ENHANCEMENT OF DIGITAL GRAYSCALE IMAGE WATERMARKING USING SPARSE MATRIX

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Dedication to my loving and supportive parents, my amazing wife Ilham Abdulhadi,
my beloved daughter Maria, my brothers and sisters Jasam, Husham,
Ebtsam, Ansam, Wesam, Husam, Shekh Ahmed, Basam,
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ABSTRACT

Watermarking is a form of steganography that proved its worth in successfully protecting copyright information. It is the process of embedding data inside an audio or video or image message such that the embedded data is possible to be detected or extracted later. The core focus in watermarking techniques is their performance which is determined by imperceptibility along with robustness and capacity. These properties are often conflicting, which needs to accept some trade-offs between them. Despite the successes recorder in the area of digital watermarking, several challenges continue to persist particularly in the Areas of balancing these factors. This research aims to enhance the the processes in the watermarking technique for archieving imperceptibility with an acceptable balancing and enhance the security. The research proposed a new scheme using sparse matrix for improving the effectiveness of watermarked image using digital wavelet transform and inverse discrete wavelet transform to locate the best place and level in the image to embed the watermark. Sparse matrix is used to enhance the embedding process by selecting the proper coefficient. For more secure watermarking, additional encryption layer is utilized to increase the difficulty towards unauthorized extraction. The proposed technique generated the proper message size for each sub image based on the PSNR, which is used as an indicator for selecting the suitable level of embedding and for detecting the possibility of attacks. The proposed scheme improves watermarking quality by using the sparse matrix to select the appropriate coefficient for embedding. The experiments showed that the proposed scheme enhances 2.8479 dB of quality (PSNR) or equivalent to 5.3 % of improvements. The research proposed scheme achieved better PSNR in comparison with other research.

ABSTRAK

Penanda genang adalah satu bentuk penyembunyian maklumat yang terbukti berjaya melindungi maklumat hakcipta maklumat hak cipta. Ia merupakan proses untuk memasukan data Ko]edalam mesej audio atau video atau imej supaya mesej yang dimasukan tersebut tidak mungkin dapat dikesan atau diekstrak selepas proses tersebut. Tumpuan dalam teknik penanda genang adalah untuk memastikan prestasi teknik ditentukan oleh kebolehkenalpastian dengan tahap keteguhan dan keupayaan. Faktor penanda aras tersebut sentiasa konflik, dimana ia memerlukan keseimbangan penerimaan diantara faktor tersebut. Walaupun kejayaan bidang penanda genang digital telah dicapai, beberapa cabaran yang berterusan untuk mengimbangai diantara faktor penentu kejayaan sesuatu teknik perlu diberi perhatian. Kajian ini bertujuan untuk meningkatkan proses dalam teknik penanda genang supaya kebolehkenalpastian adalah seimbang dan meningkatkan keselamatan data. Kajian ini mencadangkan satu skema baru menggunakan matriks *sparse* untuk keberkesanan imej tera air menggunakan *digital wavelet tranform* dan *inverse wavelet tranform* yang diubahsuai untuk mencari lokasi terbaik untuk meletakkan imej tera air dan tahap imej yang untuk membenamkan penanda genang. Matriks *sparse* digunakan untuk meningkatkan proses memasukan imej dengan memilih pekali yang betul. Untuk Penanda Genang yang lebih selamat, penambahan lapisan penyulitan digunakan untuk meningkatkan kesukaran supaya proses pengektrakan tidak boleh dilakukan. Teknik yang dicadangkan dijana saiz mesej yang betul untuk setiap imej sub berdasarkan PSNR, yang digunakan sebagai petunjuk untuk memilih tahap yang sesuai menerapkan dan untuk mengesan kemungkinan serangan. Skema yang dicadangkan ini telah meningkatkan kualiti penanda genang dengan menggunakan matriks *sparse* untuk memilih pekali yang sesuai untuk proses memasukan mesej. Pengujian menunjukkan bahawa skema yang dicadangkan dapat meningkatkan nilai kualiti PSNR sebanyak 2,8479 dB bersamaan dengan 5.3% kadar peningkatan. Skema yang dicadangkan dalam penyelidikan ini mencapai nilai PSNR yang lebih baik jika dibandingkan dengan penyelidikan sebelum ini.

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CHAPTER 1

INTRODUCTION

1.1 Overview

With the prevalence of interconnected networks creation, storage, and transmission of multimedia content, digital watermarking is playing pivotal role. Digital media is always susceptible to content piracy and illegitimate manipulation. Two techniques, namely steganography and watermarking that belong to the information-hiding technology, deal with these problems (Usman *et al.*,2009).

Watermarking is basically done to infuse data inside the host image without visibly changing it, the object is to embed vital information in the data for identification purpose as stated by Tong (2012). The core purpose of this technique is to embed navigation, control or reference to the owner, copyrights or for trackers to estimate payments, billing or usage in terms of bandwidth or media being broadcast. The technique differ from conventional coding schemes where coding or coded mechanism is known to users, here an invisible message, text, audio, image or sometime video is embedded in a perceptual way not to be easily track able by unauthorized applications, persons and algorithms.

Digital watermarking method has proved its worth in successfully conveying and carrying copyright information, other controllers and useful messages using the host sound, visual or video messages. The embedded message can just be a collection of bits or owner name or company location or anything referring to the creator or for the usage estimation. This scheme has also achieve the protection from detection of

modification done by unauthorized users (Cox *et al*., 2001). Watermarking is a form of steganography but with main difference. In steganography the main priority is the capacity of the information-carrying medium while in watermarking robustness is also an important property.

Recently with the exponential growth of multimedia and internet technologies, protection of digital media ownership has gained lot of interest. The World Wide Web allows anyone to become an artist, producer, publisher or/and distributor. The increase of such original work necessitates effective copyright protection. Three issues arise when looking at copyrighting a digital work. They are copies can be produced easily and inexpensively. Copies are exact duplicates and therefore indistinguishable from the original and copies can be distributed rapidly, especially in today's networked world (Emami *et al.*, 2014).

Protection of Ownership rights is a major obstacle which needs to be overcome before artist will be comfortable for release of material in digital form. Digital watermarking is a technique which can embed a message such as (digital signature) into the a digital host document robustly and permanently. Watermarks can be used to identify an owner of digital work and also to inhibit unauthorized distribution and digital piracy (Lalit K *et al*. 2014).

Although some insights into robust watermarking with blind detectors can be gained by (Cox *et al.*, 1999), the technique however is unable to support message embedding algorithms at full due it its restriction over watermark not to be integral part of the host. Here watermarking is known to the users, hence seems this mechanism is not of use in reality. There is a need to improve algorithms that can embed watermark after using host effectively.

1.2 Problem Background

Watermarking has proven its robustness in frequency domain class, here it seems less prune to tampering and attacks than of that in other classes. But as there are increasing watermarking techniques in frequency domain, the attacks, threats and forgery is also targeting it more. The discrete cosine transform (DCT), discrete Fourier transform (DFT) and discrete wavelet transform (DWT) are three basic ways of working in watermarking techniques for images. Moreover watermarking in DWT is more effective for extracting time and frequency features and shows great accuracy with respect to visual perception of human eye (Wu, X *et al*., 2013).

One of the traditional applications of watermarking is copyright protection. In copyright watermarking, the embedded watermark encodes ownership information such as the identity of the owner and the copyright date. Detecting the invisible watermark provides the content owner with additional evidence of ownership. This might help prevent other parties from claiming the copyright in the data. Copyright protection requires a high level of quality and robustness (Karthika *et al*., 2013).

A wavelet based watermarking technique can be used for protection of images, document and grapy are in two colors only (generally white as background and black or other color as text or drawing). Such images have a large amount of white background and small content of text or graphics. Thus, the common image watermarking methods may create visual artifacts that are clearly visible in large background areas visual quality of image. To solve this problem, Patvardhan, Verma, and Lakshmi, (2012) developed an algorithm that automatically selects the watermark embedding method based on details amount available in image as text or drawing to achieve higher level of quality and robustness. The results showed that after watermark embedding, there are almost no visible artifacts in the test images thus leaving a clear white background. The robustness of watermarking technique on example images is also tested under various attacks. In case of blurring of images, this techniques does not perform so well but such types of attacks are not important as they make the document image unreadable and graphics image useless as in such images, details (sharpness) is important and blurring makes them meaningless.

The classification of watermarking techniques being used for image signals have two important classes i) watermarking in spatial domain and ii) watermarking in frequency domain. Wavelets transform domain is functions that satisfy certain mathematical requirements. Applications of wavelets can be found in the field of mathematics, quantum physics, electrical engineering and seismic geology. Wavelets method are preferred over Discrete Fourier method and Discrete Cosine method for the processing of signals which are more robust than the others (Salama *et al.*, 2011).

The previous studies using DWT and IDWT for better imperceptibility and robustness in watermarking highlighted there is a difficulty in determining the best wavelet transform level to obtain best of maximum perceptuality (P. Surekha and S. Sumathi, 2013). These properties are often conflicting, which needs to accept some trade-offs between them. Additionally, security is a significant factor for high quality watermarking. Based on that, the following hypothesis is formulated "The watermarking quality can be increased by enhancing imperceptibility and attack resistance" (Santi P. Maity *et al.*, 2013). To verify this hypothesis, the research aims to achieve some trade-offs between capacity and imperceptibility by developing an enhanced scheme using digital wavelet transform and inverse discrete wavelet transform to locate the best place and level to embed the watermark. In addition, the research utilized the sparse matrix technique to enhance the watermarking quality.

1.3 Problem Statement

The core focus in watermarking techniques is their performance, which is determined by imperceptibility along with robustness and capacity. Balancing these factors is a big challenge. Imperceptibility is computed as quality of watermarked image in terms of visible similar to the host image. Selecting the sub image of proper size and high imperceptibility can enhance the watermark performance to a large extent. To make watermark more robust against attacks larger (in size) message

amplitudes will be necessary to provide better error-resistance. So the current frameworks require an improvement to archive better performance.

1.4 Aim of Research

To enhanced current scheme for improving the effectiveness of watermarked image using Discrete Wavelet Transform.

1.5 Research Objectives

(i) To enhance the embedding process of DWT for improving the quality of digital grayscale watermarking image.
(ii) To enhance the extraction process of secret message using sparse matrix for improving the imperceptibility.
(iii) To evaluate the proposed method with PSNR for improving the proposed method is acceptable.

1.6 Research Scope

In this thesis, digital image watermarking techniques are considered. The scope of image watermarking project is listed in the following:

(i) Standard testing data set of images will be used to test the technique for imperceptibility and extracting the original images.
(ii) To test the performance of watermarked image with threshold.

(iii) The standard hosts images with size 512x512 will be in grayscale format are used as test data.

1.7 Motivation

Most researches determine the appropriate sub-band frequency level of discrete wavelet transform that should be selected to maximize the embedding capacity of the watermarking process, and imperceptibility is computed as quality of watermarked image in terms of visible similar to the host image. Selecting the sub image of proper size and high imperceptibility can enhance the watermark performance to a large extent. This motivates to conduct the research to investigate all the sub image in all level to define the candidate coefficients for embedding based on the message size. Also, improve the quality of watermarked image.

1.8 Thesis structure

The thesis is organized into six chapters as follows.

Chapter1: this chapter starts with an introduction about the role of digital water marking in protecting the copyright information. It also introduces the problem background, problem statement, research aims objectives and scope.

Chapter 2: this chapter reviews the literature. It focuses on the digital watermarking concept, basics, motivation and applications. It also describes the digital watermarking types, classification and evaluation methods. Finally, it addresses the current research in the digital watermarking field.

Chapter 3: this chapter explains the research methodology. It starts with Methodology phases followed by the research framework, which includes two stages

namely embedding and extraction processes. Finally the chapter addresses the validation process of the proposed scheme quality.

Chapter 4: this chapter demonstrates the proposed scheme and the developed algorithm, followed by the encryption technique.

Chapter 5: This chapter shows the results and discussion. It starts with the experimental setup including defining the suitable capacity of each level in the sub image to embed the target message. It also analyzes the correlation between different levels and capacity and the relation between the sub image and the perceptuality. Finally, it presents the results of the performance evaluation before and after attacks and with current schemes.

Chapter 6: This chapter concludes the research with addressing the main contributions and provides recommendations for future studies.

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