

# **UNIVERSITI PUTRA MALAYSIA**

IMAGE ORIENTATION WATERMARKING TECHNIQUE FOR COPYRIGHT PROTECTION

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# IMAGE ORIENTATION WATERMARKING TECHNIQUE FOR COPYRIGHT PROTECTION



Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

November 2016

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DEDICATION

# To My Family



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the Degree of Master of Science

## IMAGE ORIENTATION WATERMARKING TECHNIQUE FOR COPYRIGHT PROTECTION

By

## HEND MUSLIM JASIM

November 2016

# Chairman: Zaiton Binti Muda, PhDFaculty: Computer Science and Information Technology

Image copyright protection utilizes watermarking as one of the Digital Right Management techniques to protect digital images. Watermarking involves embedding a signature into a given image to produce a watermarked copy. This copy is meant to prevent any deliberate or unintentional attempt to remove the signature from its content. In return, a copyright gains its validity based on such robust characteristics. Watermarking attracts much interest in algorithm design to enable a signature to be embedded on secrecy and encryption beds. Watermarking imitates steganography in information hiding but with alternative priorities, it focuses on the cover and not on the hidden message.

The use of watermarking has still not achieved a meaningful level of reliability in copyright protection applications as to be able to resolve infringement claims in the courts. This is due to two main obstacles. The first involves the need to consider original image quality as the main evidence over any other clues. The second obstacle on watermarking reliability in copyright protection involves the lack of an adequate common measure that proves the superiority of one technique over another and then hampers improvements to the efficiency and quality of algorithms

To address this problem, this research proposes a new image-orientation watermarking technique overcoming the obstacles. The proposed technique intentionally corrupts the original images under owner signature control to generate copies for public use. Corruption is effected intrinsically by image operations such as resizing, which acts to relocate the original from its default position to an alternative over a presumed space. The design utilizes Principal Component Analysis and Blind Noise Level Estimation to resemble these transitions over image resizing operations. In addition, it formulates two measuring parameters, for evaluating protection techniques, namely Protection Requirement Parameter (PR) and Distance Decision Measure (D).

The experiment has two phases which are Pre-Protection design and, Protection and Infringement Resolve. In the Pre-Protection design, it investigates the proofing on

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image operation corruption to support the principle used in showing the preliminary impact of data corruption made by resizing. In the second phase, using Protection and Infringement Resolve, it proceeds to cover the performance of the main two procedures of the protection technique along the validity parameters devised in this work. Results set a PR threshold of 0.05 to be totally convincing as an efficient requirement controlling parameter. Compared to the existing benchmarking noise measures of PSNR, MSE, MAXERR and L2RAT analysis of variance (ANOVA) and linearity are applied to support inferences from sample limits towards population boundaries in order to establish rigid validity on PR.

The main conclusions of this research highlight the contradictions in the use of watermarking as a tool in image protection as the basis for proposing an alternative design. Digital watermarking techniques are usually complex and necessarily involve the need to satisfy many conflicting requirements and tradeoffs. Unlike these techniques, the proposed work adopts an image-oriented foundation that does not treat the owner's signature as paramount but, instead, makes the customer's image traceable through the owner's signature on a transition path that uses original image quality as the main basis for copyright resolution. Results obtained affirm the validity of this design basis along with the proposed parameters that make comparison among techniques possible.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

## IMEJ ORIENTASI WATERMARKING TEKNIK UNTUK PERLINDUNGAN HAKCIPTA

Oleh

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# Pengerusi: Zaiton Binti Muda, PhDFakulti: Sains Komputer dan Teknologi Maklumat

Perlindungan hak cipta imej menggunakan *watermarking* sebagai salah satu teknik Pengurusan Hak Digital untuk melindungi imej digital. *Watermarking* melibatkan pembenaman tandatangan ke dalam imej yang diberikan untuk menghasilkan salinan tera air (*watermarked*). Salinan ini bertujuan untuk mengelakkan sebarang percubaan yang sengaja atau tidak sengaja untuk membuang tandatangan dari kandungannya. Sebagai balasan, hak cipta memperolehi kesahihannya berdasarkan ciri-ciri yang teguh tersebut. *Watermarking* menarik minat ramai dalam reka bentuk algoritma untuk membolehkan tandatangan dibenamkan ke atas lapisan yang rahsia dan sulit. *Watermarking* meniru steganografi dalam penyembunyian maklumat tetapi dengan keutamaan alternatif, ia memberi tumpuan kepada penutup dan tidak pada mesej yang tersembunyi.

Penggunaan *watermarking* masih belum mencapai tahap yang bermakna bagi kebolehpercayaan dalam aplikasi perlindungan hak cipta yang dapat menyelesaikan pelanggaran tuntutan di mahkamah. Ini adalah disebabkan oleh dua halangan utama. Yang pertama melibatkan keperluan untuk mempertimbangkan kualiti imej asal sebagai bukti utama ke atas apa-apa petunjuk lain. Halangan kedua pada *watermarking* ialah kebolehpercayaan dalam perlindungan hak cipta melibatkan kekurangan langkah biasa yang mencukupi bagi membuktikan keunggulan satu teknik di atas yang lain dan halangan penambahbaikan kepada kecekapan dan kualiti algoritma

Bagi menangani masalah ini, kajian ini mencadangkan satu teknik baharu *watermarking* berorientasikan imej bagi mengatasi halangan-halangan tersebut. Teknik yang dicadangkan ini dengan sengaja akan merosakkan imej asal di bawah kawalan tandatangan pemilik untuk menjana salinan bagi kegunaan awam. Kerosakan dalaman dilaksanakan oleh operasi imej seperti pensaizan semula, yang bertindak untuk menempatkan semula imej asal dari kedudukannya kepada kedudukan alternatif dalam ruang yang telah ditetapkan. Reka bentuk ini menggunakan Analisis Komponen Utama dan Anggaran Paras *Blind Noise* untuk menyerupai peralihan ini

ke atas operasi pensaizan semula imej. Di samping itu, ia membentuk dua parameter pengukuran untuk menilai teknik perlindungan iaitu Parameter Keperluan Perlindungan (PR) dan Pengukuran Keputusan Jarak (D).

Ujikaji ini mempunyai dua fasa iaitu Reka Bentuk Pra-Perlindungan dan, Perlindungan dan Penyelesaian Pelanggaran. Dalam Reka Bentuk Pra-Perlindungan, ia akan menyiasat kekalisan ke atas kerosakan operasi imej untuk menyokong prinsip yang digunakan dalam menunjukkan kesan awal kerosakan data yang dibuat dengan pensaizan semula. Dalam fasa kedua, menggunakan Perlindungan dan Penyelesaian Pelanggaran, proses diteruskan untuk melindungi prestasi dua prosedur utama teknik perlindungan bersama-sama dengan parameter sah yang digunakan dalam kerja ini. Keputusan menetapkan nilai PR adalah 0.05 untuk menjadi benar-benar meyakinkan sebagai keperluan yang cekap mengawal parameter. Berbanding dengan pengukuran tanda aras bunyi yang sedia ada seperti PSNR, MSE, MAXERR dan L2RAT analisis varians (ANOVA), kelinearan digunakan untuk menyokong kesimpulan dari had sampel ke arah sempadan yang ditetapkan dalam usaha untuk mewujudkan kesahihan tegar pada PR.

Kesimpulan utama kajian ini menonjolkan percanggahan dalam penggunaan *watermarking* sebagai alat perlindungan imej menjadikan asas untuk mencadangkan reka bentuk alternatif. Teknik *watermarking* digital biasanya kompleks dan semestinya melibatkan keperluan untuk memenuhi banyak pengukuran yang bercanggah. Tidak seperti teknik-teknik ini, teknik yang dicadangkan mengamalkan asas berorientasikan imej yang tidak menggunakan tandatangan pemilik sebagai paling utama tetapi sebaliknya menjadikan imej pelanggan dapat dikesan melalui tandatangan pemilik di atas laluan peralihan yang menggunakan kualiti imej asal sebagai asas utama untuk hak cipta resolusi. Keputusan yang diperolehi mengesahkan kesahihan reka bentuk ini bersama-sama dengan parameter yang dicadangkan yang boleh dibuat perbandingan antara teknik-teknik.

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I certify that a Thesis Examination Committee has met on 3 November 2016 to conduct the final examination of Hend Muslim Jasim on his thesis entitled "Image Orientation Watermarking Technique for Copyright Protection" in accordance with the 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 Master of Science.

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Dr. Zaiton Binti Muda
Dr. Mohd Taufik bin Abdullah

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# LIST OF ABBREVIATIONS

	Abbreviation	Explicit Notation
	DRM	Digital Right Management
	PCA	Principle Component Analysis
	IT	Information Technology
	LSB	Least Significant Bit
	DCT	Discrete Cosine Transform
	MSB	Most Significant Bit
	DWT	Discrete Wavelet Transform
	DFT	Discrete Fourier Transform
	SVD	Singular Value Decomposition
	SNR	Signal to Noise Ratio
	NC	Normalized Cross Correlation
	SIM	Similarity Measure
	MAE	Mean Absolute Error
	BER	Mean Opinion Score
	ТР	True Positive
	FP	False Positive
	SR	Similarity Ratio
	FFT	Fast Fourier Transform
	PAQM	Perceptual Audio Quality Measure
	PSD	Phase Shift Detection
	PR	Protection Requirement
	D	Distance Decision
	PSNR	Peak Signal-to-Noise Ratio

	MSE	Mean Square Error
MAXERR L2RAT		Maximum Squared Error
		Ratio of Squared Norms
	ANOVA	Analysis of Variance
	FD (ANOVA)	Freedom Degree
	SS (ANOVA)	Sum of Squares
	BS	Bit Substitution
	HVS	Human Vision
	cc	Correlation Coefficient
	СР	Capacity
	s	Security
	Т	Traceability
	С	Compatibility
	А	Accessibility
	I	Integrity
	R	Robustness
	Р	Perceptibility
	MCC	Means of Correlation Coefficient
	AR	Accuracy Rate
	VSB	Vector Space Projections
	SI	Statistical Inference
	MOS	Mean Opinion Score
	LMSE	Laplacian mean squared error
	GSSNR	Global Sigma Signal-To-Noise Ratio
	HS	Histogram Similarity

- AD Average Absolute Difference
- CQ Correlation quality



#### **CHAPTER 1**

### **INTRODUCTION**

## 1.1 Research Background

Image copyright protection utilizes watermarking as one of the different Digital Right Management (DRM) techniques to secure digital images (Anthony, 2007; Mehta et al., 2012). Watermarking is used to conceal information over long time frames and emulates steganography which is a process of hiding secret messages, and is the basis of any operation in any given cover letter following an algorithm (Manoj Kumar Sharma & Gupta, 2012). Research has pointed to the value of steganography in providing copyright protection for digital products. In this application, steganography is known as watermarking and its main activity of hiding is defined as "embedding". Watermarking involves embedding and extracting in which a signature is concealed and collected, respectively in two different stages of operations. This distinction in the terminology differentiates the embedding process from that of the hiding activity such that the former is not necessarily invisible while, in the latter, the whole function relies on the capability of concealing messages within a cover and where the element of invisibility must be present (Manoj Kumar Sharma & Gupta, 2012).

The main challenge in watermarking is to balance watermark visibility and robustness (Ingemar et al., 2000), and its performance against a set of watermarking requirements is the primary aim of techniques that are developed and used. Watermarking in signature-embedding is unable to comply completely with the requirements of consistency as it is difficult to satisfy them all simultaneously (Ravi Sharma & Steve Decker, 2001). In addition, it is impossible to avoid data change during the process of embedding a signature into it.

Beyond the distinction between steganography and watermarking, DRM technologies are developing systems devised specifically to prevent the violation of intellectual property rights by attempting to restrict the arbitrary possess of digital products through enforcing copyrights to licensed owners. As one of the techniques, watermarking has gained much interest and is considered a promising tool to limit or completely prevent users from altering, sharing, copying, printing, and saving digital images. Technically, digital watermarks are used as evidence in the context of copyright infringement protection. Legal systems permit the introduction of evidence by a digital watermark or even part of it. Therefore, it has to be mandatorily robust. Although scientific information is usually provided to a court by an expert witness, courts currently experience some difficulty in assessing the knowledge of the witness or the scientific adequacy of the testimony reported. Therefore, watermarking has still not received reliable traction as it leaves many implementation details open and there is no certification infrastructure in place for benchmarking tools or experts of their related institutions (Maurice, 2011). However, copyright protection is completely governed by law enforcement. Although watermarking techniques are designed to be tricky by using complex keys, it is not possible to convict any illegal breach over

ownership rights unless protection is provided by legislation. Unfortunately, many countries lack the rules or the power to pursue copyright infringements.

This research attempts to model a new watermarking strategy in image protection systems by using original image quality features as the main part of evidence instead of its signature. So far, signature has been treated as a primary key in most of proposed technique. Here signature constituents are used to stimulate a sequence of operations on the image rather to be embedded, and that is why the mode is classified to rely on data to operation-based watermarking. For this purpose, this research reviews various publications and works in watermarking using a new classification criterion that is termed watermarking orientation. Based on this classification, most watermarking works appear to fall into the signature-oriented category. The proposed technique, identified as image-oriented, is seen as the foundation of the proposed technique design strategy where the aim of the protection is to ensure the integrity of the original image.

## 1.2 Motivation

The urgent demand for vital copyright protection makes watermarking a significant target for researchers in diverse techniques and systems. The rapid development of communication and file transfer via the internet simplifies the means for data sharing and hacking at the same time. Digital multimedia is approachable by end users without any restrictions. Human intellectual properties under this information-open media invoke the need for security and protection. In response, efforts at legislation in the face of rapid technology developments are aimed at using different means and strategies to guarantee copyright against any breaching infringement, and are usually termed as Digital Right Management techniques. Although technical evidence in courts is based on trust, there is still a huge tolerance for the assessment of techniques and participating individuals. Under these circumstances, the search for adequate watermarking techniques is very significant for its benefit as business revenue and as a valuable social service to protect human intellectual properties.

#### **1.3 Problem Statement**

The use of watermarking has still not reached a significant level of reliability in copyright protection applications to resolve infringement claims in the courts. This is because of two main obstacles. The first involves the need to consider original image quality as the main evidence over any other clues. This in turn necessitates the creation of an obvious distinction between watermarking and steganography by emphasizing the integrity of the cover (image) as a property over the integrity of the hidden information (signature) as a security issue. This ambiguity between the two techniques generates serious confusion in defining watermarking requirements and in specifying the elements needed for evidence management in the courts. Unfortunately, watermarking is made to imitate the dominating secrecy of the algorithm and its keys in exactly the same way as steganography and is still unable to provide clarity or purity of the originals in copyright disputes.

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Generally, watermarking is distinguished from steganography based on its requirements. However, most watermarking techniques do not comply with a specific common standard requirement but interchangeably select features from among some of them. All of these are based on the common technique of hiding owner's signatures in steganography which in itself causes serious ambiguity particularly in discarding objectives and the orientation. Some researches adopt robustness as a prime requirement such as that by (Tao & Dickinson, 1997; Al-Haj & Mohammad, 2010; Thapa et al., 2011; Yusuf, et al., 2012; Deb, et al., 2012; Devi et al., 2012; Kakkirala & Chalamala, 2013; Nematollahi et al., 2014). Others select, besides robustness, perceptibility or security with (Jiansheng et al., 2009 and Sathik & Sujatha, 2010) hold on to the former while (Al-Nu'aimi & Qahwaji, 2009; Gupta, 2012; Subashini & Poornachandra, 2012) stick to the latter. Many others extend robustness and perceptibility to involve capacity such as (Mosleh & Hosseinpour, 2013; Kiran & Kanwar, 2015). The foregoing highlights the fact that although watermarking and steganography share common information-hiding activities, they have to be strictly identified and discriminated from each other in terms of their orientation in removing any ambiguity. This can be achieved by simply relying on a new criteria declaring the fact that the watermarking is explicitly designed for the cover (or the image) and steganography for a signature (or a message).

The second issue in regard to watermarking reliability in copyright protection involves the lack of an adequate common measure that proves the superiority of one technique over another and then prevents improvement on the efficiency and quality of algorithms. Based on the classification sought by researchers, different parameters and variables are proposed. (Kutter and Petitcolasb 1999) consider watermarking types depending on their inputs and outputs, and such classification involves four different categories that is, private, semi private, public, and asymmetrical watermarking systems. Accordingly, four parameters are suggested which are estimating the amount of embedded information, watermark embedding strength, size and nature of the picture, and finally the secret information considered as a key factor in the security. The metrics in this work comprises pixel-based and perceptual quality metrics. (Lalit Kumar Saini & Vishal Shrivastava, 2014) summarize the evaluation of the algorithm design's effectiveness by the quality of the watermarked image compared to its original. (Carlos et al., 2011) evaluates the function of the extracted information as a ratio onto the embedding. However, most works overlook the approval of the performance and merely declare the design perspective of the presented technique, such as (Preeti Parashar & Rajeev Singh, 2014; Afrin Husaini and Nizamuddin, 2010). In summary, although broad proposals have been made on evaluating various digital watermarking methods, no standard criteria have been established and they vary from one to another (Jean-Paul & Marten, 1998). Recent literature has brought up the metrics of PSNR, MSE, MAXERR, and L2RAT in assessing performance in terms of the design interchangeably of the different works and approaches.

In brief, this research concludes two main concerns about watermarking application in copyright protection, they are;

1. The need to consider original image quality as the main evidence over any other clues.

2. The lack of an adequate common measure that proves the superiority of one technique over another.

## 1.4 Research Objective

The main objective of this research is to address and overcome the need to consider original image quality as the main evidence over any other clues, and the lack of an adequate common measure that proves the superiority of one technique over another, on the reliability of watermarking in image protection applications through a technique that employs image oriented watermarking instead of the standard signature oriented method.

For this purpose the research addresses two main goals:

- 1. To propose new distinguishing criteria that removes any element of ambiguity between watermarking and steganography.
- 2. To propose an adequate common measure used in approving the performance of one technique over another and to assess the validity of the protection in the proposed technique of this work within different embedding of watermarking signatures.

## 1.5 Research Scope

This research focuses on the use of watermarking in image protection. While works on watermarking use an embedded signature as the main evidence in copyright matters, this research focuses on the quality of an original as opposed to signatureembedding as the main clue. This research adopts Principle Component Analysis (PCA) as a tool to project any image in a presumed space by reducing its dimensions. The allocation of images facilitates the measurement of noise in image segments. Yet this research invokes a proper method to estimate noise on a blind bed to construct the X input matrix of the PCA. This, in turn, compensates for the expense in computation costs mainly by substituting noise measures of image segments instead of using its literal data content. When applied, the protection method considers all existing techniques of signature embedding in both spatial and transformational dimensions as image-oriented and noise resources. So far, none of these techniques are able to certify the original characteristics of images in resolving copyright infringement issues, but they act to corrupt images under the claim of protecting them.

## **1.6 Research Contributions**

Principally, this research proposes a new technique to support decision-making in image copyright protection issues. It shows the practical view of such protection by invoking robust elements of the evidence needed along with decision-making process requirements. In general terms, the main contributions of this research are:

- 1. Implementing a new basis for incorporating original image quality as the main evidence in infringement resolving in the design scheme of the presented technique. This new basis is established on new classification foundations to easily and clearly distinguish the objectives of watermarking application from steganography and helps make the design algorithm-independent; even when security keys are hacked the original image is still protected. This is more applicable for court litigation where hacking is stranded.
- 2. Formulating new parametric measures. Protection requirement (PR) and Distance Decision (D) measures offer common reference points for comparison among different watermarking techniques and methods in image protection and cover the essential effect of noise and image data perturbations.

### 1.7 Thesis Organization

This thesis is organized into six chapters.

**Chapter one** is a preliminary introduction to the research work to propose and investigate a new technique for digital image protection. It provides some essential background information on relevant topics on the problem statement, research objectives, scope, and major contributions of the study.

**Chapter two** highlights the literature review and the justification behind the need to search for an alternative watermarking technique to existing techniques. It provides a comprehensive summary table on watermarking different techniques and evaluation schemes showing apparently that there is no common background comprises facts on evaluation and assessment.

**Chapter three** reviews the methodology of the different processes adopted in this research. The methodology is detailed as a five-process model involving Requirement Analysis, Design, Implementation and Coding, Experiment Design and Results and Documentation for illustration and elaboration purposes.

**Chapter four** focuses on the proposed technique. Relevant algorithms are presented in accordance to the incorporating procedures; watermarking and infringement resolve of this work. Details are well depicted at all levels besides adequate justification for parameters and measures. The most important of this defines two equations (5) and (6) as the fundamental mathematical derivation of two formulated parameters for resolving copyright infringement and for approving the validity of protection, D and PR in general.

**Chapter five** overviews the experimentation process of the research. It depicts two stages of the experiment that is before and after the design. In the first stage, the pretests investigate the impact of trying different operations on images to elicit some means of corrupting an image to be intrinsically systematic. The second stage involves the main two protection procedures in addition to analysis stage of ANOVA and

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linearity investigations. Adequate justification is made for such protection requirements to be highly recommended as it successfully encompasses many estimates of signal-to-noise ratios in a unique measure and through performance study.

**Chapter six** is the conclusion covering the results and the design principles of the protection system in general and ends with a discussion on promising areas that might be further explored in this field.

## 1.8 Summary

This chapter introduces the essential aspects of watermarking as one of the widely investigated tools used in image protection. The main arguments against it are the ambiguity of application to principles stemming from steganography yielding priority of signature over image in evidence management besides the lack of standard referencing in its common measures to determine the superiority of one proposal over another. All have been reported in the problem statement section and are pursued as the main goals of the whole work. The contributions of various research works have also been noted in terms of the major deliverables achieved in this study. This chapter provides the introduction to the thesis and to the following chapters in discussing the proposed technique of image oriented watermarking with reliable characteristics to enhance the performance of watermarking in image copyright protection.

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