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A copyright protection watermarking algorithm for remote sensing image based on binary image watermark

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ABSTRACT

As the internet keeping developing, copyright protection of the remote sensing image has become more and more important. This paper designs the algorithm that protects remote sensing image's copyright by using the binary digital watermark technology, and analyzes security and imperceptibility of the algorithm. As the experiment result shows, the algorithm put forward in this paper has better security, imperceptibility and anti-attack robustness, and thus it can meet the requirements in protecting copyright of the digital remote sensing image in an effective manner.

1. Introduction

As the computer network technology rapidly develops, it becomes increasingly common to see public data transmission channel, public information publication platform, shared data and easily copying of digital data [1]. All of these factors have helped improve quality of information service, but these also cause the potential data insecurity at the same time [2]. The rapid development of aviation and aerospace technology promotes remote sensing images gradually become the main source of space-based information for civilian services [3]. The problem of copyright ownership for the digital remote sensing images and data integrity has become one of the key technology problems in providing reliable spatial information service [4]. In addition, the digital watermarking technology, as an effective technology for copyright protection, has been studies and applied in the fields such as image, audio and video [5]. As a result, the digital watermarking technology of the remote sensing images is a good solution which can solve copyright protection problem of the remote sensing images.

The rest of the paper is organized as follows. In Section 2, we present a brief survey on the watermarking methods recently introduced in the remote sensing image. Section 3 describes the proposed scheme. Experimental results are reported in Section 4 and conclusions are drawn in Section 5.

2. Related work

At present, quite a number of scholars have devoted to studying how to apply the digital watermarking technology into copyright protection of the digital remote sensing images.

Serra-Ruiz et al. [6] propose a semi-fragile forensic watermarking scheme for remote sensing image. They propose to embed a mark into remote-sensing image applying a tree-structured vector quantization approach to the pixel signatures, instead of processing each band separately. The signature of the multi or hyperspectral image is used to embed the mark into it in order to detect any significant modification of the original image. The image is segmented into three-dimensional blocks and a tree-structured vector quantizer is built for each block. These trees are manipulated using an iterative algorithm until the resulting block satisfies a required criterion which establishes the embedded mark. The method is shown to be able to preserve the mark under lossy compression, but it detects possibly forged blocks and their position in the whole image.

Ren et al. [7] propose a semi-blind watermarking algorithm for high-resolution remote sensing image. The algorithm firstly analyzes the characteristics of high-resolution remote sensing images, then proposes the key matrix to save the matching result whether the highest significant bit value of image pixel value equal with the watermark value or not. In the watermark extraction stage, a key matrix is used to extract the spread spectrum watermark.

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After extracting the spread spectrum watermark information, the original watermark is employed as the template and in accordance with the template matching methodology is used to extract the region with the maximum correlation coefficient as the extracted watermark information.

Melgani et al. [8] propose to adapt a state-of-the-art spread spectrum method found to be particularly powerful for real world images to make the watermark insertion process near-lossless while preserving most of its effective robustness capability. This is done by embedding the watermark in the middle-frequency range of the discrete cosine transform (DCT) domain instead of the low-frequency range. The exact position is determined by a numerical root-finding method, targeted to achieve a user-specified minimum level of robustness against a given ensemble of attacks. In this way, an optimal trade-off can be obtained between quality and robustness.

Kumari and Rallabandi [9] propose a modified patchwork-based watermarking (MPW) scheme in the spatial domain. The proposed MPW algorithm is capable of embedding a watermark with minimal manipulation of the original image pixel values. The watermark contains information about the provider and the intended recipient of the data. The MPW watermark embedding process does not create any visual artifacts and is imperceptible. The watermark retrieval process operates with the help of a key and does not require the original image.

Jing et al. [10] propose a robust zero-watermarking method that constructs watermarks from the host data instead of embedding watermark into that data. The proposed method constructs two watermarks from host image. One is constructed from low-frequency coefficients in discrete wavelet transform domain of the host image, and the other is constructed from that of the log-polar mapping image of the host image.

In fact, digital remote sensing images are mostly binary images consisting of two strong contrast colors [11], however, the digital watermarking algorithm in the above-mentioned studies consider the characteristics of the binary image less. In this regard, this paper presents a new digital watermarking algorithm based on the binary image technology to protect the copyright of remote sensing image. The basic procedure of this algorithm is to divide the digital remote sensing image into different blocks, and then to embed the watermark signal into the image by modifying parity of the white pixel in the image block. By doing so, the watermark signal can be extracted by using parity of the white pixel in the image block.

3. Proposed scheme

Digital watermarking technology mainly refers to embed the watermark information into digital images covertly, and the watermark information is to prove as copyright basis. The basics of digital watermarking can refer to reference [12]. Before the watermark information is embedded, it is required to perform the scrambling encryption operation to the watermark information first, with the purpose of enhancing security of the embedded watermark. In this paper, the improved Arnold transformation is used for the scrambling encryption.

3.1. Watermark embedding algorithm

The watermark embedding procedure is a procedure which embeds the digital watermark information into host image (this article refers to the remote sensing image) by using certain rules and methods. Before describing the watermark embedding procedure, we should define several variables first:

I: means original host image, i.e. digital remote sensing image; its size is $I_l \times I_w$;

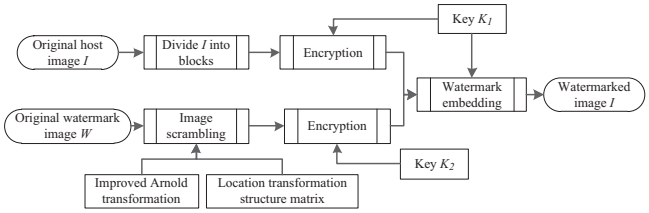

Fig. 1. Watermark embedding process.

W: means watermark information, i.e. copyright identification image or pseudo random code, it is the $W_l \times W_w$ binary image in this paper;

a, b, c, d, $chaos\_n$: means parameters of image scrambling. In this paper, a, b, c, d means parameters of the improved Arnold transformation and $chaos\_n$ means the scrambling times;

clm: means the location transformation structure matrix which records the location transformation caused by improved Arnold transformation of the watermark image;

K_1: means the key matrix to encrypt host image, it is a random binary matrix.

K_2: means the key matrix to encrypt watermark image, it is a random {0, 1} binary matrix;

After the definition, this paper designs the watermark embedding algorithm of the digital remote sensing image by using binary feature of the image, as shown in Fig. 1:

The watermark embedding procedure is described as below:

Step 1: Read the host image I (the digital remote sensing image) and the watermark image W (the copyright identification image) respectively.

Step 2: Enter a, b, c, d and $chaos\_n$ to scramble the watermark image W, and save the location transformation structure matrix clm.

Step 3: Divide I into non-overlapping image blocks with size of $W_l \times W_w$, and then record it as $I_{i,j}(1 \le i \le I_l/W_l, 1 \le j \le I_w/W_w)$.

Step 4: Encrypt the image blocks $I_{i,j}$ via K_1:

$$I_{ij} = I_{ij} \oplus K_1 \tag{1}$$

Step 5: Encrypt the scrambled watermark W via K_2:

$$W = W \oplus K_2 \tag{2}$$

Step 6: Calculate sum($I_{i,j}$) of $I_{i,j}$ (image block) and then apply the sum($I_{i,j}$) to do $sum(I_{i,j})$mod 2 operator. If the $W(i, j)$ is equal to the sum($I_{i,j}$), do not make any change; otherwise, select any pixel in $I_{i,\,j}$ and apply the formula to get the inverse value;

Step 7: Decrypt $I_{i,j}$ via K_1;

Step 8: Repeat steps 4 and 7 until all image blocks are embedded successfully.

3.2. Watermark extraction algorithm

The watermark extraction refers to the procedure that extracts the watermark in the digital remote sensing image to be checked, the watermark extraction algorithm is the reverse procedure of the watermark embedding algorithm. The embedded watermark information is an identity image, so the copyright of the remote sensing image can be determined visually through the watermark image is extracted. The paper designs the watermark extraction procedure by combining with the detection model as shown in Fig. 2.

The steps of the watermark extraction algorithm are described as below: