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Fortgeschrittene Segmentierung und Visualisierung von Blutgefäßen für die CT-Angiographie

Enhanced Segmentation and Visualization of Blood Vessels in CT-Angiography Applications

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Problem Statement

Current CT scanners deliver high resolution three-dimensional data. However, despite the growth in the accuracy of scanned data, a correct 3D visualization of features of interest is still a challenge in many situations. The visualization of blood vessels from CT-Angiography data is a good example. In a typical scenario the patient is injected a contrast agent before the scan. This makes blood vessels to present high intensity values in the CT-scan, usually in the same range as bone structures. Normally the resolution of the scan is high enough to discern between blood vessels and bones. However in critical cases where both structures are very close to each other, it is not possible to distinguish among them. This is a direct consequence of the limited spatial resolution of scanning techniques, that introduces artifacts (false material connections) by the so-called partial volume effect. In such cases, an extra segmentation of the blood vessels is necessary in order to obtain a correct visualization. Here we present a simple and efficient segmentation pipeline able to handle this problem. The results are visualized in 3D using indirect volume rendering, providing a fast and accurate insight of the extracted blood vessels and bone structures.

Materials and Methods

The segmentation pipeline is composed of the following main stages:
Threshold Segmentation: The scanned volume is first binary segmented into bone and blood vessels on the one hand, and soft tissue and air on the other hand.

Distance Field Computation: The binary volume obtained from the first stage is here processed to compute a distance field. This results in a value for each voxel corresponding to the distance from the given voxel to the closest boundary.
Path Search: Within the distance field volume, a path is searched that approximately maximizes the distance to the boundaries. By defining one start point in one material and a target point in the other, we obtain a line connecting the two different materials (bones and blood vessels) without intersecting any boundary.
False Connections Removal: Finally, oblique cross-sections are computed along the obtained path. Those points where a minimum cross-section is found are identified as most likely false connection points and therefore removed.

Once the blood vessels and the bone structures have been segmented, they can be visualized in 3D using indirect volume rendering. Therefore a polygonal representation of the features of interest must be generated using an isosurface extraction algorithm. We use the implementation of the Marching Cubes algorithm from the Visualization Toolkit (VTK). After isosurfaces corresponding to the bones and the blood vessels have been generated, the compound result can be directly displayed on the screen, or exported to a file in several standard 3D formats (3DS, VRML...) for an eventual further use during diagnosis or intraoperative practice.

Results and Discussion

A new solution for the correct visualization of blood vessels in CT-Angiography applications has been presented. The proposed method consists in a simple segmentation pipeline, which combined with indirect volume rendering allows an efficient analysis of CT-Angiography data in a 3D environment. Preliminary results show that false connections between blood vessels and bone structures are satisfactorily removed, thus providing the radiologist with a more accurate and reliable 3D data representation.