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Semantic Visualization Mapping for Illustrative Volume Visualization

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Measured and simulated data is usually divided into several meaningful intervals that are relevant to the domain expert. Examples from medicine are the specific semantics for different measuring modalities. A PET scan of a brain measures brain activity. It shows regions of homogeneous activity that are labeled by experts with semantic values such as low brain activity or high brain activity. Diffusion MRI data provides information about the healthiness of tissue regions and is classified by experts with semantic values like healthy, diseased, or necrotic. Medical CT data encode the measured density values in Hounsfield units. Specific intervals of the Hounsfield scale refer to different tissue types like air, soft tissue, bone, contrast enhanced vessels, etc. However, the semantic parameters from expert domains are not necessarily used to describe a mapping between the volume attributes and visual appearance.

Volume rendering techniques commonly map attributes of the underlying data on visual appearance via a transfer function. Transfer functions are a powerful tool to achieve various visualization mappings. The specification of transfer functions is a complex task. The user has to have expert knowledge about the underlying rendering technique to achieve the desired results. Especially the specification of higher-dimensional transfer functions is challenging. Common user interfaces provide methods to brush in two dimensions. While brushing is an intuitive method to select regions of interest or to specify features, user interfaces for higher-dimensions are more challenging and often non-intuitive. For seismic data the situation is even more difficult since the data typically consists of many more volumetric attributes than for example medical datasets.

Scientific illustrators are experts in conveying information by visual means. They also make use of semantics in a natural way describing visual abstractions such as shading, tone, rendering style, saturation, texture, etc. Direct volume rendering techniques do conventionally not make use of these semantics. The transfer function actively prevents the use of these semantic parameters for the description of visualization mappings.

In our work on semantic layers we propose an alternative method to achieve meaningful visualization mappings from volumetric attributes to visual appearance. Semantic parameters are used to describe meaningful intervals of data and the rendering techniques. Visualization rules are used to specify a visualization mapping from expert semantics to illustration semantics. Our method enables a multi-dimensional mapping from several volumetric attributes to multiple visual abstractions. Semantic values for volumetric attributes and for visual abstractions are represented as membership functions of fuzzy sets. Visualization rules are specified by the user to establish the semantic visualization mapping from various volume attributes to given visual abstractions. The visualization rules are interactively evaluated on modern graphics processing units using fuzzy logic arithmetics. With this approach it is possible to establish a visualization mapping between semantics from expert domains and scientific illustration techniques.