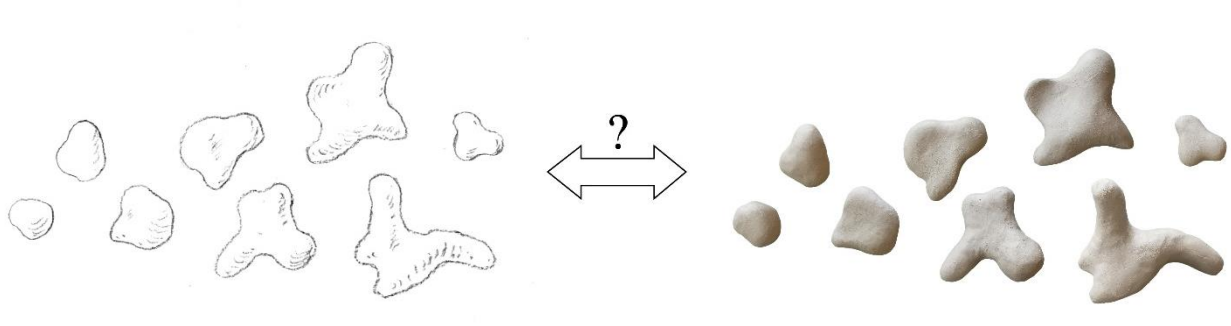
Bachelor Project

Learning the relationship between hand-made drawings and 3D shapes



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Context and motivations

Hand-made drawing and 3D shapes usually belong to two very different worlds: while a drawing consist in strokes made on paper (in French "des traits sur papier"), directly visible through the eyes, 3D shapes have to be visualized through virtual cameras, using shaders and projective geometry. However, both address the same question: how can we represent a form in space? Consequently, there must be a relation between the two.

Creating a 3D model from 2D sketches is the goal of the sketch-based modeling approach. The problem has been solved in certain situations, using hypothesis on the geometry of the object (flat silhouettes only [1], buildings with flat walls [2], vessels with round shapes, folded surfaces…). On the other direction, non-photorealistic rendering techniques have been widely developed to produce the appearance of animated drawing at the output of 3D pipelines. This was used to build artificial datasets of pre-labelled examples, used to learn the inverse mapping from stroke-based rendering to 3D [3, 4, 5].

Despite all those achievements, the deep relationship between "2D" and "3D" remains mysterious, and we can start to understand why. On the one hand, recent studies indicate that drawings contain more spatial information than what the expression "2D" or "2.5D" suggests [6]. Some of this latent information may be accessible through simple image processing operations, associated with geometric rules. But on the other hand, some parts of the drawing process may involve too many dimensions to be described this way. Modern AI techniques make it possible to learn such non-linear mappings between points and vectors in high-dimensional spaces.

Considering those new possibilities, is it possible to imagine a new approach for producing 3D from drawing and drawings from 3D?

Objective

The general goal of this project is to develop a mapping method between drawings, considered as "series of strokes made on paper", and 3D shapes. Working with complex drawing as well as complex 3D shapes would be too far-fetched for this project, so we will focus on the diversity of simple shapes and their deformations.

The mapping is supposed to go in both directions: "drawing > 3D model" and "3D model > drawing". This should allow experiments such as "drawing > 3D model > *turn the 3D model* > drawing", in order to compare the result with conventional morphing approaches.

If successful, even with simple shapes, this project could be directly applied in the context of multi-scale scientific sketching.

Methodology

We will build on the idea that strokes can be interpreted as transformation possibilities (translation, rotations, scale changes…) at various scale. Consequently, a range of rigid and non-rigid transformations can be inferred from an appropriate processing of the strokes, but learning may be necessary to make a choice between all those possibilities. The types of learning techniques to be used must be defined accordingly to these needs.

The production of 3D shapes may be purely digital or use real clay modeling, which can be filmed or reconstructed in 3D through photogrammetry. In both cases, a projection device will allow us to create hand-made drawing matching different view of those shapes. One or several professional artists will be involved in both sculpting and drawing.

Then, we will take advantage of the possibility of generating "automatic strokes" from 3D or video images, simply by computing the difference between two slightly different views of the same object, obtained through a controlled transformation. The similarity between "automatic" and "hand-made" strokes will be used as a link between the worlds of drawing and 3D.

Environment provided

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, camera, camera stand, projector) will be provided.

Expected skills

We are looking for candidates with a good scientific background in math and computer science, and a good level in both artificial intelligence and visual computing (Computer Graphics, image processing, etc). Experience in Java programming and/or CG programming is mandatory. (eg. C++/ OpenGL or Javascript/WebGL). A good vision in space, as well as skills or interest for drawing and modeling, will be greatly appreciated.

Bibliography

[1] Matisse: Painting 2D regions for Modeling Free-Form Shapes. Adrien Bernhardt, Adeline Pihuit, Marie-Paule Cani, Loic Barthe. SBM'08 - Eurographics Workshop on Sketch-Based Interfaces and Modeling, Jun 2008, Annecy, France. pp.57-64,

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[3] BendSketch: Modeling Freeform Surfaces Through 2D Sketching, C. Li, H. Pan, Y. Liu, X. Tong, A. Sheffer, W. Wang, ACM Transactions on Graphics (Proc SIGGRAPH), 2017.

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[5] Lifting Freehand Concept Sketches into 3D, Y. Gryaditskaya, F. Hähnlein, C. Liu, A. Sheffer, A. Bousseau, ACM Transactions on Graphics (Proc SIGGRAPH Asia) 2020

[6] From Sketches to Morphing: New Geometric Views on the Epistemological Role of Drawing (archives-ouvertes.fr). Renaud Chabrier. In: Flash T., Berthoz A. (eds) Space-Time Geometries for Motion and Perception in the Brain and the Arts. Lecture Notes in Morphogenesis. Springer, 2021, pp.151-183