Abstract

HIGH-QUALITY VOLUME RENDERING OF MEDICAL DATA FOR VIRTUAL ENVIRONMENTS

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INTRODUCTION

In diagnosis, radiotherapy, surgery and treatment planning the knowledge of relative placement and size of anatomical structures is indispensable. Therefore, volumetric visualization of medical data sets acquired by Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) has become more and more important. Usually the two dimensional MRI or CT images have to be transformed mentally together to get an idea of the real three-dimensional image. Contrarily, volume rendering enables the visualization of the whole 3D object - even of inner structures. A virtual environment (VE) additionally enables a truly three dimensional view of the data, which could simplify their interpretation significantly. It also provides input devices with six degrees of freedom (6-DoF) for intuitive exploration of the data.
This work presents a system which offers a visualization of volume data within a virtual environment. It deals with the integration of high-quality hardware based volume rendering into the virtual environment Studierstube.

METHODS

Virtual Reality Framework
Studierstube [4] is an enhanced virtual reality (VR) system which implements basic interaction methods like positioning objects by dragging them with a 6-DoF pen as well as conventional 2D interaction elements, like sliders, dials, and buttons for parameterizations of visualization methods. These purely virtual interface elements are positioned on the Personal Interaction Panel [5], a handheld tablet. Users hold this board in their non-dominant hand while they make adjustments to the interface elements with the same pen they use for 6-DoF interaction. Studierstube supports a wide range of input and output devices and is thus configurable for many different hardware setups. Studierstube relies on polygonal rendering via OpenGL.

The HVR Framework: High-Quality Hardware Volume Rendering
Our HVR framework [3] for volume rendering combines high-quality with real-time performance on consumer graphics hardware. It uses GPU based ray-casting because of its superior image quality and efficiency in comparison to slice-based approaches and provides custom rendering modes, like iso surface rendering, shaded and unshaded direct volume rendering as well as more sophisticated rendering modes. The image quality can be reduced during interaction. Therefore interactivity is also ensured for large datasets. Settings like color, opacity, iso value and modifications in the transfer function can be done in real-time. Perspective rendering is supported with no performance decrease. Viewing the volume from the inside or fly-throughs are also possible (enabling Virtual Endoscopy).

Integration of HVR into Studierstube
For a seamless combination of volume and polygonal rendering, occlusions between volume and OpenGL geometry have to be considered to create a perception of space. Those intersections are essential for an intuitive interaction with the volume which should be as natural as possible. Occlusions between volume and opaque OpenGL geometry are achieved by rendering a depth image of the geometry and terminating the rays in the ray-casting process at exactly that depth in volume coordinates. This extension offers a native combination of volume and polygonal rendering.

VR Interaction with Volume Data
The most obvious direct interaction method is navigation. The user is able to move the volume by positioning the input device inside the volume’s bounding box and then pressing the primary button on the input device. The object follows all motions and rotations of the input device as long as the user pushes the button. We also provide axis-aligned clipping, intuitive lighting by directly moving the light-source and a traditional slice view. The interaction methods are aided by visual feedback. The system is controlled using widgets (sliders and buttons) on the Personal Interaction Panel.

Setup

Our prototype system consists of a swivel mounted Barco Baron Table [2] with shutter glasses synchronized by an infrared emitter, an ART Optical Tracking System [1] with three cameras and a single PC running our hybrid application. Pen, tablet, glasses and table are optically tracked. We apply our full set-up for educational purposes and in pre-operative planning. For intra-operative applications, we rely on simpler hard- and software combinations, essentially a desktop virtual environment.

RESULTS

We seamlessly integrated high-quality perspective volume rendering into a polygonal VE by considering accurate occlusions between the objects although they are created by completely different rendering frameworks.

We are able to achieve interactive frame rates. Performance in the HVR framework is scalable, so the user is able to reduce the image resolution during interaction (like clipping) and change it again to high resolution to view the clipped volume in its best quality.

DISCUSSION

Preliminary demonstrations for medical students and neurosurgeons have resulted in positive feedback. We will continue the evaluation of our system in collaboration with our medical partners. Further, we plan a cooperation with the Vienna General Hospital for teaching purposes, because although there is a lot of research in medical visualization all too often these techniques are either not known by clinicians or not accepted. An early introduction to these new technologies in education would familiarize students to them already during their studies which could lead to more acceptance. Furthermore the use in education could aid in validation.

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