Available online at www.sciencedirect.com

SCIENCE DIRECT®

Graphical Models 67 (2005) 189–203

Graphical Models

www.elsevier.com/locate/gmod

Generalized filleting and blending operations toward functional and decorative applications

Gershon Elber*

Department of Computer Science, Technion—Israel Institute of Technology, 32000 Haifa, Israel

Received 30 June 2004; accepted 30 June 2004
Available online 12 August 2004

Abstract

The use of blending and filleting operations in solid modeling and computer-aided geometric design is well established. The question of filling a gap between two (or more) surface boundaries or rounding a sharp edge has been extensively investigated. The vast majority of the prior work on blending and filleting concentrated on a wide variety of fitting schemes as well as attempts to establish and guarantee better continuity conditions. This work extends the notion of filleting and blending modeling tools and elevates them into shaping operations that are either functional or ornamental in nature. The extended shaping operations can be conducted between two boundaries of two adjacent surfaces, much like traditional blending or filleting methods. Furthermore, the presented extended forms can also be applied to the interior of a single surface, guided by arbitrary parametric curves in the domain of the patch.

Keywords: Curves and surfaces; Decoration; Ornaments; Geometric modeling operations; Rounding; Cubic Hermite

* Fax: +972 3 829 1128.
E-mail address: gershon@cs.technion.ac.il.

doi:10.1016/j.gmod.2004.06.005

1. Introduction

Blending and filleting operations are important tools in any contemporary geometric modeling environment. The ability to smooth corners or to continuously connect two adjacent surfaces into a single object is considered mandatory in any computer-based modeling environment. Blending and filleting surfaces are typically required to be G^1. That is, the blending surface must share a tangent plane with the surfaces whose gap it fills, along their shared boundary.

Different authors denote these types of surfaces differently. Blending surfaces, filleting surfaces, or even joining and rounding surfaces are the terms typically used. For the sake of consistency, we only employ the term blending surface in this work.

Classically, a blending surface is constructed along a shared seam or an intersection between two other already specified surfaces, called the *primary surfaces*. Typically, two of the boundary curves of the blending surface lie on the primary surfaces. These two boundary curves will be referred to as *rail curves*, following [8].

Blending surfaces may be subdivided into two types. The first is the exact type, in which the cross-section must follow a prescribed form, typically circular; the second is the imprecise type, in which the cross-section is only loosely specified. The former is known as constant radius blending and the latter as a "thumb fill," having a thumb running along the filleted area creating a non circular yet G^1, or tangent plane, continuously smooth filling.

Given a seam along which a blending surface needs to be constructed, the standard approach for deriving the rail curves is based on offsetting both primary surfaces [5,15,16]. This approach also guarantees the exact radius distance needed for constant radius blending. Another alternative to constructing the rail curve is by forming an intermediate circular sweep surface around the seam and intersecting it against the two primary surfaces [4].

In [2,8,14], blending approaches that do not use a constant radius are presented. These approaches are appealing for their simplicity and the elimination of the requirement of an offset surface computation. Blending algorithms for algebraic surfaces, including [1,18], have been developed separately. See [17] for a nice survey of the different existing blending techniques.

Another type of related work, such as [3], includes feature pasting over spline surfaces. These works add details to the spline surface in the form of a displacement map. This approach is an extended view of the hierarchical B-spline refinement scheme presented in [11].

In our work, the blending operations are extended into three-dimensional decorative features on the surface, for ornamental purposes. Hence, we are also interested in related previous work on three-dimensional texture and displacement mapping [10]. In computer graphics, texture mapping is considered an important and successful tool toward photorealism in image synthesis and rendering. A variant of texture mapping that creates the illusive perception of three-dimensional surface details is known as bump mapping. This variant is a special type of texture mapping where