Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 29 (2012) 285 – 289

Procedia Engineering

www.elsevier.com/locate/procedia

2012 International Workshop on Information and Electronics Engineering (IWIEE 2012)

A Blind Digital Watermark Method Based on SVD and Chaos

Jianhua Song[a*], Jianwei Song[b], Yuhua Bao[b]

[a]*School of Electronic Engineering, Heilongjiang University, Harbin,150080, China*
[b]*Department of Electrical and Mechanical Engineering, Qiqihar Institute of Engineering, Qiqihar,161005, China*

Abstract

A blind digital watermark method based on singular value decomposition (SVD) and Chaos was proposed in this paper. Firstly the watermark was encrypted by Tent chaotic sequence, and then the cover image is decomposed by SVD, the encrypted watermark is embedded into the singular values of the cover image, and the watermark can be extracted without the original image. The experimental results indicate that the proposed method is robust against attacking such as JPEG compression, addition of noise, cropping, rotation and contrast adjustment.

Keywords: digital watermark, SVD, Chaos ;

1. Introduction

The digital multimedia grows rapidly and achieves extensive success with the fast development of internet and multimedia technology. Because the digital products are easy to copy, modify and embezzle, how to protect copyright of digital products has become a great challenge. Digital watermarking technology, as an effective approach to copyright protection, has attracted much attention in recent years.

The SVD matrix of an image has good stability. When a small perturbation is added to an image, large variation of its singular value does not occur [1,2]. Using this property of the SVD matrix of an image, the watermark can be embedded to this matrix without large variation in the obtained image. A digital image watermarking algorithm using DWT and singular value decomposition was proposed in reference [3], the watermark is not embedded directly on the wavelet coefficients but rather than on the elements of singular

* Corresponding author. Tel.: +86-013766869791
E-mail address: 98dg_sjh@163.com.

1877-7058 © 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
doi:10.1016/j.proeng.2011.12.708

values of the cover image's DWT sub-bands. Reference [4] suggested a grayscale watermark algorithm based on SVD, the pixel value of watermark is embedded into the blocks of largest singular value by the quantization. Based on the methods above, a novel blind digital watermark method based on SVD and chaos was presented in this paper.

2. Tent Chaotic Map and Its Binarization

2.1. Tent Mapping

Tent mapping is a one-dimensional discrete chaotic system, the equation is

$$x_{n+1} = \begin{cases} \dfrac{x_n}{a}, & 0 < x_n < a \\ \dfrac{1-x_n}{1-a}, & a \le x_n \le 1 \end{cases} . \quad (1)$$

When the control parameter $a \in (0,1)$, formula (1) works in the chaotic state, compared with the Logistic mapping, Tent mapping has faster iteration speed and better convergence property[5], and variable density of Tent mapping is stable than Logistic mapping[6]. Take the initial value x_0=0.32, control parameter a=0.43, chaotic sequence is shown in Fig. 1(a).

2.2. Chaotic Sequence Binarization

According to the existing method of binary, chaotic sequence values can be compared with the median value or mean value, and corresponding discretized into 0 or 1[7], but the pseudo-randomness of these two methods is not good, in this paper, a generation method of binary chaotic sequence that has better pseudo-randomness is adopted. Let the binary chaotic sequence be y_k (k=0,1,…,N), the real value Tent chaotic sequence is x_k, the specific formation process is as follows:

Step1: if $x_N \ge x_{N-1}$, then y_0= 1; elseif $x_N < x_{N-1}$, then y_0= 0.
Step2: if $x_0 \ge x_N$, then y_1= 1; elseif $x_0 < x_N$, then y_1= 0.
Step3: for k =2, 3, 4, …, N
  if $x_{k-1} \ge x_{n-2}$, then y_k = 1; else if $x_{k-1} < x_{k-2}$ then y_k= 0.

3. Singular Value Decomposition (SVD)

From the perspective of linear algebra, a digital image can be viewed as a matrix composed of a number of non-negative scalars, singular value decomposition (SVD) belongs to an orthogonal transformation, it can make the image matrix diagonalization. Let $A \in R^{m\times n}$ denote an image matrix, two orthogonal matrixes: U=[u_1, u_2, u_3, ⋯,u_m]$\in R^{m\times m}$ and V=[v_1, v_2, v_3,⋯, v_n]$\in R^{n\times n}$, there exist a factorization of the form

$$A=USV^T, \quad (2)$$

where $S \in R^{m\times n}$ is a matrix of all elements are zero except for its diagonal elements, and the diagonal elements are

$$\lambda_1 \geqslant \lambda_2 \geqslant \lambda_3 \geqslant \cdots \geqslant \lambda_r > \lambda_{r+1} = \cdots = \lambda_m = 0, \quad (3)$$

where r is rank of A, λ_i (i=1, 2, ⋯, r) is uniquely determined by the SVD and called the singular values of