

Watermarking Spatial Trajectory Database

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Abstract. Protection of digital assets from piracy has received increasing interests where sensitive, valuable data need to be released. This paper addresses the problem of watermarking spatial trajectory database. The formal definition of the problem is given and the potential attacks are analyzed. Then a novel watermarking method is proposed, which embed the watermark information by introducing a small error to the trajectory shape rather than certain data values. Experimental results justify the usefulness of the proposed method, and give some empirical conclusions on the parameter settings.

Keywords: Digital watermarks, spatial trajectory, database security.

1 Introduction

Recent advances in geographic data collection techniques have increased the production and collection of spatial trajectories of moving objects [1][2][3][4]. Generally, trajectory is a sequence of consecutive locations of a moving object in multidimensional (generally two or three dimensional) space [3]. Real world examples could be found in global positioning systems (GPS), remote sensors, mobile phones, vehicle navigation systems, animal mobility trackers, and wireless Internet clients. Recently, protection of such digital assets from piracy has become a crucial problem in both research and industrial fields, especially where sensitive, valuable data need to be released.

Digital watermarking is a promising technique to solve the issue of copyright protection. Unlike encryption techniques[5], watermarking approaches do not prevent copy or further use of the data, rather it deters illegal copying by providing a means of establishing the original owners an authorship-aware copy. This technique is based on an important assumption that database can be updated in some data items, which are such that changes in a few values do not affect the usability of the data. Accordingly, watermarking is to embed into the data a group of indelible, small errors (termed *watermark information* or simply *watermarks*) that (1) exhibit certain patterns representing the ownership of the digital assets, and (2) preserve the usability of the data [6][7][8]. For example, image data can be watermarked by introducing minor noises, which served as the watermark information, into the high frequency in transformed domain [9]. Since such modifications have little impact on the visual quality of the image

from the viewpoint of human's sensitivity, the modifications are acceptable with respect to the potential use of the image. Once an illegal copy occurs, the owner of the data could therefore extract the noises that represent the watermarks from the image to verify his ownership of the data.

Due to its importance, there have been several efforts to develop effective and efficient watermarking methods for various types of data, such as multimedia data [8][9][10], software[11][12][13], relational data [14][15], and parametric curves and surfaces [16]. However, to the best of our knowledge, watermarking technique for protecting the spatial trajectories remains unexplored.

Researches on watermarking techniques are highly data-oriented, that is, they are closely related to the type and potential usage of the data. Therefore, given data objects with different characters, the respective watermarking strategies are usually of fundamental differences. Consider the trajectory data, some distinctive characters should be addressed. First, multimedia data, e.g. image, audio and video, contain large portion of redundant information, on which the modification is insensible for human being. However, consider the trajectory data in real applications, the redundancy is relatively rare. Then modifications of same "scale" on trajectory data will lead to more distinct usability decrease than that on multimedia data. Another aspect of spatial trajectory data that challenge the watermarking process is that trajectory is usually accessed as a whole data object, and the meaning of it consists in the sharp of movements, rather than any individual location value. Therefore, spatial transforms do not decrease the usability of trajectories, e.g. zoom it to another scale, or shift it to another position. Since all the data values might be completely regenerated during the spatial transform process, the watermarks that dependent on certain bits of data values are apt to be completely erased.

These particular features of trajectory data disables the application of vast previous approaches that consider precise values in a database, such as the primary key based methods for watermarking relational data [14], and the transform based methods for watermarking multimedia data [9]. A more similar effort is on watermarking vector digital maps [17]. However, the watermarks in this work is extracted by comparing the original data with the watermarked data, which is often a extremely difficult task in watermarking trajectories because the original data themselves are often hard to be validated without a proper escrow that rarely appears.

Therefore, developing a new method for watermarking trajectory data is by no means trivial. In this paper, we propose a novel watermarking method for spatial trajectory database. The main idea of our method is to embed the watermark information by introducing a small error to the shape presented by the trajectory data. Since the shape should be preserved within any migration versions and piracy versions (otherwise the data become useless), the watermarking information is also preserved within these versions.

The rest of this paper is organized as follows: Section 2 describes the problem and gives some remarks on the requirements and potential attacks. Section 3 describes our watermarking method. Section 4 presents the experimental results and some discussions. Finally, section 5 offers some concluding remarks.