3D Model Partial-Resizing via Normal and Texture Map Combination

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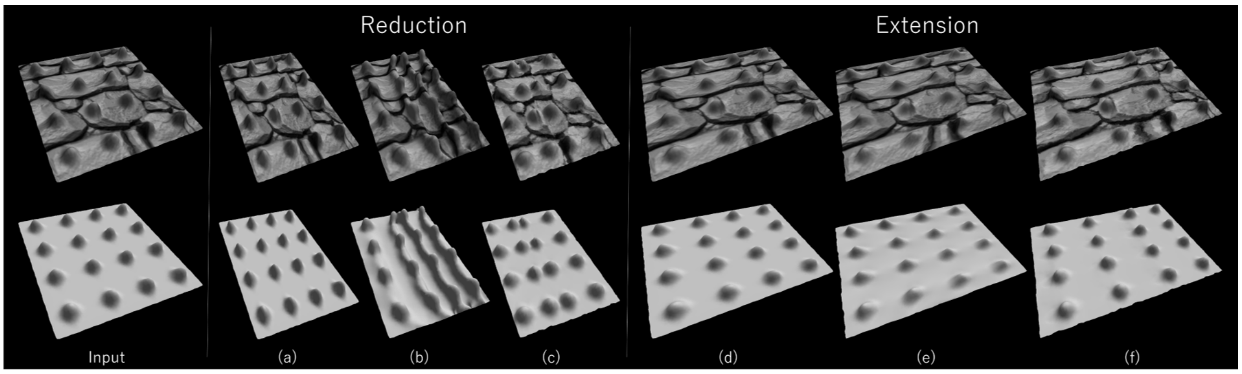

Figure 1: Examples of the resizing results with (a)(d) normal resizing, (b)(e) Laplacian-based resizing [2], and (c)(f) our method.

CCS CONCEPTS

• **Computing methodologies** → *Mesh geometry models*;

KEYWORDS

Geometry Image, Seam Carving

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1 INTRODUCTION

Resizing of 3D model is necessary for computer graphics animation and application such as games and movies. In general, when users deform a target model, they built on a bounding box or a closed polygon mesh (cage) to enclose a target model. Then, the resizing is done by deforming the cage with target model. However, these approaches are not good for detailed adjustment of 3D shape because they do not preserve local information. In contrast, based on a local information (e.g., edge set and weight map), Sorkine et al. [Sorkine and Alexa 2007; Sorkine et al. 2004] can generate smooth and conformal deformation results with only a few control points. While these approaches are useful for some situations, the results depend on resolution and topology of the target model. In addition, these approaches do not consider texture (UV) information.

To address these problems, we introduce a novel resizing method by combining geometry and texture information. Our system follows three steps: (i) generating geometry images, which store vertex position, normal and surface colors in similar 2D arrays using same implicit surface parameterization, from the target model; (ii) applying an image resizing (seam curving) into the images; and (iii) reconstructing the target model on the image space. In our system, we can resize the target model based on the image resolution. In addition, in order to prioritize the geometry of texture preservation for a specific region, our system allows the users to adjust the weights on 2D space.

2 GEOMETRY IMAGE AND TEXTURE GENERATION

Our system is mainly inspired by the concept of Gu et al. [Gu et al. 2002] and calculates a dense correspondence between 3D geometry and 2D texture. Our algorithm receives as input a set of key points on the target surface. Based on key points, an indeed domain is generated by Dijkstra's shortest path. Secondly, the domain is parameterized on an 2D image plane (geometry image) as follows:

$$\mathbf{x_i} - \sum_{j \in N_i, j \leqq n} \omega_{ij} \mathbf{x_j} = \sum_{j \in N_i, j \geq n} \omega_{ij} \mathbf{x_j} \qquad (1)$$

$$\omega_{ij} = \frac{1}{r_{ij}} \left(\tan \frac{\alpha_{ij}}{2} + \tan \frac{\beta_{ij}}{2} \right)$$

where n is the number of the intra vertices, x_i is the i-th vertex position and N_i means its neighbors, ω_{ij} is weight of each edge, and α_{ij}, β_{ij} are base angle of a triangle whose base is r_{ij}. The weight

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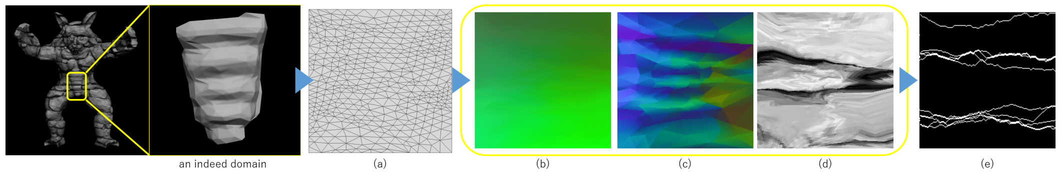

Figure 2: Geometry Images. (a) 2D parameterized domain, (b) vertex position, (c) normal vector, and (d) texture colors. Based on them, our system detects (e) seams. We use the model of [Stanford University Computer Graphics Laboratory 2014].

yield a vertex of trigonal pyramid in triangle composed of the other vertices. Based the parameterization result, we generate three type of geometry images, which stored a set of 3D vertex coordinates, normal vectors, and texture color separately (as shown in Figure 2). As a result, the pixel-to-pixel correspondence between the images are defined.

3 GEOMETRY IMAGES RESIZING

For context-aware image resizing, our system employs seam carving [Avidan and Shamir 2007] and modify the result image by poison image editing [Pérez et al. 2003] .

3.1 Seam Detection

We find seams (paths of least importance) from one end of the geometry image to another(Figure2). In this paper, we focus on a gradient magnitude, and apply difference of Gaussian (DoG) operator to each image. By integrating the gradient magnitude of the normal map and the texture map, the importance function E is formulated as:

$$E = \alpha \mathbf{DoG}_{\mathbf{texture}} + \beta \mathbf{DoG}_{\mathbf{normal}} \tag{2}$$

Generally, the weights are set as $\alpha = 1.0$ and $\beta = 1.0$ to balance contribution of different term.

3.2 Image Modification

We remove the seams to reduce the size of the image which contains vertex positon, or insert seams to extend it. However, the pixel value is not changed and the 3D shape is not resized. Therefore, we apply a Poisson solver [Pérez et al. 2003] to the them for smoothly connecting portions enclosed by seams as follows

$$argmin \int_{\Omega} (\Delta f - \nabla \mathbf{v})^2 d\Omega \quad with \quad f|_{\partial\Omega} = f^*|_{\partial\Omega} \tag{3}$$

where $\partial\Omega$ is boundary and $\mathbf{v}$ is intensity gradient of region indicated by mask image. f and f^* are intensity of indicated and connected region.

4 3D RECONSTRUCTION

Our system reconstructs 3D surface shape (resizing result) from the modified image. In case of partial 3D resizing, we firstly generate the resizing 3D parts, and deform the other region based on Laplacian system [Sorkine and Alexa 2007] (as shown in Figure 3).

5 RESULT AND CONCLUSIONS

For comparison, we use two resizing methods: (1) normal resizing, and (2) laplacian-based deformation [Sorkine and Alexa 2007]

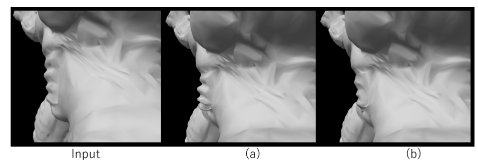

Figure 3: Partiall resized model by (a) [Sorkine and Alexa 2007] and (b) our method. The indeed domain is indicated in Figure 2.

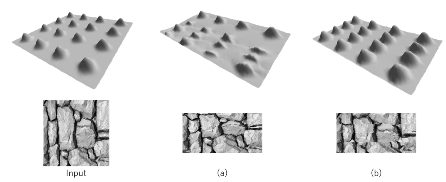

Figure 4: Comparison: We resize a surface in half with (a) $\alpha = 1.0$, $\beta = 0.0$ and (b) $\alpha = 0.0$, $\beta = 1.0$

(Figure 1). As a result, our system can resize the target model with preserving local structure. In addition, Figure 4 indicates the effort of the weight. However, the target model is firstly parameterized onto a 2D square, so this puts a limit on three-dimensional resizing: width, height and depth resizing. In addition, to edit 3D complex model which consists several parts, we need to parameterize each part from the input separately. In future, we are planning to extend our combination idea for up-sampling coarse models more smoothly.

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