植基於頻率域特徵不變量之智慧型影像浮水印

Intelligent Image Watermarking Based on Invariant Features of Frequency Domain

研究生：王國俊　　　　　　　　　　　　　　　指導教授：蔡鴻旭 博士

摘要

本論文提出兩種基於頻率域特徵值的強韌型浮水印技術。第一種技術稱為 WIWROC (Wavelet-domain Image Watermarking based on Rank Order and Classification approach)，此方法利用 Rank-Order 的方式在小波頻域的三個子頻帶(subband)萃取出特徵值，利用這些特徵值可將區塊分為三種類型，再依據不同類型給予適合的浮水印嵌入方法。此外，本論文也以基因演算法(Genetic Algorithm, GA)來提升 WIWROC 的強韌性。本論文提出的第二種技術稱為 SVMLIWG (SVM-based Lossless Image Watermarking against Geometrical attack)，此方法可提升 WIWROC 的透明性(transparency)與強韌性(robustness)。在透明性方面，本方法提出一個非失真的影像浮水印方法(lossless-image-watermarking method)，此方法不需修改原圖就能藏入使用者簽章，在強韌性方面，本方法利用傅利葉轉換(Fourier Transform)與對數極座標(Log-Polar Mapping, LPM)找出幾何不變量，再將此不變量的特徵值與原浮水印做互斥或(XOR)運算產生私密鑰(Secret key)，為了在萃取浮水印時不使用原圖，本方法利用支持向量機(Support Vector Machine, SVM)來找出特徵值與私密鑰的對應關係，並利用粒子族群最佳化(Particle Swarm Optimization, PSO)來訓練支持向量機的參數。在萃取浮水印的過程中，首先利用訓練後的支持向量機估計出私密鑰，再將特徵值與私密鑰做互斥或運算即可萃取出浮水印。經由實驗結果得知，上述的方法都具備透明性，對於一般的影像攻擊也具備強韌性，而 SVMLIWG 除了能抵抗一般攻擊，在抵抗幾何攻擊的效果也

比過去學者提出的方法要好。

關鍵詞： 數位浮水印、離散小波轉換、快速傅利葉轉換、對數極座標、幾何攻擊、基因演算法、支持向量機、粒子族群最佳化

Intelligent Image Watermarking Based on Invariant Features of Frequency Domain

Student: Kuo-Chun Wang Advisor: Dr. Hung-Hsu Tsai

Abstract

The thesis presents two robust watermarking techniques based on invariant features of frequency domain. The first technique, called Wavelet-based Image Watermarking using Rank Order and Classification (WIWROC), explores the features, distances among rank orders of the wavelet coefficients in three subbands of a wavelet transformation image. These features are then utilized to develop a classification algorithm which can divide the wavelet blocks of the image into three categories. Subsequently, a Genetic Algorithm (GA) is applied to optimize the WIWROC technique so as to further enhance its performance. Next, the SVMLIWG (SVM-based Lossless Image Watermarking against Geometrical attack) technique is proposed to enhance both transparency and robustness of the WIWROC technique. The SVMLIWG technique enhances its transparency by performing a lossless-image-watermarking method which does not corrupt original images during embedding. Moreover, it creates geometrical invariants, based on Fourier-Transformation (FT) and Log-Polar-Mapping (LPM) domains, to generate an image-dependent watermark (signature), and then applies the XOR operation to an original watermark and an image-dependent watermark to produce a secret key which carries implicitly the original watermark. In order to extract the original watermark without the original image, the technique trains a Support Vector Machine (SVM) as a function mapping an image-dependent watermark to the secret key. That is, the trained SVM can memorize the relationships between an image-dependent watermark and the secret key. Meanwhile, a Particle Swarm Optimization (PSO) algorithm is also applied to improve the training performance of an SVM. During watermark extraction, the SVMLIWG technique first presents the trained SVM with an image-dependent watermark to calculate the estimated secret key, and then applies the XOR operation to an image-dependent watermark and the estimated secret key to produce the embedded watermark. Finally, numerous experiment results claim that the WIWROC and the SVMLIWG techniques are satisfyingly imperceptible and are considerably robust to withstand common- image-processing attacks, and they definitely outperform other existing methods.

Keywords: Digital watermarking, Discrete Wavelet Transform, Fast Fourier Transform, Log-Polar-Mapping, geometrical attack, Genetic Algorithm, Support Vector machine, Particle Swarm Optimization