XOR Based LSB Watermarking for Information Protection in Land Consolidation Project

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Abstract: - Land consolidation plays an important role in enlarging farming plots and enhancing crop productivity. And remote sensing imagery can provide the spatial data/maps and offer great advantages for the fulfillment of a land consolidation project. This paper presents a LSB watermarking algorithm to embed the land reorganization planning map into a remote sensing image of the same area for information security and copyright protection. The land reorganization planning map is compressively encoded before embedded into the protected remote sensing image. The contradiction between large information quantity and invisibility of digital water marking is perfectly eliminated. To avoid the shortcoming of being easily attacked in the original LSB method, the host image is preprocessed by exclusive-OR (XOR) operation. That is, the value of the least signification bit is decided by the XOR result of the first seven bits. The watermark signal is embedded into the LSB of the processed host image by XOR operation. The experimental results fully illustrate that the embedded watermark is not only imperceptible to the human eyes, but also has better security in the statistical sense.

Key-Words: - land consolidation, watermarking, least significant bit (LSB), exclusive-OR (XOR) operation, remote sensing imagery

1 Introduction

The availability of suitable farm land is one of the most critical challenges facing the agriculture. Land consolidation is a long-term practice to enlarge farming plots and to enhance crop productivity [1,2].

Land consolidation refers to a serial of activities, which deal with improving of productivity and working conditions in rural areas, production of reconstruction plans for rural settlement, and proving of rural life. With the growing concern about land resource management and the associated decline in land quality in many countries, land consolidation has become one of the most attractive worldwide research topics. And the requirement for land consolidation also becomes higher[3-5]. The land consolidation pays attention not only to the quantity but also to the quality and zoology protection.

The fulfillment of each land consolidation phase more or less depends on supplement of spatial data. There are a variety of manners to collect spatial data. Remote sensing is a fast and easy spatial data collection manner for a land consolidation project. The use of remote sensing high resolution images will be extremely feasible in the land projects[6]. By using satellite images, land consolidation can be completed in half of the time that classical techniques require and the project can cost 35 times cheaper than that the classical techniques cost [7].

However, the data security studies in the land consolidation projects mainly focused on database security design. And there is little attention to the security of remote sensing imagery used in land consolidation. Though Kumari and Rallabandi[8] applied digital watermarking to remote sensing image, the study mainly discussed the application of common watermark techniques in remote sensing images. They did not take the characteristic of the land consolidation into account. So if the image content is tampered, the remote sensing image cannot provide strong evidence of land consolidation effect, and will have a negative impact on land consolidation decision-making.

To resolve the problem, this paper presents a LSB watermarking algorithm to embed the land reorganization planning map in a remote sensing
The LSB modification is one of the earliest data-embedding methods and the simplest way to achieve image hiding[9, 10]. In this conventional method, the payload message is inserted into the LSB of each pixel value. If additional information capacity needs to be embedded, two or more LSBs of each sample byte can be overwritten. The extraction of the information is accomplished in the reverse way, i.e., by reading the bits in the same scanning order to reconstruct the payload data. In this well-known LSB method, the distortion can be considered unnoticeable in the sense of the human vision, because the pixel values are shifted by only one level of 255 color levels. But the LSB algorithm could be easily attacked by the counterfeiting attack, especially from the point of statistical property. When a uniformly random sequence is scattered in the LSB plane, its random nature can lead to its detection. Furthermore, when the same information is inserted to a series of host images, the payload information can be detected and thus the watermark can be removed from the images or be forged.

To overcome the shortcoming of the traditional LSB embedding algorithm, this paper makes use of the XOR operation to remedy the statistical problem. In this developed method, the LSB signal is preprocessed by the XOR operation, and then the watermark data are inserted by bit’s XOR of watermark sequence and LSB sequence. So the embedded data depend substantially on the original data and the watermark is invisible. In the similar way, we extract the watermark using XOR operation.

The remainder of this paper is organized as follows. Section 2 describes the algorithm of developed LSB watermarking algorithm. In Section 3, we perform some comparisons with traditional method to verify the performance of the proposed scheme and report the experimental results. Finally, Section 4 concludes this paper.

2 Problem Formulation
The traditional LSB scheme outlined in the previous section can be directly used for data embedding with lower perceptibility. However, the embedded information can be detected using its statistical property, especially if the watermark has unique statistical character. This shortcoming can be remedied by encrypting the LSB signal when inserting the payload information. Our method accomplishes the encrypting by XOR operation. Fig. 1 shows a block diagram of the proposed algorithm.

The detail methodology and principles are listed below.

![Fig. 1 Watermark Embedding and Extracting algorithm](image)

**2.1 Watermark image compression encoding**
Land reorganization planning map contains the land use plan information and has high correlation with remote sensing image of the same area in land consolidation. So it is suitable to be embedded as watermark. Usually, land reorganization planning map is of the similar dimension of the remote sensing image, so it is necessary to encode the planning map compressively.

To preserve all the information in the planning map, we develop a lossless compression algorithm. In the image of planning map, there are only several kinds of color as shown in Fig. 2. In fact, it is not necessary to use three Bytes to describe a pixel as the BMP image format. According to our observation, there are no more than ten kinds of colors in the usual planning map images. Using the concept of indexed color, we define sixteen numerals (0-15) to describe the colors. Thus, one pixel can be described by only four bits and one byte can contains two pixels, that is, the higher four bits and lower four bits describe two different pixels. In addition, we use 48 (16*3) bytes to describe the indexed color. Finally, the compressed data obtains an indexed image and sixteen color levels.

![Fig. 2 A sample of land reorganization planning map](image)

Using this scheme, the volume of planning map can be reduced largely while keeping information lossless. For example, the volume of one 128*128 RGB image is 49152 (128*128*3) bytes in the BMP
format and the volume is 8240 (128*128*0.5+16*3) bytes after our preprocessing. The smaller size makes it easy to embed the planning map into remote sensing images.

2.2 Pre-processing for LSB
The purpose of the pre-processing for LSB is to scramble the statistical character of the information.

When a grayscale image such as panchromatic image is considered as the host image, the least significant bits (LSBs) of the remote sensing image pixels are firstly calculated. Assuming the host data can be expressed as a sequence of bits \( X = \{x_i, i = 0,1,2,3,\ldots, 7\} \), the pre-processing for every byte data is to produce the LSB value based on the first seven bits:

\[
x_0 = x_1 \oplus x_2 \oplus \cdots \oplus x_7
\]

where \( \oplus \) denotes exclusive-OR (XOR) operator.

The XOR based LSB method also can apply to color images directly. If the host is a multi-spectral image with three bands: red, green, and blue bands, LSBs would be obtained for R, G, and B, three channels respectively.

2.3 Watermark embedding
Now we’ll embed the watermark bit stream into the least significant bits of the corresponding embedded pixel.

After the index compression encoding of the watermark image is finished, the watermark information can be considered as binary data stream. And the LSB sequence of host image can be obtained based on Eqn. 1. To assure the accuracy detection of watermark, the watermark data include three parts: the size of the planning map, indexed image and color level information. Assuming the LSB sequence can be represented using matrix-vector notation \( X_0 = \{x_{0n}, n = 0,1,2,3,\cdots\} \) and the watermark data sequence is expressed as \( S = \{s_n, n = 0,1,2,3,\cdots\} \), the watermarked sequence will be obtained by combining the LSB sequence and the watermark sequence with exclusive-OR (XOR) operator:

\[
y_n = x_{0n} \oplus s_n
\]

where \( Y = \{y_n, n = 0,1,2,3,\cdots\} \) is the watermarked sequence.

Then let \( Y \) substitute the LSB of the host data, and the watermarked image is obtained as shown in Fig. 3.

For a multi-channel remote sensing image pixel, eg., a multi-spectral image pixel with RGB three bands, three watermark bits can be embedded. And for a each gray remote sensing image pixel, only one secret bit can be embedded. Usually, a remote image with lower spectral resolution will have higher spatial resolution. So it is not difficult to embed the planning map into the multi-spectral image or the panchromatic image.

![Fig.3. LSB data embedding](image)

The watermark inserted in this way is not nakedly exposed to the detector as in the traditional LSB embedding methods. Because the XOR operation makes the statistical property of the LSB data in the watermarked data not the same as the watermark information and stochastic, the watermark is now not so easy to detect.

2.4 Watermark Extracting
In the proposed watermark detection scheme, planning map is determined without the original image.

See Fig. 1, the extraction of the watermark can be accomplished in the inverse way of the embedding operation. Firstly, the watermarked sequence \( Y \) can be gotten by scanning the LSB data of the watermarked image in the same order as the embedding process. Then the watermark data will be obtained by the following step:

\[
s_n = x_{0n} \oplus y_n
\]

where \( x_{0n} \) can be gotten in the same way as shown in section 2.2, i.e., it can be computed as follows:

\[
x_{0n} = x_{1n} \oplus x_{2n} \oplus \cdots \oplus x_{7n}
\]

Evidently, if one doesn’t know the embedding algorithm, the watermark does not been modified or forged by simple method of testing or statistical analyzing.
3. Experimental Results

The simulation results are presented to show the performance of the developed LSB embedding algorithm in this section. The experiments are carried out from two main points of view: (i) watermark invisibility in the sense of human sense, (ii) watermark imperceptibility in the sense of statistical property.

In our experiments, we employed 2 remote sensing images, shown in Fig. 4, to be the host images. The host images are a multi-spectral image with the size of 465×750 and a panchromatic image with the size of 1744×3270. And the watermark image shown in Fig. 2, is a 726×355 planning map of almost the same area as the host images. The experiments were implemented on a personal computer with 512M RAM and a 1.60 GHz processor.

3.1 Watermark Invisibility

The corresponding watermarked images are given in Fig. 5. It can be seen that the watermarks are intuitively invisible to human eyes for both RGB image and gray image.

The perceptibility performance is quantified in terms of the peak signal to noise ratio (PSNR) given by:

$$PSNR = 20 \log_{10} \frac{255}{RMSE}$$

(5)

where RMSE means root mean-squared error of the pixel magnitudes. Let the original un-watermarked host image of M by N pixels be $x(i, j)$ and the watermarked counterpart be $X(i, j)$, then RMSE will be:

$$RMSE = \sqrt{\sum \sum (x(i, j) - X(i, j))^2 / MN}$$

(6)

The PSNR for Fig. 5a and Fig. 5b are respectively 33.06dB and 55.05dB, respectively. The PSNR values are all higher than 30 dB, which means that the watermarked image is identical to the original image under normal observation.
3.2 Statistical imperceptibility

The prominent advantage of the developed LSB algorithm is its statistical imperceptibility. Especially, when the same information is embedded to different images, this character makes a statistical analysis produce no advantage for the watermark detection and removal from the attacking point of view. To test the statistical property, we implement a comparison between traditional LSB method and our developed XOR-based LSB method with four different images shown in Fig. 7. The embedded watermark image used is the same one shown in Fig. 6. The LSB values of the watermarked images are extracted and are used to produce the histogram. Fig. 8 gives the histogram results of the images processed by the traditional LSB method and Fig. 9 is the results of the images processed by the XOR-based LSB method.

Fig. 6 Watermark image with the size of 100 x86

Fig. 7 Four original images with the size of 400x400
From Fig. 8, it can be seen that the LSBs of different images watermarked with same watermark image have the identical histogram. But if the watermark is inserted via XOR operation according to our method, the histograms of different watermarked images differ from each other as shown in Fig. 9. It demonstrates that the developed LSB algorithm tussles the statistical character of the watermarked images and makes the watermark resistant to attacks.

4. Conclusion
To protect the data security, especially in the land consolidation projects, this paper presents a LSB watermarking algorithm to embed the land reorganization planning map into a remote sensing image. In our scheme, the land reorganization planning map is compressively encoded before embedded into the protected remote sensing image. Then, the host image is preprocessed by exclusive-OR (XOR) operation to avoid the shortcoming of being easily attacked in the original LSB method. The experimental results fully demonstrate that the embedded watermark is imperceptible to the human eyes and is more secure in the statistical sense.

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