Geometrically Invariant Digital Watermarking Using Robust Feature Detectors

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Doctor of Philosophy in Software Engineering

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Abstract

Geometrically invariant digital watermarking schemes based on robust feature detectors are proposed in this thesis. First, three types of feature detectors are proposed for digital image watermarking: the Edge Based Feature Detector, the SIFT Based Feature Detector, and the Adaptive Harris Based Detector. The Edge Based Feature Detector is proposed based on edge detection and it can extract a unique feature in the specific region. The SIFT Based Feature Detector is proposed by improving SIFT algorithm to produce more robust feature points for digital image watermarking, and it can extract number of feature points. The Adaptive Harris Based Detector is proposed by revamping and enhancing the Harris corner detector and it can also extract a number of reliable feature points.

The three detectors are proven to be highly robust against both geometric attacks and also common signal processing. After locating the features for watermarking, two watermarking methods for different types of watermark are proposed: the histogram distribution based watermarking method, for a sequence of watermark data bits. And the Zernike transform based watermarking method for embedding data sequence of specific distribution and detecting its existence during the watermark extraction process.

Besides digital images, the feature extraction based watermarking scheme can also be applied in digital audio clips as well. The Robust Audio Feature Detector is proposed to extract features from digital audio clips. Then, the Stationary Wavelet Transform is applied to the extracted regions, and thus the regions are decomposed into approximation and detail coefficients. Afterwards, the watermark is embedded /

extracted into / from the approximation coefficients with the spread spectrum communication techniques.

Experiments are conducted to evaluate the performance of the proposed watermarking schemes. The proposed algorithms are proven to be robust against most of the attacks, including common signal /audio processing and geometric distortions. Furthermore, they outperform the existing representative works when under common signal / audio processing and geometric distortions.

Declaration

I declare that the thesis here submitted is original except for the source materials explicitly acknowledged and that this thesis as a whole or any part of this thesis has not been previously submitted for the same degree or for a different degree.

I also acknowledge that I have read and understood the Rules on Handling Student Academic Dishonesty and the Regulations of the Student Discipline of the University of Macau.

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List of Abbreviations

AHBD. Adaptive Harris Based Detector

DCT. Discrete Cosine Transform

DFT. Discrete Fourier Transform

DoG. Difference-of-Gaussians

DWT. Discrete Wavelet Transform

EBFD. Edge Based Feature Detector

FAST. Features from Accelerated Segment Test

FMT. Fourier-Mellin Transform

HOWA. Histogram-Oriented Watermarking Algorithm

ILPM. Inverse Log-Polar Mapping

ISWT. Inverse Stationary Wavelet Transform

LPM. Log-Polar Mapping

LoG. Laplacian of Gaussian

MSE. Mean Square Estimation Error

OFPD. Original Feature Points Dataset

PSNR. Peal Signal-to-Noise Ratio

QIM. Quantization Index Modulation

RAFD. Robust Audio Feature Detector

RST. Rotation, Scaling, Translation

SBFD. SIFT Based Feature Detector

SDG. Subject Difference Grade

SDMI. Secure Digital Music Initiative

SNR. Signal-to-Noise Ratio

SIFT. Scale Invariant Feature Transform

SSIM. Structural Similarity

SURF. Speed Up Robust Features

SUSAN. Smallest Univalue Segment Assimilating Nucleus

SWT. Stationary Wavelet Transform

TFPD. Trained Feature Points Dataset

TSM. Time Scale Modification