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Mesh resizing based on hierarchical saliency detection

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ABSTRACT

Mesh saliency is a perception-inspired metric for regional importance which is helpful to many aspects of mesh processing. However, existing mesh saliency cannot be used in mesh resizing directly because of the neglect of resizing direction. In this paper, we propose a region descriptor based on its vulnerability to a resizing direction, and use this descriptor to compute the region's saliency based on its contrast to neighboring regions. In order to avoid being misled by repeated small-scale features on the mesh, we put forward a hierarchical method for saliency computing. We build a hierarchical coarse-to-fine segmentations of the input mesh, and evaluate the saliency value on different levels of segmentations. Finally these saliency values are integrated into one saliency map after applying non-linear suppression. Equipped with the saliency map, a framework for non-homogeneous mesh resizing is presented. We regard every edge as a spring, and scale the mesh by stretching the edge. Based on the salience value, we build a global energy function on the mesh. Experiments show that our resizing method based on hierarchical saliency analysis can produce visually appealing results.

1. Introduction

The creation of 3D mesh models from scratch is still non-trivial, so it is a natural idea to create appropriate models by resizing existing ones. However, non-uniform scaling always leads to unwanted distortions of significant features, as illustrated in Fig. 1(b). To get a better scaled model, resizing must be distributed non-homogeneously throughout the mesh, protecting some sensitive parts, while stretching others excessively. To find sensitive features, traditional purely geometric measures are not enough, characteristics of human per-ception should also be taken into account.

Studies show that human visual system is more interested in less frequent features and suppresses repeated features [1]. For example, a flat region in the densely repeated high-curvature bumps will receive more attention. When we watch the lion model shown in Fig. 2, we will pay more attention to its face, nose, eyes and mouth, and ignore its hair because of its frequent occurring. Lee et al. [2] firstly proposed the concept of mesh saliency to measure the perceptual importance of mesh. The extracted mesh saliency has been applied to many aspects of geometry processing, such as shape matching, alignments, simplification, smoothing, and segmentation, etc. However, existing mesh saliencies cannot be used in mesh resizing directly, because they are computed without considering the resizing direction. For example, a cylinder is not vulnerable to scaling along its axis, but is vulnerable to scaling in other directions. Hence, a mesh should have a different saliency map when it is resized along a different direction. In this paper, we have proposed a new region descriptor based on its vulnerability to a resizing direction, and use

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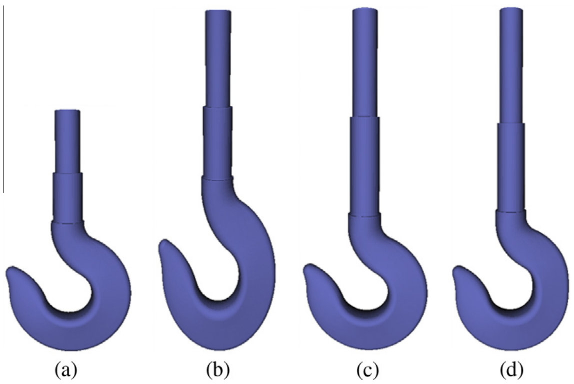

Fig. 1. Mesh resizing: (a) original hook mesh; (b) standard non-uniform resizing; (c) non-homogeneously resizing by our method; (d) resizing by Kraevoy's method.

this descriptor to compute the region's saliency based on its contrast to neighboring regions.

The saliency detection may generally be misled by the model's repeated small-scale patters and complexity, and tends to find cluttered fragments with local details. To solve this problem, we build a hierarchical segmentation tree for the input mesh. Then, we analyze saliency on multiple levels of segmentation, and integrate them into a final saliency map. For different levels of segmentations in Fig. 2, saliency detection tends to mark the lion's hair as salient regions in Fig. 2(c), while it is more likely to discover the saliency of lion's face, nose, eyes and mouth in Fig. 2(a) and (b). Our method utilizes information from multiple levels, and can gain special benefits compared with a single level.

The main contributions of this paper are: (1) proposing a mesh saliency considering the resizing direction; (2) introducing a hierarchical method for saliency computing, (3) giving a framework for mesh resizing based on saliency map. Experiments have shown that the resizing driven by our mesh saliency can result in more visually pleasing results.

2. Related work

Resizing can be regarded as a special kind of shape deformation. The deformation methods can be classified into space deformations and surface deformations. Space deformations embed the object to be deformed in a flexible solid, and propagate the deformation of the solid to the embedded object [3–6]. However, these methods treat the edited shape homogeneously and pay no special attention to its visually important regions. Most of the surface-based deformations try to propagate local transform to the whole model for a natural result [7–11]. Those methods usually penalize shear as much as bending, and try to compensate for shear by using locally rigid rotations. While shear along the resizing axes is avoidable in mesh resizing, so these algorithms cannot be used directly.

Some algorithms that focus on mesh resizing have been proposed. Kraevoy et al. [12] proposed a content-aware mesh resizing method. The method can scale the model non-homogeneously with respect to its surface vulnerability, which is automatically detected by analyzing a combination of local differential surface properties. The vulnerability metric is computed in a per-face manner, while the model is resized by a space-deformation. Wang and Zhang [13] used a similar method to measure per-edge sensitivity of a mesh, but resized the mesh directly by edge stretch, avoiding the protected cubic grid and possible interpolation non-smoothness. The energy function used in Wang's method did not consider the global surface change, so He and Zhang [14] presented a new energy function focusing on normal changes of all mesh triangles. All these methods use pure geometric metrics, ignoring the importance of human perception in mesh processing.

Recent deformation algorithms have gradually shifted focus from maintaining low-level features to preserving high-level structural characteristics such as symmetry and parallelism[structure-aware shape processing]. Gal et al. [15] introduced an analyze-and-edit approach for man-made shape manipulation. They extracted a descriptive set of wires, and analyzed the individual and mutual properties of the wires. Transformations are applied to

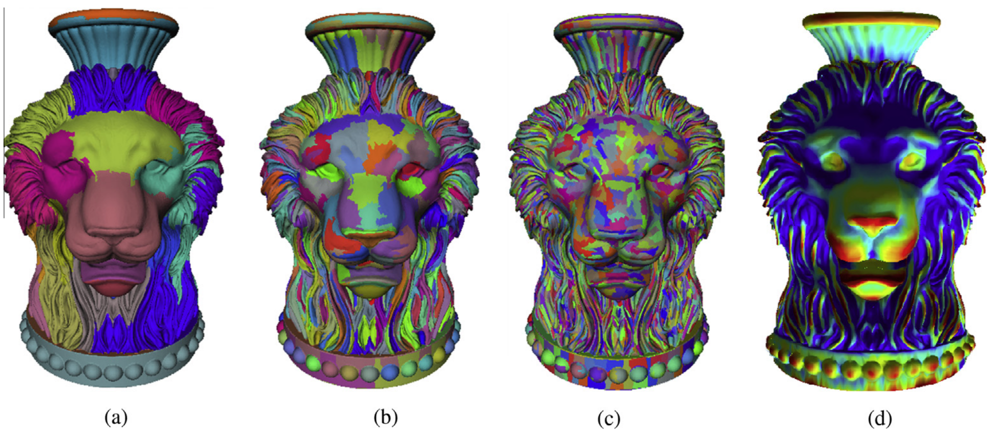

Fig. 2. Hierarchical mesh saliency computation on three levels of segmentations: (a) segmentation with 25 clusters; (b) segmentation with 580 clusters; (c) segmentation with 5800 clusters; (d) mesh saliency computed from three segmentations.

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