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Scalable watermarking for images

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NOTE

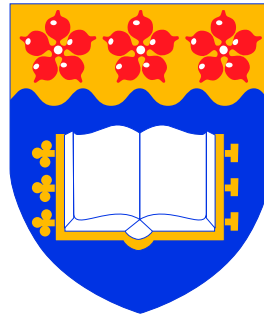
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Scalable Watermarking for Images

A thesis submitted in fulfilment of the
requirements for the award of the degree

Doctor of Philosophy

from

UNIVERSITY OF WOLLONGONG

by

Angela Piper

School of Computer Science and Software Engineering
Faculty of Informatics
March 2010

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*For my grandparents,
who encouraged my interest in all things.*

Certification

I, Angela Piper, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Computer Science and Software Engineering, Faculty of Informatics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged below. The document has not been submitted for qualifications at any other academic institution.

Angela Piper
September 2, 2010

Abstract

Digital watermarking allows the embedding of a signal in multimedia content without affecting its quality or usability. This signal can then be used to identify or confirm the creator or owner, track or prevent unauthorised distribution or verify the integrity of the content, and for a variety of other purposes; making digital watermarking a useful component in the protection of digital multimedia content.

With growing demand for both high quality and mobile content, scalable compression has become an increasingly important tool in the distribution of digital content online. It allows content to be scaled to suit a wide range of users and device capabilities in changing network conditions. In particular, resolution scalable compression allows adaptation to different display resolutions, and quality scalable compression caters for to different bandwidths.

However, for low end devices and low bandwidth connections, the scaling process typically alters the content beyond what a traditional digital watermark is designed to handle. Thus the field of scalable watermarking has emerged to provide digital watermarking algorithms that are suitable for scalably compressed content.

In this thesis, resolution and quality scalable watermarking is examined in the context of images, with the aim of developing a watermarking algorithm that is both resolution and quality scalable.

Precisely what it meant for a watermarking algorithm to be *scalable* had not previously been formally defined, and informal descriptions would often focus on a certain desirable property for a scalable watermarking algorithm to the exclusion of some other important property. A definition of a scalable watermarking algorithm is proposed, which considers watermark scalability in terms of two properties that describe the ability of the watermark to both survive high levels of scalable compression and yet still adequately protect all layers of the image. Quantitative measures of these properties are also constructed, to allow the scalability of a watermarking algorithm to be evaluated according to the proposed definition.

Although scalable image compression allowed two types of scalability – resolution and quality – prior to the work in this thesis, scalable watermarking algorithms typically

provided only one type of scalability or the other (or provided both with the provision that one of the two types be selected at the time of embedding). The problem of creating a single watermarking algorithm that provides both resolution and quality scalability, simultaneously, is considered, using JPEG2000 as a representative scalable compression algorithm.

A non-blind spread spectrum based watermarking algorithm is developed, by combining resolution scalable coefficient selection with a human visual system based embedding strength. The resulting watermark provides both detectability and graceful improvement, allowing resolution scaling to $\frac{1}{256}$ th the original image area, and quality scaling to $\frac{1}{100}$ th the original file size, exceeding the resolution and quality scalability reported for other scalable image watermarking algorithms.

A blind, quantization based algorithm is also developed, that provides detectability and graceful improvement for resolution scaling to $\frac{1}{1024}$ th the area and quality scaling to $\frac{1}{100}$ th the size, and additionally maintains an exact match between the candidate and extracted watermarks under scaling. This algorithm is adapted for image authentication, and is sensitive to small changes, including Holliman-Memon and collage attacks, but remains undamaged by JPEG2000 scaling. Previous image authentication watermarks that both tolerate scaling and are secure against Holliman-Memon and collage attacks typically offer only one type of scalability and do not provide graceful improvement.

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¹This provides me with a sudden sympathy with anyone who has ever felt compelled to write an overlong acceptance speech. I comfort myself with the thought that should my own audience become weary, they need only turn the page

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Publications

The following is a list of the journal articles and peer reviewed conference papers that have been presented during the course of the work conducted as part of this thesis.

- A. Piper and R. Safavi-Naini. “How to compare image watermarking algorithms,” Y. Q. Shi, Ed., *Trans. Data Hiding and Multimedia Security IV*, pp. 1–28, ser. Lecture Notes in Computer Science, vol. 5510, Springer Berlin/Heidelberg, 2009.
- A. Piper, R. Safavi-Naini, and A. Mertins. “Resolution and quality scalable spread spectrum image watermarking,” in A. M. Eskicioglu, J. J. Fridrich and J. Dittmann, Eds., *Proc. 7th ACM Workshop on Multimedia & Security (MM&Sec’05)*, New York, NY, USA, Aug. 1-2, ACM Press, 2005. pp. 79–90.
- A. Piper. “Refined threshold adaptation for scalable watermarking,” (best student paper award) [Abstract], in J. Fulcher and K. Ward, Eds., *SITACS Research Student Conference Abstracts*. School of Information Technology and Computer Science, University of Wollongong, Oct. 27, 2004.
- A. Piper, R. Safavi-Naini, and A. Mertins. “Coefficient selection methods for scalable spread spectrum watermarking,” in T. Kalker, I. J. Cox, Y. M. Ro, Eds., *Proc. Digital Watermarking: Second Intl. Workshop (IWDW)*, Seoul, Korea, Oct. 20–22, ser. Lecture Notes in Computer Science, vol. 2939. Springer Berlin/Heidelberg, 2003, pp. 235–246.

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