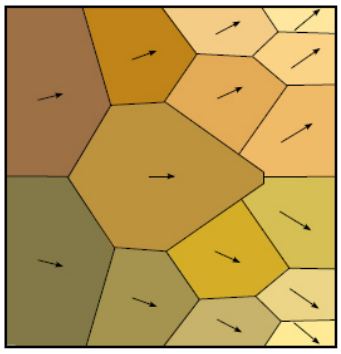
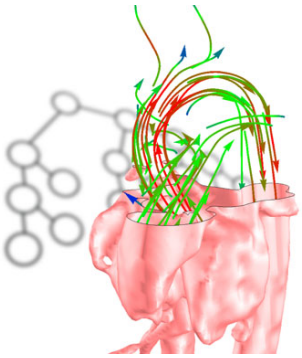
Open Project:

"Spatiotemporal hierarchical clustering and visualization of 4D MRI blood flow"



(a) Example: partitioned 2D flow [2]



(b) Example: hierarchically clustered 4D flow [1]

Introduction:
Measurements from a wide variety of modalities are used to diagnose cardiovascular diseases. Magnetic Resonance Imaging (MRI) enables such acquisitions, especially for more complex cases. Current procedures in clinical practice are based on anatomic MRI scans, while more advanced MRI scanning protocols exist that provide quantitative blood-flow information.

Clinical research takes a large interest in finding correlations between blood flow and the progression of vascular diseases. Until recently computational fluid dynamics (CFD) simulations delivered the main source of information. Nowadays also quantitative flow MRI data can be acquired; providing an actual measurement of the blood flow.

The flow measurements provide large data sets, which are hard to interpret on a slice-by-slice basis. Mental reconstruction of vascular structures can be challenging, even for a skilled radiologist. The flow measurements add a velocity field that changes over time to these complex structures, resulting in a data set which becomes exceptionally hard to understand. Novel visualization techniques could support clinical research to obtain better understanding of the acquired data.

Problem Statement:
In the previous, we have introduced the difficulties with mental reconstruction of the high-dimensional blood-flow data. To overcome these difficulties, it is relevant to provide physicians with a simplified representation of the blood-flow field, without losing essential flow information.

In the past, we have investigated spatiotemporal hierarchical clustering of the blood-flow data, aiming to simplify the time-resolved velocity field [1]. In this work, we have treated the space and time dimensions equally, taking a mathematical approach to measure the dissimilarity between the clusters. However,

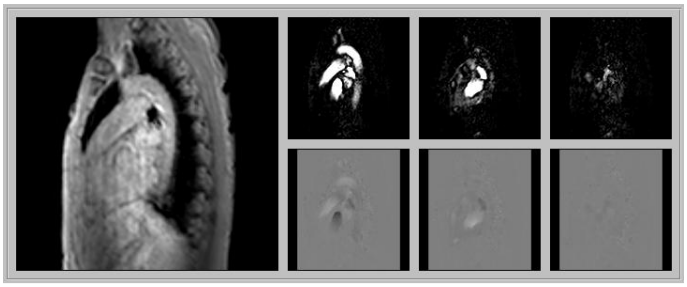


Figure 1: Sagittal view of an anatomy, phase and magnitude data slice

domain specific knowledge may be incorporated into the clustering approach, aiming for clusters that are meaningful in the context of clinical research. The results should be evaluated to verify the validity of the resulting clusters. Moreover, visualization of the 4D clusters is challenging, as the structures are defined in spacetime. Novel techniques should be investigated to convey the time-bound volumetric clusters, enabling local details on demand.

Goal:
The goal of this project is to investigate clustering and visualization of 4D MRI blood flow data, incorporating application-specific knowledge. Novel visualization techniques should be devised that convey the blood-flow clustering results, based on an existing hierarchical clustering approach. The visualization should enable interactive exploration and details on demand. Furthermore, novel dissimilarity measures should be investigated that incorporate domain knowledge. The resulting clusters should be evaluated both qualitatively and quantitatively.

Execution:
Execution of the project comprises the following aspects:

- Literature Study
  Investigate existing dissimilarity measures in literature ([2], [3] and [4]).
- Investigation of measures
  Based on the findings from the literature study, new dissimilarity measures should be proposed to cluster the 4D MRI blood flow.
- Evaluation of clustering
  Devise and execute an evaluation study, to inspect the validity of the resulting clusters.
- Implementation in C++ / VTK
  Implementation should be executed in the C++ language, with support of the visualization toolkit (VTK).
- Visualization
  Propose a novel visualization approach, effectively conveying the spatiotemporal clustering results.

References:

[1] *"Visualization of 4D blood-flow fields by spatiotemporal hierarchical clustering."*, R.F.P. van Pelt, S.S.A.M. Jacobs, B.M. ter Haar Romeny, and A. Vilanova in Computer Graphics Forum (2012)

[2] *"Visualization of 4D Blood-Flow Fields by Spatiotemporal Hierarchical Clustering"*, Sander Jacobs, Roy van Pelt, Bart ter Haar Romeny, and Anna Vilanova in Computer Graphics Forum (2012)

[3] *"The state of the art in flow visualization: partition-based techniques"*, Tobias Salzburn, Heike Jänicke, Thomas Wischgoll, and Gerik Scheuermann in Proceedings of SimVis (2008)

[4] *"Simplified representation of vector fields"*, Alexandru Telea and Jarke J. van Wijk in Proceedings of IEEE Visualization (1999)