pixel intensity values

The unknown DCT coefficient values predicted by the network are now replaced in the corresponding 8X8 matrix which is the target. The values present at the boundaries of each block of the image are replaced with the predicted values.

Experimental Results

The removal of blocking artifacts using the machine learning method has been tested with a good number of images.The obtained results of the regression value and the Mean Square Error values have been compared with other de-blocking methods.

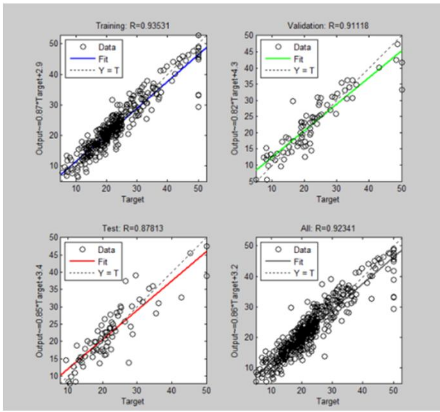

Figure 4.1: Regression value and Mena Square Error values comparison graph

The above graph shows the result of training the neural network to produce the optimal regression value. Regression is the comparison or the similarity percentage between the input image and the output final image.The proposed method has resulted in a MSE value of 190 and a regression value of 0.92. The below are the screenshots of the various stages of the proposed method's outputs for a particular input image.


Original Image Compressed Image


Gaussian filtered Image Output Image

Conclusion and Future Work

In this paper, a solution is presented for the Removal of JPEG Compression Artifacts using the Machine Learning Approach. This technique involves Building a set of Predictors (Feed-forward Neural Networks) for the removal of these artifacts. On Completion of Learning, any number of new Image instances can be processed in a short duration.

The future work involves extending the same algorithms to video processing. Furthermore, color images can be used as inputs to compute the regression values. Also low quality compressed images taken in low lighting conditions needs to be considered for obtaining high regression values.

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