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Mesh Segmentation by Combining Mesh Saliency with Spectral Clustering

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Abstract

In this paper, we present a new mesh segmentation method that achieves visually meaningful segmentation by combining mesh saliency with spectral clustering. Our method solves the segmentation problem by embedding the original mesh model into spectral space. Firstly, the mesh concave regions are determined according to the minimum rule in visual theory, and then a Laplacian matrix is defined by considering the mesh saliency and curvature information. Next, we calculate the first k eigenvectors of the Laplacian matrix by eigen-decomposition process, and embed the original mesh into a k-dimensional spectral space. Finally, we can achieve the visually meaningful segmentation by utilizing the Gaussian Mixture method, and the initial cluster centers are decided by mesh saliency. The experimental results have demonstrate the effectiveness of the proposed segmentation method. Especially for the model with convex regions and branch components, our method can achieve better visual quality.

Key words: Mesh segmentation, Spectral embedding, Mesh saliency, Clustering.

1. Introduction

Segmenting a 3D object into visually meaningful parts is a fundamental problem in geometric processing and shape understanding. Mesh segmentation provides a high-level structure of the models [1], and the segmentation process has become an important and preliminary stage in many processing tasks, such as skeleton extraction [2, 3], mesh parameterization [4, 5], deformation [6, 7], compression [8], etc.

Mesh segmentation methods can be divided into two categories: surface-type (or geometric) methods and part-type (or semantic) methods [9]. In the first case, the objective is to partition the mesh model into different patches with respect to the geometric homogeneity. In the latter case, the algorithms are greatly based on the human perception theory to segment the mesh model into meaningful parts. In addition to the segmentation methods of individual model, some co-segmentation methods have been proposed [10-13] recently, i.e., segmentation of the models as a whole into consistent semantic parts with correspondences [14]. Many segmentation methods have produced wonderful results, however due to lack of shape semantic information, it is still an open and challenging problem to design an automatic mesh segmentation method without any prior knowledge or artificial auxiliary [1].

In this paper, we segment 3D models from spectral clustering perspective, and achieve the visually meaningful segmentation results by combing mesh saliency information. Spectral clustering solves the mesh segmentation problem by embedding the mesh model of the three-dimensional space into a spectral space, and the spectral embedding is constructed by using the eigenvalues, eigenvectors derived from an appropriately defined linear operator [15]. The success of spectral method is due to the fact that the harmonic behavior of eigenvectors can individually reveal the underlying shape characteristics [1]. On the other hand, segmentation of 3D models into meaningful parts is fundamental to shape understanding and processing. There are many efforts have been made to find the meaningful segmentation of