Tremplin recherche - ESIEE

Title: Implicit surface representation using Geometric Algebra

Advisors: Vincent Nozick, Yukiko Kenmochi

Host laboratory: Laboratoire d'Informatique Gaspard-Monge (LIGM)

International Partner: Akihiro Sugimoto, Stéphane Breuils (NII-JFLI, Tokyo, Japon)

Targeted Esiee departments: Computer Science

Hosting team:
This project will be conducted by researchers from both LIGM in France and NII-JFLI in Japan. The LIGM (Laboratoire d'Informatique Gaspard Monge) is a "Unité Mixte de Recherche" supported by the CNRS and Université Gustave Eiffel, and is leader in some computer sciences fields like algorithmic and image processing. The NII (National Institute of Informatics), located in the center of Tokyo, is a very prestigious research institute covering all research aspects in computer science. Finally, the JFLI (Japanese French Laboratory for Informatics) is a CNRS International Research Laboratory, located at NII.

Both French and Japanese sides researchers involved in this project are active researchers working on the fields of Geometric Algebra, Digital Geometry and Computer Vision with recognized international expertise.

Context:
Surfaces are widely used in engineering, computer graphics, physics, and many other disciplines. In computer graphics, surfaces are usually described as a triangle mesh associated with a texture, or by some parametric equations, like splines. An emergent alternative consists in implicit surface representations, described, for example, as a (truncated) signed distance function (TSDF) f of space, where $f(p)<0$ means that a point p at position (x,y,z) is inside the volume delimited by the surface. If $f(p)>0$, the point is outside and if $f(p)=0$, then the point p lies on the surface. Naturally, all the concern is about how to define such a TSDF f.

In the context of this project, we propose to use Geometric Algebra (GA) [1-3] to define such a function. GA is a very intuitive and powerful tool to do geometry. Indeed, GA can represent some basic objects (lines, circles in a 3D space, spheres, planes, …) just by control points. Moreover, GA also provides distance information from points to objects.

The idea here is to define the implicit surface by creating several objects using GA and by combining the point to object distance functions from a point to all these objects.

We target various applications, from computer graphics to virtual reality. We are also interested in visualizing such implicit surfaces and their intersections with their geometric and topological consistency. One way to realize this goal is voxelizing implicit surfaces with the help of digital geometry and topology [4], which can provide useful tools for geometric and topological guarantee.

Plan:
The first step consists in discovering Geometric Algebra as well as implicit surfaces methods. Then, the second part deals with the point to object distance. First with GA objects, then with intermediary objects built from few basic objects, like a cube, a pyramid or a torus. Then, we want to define more complex surfaces, from a possibly large set of basic objects. Lastly we will explore and develop visualisation tools.

More information:
Contact Vincent Nozick (office: Esiee 5357) or Yukiko Kenmochi (office: Esiee 5351).

Bibliography:
[1] Vince, John. Geometric algebra for computer graphics. Springer Science & Business Media, 2008.
[2] Youtube video tutorial : https://www.youtube.com/watch?v=tX4H_ctggYo&t=197s&ab_channel=enkimute?t=18m05s
[3] Another Youtube video : https://www.youtube.com/watch?v=mz3tk4LRJjc&ab_channel=PeeterJoot
[4] Reinhard Klette, Azriel Rosenfeld. Digital Geometry: Geometric Methods for Digital Picture Analysis, Morgan Kaufmann, 2004.