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A HIGH VERIFICATION CAPACITY REVERSIBLE FRAGILE WATERMARKING SCHEME FOR 3D MODELS

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Abstract. *The protection and authentication problems for three dimensional (3D) models have become more and more important. The capability of accurately verifying, locating, and recovering any tampered vertex is one of the most important issues. Published fragile watermarking 3D model schemes have a main drawback, the synchronization problem. To increase the capacity of verification and overcome this drawback, a high verification capacity reversible fragile watermarking scheme for 3D models in the spatial domain is proposed in this paper. Initially, a reversible quantization index modulation embedding scheme employs the principal component analysis (PCA) and modulates the distance from the vertex coordinate to the gravity center of the cover model. And, the spread spectrum technique is adopted to improve the robustness while obeying the sensitive fragility and low distortion requirements for watermarking 3D models. The proposed method can achieve that 100% vertices of the cover model can be watermarked, extracted and verified, while the other 3D fragile watermarking schemes can not. In the meanwhile, the synchronization problem is overcome. Moreover, the proposed method is immune to the causality and convergence problems. Finally, the proposed scheme is robust against vertex reordering and similarity transformation attacks.*

Keywords: Fragile watermarking, Three dimensional (3D) models, Principal component analysis (PCA), Quantization index modulation (QIM), Authentication, Reversibility, Spread spectrum

1. **Introduction.** Watermarking is a technique to embed secret data into a cover digital content which can be a still image, a video, an audio or a 3D model. In still image domain, watermarking techniques have been widely studied [1-16]. Among different media types, watermarking 3D objects is comparatively hard inherent. According to the applications, watermarking techniques can be classified into robust watermarking and fragile watermarking. The main goal of robust watermarking is to make the embedded watermarks detectable against attacks. On the other hand, fragile watermarking is applied to verify the slightest unauthorized alteration and locate the changed regions. A considerable progress has been made in the areas of steganography [17-21] and watermarking [22-35] on 3D polygonal meshes. But, only a few fragile watermarking algorithms have been proposed to authenticate the integrity of 3D models [36-41].

Recently, 3D models have been widespread applied in various applications, such as digital archives, entertainment, industry and military. From a content provider's point of view, it is desirable to develop a robust watermarking scheme to protect the digital