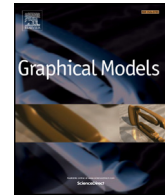




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Natural lines inspired 3D shape re-design

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ABSTRACT

We introduce an approach for *re-designing* 3D shapes inspired by natural lines such as the contours and skeletons extracted from the natural objects in images. Designing an artistically creative and visually pleasing model is not easy for novice users. In this paper, we propose to convert such a design task to a computational procedure. Given a 3D object, we first compare its editable lines with various lines extracted from the image database to explore the candidate reference lines. Then a parametric deformation method is employed to reshape the 3D object guided by the reference lines. We show that our approach enables users to quickly create nontrivial and interesting re-designed 3D objects. We also conduct a user study to validate the usability and effectiveness of our approach.

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1. Introduction

Reshaping the existing 3D objects enables interesting shape variations. However, designing an artistically creative and visually pleasing reshaped model remains challenging, since it always requires creativity and inspiration of the human artists or designers. Some artists specialize in finding inspiration from nature. For example, the wings of butterfly are popular elements in the design of jewelry, handbag or even chair. This motivates us to study how to use natural elements for easy re-design of 3D shapes.

In recent years, extracting 3D objects from a single image or sketch has been an active research topic [1,2]. Shapes generated by such approaches are based on 3D editable primitives (e.g., cylinder, cuboid). Reshaping such editable primitives is able to produce various novel designs only if appropriate deformation targets are given. Some techniques aim to leverage images or sketches as the targets to reshape the existing models [3,4]. We observe that, rather than directly using the target of the same kind, various cross-class natural objects can also pro-

vide proper targets for novel designs. As shown in Fig. 1, a 3D lamp model is re-designed inspired by a pear and a pagoda. In the other example, a folding fan and a snake guide a 3D chair model to create a novel shape design.

We propose an approach to explore proper lines (i.e., the contours and the skeletons) in nature from the photographs of various kinds of objects, and then to utilize such lines for the re-design of 3D shapes. In this process, an image database which consists of various natural objects provides the contours and the skeletons. For an input 3D shape, we first extract its editable lines (i.e., axis, outline and cross-section) of its primitives. Aiming at exploring the proper lines to guide the primitive reshaping, a suggestion mechanism is then employed to suggest both the lines similar to the editable lines and the lines which are diverse, namely, dissimilar but also suit for reshaping guidance. In this manner, certain natural lines are suggested and then used to establish the point-to-point correspondence with the editable lines in the 3D primitives. Finally, a parametric deformation method is employed to produce novel 3D objects inspired by the suggested natural lines.

We provide an easy-to-use interactive tool to assist the user for re-designing existing 3D models. The user only needs to choose the editable region in the 3D object, and

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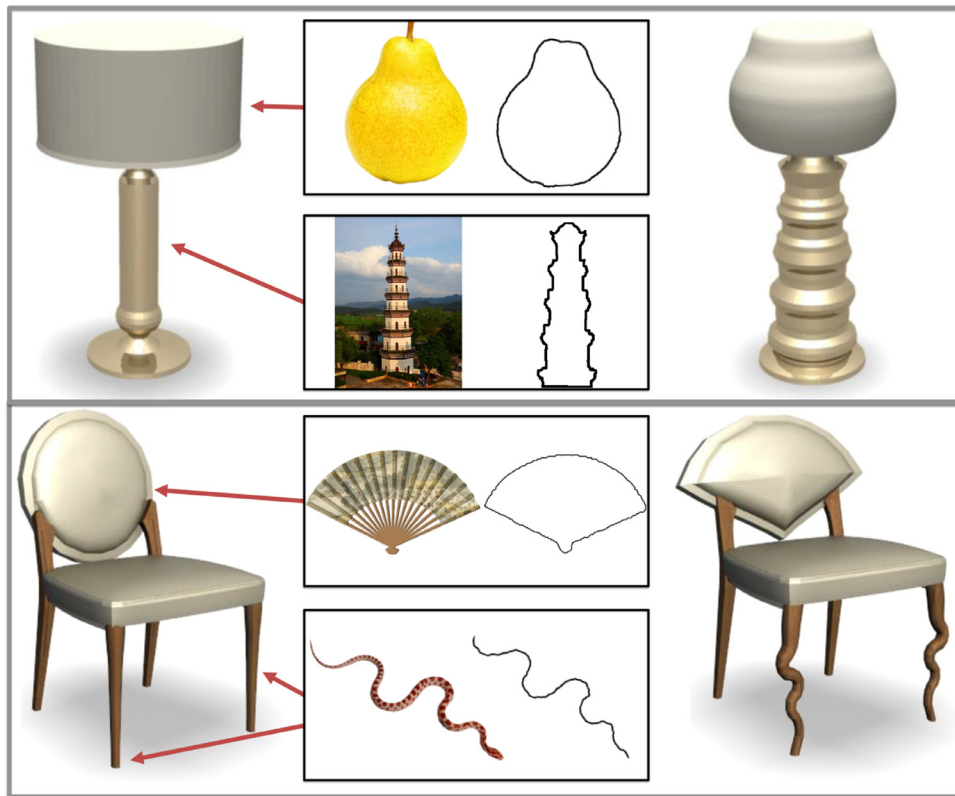


Fig. 1. 3D shape re-design. Given a 3D shape, the candidate images are suggested based on the editing parts. Lines extracted from the images provide inspirations for reshaping the corresponding parts to enable novel shape variations.

selects one of the suggested candidate images that provide the reference lines. Then the re-designed object is produced within less than one minute. We demonstrate the effectiveness of our approach by conducting experiments on various common 3D objects and an image database, leading to various interesting, nontrivial re-designed shapes.

2. Related work

In this section we first review the existing works on sketch interpretation. Then we examine the relevant works on sketch based modeling and shape editing techniques.

2.1. Sketch interpretation

Several approaches have been developed in recent years to automatically or interactively extract a sketch from an image. The state-of-the-art edge detectors (e.g., [5]) automatically produced contour from the image. To interactively extract the sketch, *ShadowDraw* [6] was proposed to guide the freeform drawing of objects. *EZ-Sketching* [7] provided an image-guided drawing interface using a tracing paradigm and automatically corrected sketch lines roughly traced over an image. Besides, other works focused on the sketch segmentation [8] or retrieval [9] inspire us to explore the proper lines for shape re-design. In our work,

we use salient object detection to extract lines from the images, and explore the appropriate lines based on a metric distance which balances the similarity and diversity of the suggested lines.

2.2. Sketch based modeling

Sketch based modeling is an easy-to-use technique for novice users to model a shape. Xie et al. [4] presented an interactive *Sketch-to-Design* system, where the user sketches prominent features of parts to combine. Zou et al. [10] proposed to reconstruct polyhedral objects from single-view line drawings. Zhou et al. [11] utilized single images to model 3D garments with the contour as the constraint. Besides, sketches can also be used for scene modeling. For example, *Sketch2Photo* [12] is able to compose a realistic picture from a simple freehand sketch annotated with text labels. *Sketch2Scene* [13] automatically turned a freehand sketch drawing inferring multiple scene objects to semantically valid, well arranged scenes of 3D models.

Our work is inspired by [1] and [2], which presented interactive techniques for modeling and manipulating simple 3D objects from sketches. Their works provide editable 3D models which can be used for shape re-design in our approach. In our work, we focus on how to use the suggested natural lines to make shape variations, and we also provide a tool for 3D shape re-design.

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