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Digital Watermarking Techniques for Images: Survey

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INTRODUCTION

Digital watermarking is defined as the imperceptibly altering a work in order to embed information about that work. In the recent years copyright-protection of digital content became a serious problem due to rapid development in technology. Watermarking is one of the alternatives to copyright-protection problem. Digital watermarking can be classified as visible and invisible (Cox, Miller & Bloom, 2002). Invisible watermarks are more secure and robust than visible watermarks. The main characteristics (Cox et al., 2002) of Digital watermark are robustness, imperceptible and security. Depending on the ability of the watermark to withstand normal signal processing operations, digital watermarking can be categorized as robust, fragile and semi-fragile watermarking. *Robust* watermarks (Cox, Kilian, Leighton & Shamoon, 1997) are detectable even after some image processing operations has been performed on the watermarked image such as image scaling, bending, cropping, and so on. Robust watermarks are mainly used for copyright protection. *Fragile* watermarks (Wong, 1998) became invalid even if a slight modification is done to the watermarked image. Fragile watermarks are mainly used for authentication purpose. *Semi-fragile* watermarks allow some acceptable distortion to the watermarked image. Beyond this acceptance level if any modification is done to the watermarked image, the watermark will not be detected. Watermarking technique can be categorized as *blind, semi-blind* or *informed* (non-blind) (Katzenbeisser & Petitcolas (Ed.), 2000) on the basis of whether the original host image is required or not during the watermark detection.

Generally digital watermarking of images can be performed in two ways, one in spatial domain and the other in frequency domain. In the spatial domain (Bruyndonckx, Quisquater & Macq, 1995) the watermark is embedded into a host image by changing the gray levels of some pixels in the host image. On the contrary, in frequency domain (Huang, Shi & Shi, 2000) the host image is transformed into the frequency domain by using Discrete Cosine Transform (DCT), Discrete Fourier Transform (DFT) or Discrete Wavelet Transform (DWT). In addition to these methods there are several other methods to perform digital image watermarking (Cox et al., 2002), such as singular value decomposition (SVD) (Chang, Tsai & Lin, 2005), spread spectrum watermarking(Cox et al., 1997) and vector quantization (Wang, Pan,

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Jain & Huang, 2004; Huang, Wang & Pan, 2001) etc. There are different quality measures used for digital image watermarking. Out of these mostly used are peak signal to noise ratio (PSNR) and normalized correlation (NC) (Shih & Wu, 2005). There are so many quality measures used other than these two such as bit correct ratio (BCR), mean absolute error (MAE) etc. The applications (Cox et al., 2002) of digital watermarking include Proof of ownership, Ownership identification, Transaction tracking, Content authentication and Copy control etc.

In this paper the review is conducted on watermarking of digital images considering both the gray-scale and color images excluding other multimedia. The review is conducted based on three intelligent techniques and independent component analysis applied to digital image watermarking. The rest of the paper is organized as follows: Section 2 presents an overview of the intelligent techniques and independent component analysis. Section 3 reviews papers discusses the literature survey of various techniques. Section 4 discusses insights of the review and section 5 concludes the review with future directions.

REVIEW METHODLOGY

The review is conducted in two broad categories: (i) Independent component analysis and (ii) intelligent techniques. The intelligent techniques considered in the review (i) support vector machines (SVM), (ii) singular value decomposition (SVD) and (iii) Cryptographic Techniques. The most important aspect of the present review is the type of techniques applied to digital image watermarking. Further, the review is conducted based on the papers published in journals/international conferences/edited volumes in the areas of digital image watermarking and information hiding. All the unpublished works in terms of Ph. D. thesis, working papers and internal reports are excluded from the scope of the review.

BACKGROUND

This section presents the overview of five intelligent techniques applied to digital image watermarking. The techniques considered are independent component analysis, support vector machines, singular value decomposition and cryptography techniques. The following sub-sections present overview of each technique individually.

Independent Component Analysis (ICA)

Independent Component Analysis (ICA) (Hyvarinen, Karhunen & Oja, 2001) is a computational method for separating a multivariate signal into additive subcomponents supposing the mutual statistical independence of the non-Gaussian source signals. It is a special case of blind source separation. When the independence assumption is correct, blind ICA separation of a mixed signal gives very good results. The statistical method finds the independent components by maximizing the statistical independence of the estimated components. Typical algorithms for ICA use centering, whitening and dimensionality reduction as preprocessing steps in order to simplify and reduce the complexity of the problem for the actual iterative algorithm.

Support Vector Machines (SVM)

Support vector machine introduced by Vapnik (1998) is a method for creating functions from a set of labeled training data. The function can be either a classification function or a general regression function. SVMs map input vectors to a higher dimensional space where a maximal separating hyper plane is constructed. The distance from the separating hyper plane to the nearest data point is maximized by using SVM i.e. nearest distance between a point in one separated plane and a point in the other separated plane is maximized by using SVM (Vapnik, 1998). In this sense, SVM is also known as maximum margin classifier.