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A Novel Digital Watermarking Algorithm Based on Wavelet Lifting Scheme and Linear Regression

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Abstract

A novel digital watermarking algorithm is proposed in this paper, which is based on Linear Regression Constrains and Wavelet Lifting Scheme. Firstly we define a fixed matrix Q and use matrix Q MOD (Modulus after Division) the low-frequency data. The data is extracted from the 1-level wavelet decomposition of each sub-image. According to the remainder matrix, we can embed and extract watermark. The simulation results show that watermarked image can obtain a large value of PSNR and demonstrate that the algorithm has strong robustness to resist noise and clipping attacks, it also can greatly reduce carrier image distortion.

Keywords:digital watermark;linear regression ;lifting wavelet transform ; information hiding

1. Introduction

Digital watermarking is proposed recently as a copyright protection technology. According to the characteristic of the redundant data and randomness of digital works, it embeds the copyright information into the digital works, helping to protect the copyright of digital works. Digital watermarking can identify and verify the information of author, owner, publisher or authorized consumer which is extracted from the digital images, videos and audio recordings, it also can trace the illegal distribution of digital works. At present, it is a more effective measure to protect digital works.

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Watermarking technology is divided into spatial domain and transform domain [1] currently. Space domain algorithm [2-4] is very simple. By using this algorithm, large amount of information can be hided and the speed of watermark information embedding and extraction is very fast. LSB (Least Significant Bit) is a classical algorithm in the Space domain, but the robustness of the algorithm and the ability of resist attack are very poor. However, transform domain [5-6] has a strong robustness to against the watermark attack, but the algorithm is very complex and the amount of calculation is very large. In this article, we introduce a new digital watermarking algorithm, which is based on linear regression and wavelet lifting Scheme.

2. Knowledge Description

2.1. Linear regression model

We often find that there is a certain relationship between the variables x and y, which is called correlation in statistics. As a kind of statistics conception, regression is used to study the correlation. Regression model is always established by the Least squares and we can use it to calculate the min value of the error square sum. Defining the formula as follow:

$$E_{\min}=\sum_{i=1}^{n}\left[y^{S}-y^{G}\right]^{2} \tag{1}$$

In this formula, y^{s} is experimental value and y^{G} is obtained from the model which is established by the special variable x .This article uses linear model and it is defined as follow:

$$y=ax+b \tag{2}$$

By the formula (2), we can get the next two Least squares linear equations.

$$\sum y_i=a\sum x_i+nb \tag{3}$$

$$\sum x_i y_i=a\sum x_i^2+b\sum x_i \tag{4}$$

The values of a and b can be calculated by formula (3) and (4).

$$a=\frac{n\sum x_i y_i-\left(\sum x_i\right)\left(\sum y_i\right)}{n\sum x_i^2-\left(\sum x_i\right)^2} \tag{5}$$

$$b=\frac{\left(\sum y_i\right)\left(\sum x_i^2\right)-\left(\sum x_i\right)\left(\sum x_i y_i\right)}{n\sum x_i^2-\left(\sum x_i\right)^2} \tag{6}$$

Because $\bar{x}=\frac{\sum x_i}{n}$ and $\bar{y}=\frac{\sum y_i}{n}$, when we put $\bar{x}$ and $\bar{y}$ into the formula (5) and a new simple formula (7) can be achieved.

$$a=\frac{\sum\left(x_i-\bar{x}\right)\left(y_i-\bar{y}\right)}{\sum\left(x_i-\bar{x}\right)^2} \tag{7}$$

At last, we make the value of slope a as our constrain condition.

2.2. Arnold scrambling technology

We use two-dimensional Cat-Map algorithm to do the chaos scrambling for watermark image. Then the two-dimensional Cat-Map can be defined as follow:

$$\begin{bmatrix}x_{n+1}\\ y_{n+1}\end{bmatrix}=\begin{pmatrix}a_{11} & a_{12}\\ a_{21} & a_{22}\end{pmatrix}\begin{bmatrix}x_n\\ y_n\end{bmatrix}=A\begin{bmatrix}x_n\\ y_n\end{bmatrix}\bmod F \tag{8}$$