Watermarking Spatial Data based on Cloud Modal

Liu Bin[1], Wang Shuliang [2], Li Deyi[3]

[1] The Compute School, Wuhan University, Wuhan, China, 430072
hurricane_liubin@yahoo.com
[2] International Software School, Wuhan University, Wuhan, China, 430072
hnyuanslwang@yahoo.com
[3] Beijing Institute of Electronic System Engineering, Beijing 100039, China
ziqin@public2.bta.net.cn

Abstract. We analyze the feasibility of watermarking spatial data to deter their piracy. This paper presents a new watermarking algorithm for copyright protection of spatial data. This algorithm ensures that "marks" can be hidden in some least significance bits of spatial attributes of some of the spatial objects. In order to enhance watermark robust the watermark is transformed into many cloud drops generated by forward extending cloud modal in the insertion algorithm，And in the detection algorithm the cloud drops are reverted to watermark by backward extending cloud modal generator. The proposed watermarking algorithm performs the blind watermarking by extracting the watermark without an original spatial data. Finally, through experiments, this paper shows the proposed method is robust enough against attacks such as the elimination of values.

1 Introduction

The piracy of digital assets such as software, images, video, audio and text has long been a concern for owners of these assets. Protection of these assets is usually based upon the insertion of digital watermarks into the data. The watermarking software introduces small errors into the object being watermarked. These intentional errors are called marks and all the marks together constitute the watermark. The marks must not have a significant impact on the usefulness of the data and they should be placed in such a way that a malicious user cannot destroy them without making the data less useful. Thus, watermarking does not prevent copying, but it deters illegal copying by providing a means for establishing the original ownership of a redistributed copy [1][2][3].

Spatial data of various kinds have become quite popular in the last few years. They are used, for example, in GPS navigation systems, geographical information systems (GIS), and in web-based map services. As a digital data, Spatial data are easy to update, duplicate, and distribute. They are also prone to forgery, illegal duplication and illegal distribution. Digital watermarking is a possible approach to counter such abuses. Digital watermark adds structure called watermark to the target data object imperceptibly and inseparably. The information encoded in the watermark can be used to identify the copyright owner or to detect tampering[3][4].

Our Contributions is to use the tolerance range of the coordinates to embed the watermark. In order to enhance the marks robustness Extending Cloud Model is used in the insertion process where each mark of watermark is represented by extending cloud drops. The rest of the paper is organized as follows. Section 2 and section 3 specify the concepts of Cloud Modal and Extending Cloud Modal. Section 4 gives our algorithms for inserting and detecting watermarks. Section 5 provides implementation details and an experimental evaluation. We conclude with a summary and directions for future work in Section 6.

2 Extending Cloud Model

The cloud model (Li et al, 1995) is a model of the uncertainty transition between a linguistic term of a qualitative concept and its numerical representation. In short, it is the model of the uncertainty transition between qualitative concept and quantitative description. The cloud model has three digital characteristics, Expected value (Ex), Entropy (En) and Hyper-Entropy (He) [5].

The extending cloud model (Li et al, 2003) extends the expected value to expected matrix, such as an image. The cloud model has three digital characteristics, Expected Matrix (Ex), Entropy (En) and Hyper-Entropy (He).

The drops generated by Extending Cloud generators is called extending drops.

3 Extending Cloud Generators

The input of the forward normal extending cloud generator is three digital characteristics of a linguistic term, (EMatrix, En, He), and the number of cloud-drops to be generated, N, while the output is the quantitative positions of N extending cloud drops and the subjection matrixes of each drop. The algorithm in details is:

AlgorithmName: ForwardECGenerator

```
|Matrix|=L //the total numbers of elements in matrix
Drops[N][L]=0,Subjection[N][L]=0;
for i=0 to N do
  //produce a normally number Eni' with En and He
  Eni'=NORM(En, He);
  for j=0 to L do
    // Produce a normal number xi with EMtrix[j] and Eni'
    xi=NORM(EMtrix[j], Eni');
    yi = e^(-(xi-Ex)^2 / 2(En'i)^2) ;     // Calculate subjection
    Drops[i][j]=xi,Subjection[i][j]=yi;
  end;
end.
```

Simultaneously, the input of the backward normal extending cloud generator is the quantitative positions of N extending cloud drops(Mi, Si) (i=1,…,N), while the output is the three digital characteristics, EMatrix, En, He. The algorithm in details is:

AlgorithmName: BackwardECGenerator

```
|Matrix|=L, En1[L]=en2[L]=En=0,He1[L]=He=0
for j=0 to L do
  //Calculate the mean value of EMatrix[i]
  EMatrix[i]=MEAN(Drops[i][j])  j=1,…,N;
  //Calculate the standard deviation of EMatrix[i]
  En1[i]=STDEV(Drops[i][j])  j=1,…,N;
    for j=0 to N do
    en2[j]=√(-(Drops[i][j]-EMatrix[i])^2 / 2ln(Subjection[i][j])) ;
    He1[i]=STDEV(en2)
    End;
End;
En = MEAN(En1);
He = MEAN(He1);
```

From above ,if a drop can be seen as a mark, all drops can be regarded as watermark.

4 Algorithm

With LSB() we denote the function which yield the *s*-least significant decimal digit positions of a value, e.g. for the spatial data x=1834, 5671[3][4].

LSB(12834, 5671)=0.5671

With MSB() we denote the function which yield the *s*- significant decimal digital positions of a value, e.g. for the spatial data x=1834, 5671.

MSB(12834, 5671)=12834

The parameters used in insertion and detection algorithm is listed.

Table 1.

parameters	meaning
η	the total tuples in spatial data database
ω	the number of repetitions of matrix inserted into in spatial data database
X,Y	the x, y coordinate of a spatial object
L	he total numbers of elements in matrix: |Matrix|=L
ɣ	Fraction of tuples marked

Watermark Insertion

```
ExtendCloud(A)=(EMatrix, En, He)
Drops[ω][L],Subjection[ω][L]=
          ForwardECGenerator (index, EMatrix, En, He);
index[L]=0;
foreach t ∈ Spatial Database do
  Pk=MSB(X) o MSB(Y);
  if(Hash(Pk)==0)
    idx=Hash(Pk,L);
    xi= Drops[idx][index[idx]],);
    yi= Subjection[idx][index[idx]];
    index[idx]++;
    [X]LSB=xi,[Y]LSB=yi;
  end
end
```

Watermark Detection

```
Drops[ω][L]=0,Subjection[ω][L]=0,index[L]=0;
foreach t ∈ Spatial Database do
  Pk=MSB(X) o MSB(Y)
  if(Hash(Pk)==0)
    idx=Hash(Pk,L)
    xi=LSB(X),yi=LSB(Y);
    Drops[idx][index[idx]]=xi
    Subjection[idx][index[idx]]=yi
    index[idx]++;
  end
end
watermark=BackwardECGenerator(Drops, Subjection)
```

5…Experiments and Analysis

We next provide some implementation notes and experimental results obtained using a simulation spatial data set containing 10000 tuples.

We ran experiments on JDataStore Version 7 using JBuilder 9 on a Windows 2000 professional with a 550MHz Intel processor, 256MB of memory, and a 15 GB disk drive.

Firstly, we use a source cloud modal SC as a watermark to insert into the spatial data. We define the cloud modal detected as SC and define the similarity between BC and DC, and the similarity between Ex of SC and Ex of DC.

$$\Delta A=[ExSC -3EnSC,ExSC+3EnSC] \quad (1)$$

$$\Delta B=[ExDC-3EnDC, ExDC+3EnDC] \quad (2)$$

$$SimCM(SC,DC)=(\Delta A \cap \Delta B)/(\Delta A \cup \Delta B) \quad (3)$$

$$SimEX(SC,DC)=\min(ExSC, ExDC)/\max(ExSC, ExDC) \quad (4)$$

Assuming SC=(0.2,0.005,0.005).The figure 1 show the result.

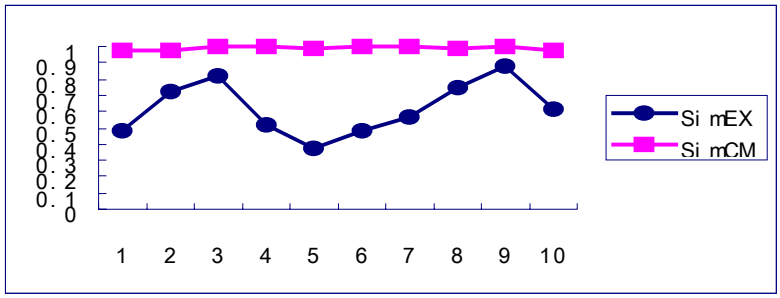

Fig. 1. The X-axis varies the percentage of spatial data marked. The percentage of Spatial data marked 1‰, 2‰, and 10‰ correspond to the values of 10, 20, 30, and 100 respectively.

We can make a conclusion from figure 1 that the variation of Ex is very small while the variation of cloud is big sometimes.

Secondly, the expected matrix is a gray image with size of 16×16,and ω=10. The figure 2 show the result. We can see the detected watermark are very clear.

Fig. 2. The left image is the source image. The six images of right are the detected images(The number of. experiments is six).

Watermarks may be attacked by all kinds of attack. Here we list the following attack: one bit round attack, one bit cut attack, two bit round attack, two bit cut attack. For example:

one_round(0.567)=0.57 one_cut(0.567)=0.57

two_round(0.567)=0.6 two_cut(0.567)=0.5

The figure 3 show the detected images after being attacked.

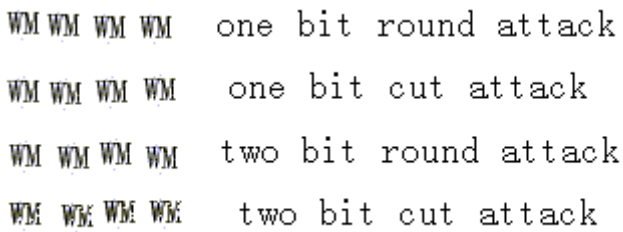

Fig. 3. The left image is the source image. The four images of right are the detected images(The number of. experiments is four).

The large marks loss is against two bit cut attack, but we also see the watermark. We can make a conclusion that this watermark algorithm is robustly against some attack.

6…Conclusion, Feature Research

We have shown that a modified correlation method is suitable for embedding and retrieving watermarks in spatial data using the tolerance range of the data[3][4].

The following are the major contributions of this paper:

Identification of the rights management of spatial data through watermarking as an important and technically challenging problem for spatial data research.

Proposal of a watermarking technique specifically geared for spatial data, based on cloud theory.

Extensive analysis the robustness of marks against some attack.

Attacks greater than the tolerance on single data can cause overflows which make worse the detection procedure. We will investigate how many of this attacks the method can handle. Another kind of attack is the removing or adding of data. We will analyze if it is still possible to detect the watermark after such an attack.[3][4]

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