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3D-Mesh Robust Watermarking Technique for Ownership Protection and Authentication

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Abstract : Digital watermarking has evolved in the past years as an important means for data authentication and ownership protection. The images and video watermarking was well known in the field of multimedia processing; however, 3D objects' watermarking techniques have emerged as an important means for the same purposes, as 3D mesh models are in increasing use in different areas of scientific, industrial, and medical applications. Like the image watermarking techniques, 3D watermarking can take place in either space or transform domains. Unlike images and video watermarking, where the frames have regular structures in both space and temporal domains, 3D objects are represented in different ways as meshes that are basically irregular samplings of surfaces; moreover, meshes can undergo a large variety of alterations which may be hard to tackle. This makes the watermarking process more challenging. While the transform domain watermarking is preferable in images and videos, they are still difficult to implement in 3d meshes due to the huge number of vertices involved and the complicated topology and geometry, and hence the difficulty to perform the spectral decomposition, even though significant work was done in the field. Spatial domain watermarking has attracted significant attention in the past years; they can either act on the topology or on the geometry of the model. Exploiting the statistical characteristics in the 3D mesh models from both geometrical and topological aspects was useful in hiding data. However, doing that with minimal surface distortions to the mesh attracted significant research in the field. A 3D mesh blind watermarking technique is proposed in this research. The watermarking method depends on modifying the vertices' positions with respect to the center of the object. An optimal method will be developed to reduce the errors, minimizing the distortions that the 3d object may experience due to the watermarking process, and reducing the computational complexity due to the iterations and other factors. The technique relies on the displacement process of the vertices' locations depending on the modification of the variances of the vertices' norms. Statistical analyses were performed to establish the proper distributions that best fit each mesh, and hence establishing the bins sizes. Several optimizing approaches were introduced in the realms of mesh local roughness, the statistical distributions of the norms, and the displacements in the mesh centers. To evaluate the algorithm's robustness against other common geometry and connectivity attacks, the watermarked objects were subjected to uniform noise, Laplacian smoothing, vertices quantization, simplification, and cropping. Experimental results showed that the approach is robust in terms of both perceptual and quantitative qualities. It was also robust against both geometry and connectivity attacks. Moreover, the probability of true positive detection versus the probability of false-positive detection was evaluated. To validate the accuracy of the test cases, the receiver operating characteristics (ROC) curves were drawn, and they've shown robustness from this aspect. 3D watermarking is still a new field but still a promising one.

Keywords : watermarking, mesh objects, local roughness, Laplacian Smoothing
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