Analysis of Fiber-Reinforced Polymers with the open_iA Framework

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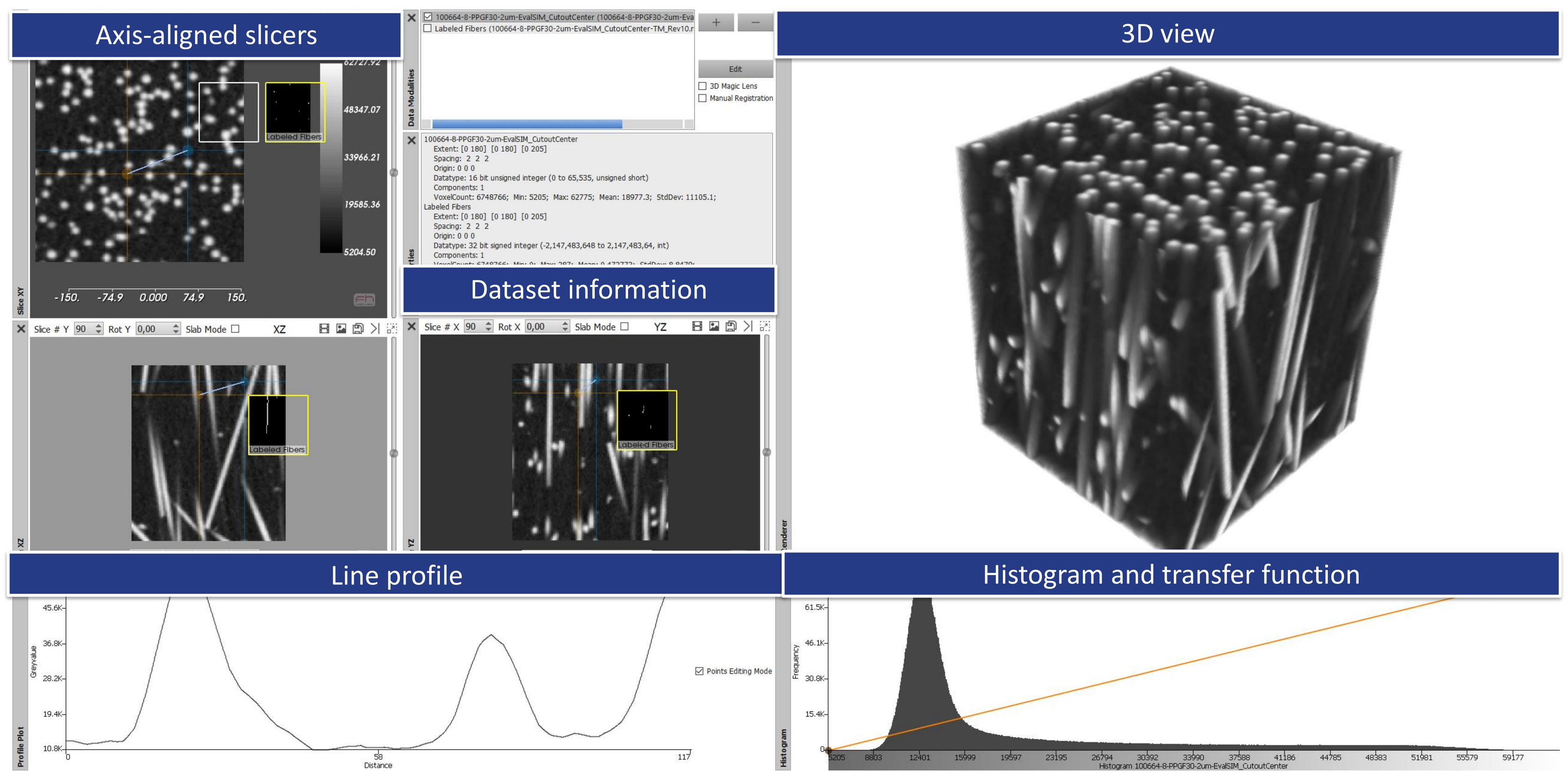
Introduction

open_iA [1] is a platform for visual analysis of volumetric datasets, with a focus on industrial computed tomography, implemented and maintained by the Computed Tomography Research Group at the University of Applied Sciences Upper Austria. The main driver behind its development was the need for a common and open framework for data analysis and visualization, providing a rich set of image processing filters, (noise reduction, segmentation, geometric transforms, morphological operations etc.) together with custom visualization methods. It also includes support for cone beam reconstruction via the ASTRA toolbox.

open_iA is written in C++, mainly using Qt, VTK and ITK, as well as some other open source libraries. It is itself open source and continuously extended. The source code as well as pre-built binaries are available on GitHub: https://github.com/3dct/open_iA



The core of open_iA provides functionality for displaying one or more volumetric datasets, along with standard tools, such as their intensity histograms as well as methods to specify transfer functions. The comparison of multiple volumes is facilitated through magic lenses as well as optional position indicators in all open child windows.

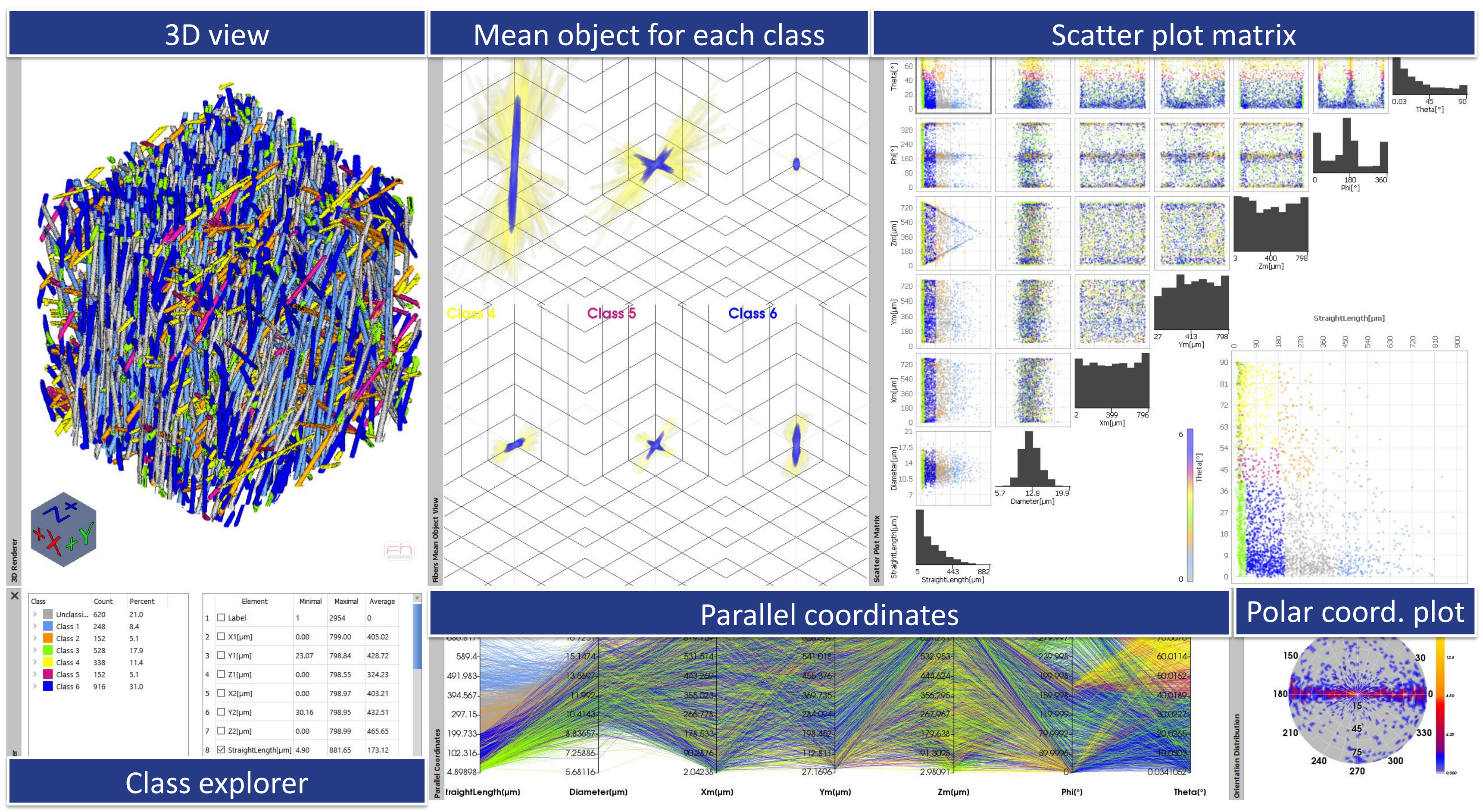
Extensibility

Since open_iA is implemented as a platform for research prototypes and tools, it is highly extensible through so-called *modules*. Modules can contain anything from simple image processing filters to complex visual analytics tools. Their additional functionality is dynamically loaded when starting open_iA. All image processing filters are also made available in a command line tool. The main repository of open_iA already includes a variety of modules with image processing filters and visual analytics tools for specific analysis scenarios. Below, we introduce a selection of four included visual analytics tools in its open source, which are especially suited for the analysis of fiber-reinforced polymers.

For more information on how open_iA can be extended, as well as tutorials on how to develop modules for it, see https://3dct.github.io/open_iA/dev

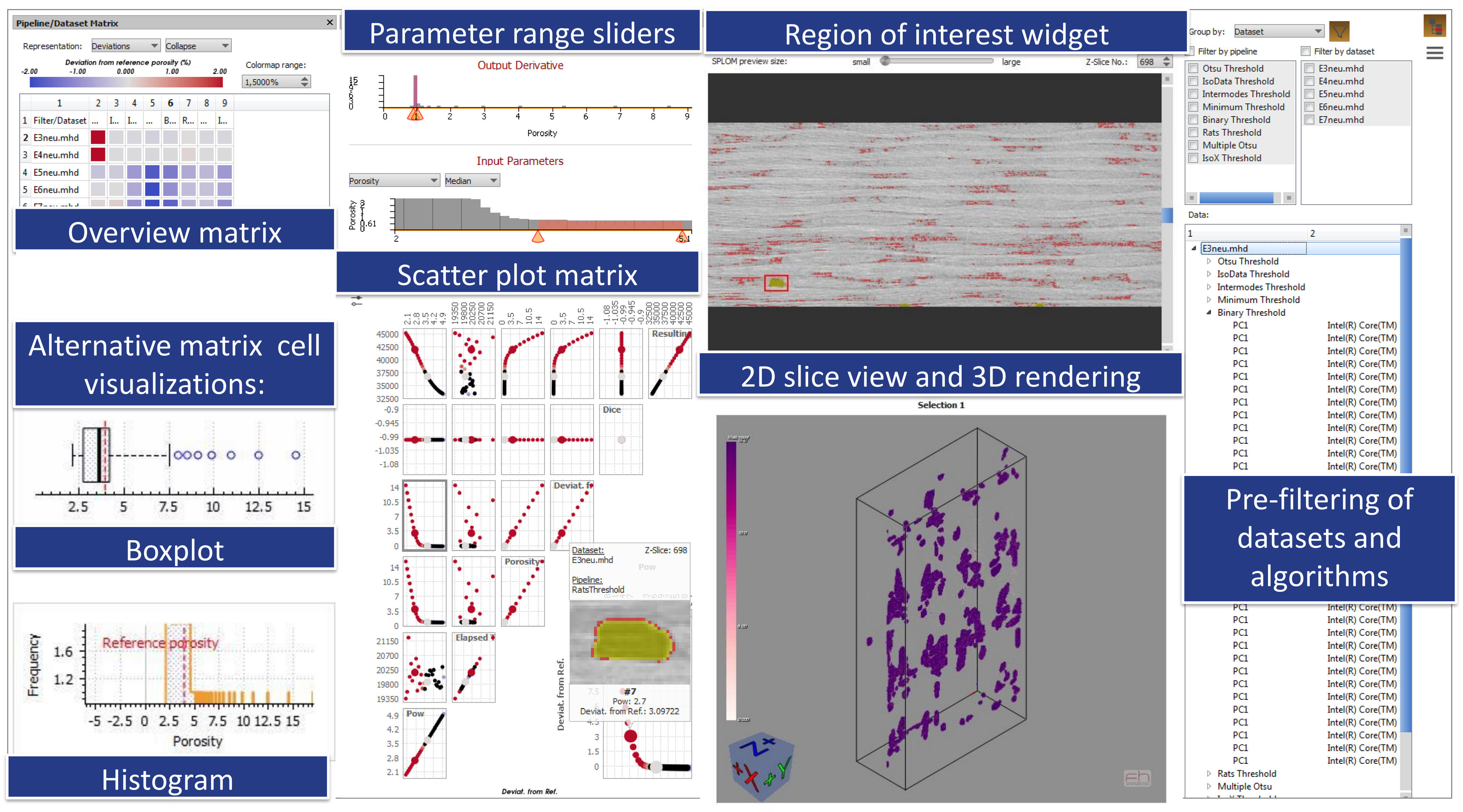
FeatureScout

FeatureScout explores features of interest (e.g., fibers, pores, cracks) in fiber reinforced polymers, as well as their properties (e.g., length, orientation). Individual objects can be filtered based on these properties, and objects with similar characteristics can be grouped into classes for further analysis. FeatureScout can show the distribution of object properties and a mean object for each defined class. Below, a glass-fiber-reinforced polymer dataset is shown, separated into classes by orientation and length.



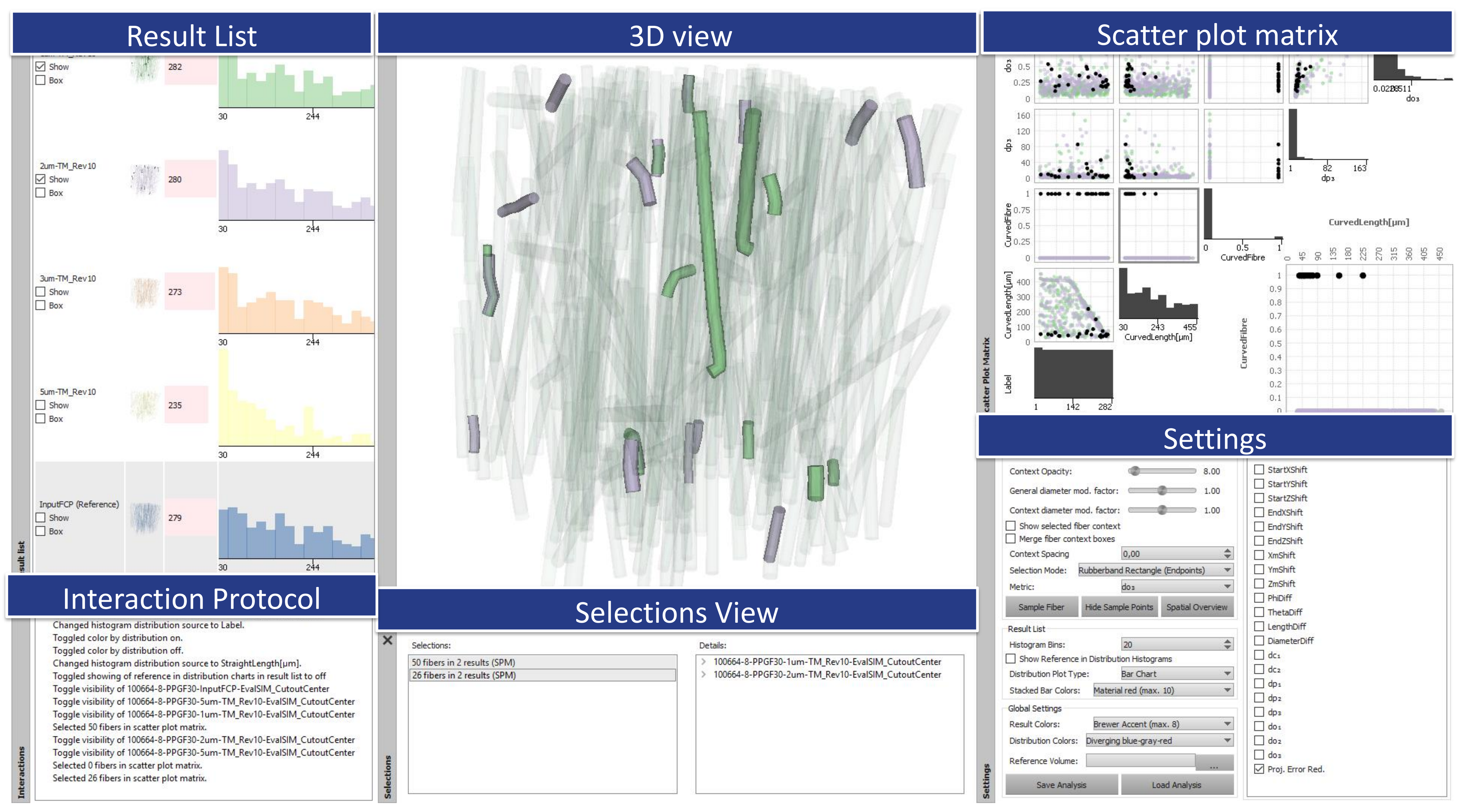
FeatureAnalyzer

FeatureAnalyzer supports the specification and parametrization of feature extraction and quantification pipelines (e.g., fibers or pores). It consists of a computation module and an analysis module. The computation module allows to setup and perform distributed computations for sampling the parameter space of (different) segmentation pipelines. The resulting segmentation masks and quantities are presented in the analysis module to find accurate and robust segmentation pipelines and parameters.



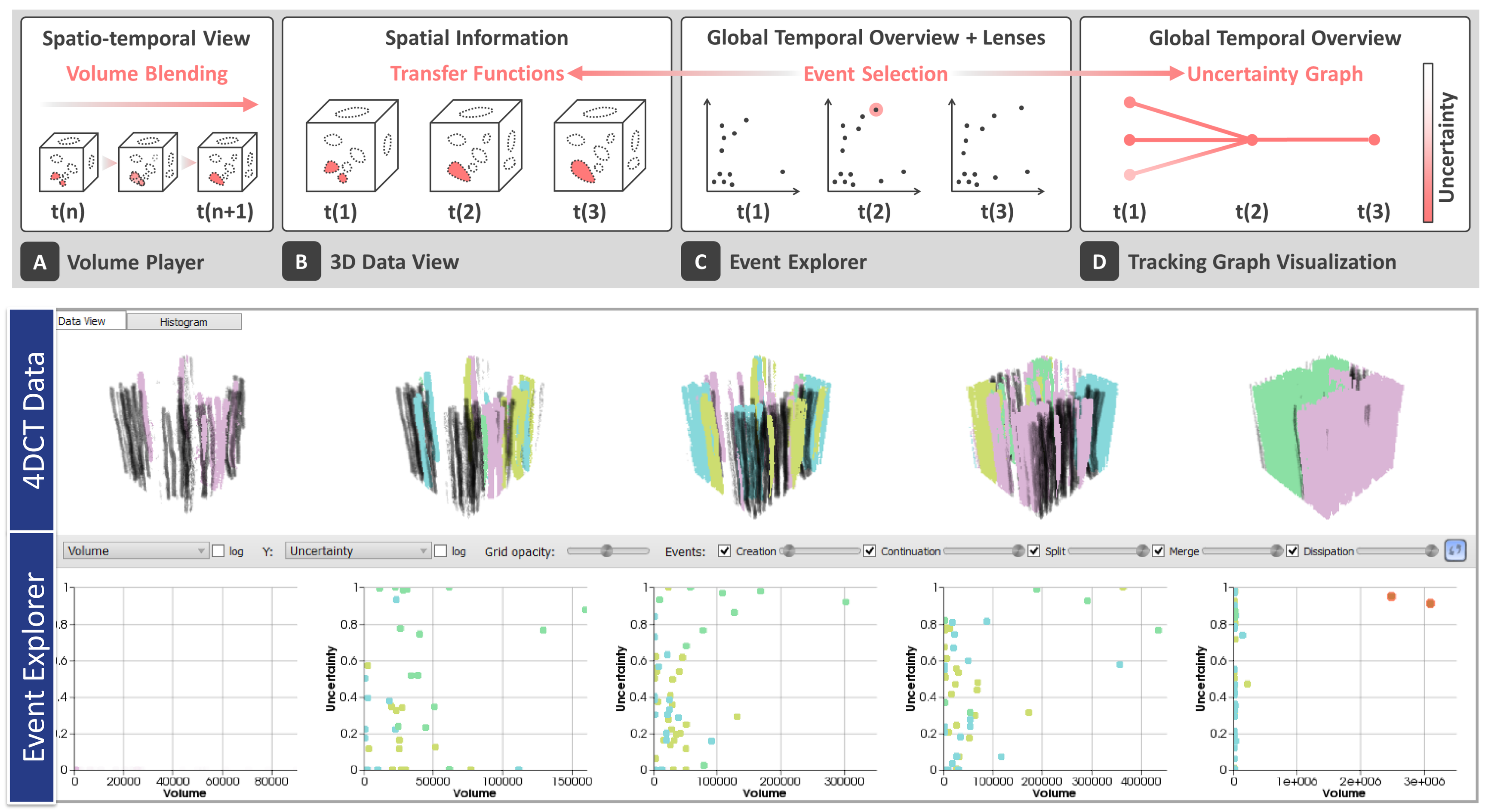
FIAKER

FIAKER analyzes and compares multiple fiber characterization algorithms. Results of fiber reconstruction pipelines are compared, e.g., from multiple algorithms or from different parameterizations of an algorithm: Qualitatively, by visualizing them side-by-side in a 3D view, as well as quantitatively, by computing the similarity between the fibers from different results through a variety of fiber dissimilarity measures.



4DCT – Feature Tracking

X-ray computed tomography, when combined with interrupted in situ tensile testing, where a work piece is scanned multiple times under varying tensile load, results in time series (i.e., 4D) CT data. Features can be tracked over the available time steps and are visualized in an event explorer and a tracking graph. The figure below visualizes an example of two small pores growing together in the second time step of the experiment.



References:

[1] B. Fröhler, J. Weissenböck, M. Schiwarth, J. Kastner, C. Heinzl, open_iA: A tool for processing and visual analysis of industrial computed tomography datasets, Journal of Open Source Software, 4 (35), 1185, 2019, doi: 10.21105/joss.01185.

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