ERCIM "ALAIN BENSOUSSAN"
FELLOWSHIP PROGRAMME

ERCIM
European Research Consortium
for Informatics and Mathematics

Scientific Report

First name / Family name	Jonas Martinez Bayona
Nationality	Spanish
Name of the *Host Organisation*	INRIA
First Name / family name of the *Scientific Coordinator*	Sylvain Lefebvre
Period of the fellowship	01/04/2014 to 31/03/2015

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During my stay at the ALICE group of INRIA Nancy, my research has been devoted to two main topics: the effective computation of offset surfaces in the context of fabrication, and the meshing of surfaces that can sampled by the rasterization pipeline.

Morphological operations (such as erosions and dilations) are important operations in solid modeling, but its computation for general inputs is difficult. In the context of fabrication, erosions and boolean differences can be used for example to hollow a solid or create a mold, while closing operations can remove small holes in a model. We introduced a novel technique to compute morphological operations that considers sequences of erosions and dilations along line segments. The technique is well-suited for direct visualization and fabrication. This work has been accepted for publication in Computer & Graphics journal, and presented at Shape Modeling International 2014 conference.

We also presented a novel approach for surface meshing. The key observation we exploited in our work is that most surface representations are rasterizable; that is, there exists an efficient algorithm to produce surface samples that are displayed on screen for visualization. Indeed, the vast majority of 3D software applications visualize 3D objects by explicitly providing rasterization routines, most often in the form of GPU pixel shaders. We proposed a highly parallelizable surface meshing algorithm that is independent from the surface representation and is applicable as long as rasterization routines are available. Our technique directly produces meshes having a good surface sampling and triangles of high isotropy. This work has been published as technical report and has been submitted to a journal.

Apart from these lines of research, I actively contributed to the development of IceSL software, a modeler and slicer for 3D printing.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Chained segment offsetting for ray-based solid representations
Jonas Martinez, Samuel Hornus, Frédéric Claux, Sylvain Lefebvre
Computer & Graphics 46 (2015), 36-47.

Abstract - We present a novel approach to offset solids in the context of fabrication. Our input solids can be given under any representation: boundary meshes, voxels, indicator functions or CSG expressions. The result is a ray-based representation of the offset solid directly used for visualization and fabrication: We never need to recover a boundary mesh in our context.
We define the offset solid as a sequence of morphological operations along line segments. This is equivalent to offsetting the surface by a solid defined as a Minkowski sum of segments, also known as a zonotope. A zonotope may be used to approximate the Euclidean ball with precise error bounds.
We propose two complementary implementations. The first is dedicated to solids represented by boundary meshes. It performs offsetting by modifying the mesh in sequence. The result is a mesh improper for direct display, but that can be resolved into the correct offset solid through a ray representation. The major advantage of this first approach is that no loss of information -- re-sampling -- occurs during the offsetting sequence. However, it applies only to boundary meshes and cannot mix sequences of dilations and erosions. Our second implementation is more general as it applies directly to a ray-based representation of any solid and supports any sequence of erosion and dilation along segments. We discuss its fast implementation on modern graphics hardware. Together, the two approaches result in a versatile tool box for the efficient offsetting of solids in the context of fabrication.

Raster2Mesh: Rasterization based CVT meshing
Jonas Martinez, Frédéric Claux, Sylvain Lefebvre
Research Report RR-8684, Inria Nancy (2015), pp.27

Abstract - In this paper, we propose to extend high quality Centroidal Voronoi Tessellation (CVT) remeshing techniques to the case of surfaces which are not defined by triangle meshes, such as implicit surfaces. Our key observation is that rasterization routines are usually available to visualize these alternative representations, most often as OpenGL shaders efficiently producing surface samples (fragments) from the surface representation. Our technique has the ability to mesh any surface for which rasterization routines are available, and runs entirely within the OpenGL rasterization pipeline. There is no intermediate representation: the triangle mesh is computed directly from the surface fragments. Our method produces high quality meshes, as it inherits the properties of CVT meshing. Contrary to existing GPU techniques for CVT computation, it does not require a surface parameterization, and it extracts the mesh topology directly from the surface fragments. Optionally, our algorithm can produce two-manifold, consistently oriented meshes. We describe our complete implementation and show a variety of applications: direct meshing of implicit surfaces, meshing of operations between solids, mesh repair, and solid sculpting. We analyze performance, correctness and mesh quality.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

International convention for Symposium on Solid and Physical Modeling (SPM) and Shape Modeling International (SMI) 2014.
October 26 - 30, 2014, Hong Kong.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

I visited the Visual Computing Lab of CNR-ISTI (Pisa, Italy) from 3 to 6 of March 2015. I have been hosted by Paolo Cignoni. During the week, I had various meetings with different team members to discuss about research in computer graphics, with special attention to 3D printing. I also gave a conference about IceSL, a software developed in our team for modeling and slicing with 3D printers, and our recent work about offsetting solids in the context of fabrication.