Surface Fitting Method Based on the Boundary Curves of a Trimmed Surface Considering the G^1-continuity with Adjacent Surfaces

Abstract

A 3D CAD (Computer Aided Design) system is a system that can design a product shape in a three-dimensional model and it has become an indispensable tool for manufacturing. The 3D CAD system, which is the core of the application of Information Technologies, is spreading widely. A 3D model designed with 3D CAD systems are becoming vital communication tools between the design process and downstream processes. The more extensive use of a 3D model outside traditional design and manufacturing is trending now. To distribute 3D data quickly to downstream departments is a significant boosts to product quality, production costs, and delivery to markets. In the downstream department, a 3D data received from a design department can be effectively utilized as a reference model for the creation of various process procedures and/or technical documents, such as creating visual assembly instructions, product manuals and product catalogs. In such works, clear visual communication for ease of understanding is important. However, size of 3D CAD data for expressing precise forms tends to be big and takes long time to compute, therefore it may interfere with communication among users. In addition, interoperability also causes poor communication since downstream applications rely on the reusability and interoperability of CAD models. Since the internal data structures and tolerances do not coincide in each system, the intended shape model for downstream distribution may not be delivered correctly. If the shape delivery fails in one system, the shape should be modified through some method to import suitably within the system. For example, a gap is one of the most serious interoperability challenges between CAD/CAM/ CAE systems. To overcome the problem, direct modeling method which modifies a curve mesh is effective. In direct modeling, modification of a trimmed surface has the restriction where boundary edges must lie on the surface within a certain tolerance. Thus,

it is difficult to maintain geometrical consistency of the modified boundary edges and surfaces. Therefore, it is effective to apply a new free-form surface to a closed region enclosed with modified boundary edges because the consistency of the trimmed surface can be maintained.

In a surface fitting method, how to guarantee a smooth connection between adjacent B-spline surfaces is very important. In a conventional surface fitting method which approximates a surface using sample points derived from the tangent plane, surface continuity with an adjacent surface will collapse because the surface was generated individually. In contrast, Muraki et al. proposed a surface fitting method in consideration of maintaining G^1-continuity with adjacent surfaces. In their method, G^1- continuity is guaranteed on part of the common boundary edges. However, when a surface connects with adjacent surfaces with G^1-continuity in two adjoining directions along the common boundary edges, the conditions used as G^1-continuous cannot be fulfilled near the corner portions with a B-spline surface.

The goal of this work is to make contribution to the communication among downstream processes using 3D data. To be more concrete, first we propose a new surface representation to solve the problems of the Muraki's method, then, contribute to the development of the current 3D models compression and retrieval method and evaluate the 3D data compression and retrieval application system. In our new surface fitting method, 3D shapes can be approximated with good accuracy as a reference model for downstream processes. Our method generates a trimmed surface that is G^1-continuous with adjacent surfaces in all directions and applicable to shapes with a hole. Our method integrates the advantages of Gregory and B-spline surfaces to define a new surface representation. First, when two surfaces are connected with G^1-continuity, we calculate the G^1-continuous control points at the common boundary by using joining equations. Next, a bi-cubic Gregory patch is constructed by the G^1-continuous control points. Since the constructed Gregory patch is insufficient for representing a trimmed surface, knots are inserted in both u and v directions for increasing the degree of freedom. Then, the

unknown inner control points are optimized using least squares approximation method. Finally, a new surface is constructed by applying our new surface representation to a closed region. The proposed method is applicable to shapes with a hole. Moreover, our method is independent of the position and the hole shape. Our method is also applicable to a region surrounded by surfaces in all directions connecting with G^1-continuity. Since our method generates surface from boundary edge information, it is applicable to various applications. For instance, by including our method in the trimmed surface compression method, a smooth surface with good quality can be generated. It is also effective for direct modeling where shapes with a hole are modified. Moreover, the performance of 3D data compression and retrieval application system is evaluated with different network environments: such as third generation of mobile telecommunications (3G) and Worldwide Interoperability for Microwave Access (WiMAX). As the result, we confirmed the effectiveness of the compression method with practical data.