Hochqualitative Volumenvisualisierung von Tagged Volumina auf PC Grafikhardware

High Quality Volume Rendering of Tagged Volumes on PC Graphics Hardware

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Purpose

Volume rendering of tagged volumes is a standard strategy for the visualization of explicitly segmented structures in the same range of intensity values. However, the binary boundaries of segmented structures lead to strong voxelization artifacts. In order to achieve smooth surfaces, an algorithm exploiting 3D textures and pixel shaders of PC graphics hardware was implemented.

Material and Methods

The developed application makes use 3D-textures and the fragment shader unit of PC-graphics hardware. Source data corresponds to MR volumes with four explicitely segmented subvolumes.

The data is stored in two 3D-RGBA-textures which are used for multi-texturing of the proxy geometry. These textures contain the intensity data and the tag IDs respectively. The tag values are coded and stored using the components of the RGBA-texture. For a voxel with tag ID 0 a 1.0 is stored in the R component while 0.0 is stored in GBA. Analogously, components GBA are used for tag IDs 1,2 and 3 respectively. As a result, the first texture provides trilinear interpolation of the intensities for each fragment. The second texture produces a RGBA value which indicates the proportions of the subvolumes involved in the present fragment. A value of 1.0 in the R component would indicate that only voxels with tag ID 0 were taken into account by the interpolation.

The interpolated intensities are combined with the tag interpolation in a fragment program in order to obtain correct post-interpolation of the sub-volumes. Four transfer functions are stored in a 2D dependent texture where the x-axis and y-axis correspond to intensity and tag ID respectively. Next, a lookup coordinate is built using the fragment intensity and the computed tag proportions.
The y-coordinate is
computed based on the RGBA values obtained from the tag ID texture. If R $\rightarrow$ 0.5 the y-coordinate is set to point at the first transfer function. This criteria is also employed for the GBA components. This ensures correct post-interpolation of the intensities without intermixing of subvolumes. Nevertheless, binary boundaries produce aliasing artifacts at the subvolume borders.

In order to avoid aliasing artifacts, an opacity scaling operator was applied. The interpolated RGBA tag texture can be used to determine the distance of the fragment to the subvolume boundary. This information is taken into account in order to create a scaling mask for the opacity. If the R component produces a 1.0 value, the fragment is unambiguously located in subvolumen 0 and no scaling is necessary. A value of 0.5 indicates that the fragment lies at the boundary center between two subvolumes. In this case, a scaling value of 0.0 is taken. Values in between are linearly interpolated. Multiplying the opacity of the fragment by the scaling value effectively removes aliasing artifacts.

Results

Evaluation was carried out with a series of cases of neurovascular compression syndromes showing its high practical value. Comparison against standard renderings demonstrated clearly superior results of the presented approach.

Conclusion

Overall, the presented strategy is based on standard consumer hardware. Thereby, its portability broadens its application spectrum.

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