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Digital image watermarking based on angle quantization in discrete contourlet transform

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Abstract A robust and transparent watermarking scheme based on contourlet transform and quantization index modulation is proposed in this paper. In proposal algorithm, after taking contourlet, the coefficients are divided into three quadrants by using the symmetric property of the contourlet coefficients, then the angle coefficients are modulated for each of three points. The experimental results revealed that if the information of the image is utilized to determine the watermark and by using quantization index modulation properties, a higher robustness and more effective imperceptibility in proposed algorithm are achieved.

1. Introduction

In recent years, computer networks and digital systems have been widely developed yielding to the rapid growth of internet users and a massive demand for sharing and distributing multimedia data, especially images, sounds and films. As a large number of these data are subject to copyright law, protection of digital documents against illegal distribution is one of the issues which have allocated many researches (Nematollahi et al., 2015a,b,c).

Some recent researches show that watermarking is one of the most effective methods for protecting of digital multimedia (Nematollahi et al., 2015; Malakooti and et al., 2012). Although watermarking faces some major issues, many companies still offer copyright protection and broadcast monitoring based on watermarking (Sharma and Jaiswal, 2015). Firstly, the embedding of watermark information via watermarking algorithm is more complicated than setting this information in a header file. Secondly, addition of watermark may reduce the vocal or pictorial quality of the main signal.

In a watermarking system, some additional information known as watermark is added to the digital document in the form of noise signal, a different image or a binary sequence of data to be used for rightful ownership and protecting copyright (Nematollahi and Al-Haddad, 2013). The main assumption in watermarking is the additional information should not destroy the quality of the main signal or omit the simplicity from the main signal.

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Watermarking techniques are classified into two categories: embedding watermarks in the spatial domain or getting help from different transform domain techniques (Rani et al., 2015). On comparing with the transform domain, the spatial domain needs a shorter processing time and less hardware complexity. Least Significant Bit (LSB) is the simplest technique in the spatial domain which directly modifies the intensity of some selective pixels in an image (Bhatt and et al., 2015).

Transform domain methods are more robust than spatial domain algorithms because of providing the possibility to choose a transform with some desired properties and using it to optimize the embedding of the watermark (Chandran and Bhattacharyya, 2015). Furthermore, for an image, watermarking is atypical in the spatial domain due to its complexity for the resulted signal to be read and modified for aggressors (Chandran and Bhattacharyya, 2015).

In transform domain (or frequency) methods, the information is initially taken to transform domain. Then, the watermark information is embedded to the image via transform coefficients. Well-known transform domain methods are DFT (Cedillo-Hernandez et al., 2012), DCT (Gupta et al., 2015), DWT (Keshavarzian and Aghagolzadeh, 2015), CT (Mohan and Kumar, 2008; Akhaee et al., 2010), and SVD or a combination of them (Fan et al., 2014).

This paper demonstrates the watermarking scheme in the transform domain based on discrete contourlet transform (CT) and angle quantization index modulation (QIM). The main contribution of the paper is to develop a digital image watermarking system which not only provides enough robustness against geometrical and non-geometrical attacks, rather, it provides a good capacity and transparency. Capacity is referred to as carrying enough information to represent their unique identities and transparency is referred to as visual quality of the watermarked image which should not be disturbed by the embedded watermark.

The outline of this paper is as follows. Section 2 describes the background on discrete contourlet transform. In Section 3, the methodology of the proposed method is introduced. Experimental results and analysis are then given in Section 4.

2. Background

CT, as presented by Do and Vetterli (2005), captures the intrinsic geometrical structure that is the key in visual information. The nature of digital data is discrete and makes a challenge in exploring geometry in an image. Unlike the Curvelet method that initially develops a transform in the continuous domain and then discretizes it for sampled data (Channapragada et al., 2015), CT starts with a discrete domain construction and then seeks its convergence to an expansion in the continuous domain. CT generates a discrete domain with multi-resolution and multi-direction expansion by using some non-separable filter banks. It yields to flexible multi-resolution, localization, and directionality for image expansion using contour segments.

Wavelet transform is a multi-resolution transform and is applied in order to identify point discontinuity of an image derived from filter banks in the same way. If wavelet transform is combined to a directional filter bank, point discontinuities can be transformed to a linear structure. This combination is called as Pyramidal Directional Filter Bank (PDFB) and its expansion is CT method (Akhaee et al., 2010; Fan et al., 2014; Po and Do, 2006).

Fig. 1(a) illustrates a block diagram of CT as an iterated combination of the Laplacian pyramid and the directional filter bank. It has a valuable frequency decomposition and the spectrum is divided either radially and angularly. The obtained frequency division is shown in Fig. 1(b).

In CT, the number of directional bands can be determined by the user. As seen in Fig. 2, the main image is decomposed up to 5 levels, including 1, 2, 4, 8, and 16 under directional band, in which L is low frequency band of image and W, X, Y and Z are directional partial bands (Narasimhulu and Prasad, 2010).

3. Methodology

The combination of discrete CT and QIM in watermarking algorithms results in more robust algorithm against attacks

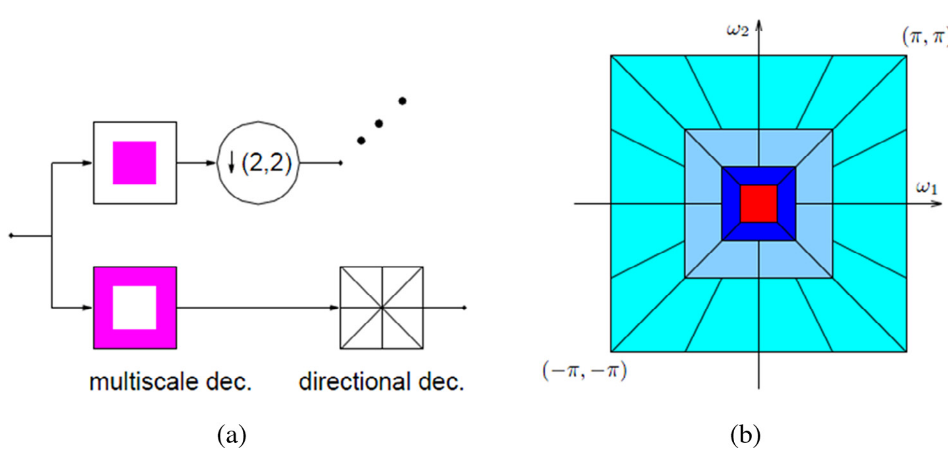

Figure 1 Pyramid directional filter bank of CT: (a) block diagram of PDFB, and (b) the style of obtained frequency division (Akhaee et al., 2010; Do and Vetterli, 2005; Do et al., 2003).