Smooth Navigation between Nested Spatial Representations

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Abstract

We investigate the dedicated control of multiple levels of semantic and sampling-based abstraction in 3D datasets, i. e., different types of data abstractions as opposed to sampling-based abstraction which shows more or less data. This dedicated navigation in the abstraction space facilitates the mental integration of different existing visualization techniques in many application areas including our example domain of fluid simulation. We realize the continuous abstraction control by interpolating between the levels while being able to simultaneously show multiple abstractions. We employ a halo-like shading technique based on distance fields to blend between several levels while continuously navigating between focus and context abstractions. We further add a semantic lens to find focus abstractions close to a user-defined context abstraction. Our entire implementation uses 2D image-based techniques to enable real-time performance, which seamlessly integrates within a 3D visualization tool.

1. Introduction

Often, different high-level abctractions of a dataset are used to emphasize specific chosen aspects of interest to the viewer. All these visualizations can show different important aspects of the same dataset. We propose a technique which allows users to understand the relation between different abstractions in the case they are *spatially nested*, i. e. abstractions which are defined in the same spatial region but using a decreasing amount of screen space. The nesting property allow us to use two-dimensional techniques to generate real-time halos which appear volumetric and separate the different representations visually.

2. Model

Consider a dataset $d \in D$ and visualizations of d modeled as $V_{1 \leq i \leq N} : D \rightarrow \mathbf{R}^2$ with each producing an 2D image $A_i = V_i(d)$. We call these images *abstractions* of d if they represent the information in d on different levels of detail. We distinguish two types of abstraction:

Semantic abstractions simplify the information by showing varying amounts of information using different visual representations

Sampling abstractions reduce the amount of points produced by using data sampling

We assume the set of abstractions $A = \{A_i\}$ can be ordered in an increasing amount of provided simplication from the densest abstraction A_1 to the sparsest one A_N. At the same time we require the abstractions to satisfy the property of *spatial nesting*.

3. Navigation

Given a set of abstractions as described above, we design a *navigation function* which allows users to browse through the abstractions in a smooth manner. Given a level of highest abstraction A_f, we want to create a visualization showing the *focus* A_f with all $A_i, i < f$ as *context*.

In order to show all appropriate abstractions, we do not use toggling or morphing operations to navigate through the abstraction space. Instead, we propose a continuous navigation function $Nav : A \times [0,1] \rightarrow \mathbf{R}^2$ which given the set of abstraction A and a focus abstraction level $f \in [0,1]$ result in the visualization V as described above.

The visibility (or opacity) of a given abstraction A_i is given by a trapezoidal function which is defined on the region $[f_{in}, f_{out}]$ for which the abstraction should be visible. To allow visual separation between the different abstractions, we generate halos around the nested abstractions which are growing in size when the new abstraction is faded into view.

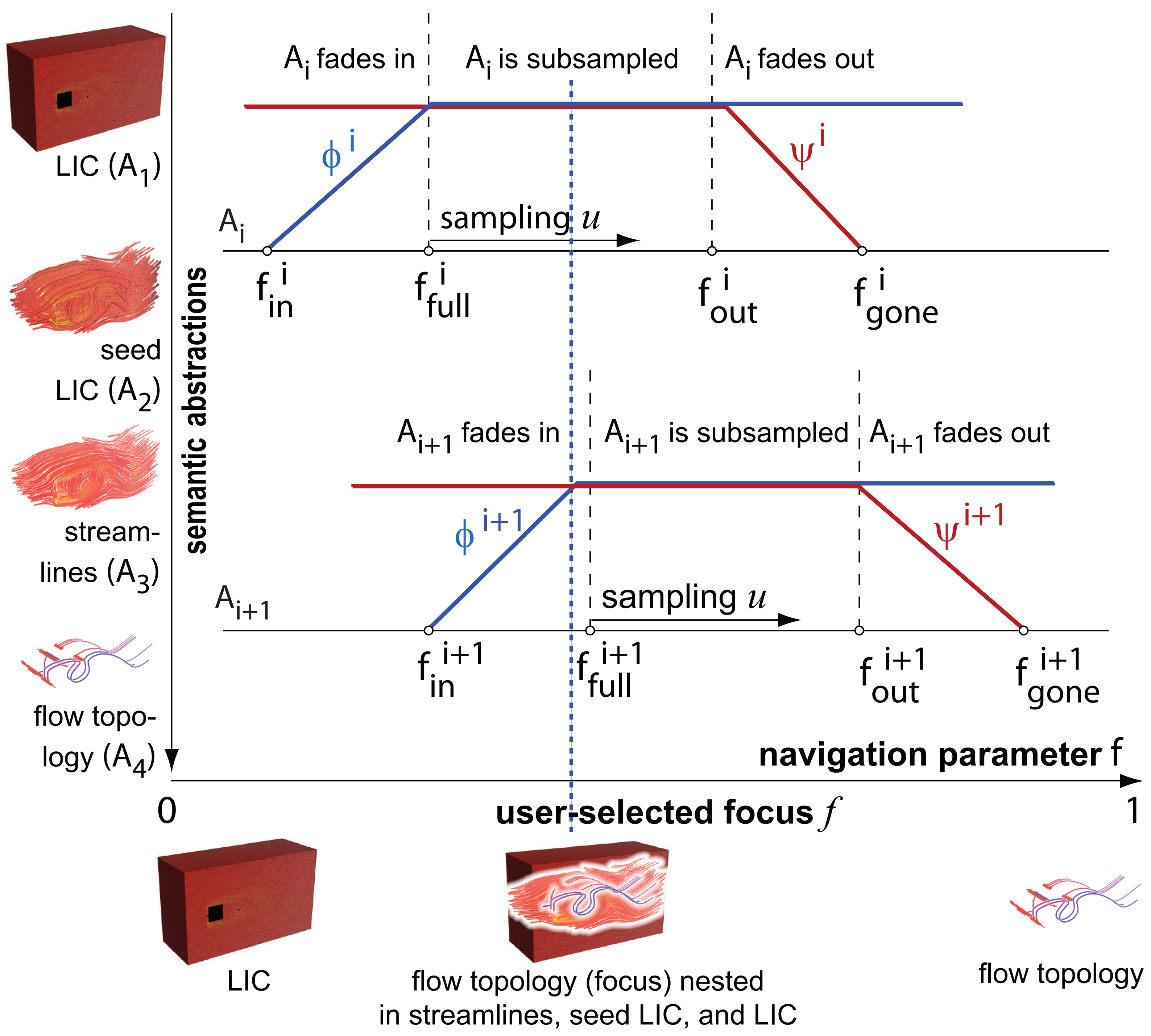

Figure 1: *Continuous navigation in a flow visualization abstraction space with four abstractions* A_1–A_4.

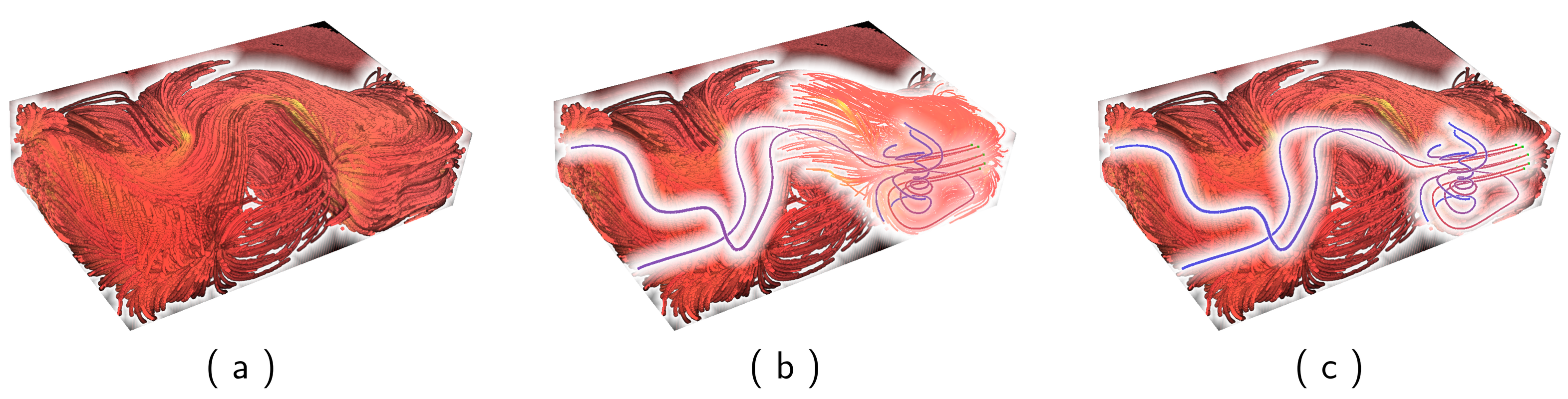

Figure 2: *Three example stages of navigating the abstraction space.*

4. Local Exploration

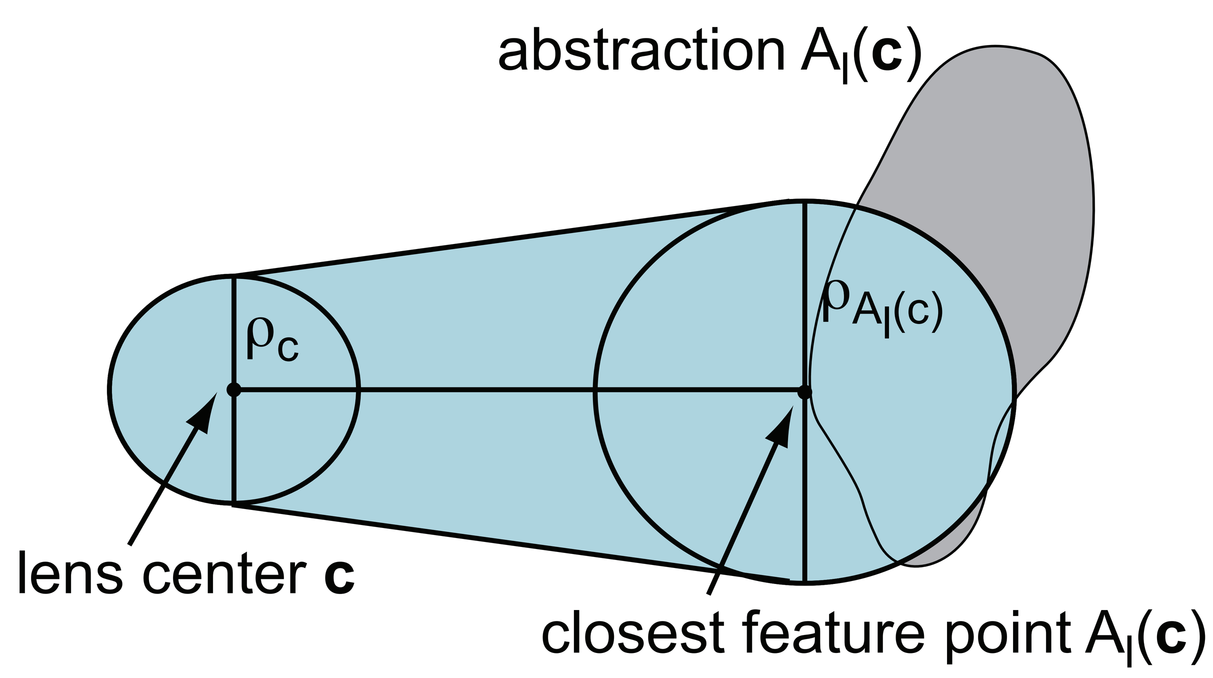

Figure 3: *Construction of the focus guided lens.*

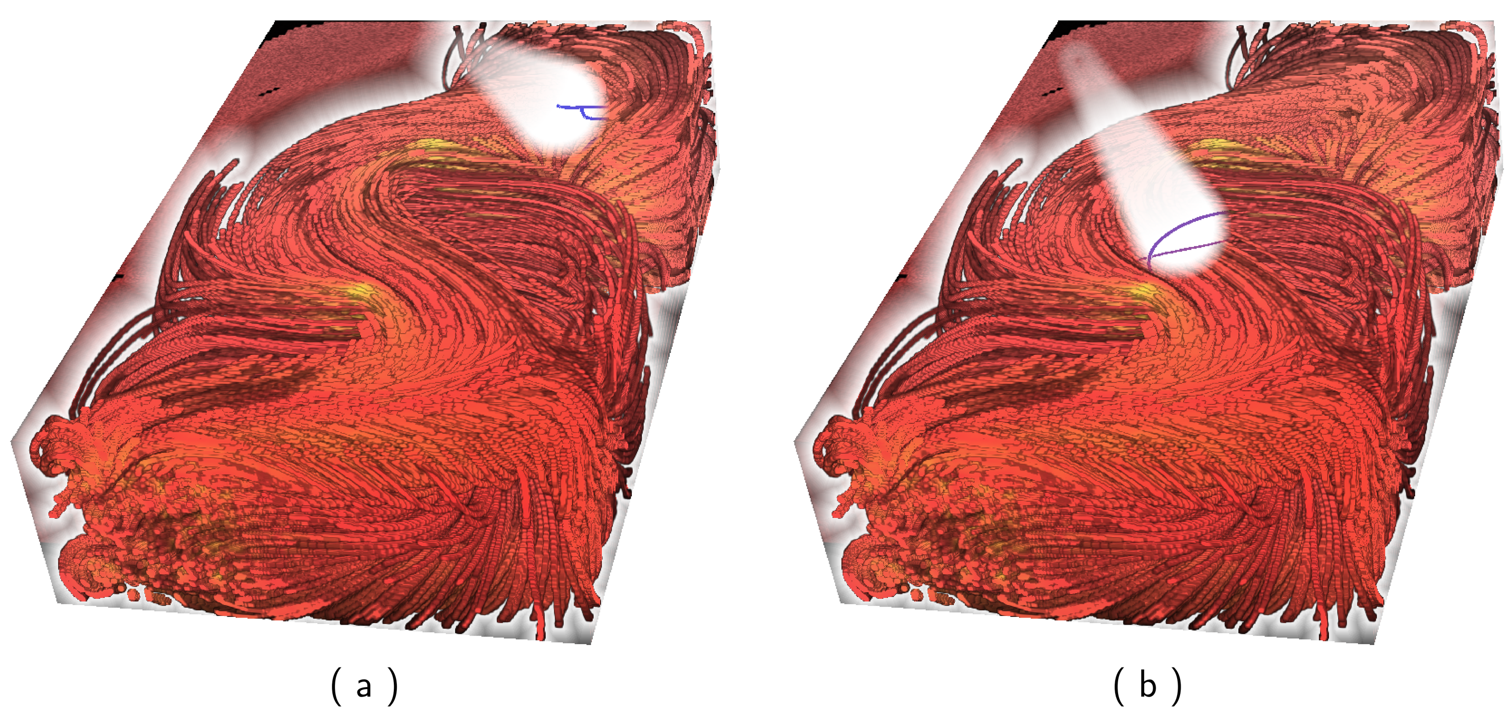

Figure 4: *Examples of lens-based local exploration.*