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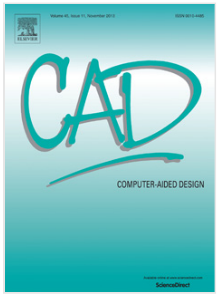

High-quality quadratic curve fitting for scanned data of styling design

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High-quality quadratic curve fitting for scanned data of styling design

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Abstract

We propose a new method for fitting a high-quality planar curve to styling design data by using a curvature continuous (G^2) quadratic B-spline curve. In order to attain G^2 continuity of the B-spline curve, we use a non-uniform knot vector, which also enables the curve to be composed of fewer segments as compared to a uniform curve. In our method, control points and the knot vector of the B-spline curve are calculated separately; therefore, we can avoid solving a complicated nonlinear optimization problem. By conducting experiments, we demonstrate that high-quality curves can be generated from both artificial noisy data and real-world scanned data.

Keywords: quadratic B-spline curve, non-uniform knot vector, G^2 continuity

1. Introduction

In the design of free-form shapes, typically in automotive styling design, the following two requirements are essential. First, the curves fitted to input data should be aesthetic as well as be close to the data within a specified tolerance. Aesthetics is very important for a variety of curve design applications, and studies on aesthetic curves have been rapidly developed in recent years [32, 33]. Aesthetics is generally represented by the monotonicity of curvature [3] because a subtle change in curvature affects the quality of a curve, and it is extremely difficult to control such changes [30]. Second, low-degree curves are preferable to higher-degree curves or other complex expressions, so long as the design objective is attained by connecting low-degree curves such as Bézier and B-spline curves [8].

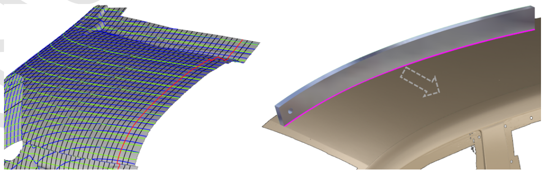

Figure 1: Section curves (left) and sweep modeling [28](right).

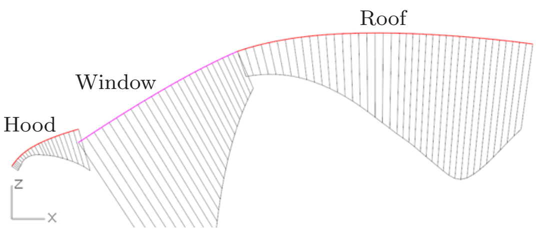

Figure 2: Example of section curves created by CAD experts. The magnitude of the profiles is set to 1/10 of the curvature radius.

A planar curve is the most fundamental free-form shape, and the quality is highly desired. As a typical example, planar curves appear in surface modeling for scanned clay models of cars (Fig. 1). When a curve is properly given, the surface generated by sweeping it can ensure high-quality of the shape. Fig. 2 shows an example of section curves created by CAD experts along with their curvature profiles. The curvature profile indicates the normal directions of a curve by the scaled magnitude of curvature or its radius.

In practice, CAD experts struggle with the following two aspects of creating high-quality curves that satisfy the requirements mentioned above without undesirable curvature extrema: (i) finding the minimal number of features such as locations of curvature extrema (curve segmentation), and (ii) creating aesthetic curves for each segment so as to represent a totally smooth shape for each part. Here, we notice that CAD experts often create curves with no inflection point (non-vanishing curvature). In fact, we can observe that each part shown in Fig. 2 has a curvature of constant sign. If such a point exists in the data and should be represented, CAD experts split the input data at that point and create their respective curves.

It is difficult to deal with the problems mentioned above by using curves of degree 2, mainly because such curves are incapable of representing free-form shapes owing to insufficient degrees of freedom. In fact, existing commercial software tools provide a functionality for generating *Class A* curves of degree 3 or higher. However, quadratic curves offer several advantages such as monotonicity of curvature and robustness of fitting to noisy data. Therefore, in this paper, we address the issue of fitting a quadratic planar

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