Algorithmic aspects of converting surface mesh data to volumetric images

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Introduction

In image analysis, some processes might imply a change or conversion in the structure of the data. The structure types will depend on the processing method and applications, and can consist of pixel data, point sets, finite elements, vector fields, implicit surfaces, graphs, basic shapes (spheres, cylinders, or cubes), etc. The work presented here discusses the problem of converting a triangulated surface mesh to a 3D image, a need that arises for example when using active surface-type segmentation methods of 3D images, shape-fitting, or combining data from laser surface scanning with 3D imaging. During the course of numerous projects, two main classes of mesh-to-image conversions have appeared: those identifying voxels (pixels in a 3D image) that intersect the mesh, or voxels that are contained in the mesh, supposing it defines a closed surface.

Materials and Methods

Developing solutions to these two classes of conversion do not require complex mathematics, only basic 3D geometry is involved, but to develop accurate and efficient (i.e. with minimal computation time and memory usage) solutions, care must be taken in the definition and development of the methods.

The first class, identifying the mesh-intersecting voxels, consists in testing for this intersection using distance measurements with the infinity norm, and propagating the tests in the 6-neighbourhood. The latter class, finding the voxels inside the surface, uses a ray-tracing approach followed by a connected component identification.

The methods have been implemented in C++ and integrated into the Avizo software.

Results and Discussion

One example of the application of this conversion process is shown in figure 1: micro-tomographic reconstructions of a 1 cm diameter polypropylene foam sample are made (see the reference for the context of this work). Characteristics are sought at the bead level, and after several operations to extract the bead centers an active surface algorithm generates a triangulated mesh identifying bead interiors. Converting this data back to a 3D mask and combining it with the greylevels of the original image we can extract density characteristics for each bead.

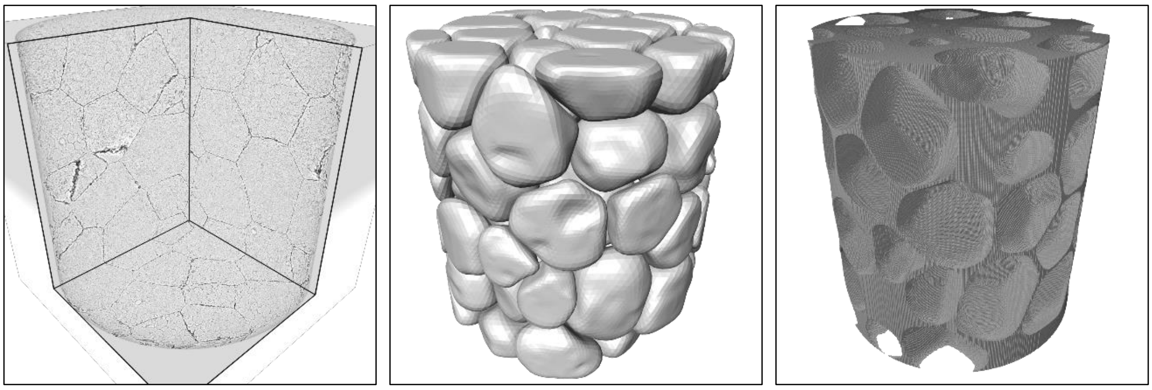

Figure 1. From left to right: orthogonal cross-sections in a tomographic reconstruction of a polypropylene foam sample; triangulated mesh resulting from the active surface algorithm that identifies the bead interiors; voxel rendering of the outside of those beads, after converting the mesh to a 3D image.

Conclusion

Efficient data structure conversions should be a basic requirement in any scientific data processing toolbox. When handling 3D image data the passage from a surface mesh to voxels in a cubic grid may arise, and when the data to process is very large (particularly several gigabytes in the case of tomography), the usability of any data processing depends on reasoned algorithmic choices.

References

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