Tomographic image analysis of reinforcement distribution in composites using a flexible and material's specialist-friendly computational environment

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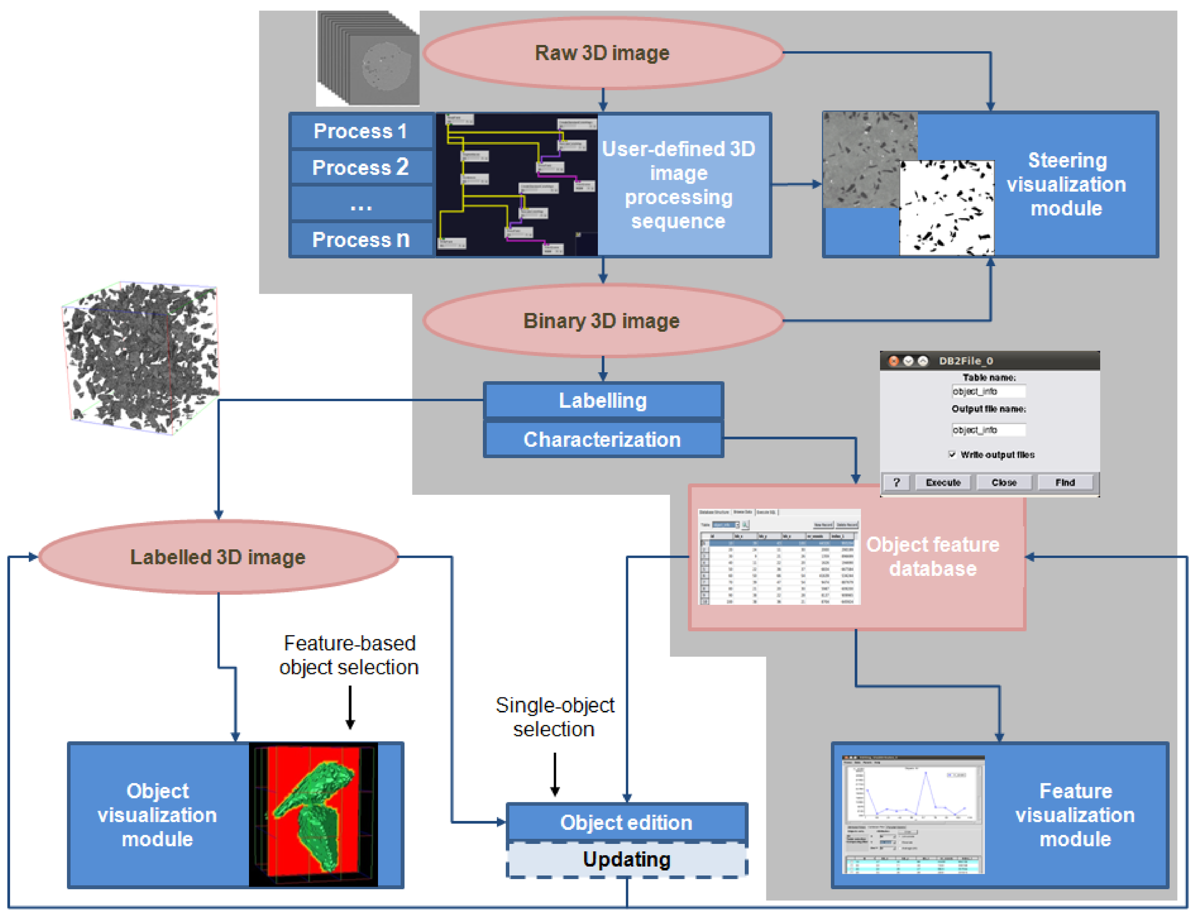
Abstract

A computational environment - in the following called Problem Solving Environment (PSE) - dedicated to the analysis of tomographic images of composite materials is presented. The PSE current version is centered on reinforcement characterization and its main features are: (i) running on a desktop PC equipped with GPGPUs (General Purpose Graphical Processing Units); (ii) allowing a non-specialist in Computer Science to define visual programs that specify a sequence of processing steps; (iii) execution times compatible with an interactive use, due to the computational processing power of GPUs; (iv) the inclusion of visualization modules and the possibility of steering the computations through parameter changes.



System overview

Materials Characterization By Ct

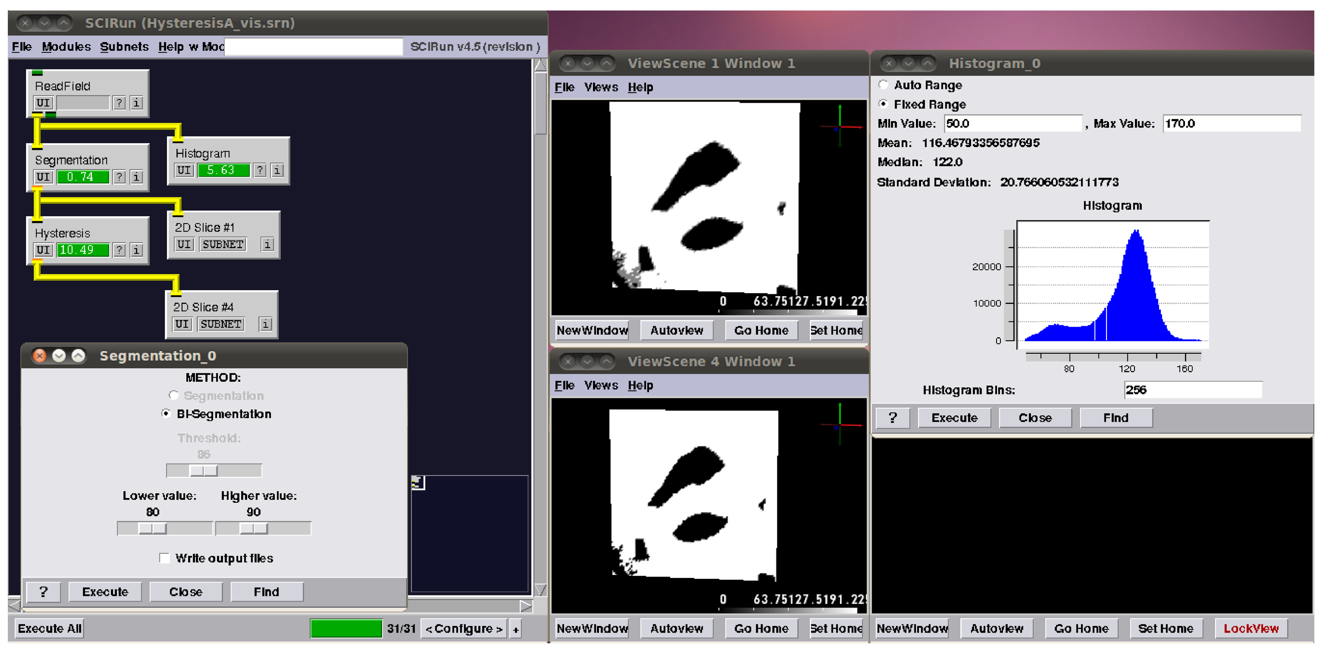
To solve structural characterization problems Materials Science specialists need a dedicated software application capable of:

- 3D data visualization;
- Support of image processing operations allowing adequate identification and labelling of the relevant objects;
- Determination of geometric characteristics of the previously identified objects;
- Flexible representation of those characteristics;
- Adequate storage of the processing results, allowing further investigation to be performed.

The TOMO-GPU system

TOMO-GPU is specifically designed for materials characterization through tomography, was developed over the SCIRun open access software platform. Its main advantages over existing systems are the flexibility in defining processing steps and the exploitation of parallel processing.

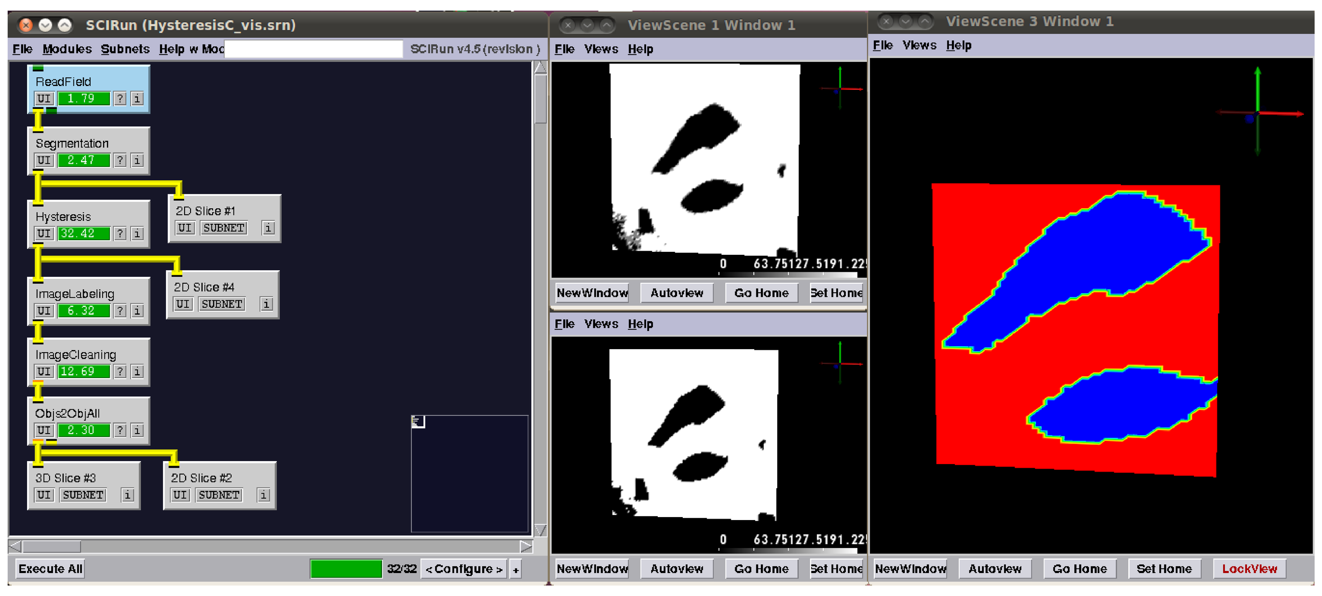
By adopting a parallel-computing approach, TOMO-GPU takes full advantage of the processing power of the Graphical Processing Unit to significantly speed-up 3D image processing in commodity hardware.



Hands-on session with TomoGPU

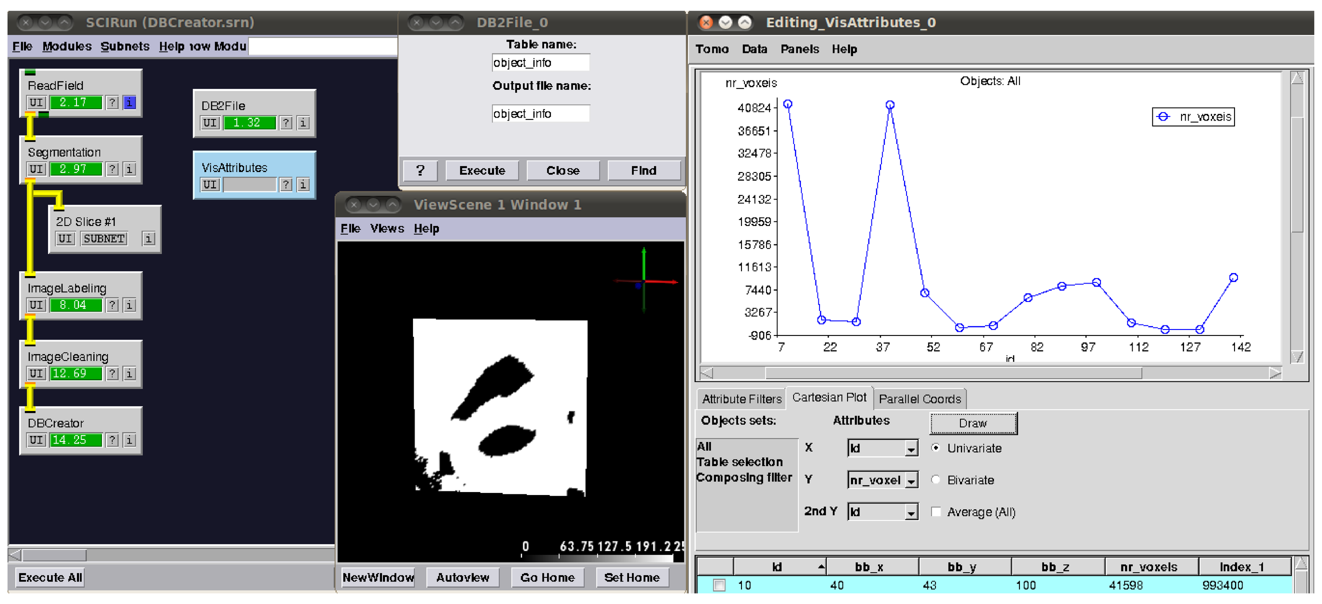
Getting a black and white image (Segmentation)

The processing sequence used to achieve adequate segmentation into a black and white image is illustrated at right. The left window describes the visually-built program sequence, including the bi-segmentation and hysteresis modules. Also shown are two windows used for visual comparison of the resulting image in different processing stages, as well as the histogram that guides the user's steering of the bi-segmentation process.



Labelling the image

A more advanced stage of the processing sequence is shown at left. The main addition concerns the image labelling module, which is tasked with the identification of the relevant objects present in the sample. For each identified object, the system assigns a distinct label, computes its size and codifies the coordinates of each of its voxels.



Object characterization

The final stages comprise two main modules: one generates a database containing each object's characteristics considered relevant by the user, while another is tasked with producing a graphical representation of the sample's selected statistics.

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Conclusions

- TOMO-GPU significantly expedites processing of tomographic images for composite materials characterization.
- Extensive imaging and information visualization modules are provided, both for image processing steering and final analysis of the results.
- Time-consuming processing steps are reduced through the use of 3D image processing algorithms been tailored for efficient execution in GPGPUs.
- Database storage of object characteristics and interactive graphical object selection have been added to allow material analysis in detail.

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