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Media pattern exhibition mechanism via mobile devices

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ABSTRACT

This paper describes a new methodology of pattern exhibition for digital media that can conceal an imperceptible but recognizable watermark on the media captured with mobile devices. From the human perception, the imperceptible watermark of marked media can preserve the fidelity and readability of the image's content. With the designed, window-based histogram operation, the embedded pattern of the marked media can be exhibited and recognized visually. That is, the designed mechanism can satisfy the essentials of both visible and invisible watermarking techniques to promote significant pattern sharing and identification for mobile applications. Simulations demonstrate that the peak signal-to-noise ratio (PSNR) of the marked image is superior (around 50–70 dB) to many of the existing watermarking algorithms. The process is of low computational complexity, efficient and can be applied in the real world via mobile devices via inner histogram operation.

1. Introduction

Mobile devices, such as smart phones, digital still cameras and video recorders, are commonly utilized to capture real-world scenes in recent decades. The captured digital media can be shared and conveyed through the Internet and storage instruments, which have also become common practices. The digital media, however, could be easily copied, tampered with and pirated while communicated [1–4]. To prohibit the unlawful manipulation of such media, digital watermarking refers to a set of techniques aimed at protecting the ownership and the integrity of digital multimedia [5–8].

Depending on the task for ownership protection, the watermarking technique can be classified as visible and invisible watermarking approaches [9,10]. Normally, the visible watermarking approach [11–15] superimposes a mark such as trademark and logo on media content. The watermark of the marked media is visible and recognizable. One can observe the visible pattern from the surface of the media through basic human visual perception. The mechanism provides a claim of media pattern immediately and prohibits an intruder from illegal use. Nevertheless, the visible watermark inevitably distorts the content and degrades the readability of digital media. Thus, the quality degradation reduces the commercial values and limits the applicability of a visible watermark technique in the real world.

On the contrary, an invisible watermarking approach [5,16–19] embeds a mark into the spatial domain or the frequency domain of media. From the surface of media, one is incapable of identifying the difference between the original media and the marked media. The invisible mechanism can preserve the quality and readability of marked media. To satisfy the essentials of robustness, quality and security, the invisible watermarking algorithm usually is one of computational complexity and needs additional instruments, as compared with the visible watermarking approach.

The visible and invisible watermarking approaches are designed for different applications according to their essentials [9,10]. Nevertheless, these developed methods pay more attention to conventional applications and are lacking in their application for mobile devices. In this article, we offer a novel solution to mitigate the unbalance of visible and invisible watermarking for low computational complexity devices. Based on the common operations of mobile devices, the new scheme utilizes the histogram operation to achieve the visible watermark's purpose. In addition, to avoid suffering from the annoying quality-degradation problem of the visible pattern from marked media, the scheme can superimpose the visible pattern into the media with imperceptibility. This mechanism can thereby enhance the readability and commercial values of the captured media.

To exhibit the visible pattern of media, the mobile devices can modulate the media characteristic by an inner histogram operation, while the visible watermark can be recognized by the human eye from the mobile devices and used to claim the property pattern of media. Hence, the new scheme can satisfy the advantages of both visible and invisible watermarking approaches. The exhibition procedure is efficient and of low computational complexity

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that can be applied to convey the pattern of the captured media via mobile devices in advance.

The rest of the article is organized as follows. Prior work on the topic is introduced in Section 2. The proposed imperceptible visible watermarking scheme using color distribution modulation is discussed in Section 3. Experimental results are shown in Section 4, while the simulation applications and performance comparisons are analyzed in Section 5. Finally, conclusions are made in Section 6.

2. Prior works and motivations

Huang et al. proposed a novel watermarking method, called unseen visible watermarking [20,21], to deliver auxiliary information via visual content. The method utilized gamma correction to hide information within a digital image. By performing the adequate gamma operation, the hidden information of the marked content will be disclosed and recognized by users. The major principle is to discover the unseen intensity values of the image that become visible after applying the gamma operation. The watermark bits are embedded into a selected region of the image by adjusting the intensity of the image's pixels.

Due to the fact that gamma correction could be provided by almost all display devices, this scheme eliminates the requirement of specific watermark extractors. The scheme is a novel approach to hide information covertly and then extract the information directly via human vision. Nevertheless, a shortcoming of the scheme is that the embedded region of an image must be dark and flat. The scheme cannot be applied to images lacking this dark and flat region.

In 2012, Hsieh and Lin [22] proposed a concept of imperceptible visible watermarking to diminish the visual distortion but preserve the advantages of the invisible watermarking approach. The scheme conceals a watermark into an image region by changing the pixel values of the region to a specific intensity value. To reveal the visible watermark of the marked image, the scheme needs to modulate the histogram interval laboriously until revealing the visible watermark. The weaknesses of the scheme are that the suitable intensity value is too varied to be determined and finding an optimal histogram interval is indefinite. This reduces the quality of the marked image and the ability to see the watermark pattern.

Though the schemes [20–22] offer the concept of novel watermarking procedures, the common predicament encountered is finding unseen/appeared intensity values. That is, these schemes are incapable of concealing the watermark into an image lacking the unseen/appeared intensity values after applying the gamma correction/histogram modulation operations.

Inspired by the novel concept of the schemes [20–22], this article focuses on designing an imperceptible but recognizable watermarking mechanism which satisfies the essentials and overcomes the potential threats of [20–22]. Besides, to increase the applicability and commercial values of the proposed mechanism for electronic computers and low-power mobile devices, the window-based inner histogram operation of devices is utilized to provide pattern exhibition capability for captured media.

3. The proposed mechanism

Considering the post-camera operations for processing the digital image in the computer devices and the mobile devices, histogram processing is commonly used to evaluate the hue distribution of an image. In observation, we exploit a new watermarking process, which can be applied not only in the computer devices but in the devices with inner histogram operation, such as the mobile devices, digital cameras, digital recorders and tablet computers. The detailed watermarking and exhibition procedures are described below.

3.1. The watermarking procedure

Let O be the captured color image and b be the to-be-embedded block of O with block size $M \times N$ pixels. Here, the block b could be determined by finding the largest smooth region with smallest variance in O.

For the color block b, assume that $b_R(i)$, $b_G(i)$ and $b_B(i)$ be the i-the red pixel, green value and blue pixel of corresponding red, green and blue planes, with each pixel value ∊ [0, 255]. The watermark W afterward can be concealed into the block b imperceptibly in terms of the algorithm.

3.2. Watermark concealed phase

(1) Compute the mean values m_R, m_G and m_B of the corresponding planes $b_R(i)$, $b_G(i)$ and $b_B(i)$,

$$m_R = \frac{1}{M \times N}\sum_{i=1}^{M\times N} b_R(i),\quad m_G = \frac{1}{M \times N}\sum_{i=1}^{M\times N} b_G(i),\quad m_B = \frac{1}{M \times N}\sum_{i=1}^{M\times N} b_B(i). \tag{1}$$

(2) Select the maximum mean value from the m_R, m_G and m_B as the value of m.

$$m = \max(m_R, m_G, m_B). \tag{2}$$

Let $b_P(i)$ be the plane with the maximum mean value m, P∊ {R, G, B}. For instance, if the mean values of m_R, m_G and m_B be 204, 186 and 100, respectively. The maximum value among these mean values is 204, and the plane with the maximum mean value 204 is $b_R(i)$.

(3) Consider the extreme case of watermark concealment. The value of m should be reduced in advance for preventing the overflow situation. The condition is defined as

$$m = m - 2, \quad \text{if } m \geqslant 254. \tag{3}$$

(4) Rescale the watermark W into size $M \times N$ as the same size of block b. The binary values of the watermark is represented as

$$W = \{w(i) | w(i) \in (0,1), \quad \text{and } i = 1, 2, \ldots, M \times N\}. \tag{4}$$

Here, $w(i) = 1$ indicates that the watermark bit is black; otherwise, the watermark bit is white.

(5) Superimpose $w(i)$ into the red, green and blue planes of $b_Q(i)$, Q ∊ {R, G, B} for $i = 1, 2, \ldots, M \times N$, according to the formula:

$$b_Q(i) = m, \quad \text{if} w(i) = 1 \quad \text{and} \quad b_Q(i) \geqslant m + 1. \tag{5}$$

3.3. Dilation operator phase

To highlight the visibility of the to-be-disclosed watermark pattern, the dilation operator phase is applied to the plane $b_P(i)$ (the plane with the m value) by the following steps.

(1) Create an $M \times N$ mask, called $mask(i)$, $i = 1, 2, \ldots, M \times N$. The value of $mask(i)$ is determined by sliding an $k \times k$ window from top to bottom and from left to right in $w(i)$. The value of $mask(i)$ is "1" if the i-th is the center of the sliding window and there exists any watermark bit with value "1" in the