Gradient based Volume Visual Attention Maps in Ray Casting Rendering

**Introduction**
Interactive volume data visualization technique for ray-casting, combining the visual focus of attention and automatic a-priori region segmentation.

Automatically segmented regions which are the user's focus of attention are highlighted while the rest is faded out using different techniques (opacity and color hue).

**Volume Visual Attention Maps (VVM):** Adaptation of traditional 2D visual attention maps for dense volume datasets, focused on ray-casting based rendering.

The problem:
- Complexity of visualizing dense volume data on conventional 2D monitors, superposition of many data layers in the view plane
  - Surface rendering methods: view of a limited portion of the data
  - View of the whole dataset achievable with Direct Volume Rendering (DVR), like ray-casting, but most convenient visualization requires difficult transfer functions adjustments
- Increasing patient number and less time for medical professionals (e.g., radiologists) to achieve same tasks
- Need of high effectiveness at high efficiency

Evidence:
- Radiologists intentionally focus their eyes on important regions for diagnosis
  + VAM represent person's focus of attention during certain time period [1]
- Automatic image segmentation techniques:
  - Not completely accurate nor robust
  - Not consider the specific requirements of the user
  + Can be quicker, more objective and even recognize regions non-identifiable by human eye

Objectives:
1. More intuitive and quicker interactive volume data visualization process, while keeping record of the regions reviewed by the user
2. Eye gaze based UI to control ray-casting based visualization
3. Develop a ray-casting based interactive (GPU based) DVR algorithm which uses a VVM to highlight the important data for the user while fading off the non-important

**Materials**

Prototype components:
- Point-of-regard based, non-intrusive eye tracker
- 2 implementations of the VVM guided ray casting

Interaction:
- Eye tracking used for interaction with the visualization in different ways:
  1. Virtual camera control
  2. Compute VVM (to guide rendering process)

**Methods**

Preliminary results:
- Prior naive approach from the author, presented in MMVR19 [3]

New Contributions:
+ More realistic visual attention model (including considerations of early-ray termination in ray casting)
+ Data element importance measure combining the visual attention model and knowledge about the homogeneous regions in the visualized dataset (e.g., Watershed)
+ Adapted ray-casting algorithm for importance based volume rendering

**Conclusions and Discussion**

- Interactive semi-automatic data visualization method
  - A priori data set knowledge exploitation: automatic pre-segmentation (e.g., Watershed [4]) producing an over-segmented result
  - User’s visualization requirements gathering: dynamic model of the user’s visual attention on the data set
  - Data knowledge and visual attention knowledge fusion onto an importance measure for every data element in the data set
  - Importance based ray casting direct volume rendering algorithm with a simple yet effective illustrative rendering style
  - Validation in clinical practice is still required in terms of both effectiveness and efficiency of the technique
  - Future migration into a WebGL based implementation

**References**


http://www.vicomtech.org