ERROR CONCEALMENT TECHNIQUE USING WAVELET NEURAL NETWORK FOR WIRELESS TRANSMITTED DIGITAL IMAGES

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ERROR CONCEALMENT TECHNIQUE USING WAVELET NEURAL NETWORK FOR WIRELESS TRANSMITTED DIGITAL IMAGES

By

ALAA KHAMEES AL-AZZAWI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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DEDICATION

To

Those who have dedicated themselves in the service of science and humanity, God will confer them the paradise.
Continuous flow to send images via encrypted wireless channels may reduce the efficiency of transmission. This is due to the damage or loss of the numerous large-blocks from these images. Therefore, it is difficult to rebuild these blocks from the point of reception. In addition, some packets may be lost via the limited bandwidth networks when congestion occurs. However, compressing of bit-streams of images with variable length coding (VLC) will add another burden to the transmission in cases where these streams are sent via the noisy channels.

Several techniques have been proposed in the past decade, particularly error concealment (EC) algorithms. In this study, attention is focused on the algorithms that have high efficiency to fill-in the damaged patches, for example, Multi-directional interpolation (MDI), neighboring matching EC, etc.
Accordingly, two frameworks are proposed to tackle the following problems: (1) loss of the damaged blocks; (2) artifacts that appear after the process of filling-in (i.e., blockiness and blurring), and (3) white-Gaussian noise.

The first framework is proposed to compensate for the loss of damaged patches. The compensation information includes patches that differ in size and location. Moreover, the concealment includes patches for both smooth and nonsmooth areas. This framework is implemented in three key steps. The first step is devoted to detecting invisible patches. Further, an efficient color contrast scheme is proposed. The goal behind this scheme is to detect invisible patches that are either occurred in a dusky areas of the image or have been deliberately hidden during the encryption process.

Next, a multi-directional interpolation (MDI) technique is proposed. The method is used to estimate the lost coefficients in the wavelet-domain. Accurate values for the weighting coefficients were efficiently calculated to minimize the mean squared errors (MSE) at the top, bottom, left, and right of the missing blocks. The proposed EC schemes in the second step have been used to compensate for the loss of different damaged patches at the geometric information, with minimal artifacts from blurring and blockiness, as well as improving the Peak Signal-to-noise ratio (PSNR).

In the meantime, a new technique called 'wavelet neural network' is proposed and implemented in the third step. This technique merges the estimated matrices' results of the proposed schemes in the second step with an artificial neural network (ANN), with the intention of obtaining results with high accuracy, as well as to overcome all
the problems that may arise after the process of filling-in (blurring and blockiness artifacts). The neural network architecture that can be used to implement a nonlinear vector predictor, including a multilayer perceptron (MLP), and a radial basis function network.

In the case, where the missing regions of pixels are containing textures, edges, and other image features that are not easily handled by concealment algorithms. It therefore, necessitated to use denoising rather than EC algorithms.

Finally, the proposed second framework is exploited for denoising a chain of images that are affected by white-Gaussian noise to the lowest possible rates, as well as concealing these images. Experimental results demonstrate that the proposed methods simultaneously provide significant improvements in terms of both loss concealment and artifacts, especially those associated with edges. The performance efficiency has been computed in terms of the PSNR, and mean squared error (MSE) yielded 87% accuracy and tested for various images and combinations of lost blocks (CT image). The results are similar to those shown in [3], [98], and [129] with a noticeable interference pattern in the reconstruction from the uniform array. The reconstructed images by our schemes produced PSNR ranges from 33 dB to 37 dB and the lowest MSE values are obtained for percentages near to 50%.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan Ijazah Doktor Falsafah

TEKNIK PENUTUPAN RALAT MENGGUNAKAN RANGKAIAN “WAVELET-NEURAL” BAGI PENGHANTARAN IMEJ DIGITAL SECARA WAYARLES

Oleh
ALAA KHAMEES AL-AZZAWI

Jun 2012

Pengerusi: Professor Madya M. Iqbal Saripan, PhD
Fakulti: Kejuruteraan

Penghantaran imej secara terus-menerus melalui saluran wayarles yang dienkripkan boleh mengurangkan kecekapan penghantaran. Ini disebabkan oleh kerosakan atau kehilangan banyak blok daripada imej tersebut. Oleh itu, adalah sukar untuk membina semula blok ini di titik penerimaan. Tambahan pula, beberapa paket berkemungkinan hilang menerusi rangkaian lebar jalur yang terbatas apabila kesesakan berlaku. Juga, pemampatan aliran bit imej dengan pengekodan berbeza jarak (VLC) akan menambah lagi beban ke atas penghantaran.

Pelbagai teknik telah dicadangkan sebelum ini, terutamanya algoritma penutupan ralat (EC). Dalam kajian ini, perhatian ditumpukan kepada algoritma yang mempunyai tahap kecekapan yang tinggi untuk mengisi blok yang rosak, sebagai contoh interpolasi pelbagai arah (MDI), EC pemadanan jiran dan sebagainya.
Sehubungan dengan itu, dua rangka kerja telah dicadangkan untuk mengatasi masalah kehilangan blok yang rosak iaitu kemunculan kesan akibat proses pemenuhan (contohnya “blockiness” dan kekaburan) dan hingar putih Gaussian.

Rangka kerja pertama dicadangkan untuk menggantikan kehilangan tompokan yang rosak. Maklumat penggantian tersebut termasuklah tompokan yang berbeza dari segi saiz dan lokasi, dan ia boleh terjadi di kawasan licin atau tidak licin.

Rangka kerja ini dilaksanakan melalui tiga langkah utama. Langkah pertama dikhususkan untuk mengenalpasti tompokan tersembunyi. Seterusnya, suatu skim pertentangan warna yang cekap dicadangkan. Skim ini mampu mengesan kedua-dua jenis tompokan yang rosak dari segi saiz dan lokasi di dalam kawasan gelap yang sukar dilihat oleh mata kasar.

Kemudian, transformasi wavelet diskrit (DWT) dengan tiga tahap penguraian Haar-wavelet yang dieksploitasi di dalam analisa imej rosak. Di sini, pekali kehilangan pada sub-jalur frekuensi tinggi bagi setiap tahap penguraian dianggarkan dengan analisa interpolasi menegak dan melintang. Nilai tepat untuk pekali ini diperoleh dengan menghitung ralat min kuasa dua pada bahagian atas dan bawah blok yang hilang. Skim EC yang dicadangkan di dalam langkah kedua telah digunakan untuk menampung kehilangan pelbagai tompokan rosak pada-maklumat geometri, dengan kesan kekaburan dan “blockiness” yang minima, serta menambahbaik nisbah isyarat hingar puncak (PSNR).
Seterusnya, teknik baru yang dikenali sebagai rangkaian neural wavelet dicadangkan dan dilaksanakan di dalam langkah ketiga. Teknik ini menggabungkan hasil anggaran matrik yang diperoleh daripada skim yang dicadangkan dalam langkah kedua dengan suatu rangkaian neural buatan (ANN), dengan harapan untuk mendapatkan hasil berketepatan tinggi, serta untuk mengatasi segala masalah yang mungkin timbul setelah proses pemenuhan. Senibina rangkaian neural boleh digunakan untuk melaksanakan suatu jangka vektor tak linear, termasuklah perceptron berbilang lapisan (MLP) dan rangkaian fungsi asas jejari.

Akhir sekali, rangka kerja kedua yang dicadangkan dieksplotasi untuk membuang hingar suatu rantaian imej yang rosak akibat hingar putih Gaussian kepada kadar serendah mungkin, serta memulihkan imej tersebut. Hasil eksperimen menunjukkan bahawa kaedah yang dicadangkan secara serentak menghasilkan penambahbaikan yang signifikan dari segi kedua-dua penutupan kehilangan dan artifak, terutamanya imej yang berpinggir. Prestasi kecekapan dikira dari segi PSNR dan ralat min kuasa dua (MSE) menghasilkan 87% ketepatan dan diuji bagi pelbagai imej dan gabungan blok hilang (Imej CT). Imej yang dipulihkan menggunakan skim kami menghasilkan PSNR dari 33Db kepada 37Db dan nilai MSE yang terendah diperolehi dari peratusan hampir kepada 50%.
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I certify that a Thesis Examination Committee has met on 12, June 2012 to conduct the final examination of ALAA KHAMEES AL-AZZAWI on his thesis entitled ERROR CONCEALMENT TECHNIQUE USING WAVELET NEURAL NETWORK FOR WIRELESS TRANSMITTED DIGITAL IMAGES, in accordance with Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

ALAA KHAMEES AL-AZZAWI
Date: 12 June 2012
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4.78 Reconstruction steps to the misses' details.

4.79 Reconstruction steps for the contiguous lost blocks.
LIST OF ABBREVIATIONS

ARQ                  Automatic Retransmission Query
ANN                  Artificial Neural Network
APIBS               A Priori Information Block Wise Similarity
ADDA               Adjacent Domain Division Algorithm
ART                  Adaptive Resonance Theory
AEC                  Adaptive Error Concealment
BMA                 Boundary Matching Algorithm
BNM                 Best Neighbor Matching
BP                     Back Propagation
BSC                 Binary Synchronous Communications
CQF's                Conjugate Quadrature Filters
CvT                    Curvelet Transform
CWT                  Continuous Wavelet Transform
CCvT                 Continuous Curvelet Transform
DCT                   Discrete Cosine Transform
DC                     Direct Current
DDC                  Difference in Direct Current
DED                 Dominate Edge Directions
DFT                  Discrete Fourier Transform
DMVE               Decoder Motion Vector Estimation
DP                  Decoder Performance
DS                   Dominate Sort
DST                 Discrete Sine Transform
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<tr>
<td>DWT</td>
<td>Discrete Wavelet Transform</td>
</tr>
<tr>
<td>DDO</td>
<td>Discrete Differential Operator</td>
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<td>EB</td>
<td>Error Block</td>
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<tr>
<td>EC</td>
<td>Error Concealment</td>
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<td>ED</td>
<td>Edge Detection</td>
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<tr>
<td>ER</td>
<td>Error Recovery</td>
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<td>ENO</td>
<td>Essential Non-oscillatory</td>
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<tr>
<td>FEC</td>
<td>Forward Error Concealment</td>
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<tr>
<td>FFT</td>
<td>Fast Forward Transform</td>
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<tr>
<td>FIR</td>
<td>Finite Impulse Response</td>
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<tr>
<td>FMV</td>
<td>Forward Motion Vector</td>
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<tr>
<td>GMM</td>
<td>Gaussian Mixer Model</td>
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<tr>
<td>GMRF</td>
<td>Gaussian Markov Random Field</td>
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<tr>
<td>HEC</td>
<td>Hybrid Error Concealment</td>
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<tr>
<td>HVS</td>
<td>High Variance Sort</td>
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<tr>
<td>IWT</td>
<td>Inverse Wavelet Transform</td>
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<td>JPG</td>
<td>Joint Photography Group</td>
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<td>JPEG</td>
<td>Joint Photography Expert Group</td>
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<tr>
<td>LMS</td>
<td>Least Mean Square</td>
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<tr>
<td>LV</td>
<td>Low Variance</td>
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<td>MA</td>
<td>Moving Average</td>
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<tr>
<td>MAP</td>
<td>Maximum A Posteriori</td>
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<tr>
<td>MB</td>
<td>Macro-Block</td>
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<tr>
<td>MD</td>
<td>Multiple Description</td>
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<tr>
<td>MDC</td>
<td>Multiple Description Coding</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>MDCT</td>
<td>Modified Discrete Cosine Transform</td>
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<tr>
<td>MDI</td>
<td>Multi-Directional Interpolation</td>
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<tr>
<td>MDTC</td>
<td>Multiple Description Transform Coder</td>
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<td>MLP</td>
<td>Multilayer Perceptrons</td>
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<td>MSE</td>
<td>Mean Squared Error</td>
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<td>MPEG</td>
<td>Moving Picture Experts Group</td>
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<td>MMA</td>
<td>Motion Vector Averaging</td>
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<td>MV</td>
<td>Motion Vector</td>
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<td>NFL</td>
<td>Neuro Fuzzy Learning</td>
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<td>NMEC</td>
<td>Neighboring Matching Error Concealment</td>
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<td>NURBS</td>
<td>Non-Uniform Rational B-splines</td>
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<td>PDE</td>
<td>Partial Differential Equation</td>
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<tr>
<td>PFA</td>
<td>Parabola Fitting Algorithm</td>
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<td>PSNR</td>
<td>Peak Signal-to-Noise Ratio</td>
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<td>QMF's</td>
<td>Quadrature Mirror Filters</td>
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<td>ROC</td>
<td>Receiver Operating Characteristics</td>
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<td>SAD</td>
<td>Sum Absolute Difference</td>
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<td>SEC</td>
<td>Spatial Error Concealment</td>
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<tr>
<td>SER</td>
<td>Spatial Error Recovery</td>
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<td>SOM</td>
<td>Self-organizing Map</td>
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<td>SSA</td>
<td>Single Spectral Analysis</td>
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<td>SSEC</td>
<td>Spatial Split-match Error Concealment</td>
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<td>STFT</td>
<td>Short Time Fourier Transform</td>
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<tr>
<td>TEC</td>
<td>Temporal Error Concealment</td>
</tr>
<tr>
<td>TER</td>
<td>Temporal Error Recovery</td>
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<tr>
<td>Abbreviation</td>
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<tr>
<td>VLC</td>
<td>Variable Length Coding</td>
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<tr>
<td>VP</td>
<td>Verge Point</td>
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<tr>
<td>WMRA</td>
<td>Wavelet Multi-resolution Analysis</td>
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<tr>
<td>WT</td>
<td>Wavelet Transform</td>
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<td>WNN</td>
<td>Wavelet Neural Network</td>
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CHAPTER 1

INTRODUCTION

1.1 Background of study

Even the loss of one bit that happen during the transmission of a digital image will lead to the loss of a vital information in an image. The corrupted transmitted image will be facing a further degradation when it undergoes a bit-stream compression process using VLC [1]. Figure 1.1 presents some examples of corrupted images received from wireless channels [2]. As shown in the figure, these images suffer from several damaged patches that reduced the quality of the images.

Figure 1.1 The received wireless images: (a) Jet (512 x 512 pixels); (b) Lena (512 x 512 pixels), and (c) Peppers (512 x 512 pixels).

The transmission of bit-stream images via wireless networks is very difficult because of the use of a predictive-encryption technique and the use of VLC in the process of image compression [3]. A bit stream image is a sector-by-sector or bit-by-bit exact
copy of a hard drive, preserving all latent data in addition to the files and directory structures.

There are some approaches that have been introduced to prevent this. They are done by inserting an additional or redundant data into the bit-stream. However, this technique only able to partially solve the problem, since they always involve changes at the encoder level, and therefore the possibility of losing some important information still persists [4, 5]. It should also be noted that a large number of statistical redundancy coefficients at high-frequency subband is removed after the process of quantization [6], when further adapted to those coefficients are achieved. It was shown by Lee, et al. that the coefficients can be efficiently encrypted [7, 8] by preventing the errors from propagating across the block boundaries to a reasonable extent. This follows the recent work by Salama et al. [9] and Wook and Lee [10].

Recently, Zou, et al. [11] have presented a method for estimating the quantization error of each frequency component separately within intra frame coding structure based on the statistical properties of the transformed coefficients at each frequency position under certain prediction mode. Further, the error recovery of VLC in the case where the encoded bit-stream is transmitted over Binary Synchronous Communications (BSC) with arbitrary crossover probability has been estimated in [12]. Therefore, it is often preferred to adopt a more efficient filling-in techniques aim at improving image quality after the process of the loss compensation of the damaged blocks.
Filling-in the corrupted blocks with the available and limited information from their surrounding neighbors is a method that we could use to overcome the problem. This method is not only useful in an image encoding and wireless image transmission (e.g., reconstructing missing blocks), but could also be used in removal of unwanted features and image restoration (e.g., scratch removal) [13, 14]. This information can be automatically detected as in [15], or hinted by the user as in more classical texture filling techniques [16].

For clarification, the decomposing reconstruction process of all the subscribed approaches for recovering missing blocks introduced some of the aliasing distortions. This problem has been discussed in many papers and resolved using the Quadrature mirror filters (QMFs) [17], or conjugate quadrature filters (CQFs) [17, 18].

The method in [19] can be classified in order to be compatible with the JPEG 2000 image compression, in which the missing blocks in the wavelet-domain were efficiently recovered. Liew and Yan [20] have presented a highly efficient deblocking algorithm for block artifacts suppression. This algorithm can tackle both the blocking and ringing artifacts very successfully.

Chen, et al. [21] present an example-based boundary matching approach (BMA) in which the blockiness effect after applying some of the second order of the Partial differential equation (PDE) reduced. Similar to [21] is the work in [22], where the authors describe an algorithm that used to find the edge directions of a lost block.

EC is a post-processing technique that has been exploited to fill-in damaged blocks after using the implicit redundancies of the decoded received image. Many of the EC
techniques have the capability to detect damaged blocks before reconstructing them [23]. While others need to support any appropriate conversion format and/or an EC algorithm, to facilitate the detection of damaged blocks [24, 25]. Among these techniques, EC algorithms have been extensively studied for their efficient possibilities in practical applications.

In this context, several methods have been suggested, such as layered coding [26], and automatic retransmission query (ARQ) [27]. In addition, innovative concepts for a variety of interpolations-based spatial EC schemes have been considered. For example, directional interpolation [28], Non-uniform rational B-spline (NURBS) interpolation [10], and block-matching interpolation [22] for consecutive block loss patterns.

Some techniques which take advantage to address such problems have been developed [29, 30]. However, these techniques indicated that EC techniques at the decoders efficiently succeeded in concealing many of the erroneous blocks after the exploitation of the decoded information correctly, without modifying the source that handled both complexity in the off-line design of the quantizer, and feedback requirements in the on-line operation of the system and channel coding schemes that handle circuits of depth.

Accordingly, the EC applications are required to comply with some specific packetizing restrictions that permit packets to be decoded independently. The method in [31] is an EC scheme for JPEG coded image transmission via the wireless networks, in which both spatial redundancy and data-hiding are used.
There are several EC methods that lagged not only in the detection of the edges, but also in the visual quality of the images. The technique in [32] based on structural alignment, which uses edge gradient as the distortion criterion to achieve better results. Agrafiotis, et al. [33] propose a highly efficient EC scheme for edge-related information that preserves existing edges, as well as to avoid the introduction of new strong ones by switching to a smooth approximation of missing information. The EC methods [34, 35] are based on both joint interpolations of the image graylevels and image gradient directions. Bourdon et al. [36] describe a geometric method to conceal damaged patches of images of multiple resolutions.

Most of the methods that have been presented above failed in tackling both blocking and blurring artifacts, specifically within nonsmooth areas. A posteriori approach aimed to predict the blocks containing edges with a high accuracy, as well as enhancing the quality of images in terms of visual perception. In addition, overcoming all the problems that may arise after the process of filling-in. In this context, features of the theoretical wavelet transformation should be addressed in terms of concepts that contribute to the development of the network construction methods. The basic idea of combining wavelet theory with neural networks has resulted in a new technique known as 'wavelet neural network'. These techniques are characteristically used in the categorization and predefining of problems.

The authors in [37] presented a method to automatically obtaining an optimal training set by resampling the positive samples. While, the authors in [38] have combined the advantages of two neural network models; direct classification model that borrows some features from the adaptive resonance theory (ART), and the
Kohonen self-organizing feature map (KSOFM) in order to achieve high image quality at high compression ratios.

In the case where the missing blocks are containing textures, edges, and other image features that are not readily handled by EC algorithms, it therefore, necessitated to use denoising rather than EC algorithms. In this case, the missing information is likely recovered under the MSE fidelity metric using the sparsity constraint that a portion of the images transforms coefficients over missing regions are zero or close to zero. A method of denoising images based on spares and redundant representations is developed and reported in [39] and [40].

Crouse, et al. [41] explained that the eventuality exemplars of the wavelet coefficients can be exploited properly if included Gaussian mixture, Gaussian scale mixture [42], and circular-symmetric Laplacian [43].

Methods for removing noise from digital images corrupted by the additive, multiplicative, and the mixed noise had been proposed by Hirakawa and Park [44], and Kervrann and Boulanger [45]. Wu, et al. [46] explained that it is very easy to separate the edge curves from each other by applying each of the adjacent domain division algorithms (ADDA) and the parabola fitting algorithms (PFA).

1.2 Problem Statement

In the encoded block images' systems, parts of bitstreams may be corrupted due to noise or even the loss of one bit often leads to the loss of whole blocks, in the case
where they are sent via wireless communication networks and, specifically, with unreliable channels. Furthermore, we see that some of the packets may be lost via the limited bandwidth networks when congestion occurs. In all cases, there will be a severe reduction in the quality of the received images. However, compressing of bit-streams of image with VLC immediately with a rapid response to noise via a noisy channel will add another burden to the transmission, and also lead to introduce distortion into decoded video information. Consequently, some of these packets are likely to be corrupted because of noise, while others may break due to congestion. These restrictions will also cause severe shortages in the quality of the image to be reconstructed.

From another point of view, the industrial viewpoint, image decryption will also be suffering serious deformation in situations where the compressed bitstream has little damage. In other words, in still images, only the lost blocks can be recovered within the phase of spatial processing. Whereas, artifacts that may appear to be directly associated either with the significant extracted images' edges or within the whole image after the process of filling-in. Therefore, there may be great difficulty in addressing this issue.

There is another important issue that requires investigation. Most of the traditional methods used in the detection of damaged patches of digital images resort to sharp focusing of all the details of these images, with the intention of distinguishing those patches. However, we see that in many cases these methods have failed to detect many of the patches. This might be because they are located in a dusky region, or deliberately concealed during the process of encryption.
EC techniques are used in the creation of bitstreams of the original image, by separating the streams containing errors at the decoder, as well as improving the quality of the receiving images. However, in other cases, an incorrect large neighboring block is recovered with similar large errors, which reflects negatively in the reconstruction of the next ones. This phenomenon is known as recovery dependency.

Finally, in image applications over unreliable channels, the decoder has to contend with data corrupted by channel errors. These error lead to missing rectangular regions, which need to be perfectly estimated by appropriate recovery and concealment algorithms. Further, in the case where the missing regions of pixels are containing textures, edges, and other image features that are not easily handled by EC algorithms, therefore requires appropriate solution to this problem.

1.3 Objectives

The main goal of this study is to conceal the loss of the encoded damaged blocks with minimal blurring effect, minimal blockiness effect, as well as tackling the white-Gaussian noise. To achieve the main aim, these specific objectives are embarked:

1 - To design and test detection framework that can handle the invisible damaged blocks for medium and high resolution images.

2 - To design and test EC framework that can handle loss of the damaged blocks for medium and high-resolution images.
3 - To design and test EC framework that can handle effects after filling-in process for medium and high-resolution images.

4 - To apply and assess the performance of the proposed EC framework on images corrupted by white-Gaussian noise.

1.4 Thesis Scope

The flow of the research is illustrated in Figure 1.2. The bold lines represent the direction followed in this thesis to achieve both the goal and objectives, whereas the dotted lines are referring to other research areas that are out of the scope of this work. The loss information in wireless transmission systems, specifically with the encoded block images, part of bitstreams may be corrupted or damaged due to noise and the loss of even one bit. The figure shows that, the loss information can be recovered in several techniques.

In this thesis, the attention focuses on the techniques that have the capability of efficiently compensating for the damaged patches of digital images that are caused by the weaknesses in the channels of transmission. Therefore it requires a focus on the algorithms that use sequential recovery based on the following models; 1) Statistical pixelwise, 2) MDI based on the geometric structure, 3) Best neighborhood matching (BNM), and 4) Spatial split-match error concealment (SSEC). In addition, the possibility of how to remove the blocking artifacts located at the block boundaries of subbands, as well as the performance efficiency of the filling-in is studied. Further, a wavelet neural network (WNN) architecture that supports the processes of filling-in is proposed, with the intention of enhancing image quality.
Finally, the study focuses on how to extract the edges for images corrupted by white-Gaussian noise, to easily providing sparse decompositions over missing regions.

Figure 1.2 Study Module
1.5 Thesis Contributions

The contributions of this thesis are as follows:

1. A framework that can handle the invisible damaged patches for medium and high resolution images was developed. The method can detect both size and location of the damaged patches in the dusky areas that normal eyesight could hardly detect. The detection is carried out after applying the logarithms to the details of doubled logic images.

2. An error concealment framework that can handle loss of the damaged blocks using the similarity segmentation (i.e., Pixels-to-Feet conversion) was proposed.

3. A wavelet neural network technique (WNN) to handle both the blockiness and blurring artifacts after filling-in process for high-resolution images was proposed. The motivation behind the proposed WNN is to predict the blocks containing edges with a high accuracy, as well as enhancing the quality of images in terms of visual perception.

4. A technique to enhance images that are affected by white-Gaussian noise was developed. The best extraction method for both the vertical and horizontal image gradients is achieved after changing the magnitude of the threshold. These are extracted from the histogram of those gradients.
1. 6 Thesis outline

This thesis contains five chapters and is organized as follows:

Chapter 1 is the introduction, which presents the background of the study, the problem statement at hand, thesis objectives, thesis scope and study module, and thesis outline.

Chapter 2 presents the background of the subjects related to the methodology in this thesis and discusses another literature related to the design schemes of interpolation analysis, algorithms to conceal damaged patches, algorithms to improve the quality of the images to be reconstructed, and methods used to extract image gradients.

Chapter 3 presents an introduction to the methodology and brief discussion of the proposed frameworks is given. Further, a comprehensive description to the proposed EC schemes is outlined. On the other hand, this chapter elaborates on the analysis of algorithms, which have been proposed in this study, for example, detection of invisible damaged patches, low-complexity EC scheme, artificial neural network structure, and image de-noising analysis.

Chapter 4 reports experimental simulation and results of a number of standard test images to the following issues; 1) image compression, 2) Haar wavelet decomposition, 3) performance efficiency of the proposed invisible detection scheme, 4) EC schemes, 5) wavelet neural network, and 6) chains of images affected by the white-Gaussian noise.

Chapter 5 presents the conclusion and suggestions for future works.
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[95] LP500HUVUHDXDQG<$OWXQEDVDN\z$OXLQDUDYHPRXW &61JRUHDFLJQ DQG 'HQRQ 'DQDQWHG(RU,(((7UDQVDFWLQRVQR, PDJH3URFHVQLQJ, Ob. 12, pp. 1547-1553, 2004.


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