Reversible Fragile Watermarking for Locating Tampered Polylines/Polygons in 2D Vector Maps

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ABSTRACT

For 2D vector maps, obtaining high tamper localization accuracy without requiring extra space is a technically challenging problem. Using an adaptive group division approach and an improved reversible data hiding approach, the author proposes a reversible fragile watermarking method for locating tampered Polylines/Polygons in 2D vector maps. In particular, the author adaptively divide the features of the vector map into groups according to a predefined threshold, calculate an authentication watermark for each group, embed the watermark using the improved reversible data hiding approach, and hide the mark of each feature into the feature itself. Since the adaptive group division method and the improved reversible data hiding method are combined in an attempt to make full use of the watermark embedding space, superior tamper localization accuracy and original content recovery can be ensured. Besides, no extra space is required by hiding the mark of each feature. Experimental results have been provided to demonstrate the effectiveness of our method.

KEYWORDS

2D Vector Map, Authentication, Fragile Watermarking, Reversible Data Hiding, Tamper Localization

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INTRODUCTION

With the development of digital-content design and processing techniques, transferring and accessing 2D vector maps via internet become more and more popular. These highly accurate geo-spatial data are of great value (Lee & Kwon, 2013; López, 2002; Niu, Shao, & Wang, 2006; Peng, Yue, Wu, & Peng, 2014). However, thanks to powerful available tools and equipment, it is very easy even for an amateur to illegally modify these data and create “perfect” forgeries. Tools that help us verify the integrity and authenticity of the 2D vector map content are thus essential.

2D vector map integrity and authenticity can be guaranteed through the use of fragile watermarking techniques (Ren, Wang, & Zhu, 2014; Shao, Wang, & Xu, 2005; Wang & Men, 2012; Wang & Men, 2013; Yue, Peng, & Peng, 2014; Zheng, Li, Feng, & Liu, 2010; Zheng & You, 2009). In most cases of fragile watermarking, the original content are modified, and hence distorted in an irreversible way in order to embed the authentication data. The original data suffer some permanent destruction. However, due to the required high-precision nature of 2D vector maps, it is critical to reverse the embedded content back to the original version after authentication. To avoid permanent distortion, reversible (also referred to as invertible, lossless, or distortion-free) fragile watermarking, which allow the decoder to recover the original content upon authentication and locate malicious attacks have been proposed.

Currently, research on 2D vector map watermarking schemes is mainly focused on robust watermarking algorithms (Doncel, Nikolaïdis, & Pitas, 2007; Lafaye, Bégué, Gross-Amblard, & Ruas, 2012; Lee & Kwon, 2013; López, 2002; Niu, Shao, & Wang, 2006; Ohbuchi, Ueda, & Endoh, 2002; Peng, Yue, Wu, & Peng, 2014; Wang, Peng, Peng, Yu, Wang, & Zhao, 2012) for copyright protection or reversible watermarking methods (Cao, Men, & Gao, 2013; Cao, Men, & Ji, 2013; Voigt, Yang, & Busch, 2004; Wang, Shao, Xu, & Niu, 2007; Wang, Zhang, & Men, 2014; Zhou, Hu, & Zeng, 2009) for content recovery. Few works have been done on fragile watermarking schemes for authentication. Ren et al. (2014) proposed a semi-fragile watermarking method that tolerates compression, noise addition and vertex deletion operations. A drawback of this method is that it may be not able to locate deleted Polylines. By embedding a group watermark and an object watermark into each object, Yue et al. (2014) described a fragile watermarking algorithm with modification type characterization. Although it guarantees a more precise detection granularity, the invisibility may be not desirable.

In reversible fragile watermarking schemes for 2D vector maps, Shao et al. (2005) divide the vertices into non-intersecting groups, each of which contains the same number of vertices, and embed the watermark group by group by exploiting Fridrich, Goljan, and Du’s (2001) reversible watermarking approach. A drawback of this algorithm is that the tamper localization ability will be ruined if some vertices/features have been added or deleted. Zheng and You (2009) separate the vertices of a 2D vector map into several blocks according to a predefined threshold, and embed the watermark block by block. Because a feature addition/deletion attack may make the block division result different from the original one, leading to watermark extraction
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