

## A ROBUST NORMALIZATION ALGORITHM FOR THREE DIMENSIONAL MODELS BASED ON CLUSTERING AND STAR TOPOLOGY

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**ABSTRACT.** *Recently, the fast growth of 3D models has pushed people to develop efficient 3D model registration, recognition, retrieval and watermarking techniques. However, the poses and sizes of the same 3D model may be represented differently from file to file. In order to minimize these differences and simplify the complexity for 3D model registration, recognition, retrieval and watermarking, each 3D model must be normalized. This paper combines the 3D model calibration scheme, clustering scheme and star topology scheme to embed the normalization information of a model in the original model. Experimental results show that the proposed algorithm is effective and efficient in 3D model normalization and has the following advantages: (a) each vertex of a compound 3D model can be traversed due to using the clustering scheme; (b) the correct rate of extracting the normalization information is very high because it utilizes three verification codes to do triple verifications of the extracted normalization information; (c) the signal-to-noise-ratio (SNR) between the embedded model and the original model is very high and the distortion very small; (d) it is 100 % robust against the combination of affine transformations due to the fact that the normalization information is embedded in angles of meshes; (e) it is excellent at keeping robust against the cropping attack, because the embedded feature triangular meshes are uniformly and separately distributed on the model and it only needs three embedded feature triangular meshes to offer normalization information to normalize the cropped model.*

**Keywords:** 3D model, Registration, Recognition, Retrieval, Watermarking, Normalization

**1. Introduction.** Recently, 3D models have been as plentiful as images and video due to the quick development of the advanced processing techniques in digitization and visualization of 3D models. The fast growth of 3D models has pushed people to develop efficient 3D model registration [1], recognition [2-4], retrieval [5,6] and compression techniques [7,8]. Moreover, the rapid development of internet has also caused the serious problem when digital information to be easily transmitted and duplicated without authorization which could become a serious problem. There is an urgent demand for techniques to protect the copyright of the original digital data and prevent unauthorized duplication or tampering, and embedded watermarks can be used to enforce copyright and data authentication [9,10]. However, the orientation and position of the same 3D model may be represented differently from person to person. Figure 1 shows the 3D model Bunny presented with different poses, scales and locations in the same 3D-space coordinate system. Furthermore, the sizes of all 3D models are different due to the fact that they are made with different 3D tools. To minimize these differences and simplify the complexity of 3D models registration, retrieval and watermarking, 3D models need to be normalized