An Effective Reversible Watermarking for 2D CAD Engineering Graphics Based on Improved QIM

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ABSTRACT

Quantization index modulation (QIM) is widely used in watermarking, but QIM cannot be applied to reversible watermarking directly due to its inherent limitations. In this paper, an improvement is made to QIM to make it suitable for reversible watermarking. Based on the improved QIM (IQIM), a reversible watermarking scheme for 2D CAD engineering graphics is proposed. The relative amplitudes and the relative phases of entity vertices are used as hosts to carry the watermark, respectively, and the data recovery is controlled by a secret key. Experimental results indicate that the proposed scheme can strike a good balance between capacity, imperceptibility, robustness, security and complexity.

Keywords: 2D CAD Engineering Graphics, Data Hiding, Entity Vertices, Quantization Index Modulation (QIM), Reversible Watermarking

INTRODUCTION

Recently, reversible watermarking has attracted much attention from the researchers working in the field of multimedia security. Because it allows perfect recovery of the original content of the host media after the watermark is extracted, it has found potential applications in the area of medicine, justice and military, where integrity and authenticity is of paramount importance. Since the conception of reversible watermarking was firstly introduced by Honsinger et al. (1999), many works have been done on this topic.

Currently, researches on reversible watermarking are mainly focused on raster images, while little work has been done on vector graphics watermarking. Vector graphics are widely used in geographical information systems (GIS), computer aided design (CAD) and animation. 2D CAD engineering graphics is a typical kind of vector graphics, and has been intensively applied in construction, mechanism and costume design. In most application cases, high precision of the graphics is one of the most important requirements; therefore if watermarking is to be used for authentication...
purpose, reversibility of the original graphics after watermark extraction is desirable.

Chen and Wornell (1998, 2000, 2007) proposed a few watermarking algorithms based on QIM. They have proved that QIM based embedding can strike a good balance between capacity, invisibility and robustness. However, these schemes are not reversible, which limits its application in 2D CAD engineering graphics. In this work, we propose an improved version of QIM - IQIM and use it to construct a reversible watermarking scheme for 2D CAD engineering graphics.

LITERATURE REVIEW

As mentioned above, researches on reversible watermarking are mainly focused on raster images. Surveys were made by Shi and Feng (2004, 2006) and the existing reversible watermarking for raster images were classified into three categories: lossless compression (Celik et al., 2002, 2005), difference expansion (Tian, 2003; Alattar, 2004; Weng, 2009; Wang & Hu, 2009) and histogram modification (De et al., 2001; Ni & Shi, 2006; Xuan et al., 2004). Nevertheless, only a few attempts had been made towards vector graphics, such as 3D models and 2D vector maps. Because of the inherent difference between raster images and vector graphics, reversible watermarking for vector graphics are different from those for raster images. A reversible data hiding scheme for 3D point-sampled model is proposed by Wang et al. (2007). In this scheme, the coordinates of the original points are transformed into the PCA-coordinate system and the points’ coordinates are sorted to yield three lists with sorted indices, then the watermark is embedded into the lists. The reversibility is achieved by storing an extra amount of information. It not only has a large capacity, but also is robust against translation, rotation and uniform scaling. A sequential quantization strategy (SQS) was proposed for data embedding and integrity verification for 3D mesh (Cheung & Wu, 2007). It introduced a sequential quantization strategy, which makes the modulation of a host value dependent on the previous ones. The reversibility is achieved by applying SQS. However, it is sensitive to some malicious operations, and its capacity is low. A reversible data hiding method for authenticating 3D meshes is proposed by Wu and Cheung (2005). It embeds a fragile watermark to the mesh centroid of the mesh faces. The reversibility is achieved by keeping the modulation information in the watermarked mesh. It is sensitive to translation, rotation, uniformly scaling, modification and adding/deletion, and the authentication need the original watermark. A reversible watermarking for 3D model authentication is proposed by Niu et al. (2008). Watermark and modulation information are both embedded into the x-coordinate of different authentication unit. The original model can be recovered by the modulation information. The verification is carried out through a comparison between the extracted watermark and its original counterpart. The main limitation of this scheme is that it has a low resolution in tamper location. A reversible watermarking for authenticating 3D mesh models based on prediction-error expansion is proposed by Wu and Dugelay (2008). Firstly, a vertex position is predicted by calculating the centroid of its traversed neighbors, then the prediction error is expanded for data embedding. At the same time, location information is stored in the watermarked mesh for reversibility. It has a large capacity, but it may cause perceptible distortion. Two reversible data-hiding schemes for 2D vector maps based on difference expansion were proposed by Wang and Niu (2007). The first scheme hides data by modifying the difference between the adjacent coordinates, while the second scheme embeds data by modifying the differences between the Manhattan distances of neighboring vertices. The latter scheme shows better performance than the former, both
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