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Integrative 3D modelling of complex carving surface

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Abstract

Modelling of a complex carving surface is the most important process for digitization of art carving such as Chinese classical furniture carving, and it is difficult to be fulfilled. However, a complex 2D curve flower pattern can be easily acquired or drawn by handcraft or a drawing software. This paper presents a quick integrative 3D modeling method of complex carving surface based on a 2D curve flower pattern. The proposed method uses a scanning analysis algorithm, a normal distribution function and a distance function to model and create carving tracks. In this paper, the delamination, combination and interpolation of modelling process are described as well. The provided research method will make the modelling of complex carving surface more intelligent, agile, and will meet the requirement of integrative 3D modelling of digital art carving. Experimental results show that this method is of quick modelling and multi-model effective characteristics with realizable interactive designing and excellent practicability.

Keywords: 3D modelling; Complex carving surface; Multilayer model; Combinating model; Model interpolation

1. Introduction

The current digital carving technology is widely applied in machine processing, and die making and produces preferable economic benefit. However, its functions are quite limited on digital art carving aspects. For example, the carving of Chinese classical furniture and wooden architecture components need 3D modelling for complex carving flower, and transforming from 2D images or graphics to 3D models or copies of carved products. Since the physical characteristics of wood is different from metals, the processing ways are also different as metal processing is standardized in general while wood processing is more focused on aesthetics and artistry. The carved wooden product is usually an uncertain 3D random surface. Hence, digital wood carving is more complex and uncontrollable. These factors and special difficulties of the modeling of a complex carving surface restrict digital carving technology application and popularization in industries that require carving of 3D complex flower patterns such as furniture, stone processing, wood processing and decorating materials.

Some modelling methods of surface have been proposed in Refs. [1–9]. The modelling methods in [1–4] were based on pixels information of grey or colour images, but it is impossible or very difficult to distinguish the information of all pixels from complex carving images such as Fig. 1. Other modelling methods in [5–9] used complex mathematical modelling algorithm, and they only create a local model based on a closed curve region once. In fact, art carving has its own rules. For example, the carved products of furniture or wooden architecture components usually are not real 3D models but carving a limited depth in the 2D plane; and the complex flower pattern is provided with symmetry in general; many traditional and classical flower patterns are universally used in art carving etc. This paper puts emphasis on the method called Integrative 3D Modelling of Complex Carving Surface for art carving, which researches on how to find a standard and coherence way to quickly achieve convenient and integrative modelling according to these features, how to establish an art carving flower models database, and how to convert commonly used flower patterns into data models which can be combined

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Fig. 1. Some carved products.

randomly with other pattern models in various sizes to enhance the designing speed and capability.

The modelling algorithm is proposed in this paper according to traditional handcraft carving process flow that starts from 2D draft [10]. First, a complex 2D curve flower pattern is created and optimized. Then, the coupled intersection points and their midpoints between the scan lines and the pattern curves are obtained by a scan algorithm. Finally, the carving model and track are created by a normal distribution function and a distance function. In the modelling process, the technology of delamination, combination and interpolation are applied which make the visual effect, the precision, and the concave and convex varying of the model surfaces more close to the effect of handcraft carving products. The modelling algorithm can realize integrative 3D modelling of a 2D complex curve flower pattern by the method of processing a 2D data matrix, and greatly decrease operation complexity and data storage capacity while at the same time making 3D modelling of complex carving surface convenient and quick.

2. Modelling algorithm

In this algorithm, an estimation of the surface model is carried out by the following steps:

2.1. *Optimizing 2D curve flower pattern*

Although complex 2D curve flower pattern can be easily obtained or drawn, it is necessary to optimize a 2D curve flower pattern for integrative 3D modelling. A complex carving product perhaps corresponds to a 2D curve flower pattern with diversified segments, counters and regions. The optimized 2D graphics are one or multiple closed curve regions with inner islands. All curves in the graphics are closed. One pixel wide and continued curves uncrossed with each other. However, the

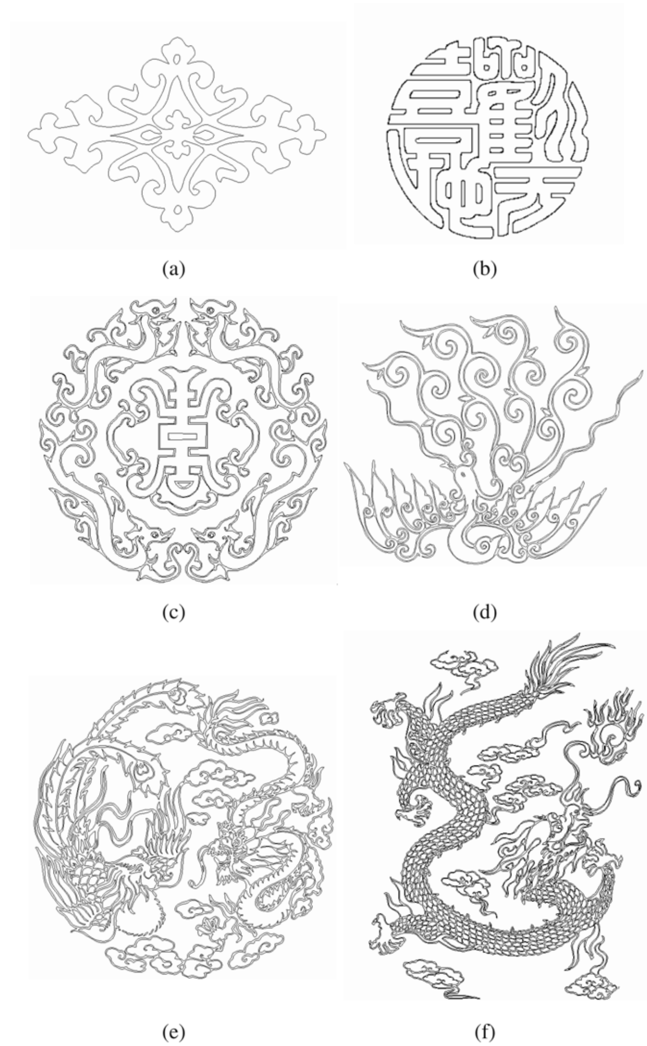

Fig. 2. Optimized 2D curve flower patterns.

independent line segments or closed curve (loop) needed to be incised which appear in the optimized 2D graphics needn't to be modelled. Their carving or incising is easily to be fulfilled by only giving a depth value. The final optimized 2D graphics are vector graphics or binary images as shown in Fig. 2. The optimized 2D graphics are classified into two main kinds according to the requirement of modelling and their structure characteristic:

(i) The 2D curve flower patterns for the requirement of single layer modeling such as Fig. 2(a), (b).
(ii) The 2D curve flower patterns for the requirement of multilayer modelling such as Fig. 2(c), (d), (e), (f).

The 2D curve flower pattern can be optimized in the following two ways:

(i) Drawing the optimized graphics directly according to above rules using 2D drawing softwares such as AutoCAD2005.
(ii) Transforming traditional handcraft 2D carving sketch to the optimized 2D graphics (e.g. transforming Fig. 3(a), (c) to (b), (d) respectively). This process will be completed by using the region segmentation, edge detection, curve fitting and vectorization algorithms [11–13] combined with the