TITRE: Multi-scale Vectorial Representation and Analysis of Detailed Geometry
EQUIPE/THEME: Image et sons, MVI3D (IPARLA)
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DESCRIPTION du SUJET:

Scientific context

In the last decade, the domain of Computer Graphics has exhibited tremendous improvements in image quality, both for 2D applications and 3D engines. This is mainly due to the availability of an ever increasing amount of shape details, either created by artists in modern digital drawing or sculpting applications, or densely scanned from real-world objects. Unfortunately, visual richness comes at a price. Indeed, detailed geometry implies huge masses of data, which go from the numerous control points and color labels necessary to create compelling 2D drawings, to the finely tessellated meshes combined with high-resolution textures found in 3D applications. Having to deal with such dense representations not only raises memory, performance and filtering issues; but it also severely impoverishes editing and animation abilities since input data contain no semantic information.
Recent methods have addressed these problems by proposing workarounds dedicated to particular topics: dynamic levels of details (e.g., [2]) adjust geometry in a view-dependent way; cage-based methods (e.g., [3]) deform space around objects of detailed geometry; new vector formats (e.g., [1]) create color gradients with a sparse set of curves. However, all these techniques require a lot (often hours) of manual tweaking and are often limited regarding input complexity. Such limitations are primarily due to the use of a dense set of low-level primitives to represent the detailed geometry.

Goal

The main goal of this thesis is to develop a novel representation for rich shape and detailed geometry. It will be defined in terms of a sparse set of vectorial primitives that represent meaningful information at multiple scales. This is to contrast with the dense set of low-level primitives that represent raw data as used in conventional applications. As an example, consider a curve in the plane exhibiting many undulations combined at various scales. Instead of representing it as a dense sequence of distinct control points, the curve will be characterized by a sparse sequence of overlapping 2D primitives, each representing one undulation at a single scale. The same approach will be taken for color gradients, or surface structures of 3D objects, and will significantly ease further processing such as editing, animation and rendering. The main challenge of this thesis is thus to identify the most appropriate family of vectorial primitives for each new type of geometric entity. It raises additional issues though: 1) provide a minimal set of tools for defining and assembling primitives; 2) offer real-time rendering and manipulation routines that work directly at the primitive level; and 3) convert geometry provided in raw data format to our vectorial format via feature extraction mechanisms.
The range of applications that will benefit from such a representation is vast; hence, the PhD candidate will be able to make his/her own choice of research directions depending on his/her personal interests.

Project

The simplest way to investigate a multi-scale vector representation is with vector drawing. There are

two interesting directions to pursue in this case. One consists in analyzing drawn curves as sequences of undulations as proposed previously: it will allow users to manipulate a curve at multiple, salient scales, and ease the creation and editing of drawings. A second approach will provide new color gradient models: existing methods [3] only have an indirect control on the geometry of gradients, and a more direct control is likely to constitute a significant contribution in the field of vector drawing tools.
With the first vector primitives and their associated reconstruction techniques established, the PhD candidate will have the opportunity to choose between a number of follow-up research directions. One would be to make use of the vector representation for more advanced 2D applications, such as automatic simplification (for printing, or web-design), or animation (for user interfaces, web games, and cartoons). Another direction would be to adapt the technique to 3D modeling and rendering applications, such as semantic levels-of-detail or facial animation (with primitives representing facial traits). In the later case a collaboration with z-brush [4] would be easy since part of the team is located in Bordeaux.
As a matter of fact, the candidate should exhibit a strong background in computer graphics and some mathematics and programing skills will be required. Finally, a knowledge of 2D drawing and/or 3D modeling tools would be a valuable plus for the project.

References

[1] Orzan, A., Bousseau, A., Winnemöller, H., Barla, P., Thollot, J., and Salesin, D. 2008. Diffusion curves: a vector representation for smooth-shaded images. In ACM SIGGRAPH 2008.
[2] Guennebaud G., Germann M. and Gross M. 2008. Dynamic Sampling and Rendering of Algebraic Point Set Surfaces. In Computer Graphics Forum (Eurographics 2008).
[3] Joshi, P., Meyer, M., DeRose, T., Green, B., and Sanocki, T. 2007. Harmonic coordinates for character articulation. ACM Trans. Graph. 26, 3 (Jul. 2007).
[4] Pixologic – Zbrush software. Url: http://www.pixologic.com/zbrush