**Extracting and Visualizing Local Statistics from Fibrous Materials**

This XTRA entry discusses the application of the “Spatial Graph Local Statistics” to extract statistical information from traced fibers in a fibrous material. It is assumed that the reader is familiar with both basic applications of Avizo and using XFiber extension in Avizo to generate fiber traces. Please refer to [this video](https://www.youtube.com/watch?v=6S2bY_bGWcE&t=) for basic Avizo application and [this video](https://www.youtube.com/watch?v=gb_j_ZGhNlY&t=) about how to use Avizo to trace fibers. The inputs required the original greyscale image and the traced fibers in the form of a spatial graph file.

This document covers:

1. **Spatial Graph Local Statistics**
2. **Overview of the Module Parameters**
3. **Results Visualization**

**1. Spatial Graph Local Statistics**

This module can be used to extract information on a localized level from traced fibers. The details of the modules will be described later in this document. But for now, select all the available options under the “Output” tab (Density, Surface Area, Orientation, Tensor, Spreadsheet, Decompose Tensor) and click “Apply” without changing other parameters. We will continue to refine this preliminary result throughout this guideline.

*Note: The Spreadsheet and Decompose Tensor options usually require large amount of memories, but since this dataset is small, it can be achieved.*

The results for density and surface area are greyscale images with higher greyscale values indicating higher volume fraction and surface area. The output for orientation is an orientation vector field and the Tensor output is a tensor field.

**2. Overview of the Module Parameters**

**Resolution and size:** The partitioning of the volume to extract statistical information from sub-partitions can be controlled using the “Resolution” parameters. There are two modes for defining this. Under the “Dimensions” mode, the users can set the total number of partitions in the X, Y, and Z directions (under resolution[px] tab) and Avizo will automatically partition the volume according to the input. Alternatively, the users can change the mode to “Voxel Size” and define the size of one partition (under “Voxel Size”). Then, Avizo will calculate and generate partitions with the defined size. In this example the Dimensions mode has been selected and the numbers are set to 20, 20, and 20 in X, Y, and Z direction.

By default, the size of the overall volume that is used for generating local statistics is the same as the size of spatial graphs bounding box. It can be changed under “Model BBox” to either a manual size or a reference size. If reference size is required, the users should first define the reference under “Data” input in the module. If a reference has been assigned and Model BBox is set to reference, local statistics will only be generated for a volume similar to the reference, not the whole volume of traced fibers.

If the information is needed for the whole volume, under “Compute Area” the output can be set to “Full Volume”. In addition, users can define the compute area with the “User Defined” option. If this option is selected, the partitions are still centered on the nodes of the lattice, based on the definition under Resolution or Voxel size, but the actual integration is performed on a cube with dimensions specified in the “Block Size”. This allows for overlap between the integration volume of neighboring partitions and smoother results. Here the values of 30, 30, 30 are selected for X, Y, and Z directions.

*Note: If you select a block size smaller than half the size of the resolution, you will not perform any integration, and this results in empty voxels in the results.*

**Accurate Measurement of Volume and Surface Area:** The spatial graph file that is the output of the fiber tracing process includes the full tensor field of all the traced fibers. However, the spatial graph file just by itself does not contain any information about the size or shape of the fibers. However, there are ways to provide this information to the “Spatial Graph Local Statistics” module, so the information can be extracted manually. The “Object Model” under “Compute Input” can be used to provide this input. There are three options for defining the shape for all the fibers under the “Compute Input”. One is using the “Cylinder”. This will assume a cylindrical shape for all of fibers, the users then can provide the radius of this cylinder and Avizo will calculate the surface area and perimeter of the fiber model automatically and use this to calculate the local distribution of surface area and volume. Alternatively, the object model can be set to “Arbitrary”, where the users can manually define surface area and perimeters of the fiber shape. When the input is set to “Cylinder” or “Arbitrary”, it is assumed that all the fibers have the same shape and cross-section. The most suitable mode, however, is using the “Use Object Mask” mode. Object Mask is a binary image that can be input under the “Data” section of the module. If provided, Avizo will use the binary image as an indication of the regions where the fiber is present and so, combined with the traced fibers, information about shape and size of fibers can be extracted. The object mask used should be a binary image which has selected all the fibers. Here, this object mask is generated by applying “Interactive Thresholding” on the original image.

*Note: When using the object mask, only the surface area between the fibers and the matrix will be calculated and not the surface area between individual fibers.*

**Masking.** There are occasions when there is a need to mask out certain regions from the image. A common example of which is when some of the partitions are on the edges of the sample and include some empty voxels that lead to inaccurate results. In this example, we have created the mask by applying a geometrical transformation (closing) to the binary image of the fibers. But other ways can also be utilized to generate a mask. Once a mask has been generated, it can be input in the “Data” under the “Mask”.

**3. Visualization of the results**

Different outputs of the module can be visualized differently. Major orientation is represented as a vector field and can be visualized using “Vector Slice” which presents the major orientation in each cross-section of the volume. Alternatively, the vector field can be converted into an RGB image using the “Vector to RGB” module. The colors in the image indicate the major orientation direction in each partition. The colors present X, Y, and Z in the same color-coding as the “Local Axes” module. Tensor field can also be visualized using the “Tensor View”. The surface area and volume are greyscale images where higher greyscale value indicate higher values for the partition.