P.h.D. thesis subject proposal

Title: Geometric characterization of the roughness evaluated on surfaces.

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Context:

Roughness is a complex concept. It is difficult to give a general definition, because it often depends on the application domain and context. Numerous studies have been carried out to assess roughness, in application fields related to physics and mechanics, where the control of the surface roughness is a major need for manufacturers. There are many mathematical tools to try to describe the notion of roughness. Standards have even been established (ISO 25178 and 16610) to define surface roughness parameters. Most of the time, these parameters are global or local statistical quantifications of surface properties, such as its frequency composition or its variations around a reference measurement (Ra, Rs, Hölder coefficient, ...). These characterizations are difficult to link to physical properties because a characteristic value corresponds to surfaces with very different geometries. It seems more relevant to propose a geometric characterization of roughness. This is based on the control of pseudo-tangent vectors [1,2] (see Figure 1: red and blue vectors). We suggest to use fractal based tools to synthesize and analyze roughness.

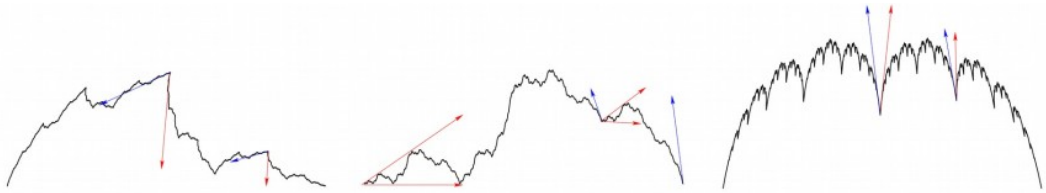

Figure 1: Examples of differential properties of rough fractal curves. It is possible to determine pseudo-tangents which characterize their differential behavior.

The generalization of pseudo-tangent vectors to surfaces is called pseudo-tangent spaces. These latter make it possible to control the surface roughness (see Figure 2).

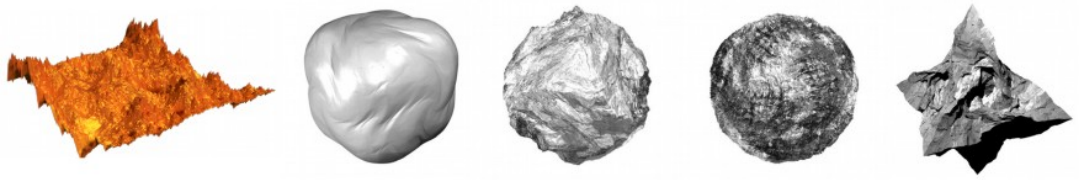

Figure 2: Examples of deterministic rough surfaces generated by BCIFS [3] (model based on fractal geometry).

The theoretical objective of this thesis is to propose a geometric characterization of surface roughness from fractal models, for objects of arbitrary topology, represented by 3D meshes. This characterization will generate a corpus of geometric models (curves and surfaces) of reference roughness. This corpus will be available to researchers and engineers of all disciplines to carry out numerical simulations. They will serve to understand the impact of roughness on a physical phenomenon and to study its properties. For this exploitation, tools for exploring the corpus will be used to extract a family of roughnesses of interest. To index each reference roughness in the corpus, it must be identified precisely thanks to standard roughness measures and a set of additional characteristics. This last characterization is to be developed using wavelet analysis methods [4]. We can then implement the opposite process: starting from a set of real surfaces and their characterization by wavelet analysis, the user will be able to find, in the corpus, numerical models with similar properties. The user can also modify the parameters of a reference model, to vary its roughness and study

the impact on the studied problem.

[1] S. Podkorytov. Espaces tangents pour les formes auto-similaires. Thèse de l'Université de Bourgogne, 2013.
[2] S. Podkorytov, C. Gentil, D. Sokolov, S. Lanquetin. Joining primal/dual subdivision surfaces. Mathematical Methods for Curves and Surfaces, Volume 8177 of Lecture Notes in Computer Science, pages 403–424 (Springer Berlin Heidelberg), 2014.
[3] D. Sokolov, G. Gouaty, C. Gentil. Boundary controlled iterated function systems. In Curves and Surfaces, volume 9213 of Lecture Notes in Computer Science, pages 414-432. Springer International Publishing, 2015.
[4] S. Mallat, W. L. Hwang. Singularity detection and processing with wavelets. IEEE Transaction on Information Theory 38(2):617 - 643, Avril 1992.

Prerequisites:
- The candidate will preferably have a computer science profile or an applied mathematics one, with good computer skills,
- good knowledge in signal processing, geometric modeling and statistics,
- knowledge in differential and algorithmic geometry would be appreciated,
- C ++ programming, OpenGL.

The planned research will take place in Dijon in the LIB laboratory (Université de Bourgogne Franche-Comté).

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