A Near-lossless Digital Watermarking Algorithm of DEM Based on DCT

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Abstract—**A near-lossless, adaptive watermarking algorithm based on DCT is presented to protect DEM from theft and illegal reproduction. Due to the high accuracy of the DEM, the focus of this paper is put on ensuring that the watermarked DEM should meet the precision requirement which also means the watermarked DEM should be near-lossless. The contribution of this work is that not only the DEM precision, but also the precision of slope and aspect are considered. In order to improve the robustness, the watermark should be embedded in the terrain lines. The preliminary results show that the error both of the aspect and the slope are very small and the watermarked DEM meets the medium error and maximum error proposed in the national DEM precision criterion. The watermarking can resist the compression and cropping attack.**

INTRODUCTION

With the development of earth information technology, high accuracy DEM plays role in construction of National Spatial Data Infrastructure more and more important. Due to the rapid development of digitization and network, the storage, transmission and replication of DEM data are very convenient, and security and copyright issues of DEM have become increasingly salient. For copyright protection of DEM, digital watermarking can provide an effective solution. Since proposed in 1994, digital watermarking technology has developed rapidly. N.Nikolaidis and I.Pitas [1] proposed a robust image watermarking algorithm using pixel modifications, which can resistant to JPEG compression and lowpass filtering. M.Barni and F. Bartolini [2] first proposed "nearly lossless" digital watermarking, and applied it to the copyright protection in remote sensing data. Santi P. Maity and Malay K. Kundu [3] used human visual system (HVS) and the spread transform to improve the ability of watermark against the various unintentional and deliberate attacks. Later M.Kutter etc. [4] introduced the concept of second generation watermarking schemes. The idea of this concept is that watermark should be embedded in salient parts of the original data to enhance the robustness. A new watermarking algorithm for the digital raster map based on integer wavelets transformation was proposed by Changqing Zhu etc. [5]. This algorithm is robust against various vicious attacks such as JPEG compression, sharpening and cutting. Chengsong Yang and Changqing Zhu [6] presented a watermarking algorithm for vector geo-spatial data based on Invariant Function. This method could resist attacks such as compressing, adding, deleting, clipping, translating, rotating, scaling and complex attacks composited of above. Mi He etc. [7] put forward a DEM watermark algorithm by modifying the generalized histogram of the DEM to achieve the goal of blind lossless.

Generally, DEM digital watermarking technique has particular requirements. Firstly the embedded watermark should be invisible, as the reason that DEM data is used for terrain visualization. Moreover, watermarked DEM should be near-lossless and meets precision standard because of DEM's important quantitative analysis function. In addition, the watermarking algorithm is required to be robust. Since the conversion of DEM data spatial reference system is essentially realized by translation, rotation and scaling of the data, DEM digital watermarking should be resistant to translation, rotation and scaling [8].

METHODS

This paper proposed a DCT digital watermarking algorithm. That is near-lossless in precision and support of watermark embedding adaptively. As two basis terrain parameters, slope and aspect are important for digital terrain analyst. Therefore, the near-lossless demand of slope and aspect are taken into consideration in this paper.

The proposed algorithm first uses Hash algorithm and MD5 function to scramble the binary watermark picture with copyright information with three passwords. Then the DEM is divided into 8×8 pixels blocks and transformed by DCT, and the scrambled watermark picture is embedded into each DEM block. Before embedded the watermark, the watermark embedding position needs to be determined. Terrain lines delineate topography relief, therefore, the digital watermark is imposed on DEM's terrain lines in this experiment to enhance the robustness of the watermark [9]. Because different terrain lines of DEM data have different positions, the terrain-line-based digital watermarking algorithm can automatically adapt the position of embedded watermark. Moreover, the watermark is embedded into the medium-frequency area of DEM to better protect the copyright of DEM, the algorithm should ensure that the strength of embedded watermark is strong enough with the constraints that the watermark is invisible and near-lossless in DEM precision. In this paper, invisibility of embedded watermark is realized by Watson visual model. The watermark is embedded in DEM using the additive rule

$$\tilde{I}_w = \tilde{I} + \alpha W, \quad (1)$$

Where $\tilde{I}$ denotes the original DEM data, $\tilde{I}_w$ denotes the DEM with watermark embedded, W represents the watermark signal and α represents watermark embedding strength [10].

To determine the watermark embedding strength, slope and aspect are extracted and medium error are calculated from the DEM firstly. Secondly, the watermark embedding strength are calculated according to the DEM maximum error, the DEM, slope and aspect medium error. Then the watermarked DEM is generated using IDCT (Inverse Discrete Cosine Transform).

RESULTS

Results show that the watermarked DEM meets the medium error and maximum error proposed in the national DEM precision criterion. Moreover, by area frequency statistics analyst, the error of the slope and aspect of watermarked DEM are very small. This shows that the algorithm can satisfy the near-lossless requirement of slope and aspect. In addition, watermark can be extracted after compression and cropping attacks to the DEM.

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