COLOUR IMAGE WATERMARKING USING DISCRETE COSINE TRANSFORM AND TWO-LEVEL SINGULAR VALUE DECOMPOSITION

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This dissertation is dedicated to my parents, my brothers and my sisters for their endless support and encouragement.

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ABSTRACT

Digital image watermarking is a technique used for hiding digital information in a carrier image. It is predominantly used for copyright protection against copyright infringement and malicious attacks. Embedding a watermark in the frequency domain is becoming more attractive for the majority of researchers as it can provide better performance. In this research, colour image watermarking using Discrete Cosine Transform (DCT) and two-level Singular Value Decomposition (SVD) is proposed. First step is preparing RGB colour image as the cover image and greyscale image as the watermark. The RGB host image is divided into R, G and B channels and the B channel is then selected. The selected channel is then divided into non-overlapping square blocks of (4x4) pixels to match the watermark size. Next, the DCT is applied to each block. DC component is then retrieved and collected from each block in order to obtain a new block of (128x128) pixels. Following that, SVD is applied to the block to generate three matrices, U, S and V. Finally, the greyscale watermark is embedded in the S matrix. Once the embedding is completed, the R, G and embedded B channel are then merged to obtain a watermarked image. Experimental results show that the average PSNR value is higher than 53 dB, which means that the proposed method is imperceptible to naked eyes. Also, the average NCC value is higher than 0.97, which indicates the proposed method has strong robustness against major attacks.

ABSTRAK

Tera air digital adalah satu teknik penyembunyian maklumat digital ke dalam imej pembawa. Ia sering digunakan untuk melindungi hak cipta dari pencerobohan dan serangan berniat jahat. Penyiratan tera air dalam domain frekuensi menjadi tarikan kebanyakkan penyelidik kerana prestasi yang lebih baik boleh dicapai melalui kaedah ini. Dalam penyelidikan ini, imej warna tera air menggunakan Jelmaan Kosinus Diskret (DCT) dan dua tahap *Singular Value Decomposition* (SVD) diajukan. Langkah pertama ialah menyediakan imej warna RGB sebagai imej penutup dan imej skala kelabu sebagai tera air. Imej hos RGB tersebut dibahagikan kepada saluran R, G, B dan seterusnya saluran B telah dipilih. Ia kemudian dibahagikan kepada blok bersaiz 4x4 piksel yang tidak bertindih untuk diselaraskan dengan saiz tera air. Seterusnya, DCT digunakan disetiap blok. Komponen DC kemudiannya didapatkan kembali dan dikumpul dari setiap blok untuk menghasilkan blok baru bersaiz 128x128 pixel. Berikutnya, SVD digunakan disetiap blok untuk menjana tiga matriks iaitu U, S dan V. Terakhir, tera air berskala kelabu diterapkan ke dalam matrik S. Setelah selesai, R, G dan saluran B yang telah dibenamkan kemudiannya digabungkan untuk mendapatkan imej tera air. Keputusan eksperimen menunjukkan bahawa nilai purata PSNR adalah lebih tinggi daripada 53 dB, yang bermaksud kaedah yang diajukan adalah tidak dapat dilihat denagn mata kasar. Purata nilai NCC juga adalah lebih tinggi daripada 0.97, yang bermaksud kaedah yang dicadangkan mempunyai tahap keteguhan yang kuat terhadap serangan utama.

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LIST OF ABBREVIATIONS

AC	Alternate Current
DC	Direct Current
DCT	Discrete Cosine Transform
DFT	Discrete Fourier Transform
DWT	Discrete Wavelet Transform
HVS	Human Visual System
JPEG	Joint Photographic Expert Group
LSB	Least Significant Bit
NCC	Normalized Cross Correlation
PSNR	Peak Signal to Noise Ratio
SVD	Singular Value Decomposition

CHAPTER 1

INTRODUCTION

1.1 Introduction

Analogue technology has traditionally been used by developers to create multimedia applications. Unfortunately it was difficult to manipulate multimedia applications using analogue technology because of limited bandwidth capacity (Friedman, 1993). However, digital technologies offer greater flexibility and reliability, allowing for easier handling (Friedman, 1993).

The characteristics of digital applications motivated developers to create a wide range of multimedia applications including multimedia communications and multimedia network applications. After further progress in the field of multimedia applications and multimedia content distribution, users began to find it difficult to protect their own content. Anyone could obtain and easily use their content as unauthorised copy. Owners need to protect their media content against theft and poor reproductive performance. Wide use of the internet widely has made multimedia files unsecure. Anyone can get data from different sources and change this data without the original owner's permission. For this reason, many copyright issues have emerged recently.

Digital watermarking is a technique for integrating watermark information into digital data such as (images, video or audio) to make a statement about the data. The watermark is created as a solution for multimedia data to protect against copyright infringement or bad performance (Dharwadkar and Amberker, 2010). This information, or watermark, can be an image or text information about the author. The watermark can be found and extracted later from the original information to recognise the original owner.

1.2 Problem Background

Now that home computers are more common and widespread, digital content has also become easy and replicas of digital content such as text, images, audio and video can be produced cost-effectively and quickly. There are many software applications which can edit and manipulate these files and people often claim that these modified files are theirs when they were actually created by someone else (Jhonson, 1998; Katzenbeisser and Petitolas, 2000).

In the past few years, a lot of digital watermarking techniques have been developed for various application scenarios. Depending on the work area where the watermark is embedded, watermarking schemes can be classified into two groups which are spatial or space domain and frequency or transform domain.

In the space or spatial domain the watermark bit is directly inserted in the cover image pixel value. The simplest method in this domain is the Least Significant Bit (LSB) which embeds the watermark information into the LSB bit of the host image. LSB embedding has some advantages such as allowing high transparency and simplicity. However, it can be weak in easily detecting hidden messages (Chang *et al.,* 2003).

In the Transform or frequency domain before integrating the watermark bits, the host image will transform from a spatial or space domain to frequency domain. The transform domain methods include Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), and Discrete Fourier Transform (DFT).

DCT and DWT are two of the more popular techniques for image compression (Barni *et al., 1998).* Both of them have their own advantages and disadvantages. DWT has a better compression ratio without losing too much image information but it needs more processing power. DCT needs low processing power but it loses a image information due to blocked artefacts (Nadenau, 2000). In recent years, Singular Value Decomposition (SVD) has been used as a different transform. The idea of using SVs for embedding watermark comes from the fact that the change of the SV's bit does not affect image quality (Liu *et al.,* 2009).

Singular Value Decomposition (SVD) is a powerful tool for the analysis of the numerical matrices that give a minimum least squares error truncation (Liu and Qian, 2011). This is because overall capacity degrees of freedom of all three matrices are equal to the host image which is used as an input image. Image watermarking based on Singular Value Decomposition (SVD) provides safe and reliable identification of the owner (Liu and Qian, 2011; Shi *et al.,* 2011).

There are two ways for embedding watermark bits into the cover image using SVD. The first is to embed the bit directly to the SVs of the cover image and the second is to transform the image using DCT or DWT, then embedding the watermark bit into the transformed coefficients SVs (Liu et al., 2009). Discrete Cosine Transform (DCT) can be used with SVD to improve and get good performance on watermark imperceptibility and robustness (Li et al., 2011; Quan and Qingsong, 2004). However, most of the previous algorithms in this area are non-blind. Without the help of some intermediate variables or original images, which are used in the embedding process, they cannot extract the embedded image.

(Quan and Qingsong, 2004) proposed a non-blind watermarking scheme using a combination of DCT and SVD. This method has good imperceptibility and is also robust against most common attacks but has the disadvantage of not being robust enough against image cropping attacks.

(Liu and Qian, 2011) proposed a non-blind watermarking algorithm based on a two level DCT and a two level SVD. In this method they embedded a 32x32 grey watermark image into a 512x512 greyscale host image. This method is robust against some common attacks but suffers from poor resistance against blurring and motion blur attacks. (Rajani and Ramashri, 2011) proposed a non-blind watermarking technique using a combination of DCT, SVD and edge detection techniques. This scheme is robust enough against some type of attacks but it is also too weak against median filter and Gaussian noise. In addition, this method depends on large blocks which decrease the capacity.

The proposed scheme in (Li et al., 2011) is a type of blind algorithm in embedding and extracting the watermark image. They used sub-blocks in SVD and large block in DCT to insert the watermark in the transform coefficients. This method can support repeated watermarking and delivers good performance when a watermark image undergoes some general image processing. Meanwhile, this method is also weak in resisting image scaling distortion because it uses fixed sub block and macro block sizes when dividing images into blocks.

1.3 Problem Statement

Digital media has had a great effect on humanity. Digital media include images, audio and video and are of such widespread use that anyone can access them and use them for commercial or personal reasons. In contrast the content can be used improperly and abused by many people. Based on the need for truly digital content, problems of abuse arise and in order to solve these problems, this study examined the use of digital watermarking.

A lot of research has been done on image watermarking in frequency domain using various algorithms like DCT, DWT and DFT. Some researchers have also used a combination of two different algorithms such as combining DCT-DWT, DWT-SVD or DCT-SVD but still some issues needs to address including:

1. How to achieve imperceptibility (transparency) without compromising robustness (reliability) and vice versa?
2. How to achieve robustness against most common attacks especially filtering such as (median filter and motion blur) and geometric such as (rotation and cropping).

1.4 Research Aim

This study's purpose is to introduce colour image watermarking method using Discrete Cosine Transform (DCT) and two-level Singular Value Decomposition (SVD) for hiding a greyscale watermark image into RGB colour host image. The proposed methodology aims to improve robustness (reliability) without compromising the watermarked image quality.

1.5 Research Objective

1. To develop existing image watermarking techniques based on Discrete Cosine Transform (DCT) and Singular Value Decomposition (SVD) in order to increase capacity and achieve both high imperceptibility and robustness.
2. To evaluate robustness against most common attacks including Salt & Pepper, Gaussian, speckle, Poisson, median filter, sharpened filter, motion blur, JPEG compression, cropping and rotation.
3. To benchmark the proposed method with other existing SVD based methods.

1.6 Research Scope

1. Host image: standard dataset of RGB colour image of (512x512) pixels downloaded from http://sipi.usc.edu/database.php dataset. The host image format is JPEG.
2. Watermark image: greyscale watermark image of (128x128) pixels. The watermark image format is JPEG.
3. Domain: Frequency domain using Discrete Cosine Transform.

1.7 Thesis Organization

Chapter 1 includes an overview on watermarking, problem background and statements and objectives. Chapter 2 includes watermarking types, applications, attacks and domains. In Chapter 3 the project methodology is described. Chapter 4 includes the experimental results that we get from applying the proposed methodology as described in Chapter3. Conclusion and future work are given in Chapter 5.

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