PROCESSING AND VISUALIZATION OF MASSIVE VOXELIZED DATA.

APPLICATION TO MICRO- AND BIO-STRUCTURES

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Research Units

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Framework

In the point of view of Computational Mechanics, the main numerical algorithms and methods are nowadays well settled, developed and stable. Today, the highest challenge is to bring and to introduce in the Computer Aided Engineering (CAE) software more and more the physics and the real description of the continuum media to be studied.

Let's consider that one intends to study the microstructure of any material or component (*think, for instance, on a plant, an insect, any metallic material or even a biomaterial, such a bone or a soft-tissue*). Any of these 3D real structures is very difficult to describe using classical CAD solid modelling, and the strong heterogeneity, the internal structures (*such as blood vessels or neuronal networks, for instance*), material properties' gradients and sharp features are difficult to identify and to take into account in numerical simulation under a CAE environment.

A possible method to discretise any of the abovementioned structures is by using a destructive technique, such as the so-called **serial sectioning**, in which the material is encapsulated and then, using a machining technique, several slices are successfully removed and the surface digitally photographed into a pixel-form data structure. Knowing the distance between slices one are able to recreate the all specimen in a 3-dimensional way, in a so-called voxelized-structure data.

It is worth noting that other destructive (electro polishing…) and non-destructive (micro-CT, CT, MRI,…) techniques can also be used, but none allows the very high resolution, accuracy and very tiny details identification achieved by serial sectioning.

But this procedure has a huge problem. Depending on the desired resolution and size of the object to be discretized, one can easily reach **many TByte** of data, which is very difficult to handle, process and, mainly, to visualize. If one is not able of ***real-time*** processing such huge amount of data, all procedure is simply useless.

The challenge is, thus, to couple the data acquisition procedure, which will be carried out at the Department of Mechanical Engineering, with the development of a set of tools, based on **HPC** tools, to process, manipulate and visualize the voxelized data and their internal structures, such as:

- Improve de images' quality (denoising);
- Assembling of 2D images
- Segmentation and identification of sharp features;
- 3D image reconstruction and 3D visualization of the 3D internal complex structures and networks;
- Develop a tool for post-processing this 3D data (meshing, attributes identification, simplification…).

This work shall help us to see deepen and inside the materials and bio-structures, as well to improve our knowledge on the microstructure of many materials. Their applicably in engineering and bio-engineering problems is enormous and an interesting challenge in the point of view of **HPC and data clustering**. Definitely, informatics plays a central and decisive role in all this process.

Objectives

The main goal of this proposal is to develop a high performance parallel scalable tool for the parallel processing, manipulation and visualization of massive voxelized data obtained from 3D structures discretization by serial sectioning.

The work includes the development of several algorithms, namely to:

- manipulate massive voxelized data;
- imaging processing and data clustering;
- process raw data acquired from serial sectioning by denoising, segmentation, sampling and identification of features (such as the internal structures, networks of vessels, neurons, fibers' fields,…);
- allow a real-time visualization: a special focus shall be put on user interaction and visualization, in real-time, of the processed voxelized data;
- visualization of the internal micro- or bio-structures;
- volume segmentation and visualization;
- 3D parallel finite element mesh generation, taking into account the specificities of serial sectioning technique.

It is worth mention that the development of this software shall potentiate many interesting collaborations in several fields of engineering and health sciences.