Master Project

Multi-resolution sketches
Zooming into scientific illustrations with unlimited levels of details

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Context and motivations

Although we mostly experience it at a single scale, nature is full of details. We are often fooled by our limited perception of it, such as interpreting as a surface what may be, at a smaller scale, some distribution of short fibers. Being able to show and explain such a multi-scale complexity can be essential for communicating about the nature and function of natural objects.

For instance, if a biologist was to explain the function of an organ, she may like to draw its rough shape over the 3D body of an mannequin in order to indicate its location; then she would zoom in to show the detailed organization of tissues - with their complex distributions of fibers, vessels, and folded membranes; and then zoom in again to reach the scale of cells; and finally she may zoom again into an individual cell to explain their internal complexity. Here, zooming in is to be interpreted as a combination of moving forwards across 3D matter, and progressively changing scale, to focus on smaller details.

There is currently no easy way to provide such inspiring, visual experience. Could we design some immersive illustration system, where the user could progressively create and enrich such a multi-resolution sketch, which could then be freely explored, by continuously zooming in and out?

Objective

The goal of this project is to develop an interactive sketching system for multi-scale, volumetric illustrations. The sketching environment should enable users to iteratively sketch a few strokes, use an interpretation module to automatically interpret them as some 1D, 2D or 3D shapes - or their distribution, and visualize the result accordingly, with the option to switch to another valid interpretation in ambiguous cases. Users should then be able to progressively zoom in and refine the visual environment, by over-sketching details from another scale. At each stage of this creative process, they should be able to freely zoom in and out within the resulting, multi-scale illustration.

Methodology

New research will be necessary to solve the problem, building at the same time on sketch-based modeling techniques in Computer Graphics (CG) - namely methods enabling to create 3D models from 2D sketches, the advanced compositing techniques used in both traditional and digital animation, and the fundamentals of scientific illustration.

Sketch-based modeling in CG was developed both in terms of iterative sketching systems for general shapes – such as the Matisse system, based on implicit surfaces, and which can be tested online [1], and as specialized creation tools for specific 3D models such as a dress [2] or a tree [3]. This second category

of systems heavily rely on prior knowledge on the shape being designed to interpret the sketch into 3D. Sketching can also be used as annotation to deform and add details on a base model [4]. To our best knowledge, multi-resolution sketches were only experimented so far in the specific case of trees [3]. But nested sketches conveying different layers of details were proposed for quick prototyping in architecture [5]. As shapes in nature and the details they carry are not isolated, but usually come as distributions of similar elements, specific works addressed the creation of distributions of objects from examples [6, 7].

This internship with focus on the remaining challenges in multi-scale illustrations, namely proposing general ways to interpret the sketched strokes, using a mix of 2D, 2,5D and 3D, designing methods to convey this interpretation through some adapted visual rendering (eg. using textures layered on planar or curves surfaces...) and developing visualization mechanisms to continuously zoom in and out.

Environment provided, and pursuit in PhD

The work will take place within the *Geometry & Visual Computing* team of LIX, bâtiment Alan Turing, 1 rue Honoré d'Estienne d'Orves, 91128 Palaiseau, on the campus of Ecole Polytechnique. All the necessary material (computer, sketching tablet) will be provided.

After a successive internship, the candidate will be given the option to apply for a grant to pursue this research as a PhD student, funded by CREATIVE AI fellowship of Hi!Paris.

Expected skills

We are looking for an excellent candidate, with a good scientific background in both math and computer science, some knowledge in artificial intelligence, and expert in visual computing (Computer Graphics, image processing, etc). Some previous experience in CG programming is mandatory, eg. C++/ OpenGL or Javascript/WebGL. Skills in drawing and illustration will be greatly appreciated.

Bibliography

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