Département d'informatique
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Université de Strasbourg

Research internship Master 2

Representation and storage of very large meshes for out-of-core interactive visualization on GPU

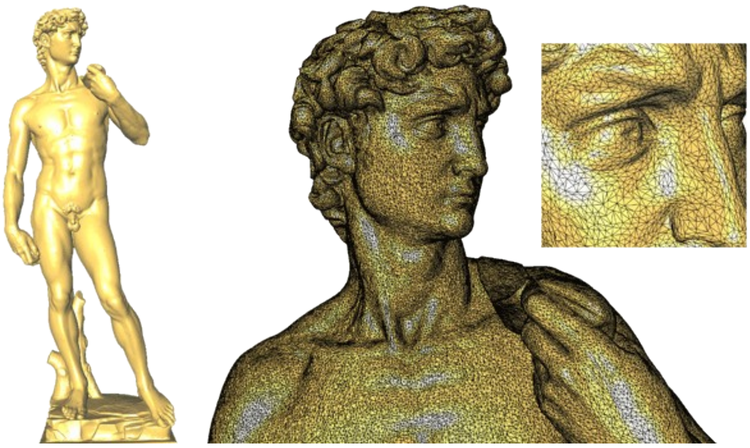

Figure 1: Large mesh from a 0.25 mm numerisation of a 5m statue of David. The Digital Michelangelo Project

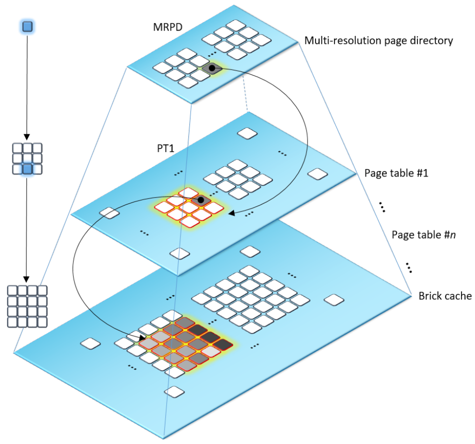

Figure 2: GPU virtual addressing structure: multi-resolution page table [1].

Location: Icube laboratory of the University of Strasbourg – Computer graphics and geometry group.
Supervision: Jonathan Sarton (sarton@unistra.fr), associate professor
Keywords: Meshes, partitioning, multi-resolution, out-of-core, visualization, GPU

Context and motivations:

Interactive visualization of data sets represented as meshes is an essential tool very commonly used in many scientific fields. In particular, meshes composed of triangles, very commonly used for the geometric representation of 3D surface models, or tetrahedral or hexahedral meshes, structured or unstructured, used for the simulation of physical phenomena, can induce complex structures that create data sets that are difficult to manipulate in interactive time due to their large size (see example Figure 1.).

GPUs are good targets for interactive visualization algorithms because of their computing power. However, their limited physical memory capacity is an issue when handling very large datasets.

We propose to address this problem by focusing on the development of an out-of-core approach capable of interactively accessing the entire mesh object, regardless of the geometry of its cells, with a memory representation greater than the physical memory capacity of the machine used for its manipulation.

Objectives of the internship:
Using an efficient data structure (illustrated in Figure 2.) for virtual addressing of very large regular 3D grids on GPUs[1], the objective of this internship is to focus on an extension for different types of surface or volume mesh.

In order to manipulate these very large meshes for interactive visualization on GPUs, we will focus on three points in this internship:

1. The decomposition of the mesh domain by a "brick" partititioning. This partitioning must consider both the spatial consistency of the mesh object and the consistency of data caching on the GPU.
2. The design of a multi-resolution representation, thus reducing the amount of data to be addressed by adapting the level of detail in a multi-resolution visualization algorithm.
3. The efficient storage of the selected representation (in 1. and 2.). This storage must be performed at different levels: mass storage on disk and an efficient caching system on the GPU.

These three points are common in a multi-resolution GPU visualization context including a paging system [2,3]. The aim here is to propose a generic method capable of manipulating different types of 2D or 3D meshes, regardless of the geometry of their cells (triangles, tetrahedrons, hexahedrons, etc.) and their structure (regular, structured, unstructured).

Candidate profile:

- Master 2 or computer engineering school student.
- An interest in 3D, geometry, topology, parallel computing and more generally mathematics and computer science is required.
- The trainee must be comfortable in C++ programming and a knowledge of GPU programming with CUDA would be a plus.

Candidates are invited to send their application letter and updated CV to Jonathan Sarton (sarton@unistra.fr). We encourage you to contact us by email with any questions or to discuss the subject further.

Références bibliographiques :
[1] Sarton, J., Courilleau, N., Remion, Y., Lucas, L.: Interactive Visualization and On-Demand Processing of Large Volume Data: A Fully GPU-Based Out-Of-Core Approach. IEEE Transactions on Visualization and Computer Graphics pp. 1–1 (2019)
https://doi.org/10.1109/TVCG.2019.2912752
[2] Gobbetti, Enrico, Dave Kasik, et Sung-eui Yoon. « Technical Strategies for Massive Model Visualization », 2008, 11.
[3] Du, Zhiyan, et Yi-Jen Chiang. « Out-of-Core Simplification and Crack-Free LOD Volume Rendering for Irregular Grids ». Computer Graphics Forum 29, nº 3 (2010): 873-82. https://doi.org/10.1111/j.1467-8659.2009.01705.x.