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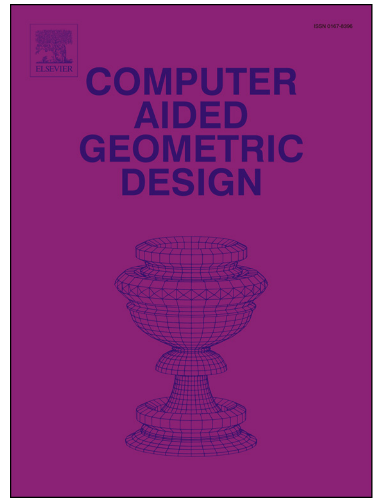

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Accurate Geometry Modeling of Vasculatures Using Implicit Fitting with 2D Radial Basis Functions

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Abstract

Accurate vascular geometry modeling is an essential task in computer assisted vascular surgery and therapy. This paper presents a vessel cross-section based implicit vascular modeling technique, which represents a vascular surface as a set of locally fitted implicit surfaces. In the proposed method, a cross-section based technique is employed to extract from each cross-section of the vascular surface a set of points, which are then fitted with an implicit curve represented as 2D radial basis functions. All these implicitly represented cross-section curves are then being considered as 3D cylindrical objects and combined together using a certain partial shape-preserving spline to build a complete vessel branch; different vessel branches are then blended using a extended smooth maximum function to construct the complete vascular tree. Experimental results show that the proposed method can correctly represent the morphology and topology of vascular structures with high level of smoothness. Both qualitative comparison with other methods and quantitative validations to the proposed method have been performed to verify the accuracy and smoothness of the generated vascular geometric models.

Keywords: Geometry modeling, vasculature, implicit fitting

1. Introduction

3D visualization of vascular structures is of practical value and importance within the field of computer assisted vascular analysis and morphometry [25]. Direct volume rendering (DVR) technique is one of the most popular methods for the 3D visualization of vessels structures contained in a volume dataset. The image generated in this way can be quite suitable for the task of diagnosing vascular disease. However, just to be able to visualize the hidden vascular structures is far from sufficient. The accurate modeling of vascular geometry is essential in many other clinical applications. For vascular intervention planning, it is not an easy task to understand the topology of a vessel tree without the actual vascular geometry. In the case of computer-guided vascular surgery, it can be very difficult to accurately locate the vessel objects directly from the generated image by DVR technique. In addition, the accurate vascular models are of utmost importance to perform reliable simulations of blood flow (computational hemodynamic) [17], which enables the study of hemodynamic characteristics such as wall shear stress and intra-aneurysmal flow patterns. A specific vascular geometry model enables us to design and evaluate possible modification of personalized vasculature, which is helpful for the treatment decision-making on vascular diseases. Furthermore, the modeling of vascular geometry is also the primary issue that needs to be solved for computer aided vascular surgery, and future fully automatic unmanned vascular surgery. Without the accurate information of vascular geometry, the computer-controlled manipulator is unable to perform the accurate collision detection, and therefore cannot achieve a fine vascular surgery.

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