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Watermarking Application System for Map Content Distribution

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ABSTRACT

Many people use digital maps in their car navigation systems or on the Web. On the other hand, the distribution service providers are still concerned about illegal copying, which may damage their businesses. Digital watermark technology that can embed identifier into digital content is expected to help with this problem. While copyright protection using digital watermark for multimedia content has received much attention, however, watermark applications for digital maps have not been discussed sufficiently. The effective usage of digital watermarks is analyzed in the context of an assumed map content distribution model. The technical requirements are also clarified for copyright claims, user tracking and resource management. Application systems using digital watermark technology are proposed for both vector maps and raster maps. As a watermark for a vector map, new information can be appended to already embedded information. The watermark then survives through the daily operation of a GIS system. Our implementation and evaluation shows that the proposed system satisfies the requirements.

INTRODUCTION

Digital maps have recently come to play an important role in user interfaces for information discovery on the web. Many information services provide practical data such as maps, regional news, weather forecasts, hotel reservations and ticketing for PC and mobile terminal users[1][2][3].

Although digital maps form the basis of these services, they include another aspect of digital content. Many commercial geographic information system (GIS) applications provide a function for distributing a subset of GIS data on the Web. Standardization of the interoperability among heterogeneous GISs has been discussed [4]. In the near future, digital map content is expected to be used more conveniently in the ubiquitous computing environment.

The negative aspect of network technology, however, including the capability of making illegal copies is increasing. Content distributors thus concerned about copyright protection.

Digital watermark technology embedding identification information into map content is expected to provide a countermeasure. There are proven technologies for copyright protection such as encryption and authentication [7]. Many of the problems in content distribution can be solved by applying these established technologies. Copyright protection using digital watermark for multimedia content has received much attention [8] [9][10]. Watermark applications for digital maps, however, have not been discussed sufficiently.

In this paper, the related works in map content distribution are described in Chapter 2. The technical requirements for digital watermarks are discussed in Chapter 3. Finally, our implementation and evaluation of digital watermark application system for digital maps are described in Chapter 4.

RELATED WORKS

Security Technologies in Map Content Distribution

A significant challenge in map content distribution is the establishment of interoperability among a variety of contents providers. Traditional GISs are currently used to manage data in their original forms, leading to many data formats and coordinate systems. In theory, a standard data format and a single coordinate system might work well, however, connectivity among GISs could also be accomplished by assuming the spatial coherency of heterogeneous data. Actual data is not in so proper style.

International standardization for geodata is discussed in ISO/TC211 ISO19118. The Open GIS Consortium (OGC) has proceeded with standardizing interoperable interfaces for commercial GISs [4]. G-XML is recommended in Japan as an industrial regulation for the data exchange format (JIS X7199). W3C recommended using Scalable Vector Graphics (SVG) 1.0 for vector graphics on the Web and SVG1.1 for increased flexibility with mobile devices [5][6]. Although the need for the countermeasure against illegal copying or illegal accessing may described in their abstract, the implementation has not been discussed yet.

On the other hand, from the security point of view, content traceability frameworks are discussed for content distribution [11][12]. Content ID Forum (cIDf □ has developed the basis of content identification management for digital content distribution by applying content ID [11]. They have developed a framework for issuing globally unique ID number for each art works, binding it to the content, and resolving whether suspect content has been illegally copied. An inspection system of content distribution on the Web and the usage of digital watermarks for illegal copy detection are also specified, however, map content is outside their scope.

Digital Watermark for Map Content

Digital watermarking can be used to embed identifiers, such as copyright information, and copy control information, in digital content, to prevent illegal copying [9]. Digital watermarks will therefore be mainly used by content holders and in content distribution systems. Watermarks representing copyright information (e.g. the author's identity) are embedded into digital content by changing the content data so slightly that the appearance of the marked content is the same as the original appearance. The copyright information embedded in the marked content can be detected by looking for changes in the content.

The digital maps are categorized into two essential types, the vector type and the raster type. Digital watermarking methods for raster images have been developed and have proven their robustness against the various data conversions processes by piracy [10][18]. Commercial products from several venders exist and can be applied for watermarking raster type map content. On the other hand, digital watermarking for vector type map content is still in the R&D phase.

Compared with other multimedia content, it is easier to change a vector map so that its marked appearance looks the same as the original appearance. On the other hand, an marked feature object can easily be replaced by another object and the feature topology is also easily changed.

Commercial GIS systems store vectors in their databases. A watermark can be applied to any database relation having attributes which are such that changes in a few of their values do not affect the applications [13].

However, vectors are usually subject to various types of transformations, such as translation, rotation, scaling or more general affine transformations. In addition, clipping, overlaying, or morphing may be casually done with drawing tools. Watermarks should survive through these transformations. Achieving such robustness requires embedding the identifier in the transformation-invariant parameters of the vector map.

Previous works are proposed on watermarking for 3D polygonal meshes [14][15] and for vector digital maps [16][17][18]. Identifiers can be expressed by placing changes added to the feature objects, coordinates or topologies. Consequently these methods slightly change feature where watermarks are least perceptible and robust. For instance, information of a bit can be embedded by displacing a group of vertices contained in a rectangle [17]. Previous studies of robust watermarking are resilient in some measure against content modification by insertion and deletion of vertices, by similarity transformation, by scrambling of order of geometric primitives in a data file, and, to some extent, or by cropping [16].

Watermarking for vector maps is a significantly different problem than that for other types of multimedia objects such as sounds and movies. Therefore, previous application frameworks for multimedia content are not enough for vector maps.

However, watermarking application systems for vector maps have not been discussed sufficiently as compared with basic algorithms. Although watermark application developers should consider the limitation of the current algorithms mentioned above, it has not been clarified how watermarks work in actual map content distribution.

TECHNICAL REQUIREMENT FOR WATERMARK

Characteristics of Digital Map Content

Watermarking maps is essentially different from watermarking other types of multimedia content in the following way.

(1) **Redaction.** A digital map distributor provides map service by adding certain values to the original map data. For instance, the values may consist of overlaying location information on the original data, or modifying the data into a simple route guide. Therefore, data redaction is a daily task for distributors. In contrast, other types of multimedia data are basically not edited by distributors, but rather are distributed as they are.
(2) **File format.** Various file formats for the map data is used in many legacy GIS systems or in the databases, although the standardization is being discussed. In contrast, there are established standards for movie and audio files.
(3) **Freshness.** Map data is easily corrupted by changes in the real world, although historical values may appear in small portions of old maps. In particular, the values of metropolitan maps are more quickly corrupted than that of country maps. In contrast, there are many long-selling titles among movies and music. Once the content protection is infringed, the business impact will continue over the long term. Therefore the required security level for map content does not exceed that of other types of media from the viewpoint of the protection period.

Distribution Model

Content distribution consists of the three stages of production, distribution and consumption. The corresponding stakeholders of the business are the provider, the distributor and the consumer. In many business models, vector maps are used in communication from the content provider to the distributor, while raster maps are used between the distributor and the consumer.

Watermarking can be applied to (a) claim copyright, (b) track users and (c) manage resources. See table 1. Firstly, by embedding the copyright owner's ID into map content, the owner can insist that suspect data is originally hers or his when an illegal copy is found. Secondly, by embedding users' IDs into map content, the owner can trace those who make illegal copies. Finally, embedding a content ID into map content supports resource management. In any cases, watermarks can be embedded by the provider or the distributor.

The embedded identifier can be detected with a software tool by the content owner, meaning either the provider or the distributor. In copyright claims or tracking users, an agent system may check the Web.

Technical Requirement

According to the characteristics of digital map content described above, a watermark application system for map content distribution should consider the following three points.

(1) Watermarks should survive data editing with GIS tools. Distributors use GIS applications that provide various functions including overlaying, selecting layers, clipping, rotation, zooming in and out, selecting features, and so on. Watermarks are expected to survive such data processing in commercial GISs. In addition, watermarking must not suspend their daily editing tasks.
(2) Watermarks should survive format conversion because various file formats exist.
(3) Security costs should be considered in balance with the effects of illegal copies. Because content ages, illegal copies cannot last long when updated content is distributed. From the viewpoint of the running costs, watermark detection should be performed by the embedded content itself. Detection by comparison with original data is not preferable because the management cost of the original data is high when it is updated frequently.

WATERMARK APPLICATION SYSTEM

Watermarks for Vector Maps

Endo et al. reported that a watermark can be represented by modifying feature, such as appending vertices without definite algorithms [19]. Based on this approach, we developed the watermarking system that can embed identifier information into vector map content. In dividing a line segment into a set of short line segments, the proportion of interior division can provide a certain information capacity. In addition, encrypting the identifier information prevents the threat of counterfeiting or interpolation. See Figure 1.

We have developed a watermarking method for vector maps based on the Vector Markup Language (VML) format. VML data can be shown in

Table 1. Purpose of Watermarking

Purpose	Watermarked identifier
Copyright claims	Owner's ID
Tracking users	User's ID
Resource management	Content ID

Figure 1. Watermarking Vector Map Content

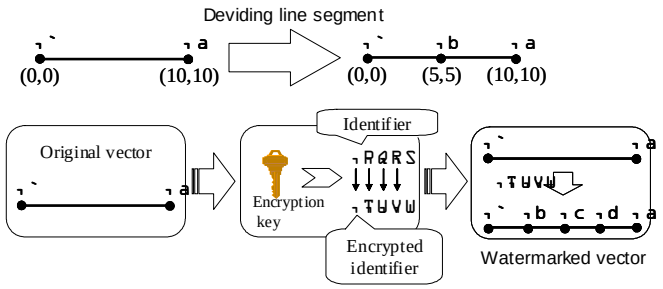


Figure 2. Watermarking for Raster Map Content (left is original, right is watermarked. Geographical Survey Institute Digital Map 2500(Spatial Data Framework))

a Web browser without any plug-in, enabling us to use a common Web system development environment. In addition, the technology can be extended to other XML-based technologies such as GML.

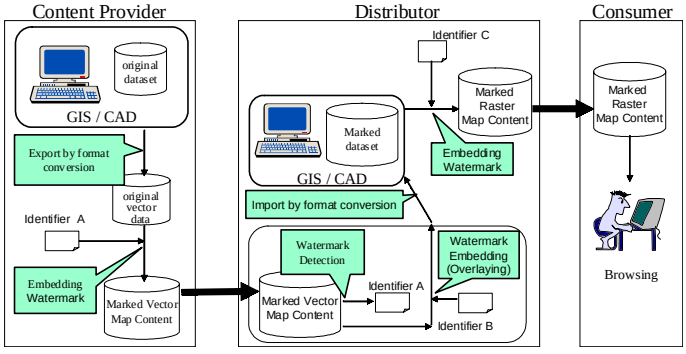
We also propose a novel function for appending new information to already embedded information. As a result, a distributor's ID can be embedded in content in which that the provider's ID has already been embedded. Both IDs are then detectable after distribution. User can then embed information further, up to the limitation defined in the program.

Watermarks for Raster Maps

We have already developed a watermarking technology for raster maps.

In the case of a map consisting of binary images, such as a printed monochrome papers, watermarks are expressed by reversing bits from 0 to 1 or vice versa. This is hard to hide it from the human visual system, as reversing bits at random degrades the image quality. Our system thus finds the location where a watermark will be least perceptible [20]. The resulting watermarks can survive serial photocopying by commodity-level scanners, printers, and copy machines, even though analog smoothing processes occur in at least the cases of printers and scanners [12][21].

Figure 3. Map Content Distribution System Using Watermarking



Map Content Distribution

We propose an application system for map content distribution using digital watermarking that satisfies the technical requirement described above. The system is implemented as a combination of watermarking functions and GIS subsystems. The content-flow in the system is shown in Figure 3 and described as follows.

(1) A content provider extracts a vector map in DXF format from their GIS system A.
(2) The content provider converts the map into VML format.
(3) The content provider embeds ID information into the map content in VML format.
(4) The content provider sends the watermarked content to a distributor.
(5) The distributor receives it after authenticating the marked content by extracting the embedded ID information.
(6) The distributor converts the authenticated content from VML format into DXF format.
(7) The distributor imports the DXF map content into their GIS system B.
(8) The distributor adds their values to the map data, and makes new vector map data for consumers in GIS system B.
(9) When a consumer requests a map, the distributor converts the requested subset of the vector data into a raster data file such as a JPEG file.
(10) The distributor embeds the ID information into the raster map and distributes it to the consumer.

Evaluation

We next evaluate the application system described above from the viewpoints of user operation and workflow.

Firstly, we examine the robustness of the watermarks.

Their survivability is verified by following tests. Watermarks perfectly survive a file format conversion test from DXF to VML and vice versa. Overlaying, rotation and zooming up are theoretically safe operations for watermarks, because marked line segments remain through the operations.

On the other hand, in the cases of zooming down, selecting layers and clipping off, marked line segments may disappear, and the watermarks may consequently along go with them. Such operations, however, also degrade content quality because major roads or landmarks will disappear at the same time. Therefore, such degraded content is worth little for user tracking or copyright claiming purposes.

Multiple topology operations on marked vectors, as in the case of optimizing of data expression, may also destroy watermarks. There is no such function, however, in common GIS products. A distributor would not perform such operation in their daily work without intention, so watermarks will survive well enough in this distribution model.

Secondly, consumed resources in this system are evaluated.

The file size for a vector map data is increased by embedding identifiers in the map with the proposed method. We assume that the IDs of content provider and distributor are each expressed with 64 bits, or 8 bytes. When 16 bytes of the two IDs are embedded in the file, the file size increases by about 1.1 KB.

For instance, a simple map of an intersection in a city may consist of 200 vectors. This map data would be about 24 KB in VML format. Therefore, the watermarked file would be 4 % bigger than the original file. The file size used in the assumed content distribution model is small enough that the effect on system performance, such as network traffic or disk access, can be regarded as negligible.

CONCLUSION

We have analyzed a map content distribution system using digital watermark technology for copyright claims, user tracking and resource management. The technical requirements are clarified as follows. Watermarks should survive daily operation in commercial GIS products. And watermarks should not disturb user's daily works such as editing content.

Digital watermark technologies for vector maps and for raster maps are developed. We also implemented and evaluated an application system based on these technologies. The watermarks for vector maps can identify multiple points along the distribution path, thus supporting copyright claims, user tracking and resource management.

Our future works include solving the following technical problems. From a practical standpoint, the simple distribution model described in this paper should be extended to actual business cases, and the technical requirement should be clarified. For instance, vector map content may be directly distributed to consumers. More severe situation should be considered. For instance, some distributor may try to delete watermarks form map content. The robustness of the watermarks should thus be improved in a manner that will not interfere user's daily work.

REFERENCES

[1] Oliver Guenther, From GISystems to GIServices : Spatial Computing on the Internet Marketplace, *Proc. of INTEROP'97,* Santa Barbara, pp.78-80, 1997

[2] Hiroshi Tsuji, Takaaki Yamada, Maki Tamano, Tsuneo Sobue and Shuji Kitazawa, Environment for Spatial Information Sharing , *Proc. of the 2nd Int'l Workshop on Digital City*, 1999

[3] Wiederhold, G., Mediators in the Architecture of Future Information Systems, *The IEEE Computer Magazine*, March 1992 38-49

[4] The OpenGIS Guide - Part I of the Open Geodata Interoperability Specification(OGIS), Open GIS Consortium, 1996

[5] "Scalable Vector Graphics (SVG) 1.1 Specification", W3C Recommendation 14 January 2003

[6] "Vector Markup Language(VML) ", W3C NOTE- VML-19980513, 13-May-1998

[7] Bill Rosenblatt, Bill Trippe and Stephen Mooney : "Digital Rights Management, Business and Technology", M & T Books, 2001

[8] Neil F. Johnson, Zoran Duric, Sushil Jajodia : Information Hiding: Steganography and Watermarking - Attacks and Countermeasures", Kluwer Academic Publishers, 2001

[9] Ingemar J.Cox, Matthew L.Miller, Jerey A.Bloom : "DIGITAL WATERMARKING", Morgan Kaufmann Publishers, 2002

[10] W. Bender, D. Gruhl and N. Morimoto, "Techniques for Data Hiding," IBM Syst. J., Vol. 35, 1996.

[11] Content ID Forum : "cIDf Specification 2.0", http://www.cidf.org/ , 2004

[12] Takaaki Yamada, Yasuhiro Fujii, Isao Echizen, Kouichi Tanimoto and Satoru Tezuka : "Print Traceability Systems Framework using Digital Watermarks for Binary Images", In proc. of IEEE Int'l conf. on Systems, Man & Cybernetics, Oct 10-13, 2004 The Hague, The Netherlands(To appear)

[13] Rakesh Agrawal, Jerry Kiernan : " Watermarking Relational Databases", In Proc. of the 28th Int'l conf. on Very Large Databases(VLDB) Hong Kong, China, August 2002

[14] M. G. Wagner: "Robust Watermarking of Polygonal Meshes", Proc. Geometric Modeling & Processing 2000, pp. 201-208, Hong Kong, April 10-12, 2000.

[15] Ryutarou Ohbuchi and Hiroshi Masuda: "Managing CAD Data as a Multimedia Data Type Using Digital Watermarking", IFIP WG 5.2, in proc. of the 4th Int'l Workshop on Knowledge Intensive CAD (KIC-4), pp. 113-125, Parma, Italy, May. 22-24, 2000.

[16] Ryutarou Ohbuchi, Hiroo Ueda, Shuh Endoh : " Watermarking 2D Vector Maps in the Mesh-Spectral Domain", Int'l Conf. on Shape Modelling and Applications 2003 (SMI 2003), Seoul, Korea, pp. 216-225, May, 2003.

[17] Ryutarou Ohbuchi, Hiro Ueda, Shu Endoh : "Robust Watermarking of Vector Digital Maps", in Proc. IEEE Conference on Multimedia and Expo 2002 (ICME 2002), Lausanne, Swistzerland, August 26-29, 2002.

[18] Sanjeev Khanna, Francis Zane : "Watermarking Maps: Hiding Information in Structured Data", Proc. of the 11th ACM-SIAM symposium on Discrete algorithms, San Francisco, pp.596 - 605, 2000

[19] Shuh Endoh, Hiroshi Masuda, Ryutarou Ohbuchi, Satoshi Kanai : "Development of Digital Watermarking Technology for Vector Digital Maps", IPA Technology Expo 2001 Reports, 2001 (Japanese)

[20] Yasuhiro Fujii, Kazunori Nakano, Isao Echizen, Hiroshi Yoshiura and Satoru Tezuka : " A Method of Maintaining the Image Quality of Digital Watermarking for Binary Images Using Local Measures", IPSJ Journal, Vol.44 No.8 pp.1872-1885, Augst 2003(in Japanese)

[21] The Japan Corporate News Network, "Hitachi Develops Improved Digital Watermark Technology", http://www.japancorp.net/Article.Asp?Art_ID=5736, Oct. 6 2003