Dynamic Sketches :
Coarse to fine modeling of 3D shapes in motion

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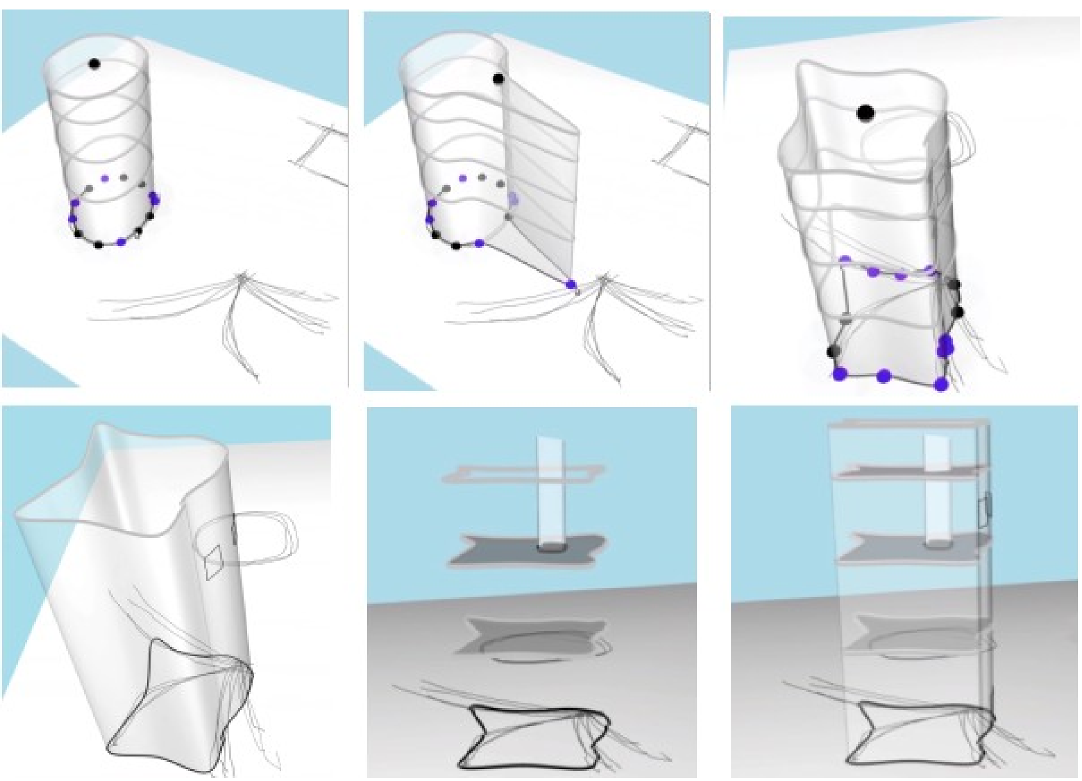
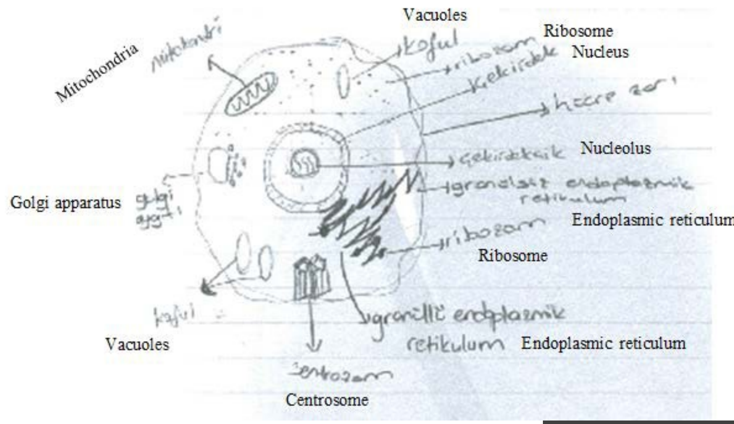
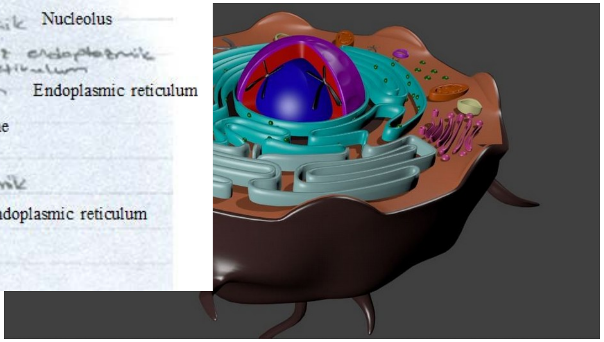


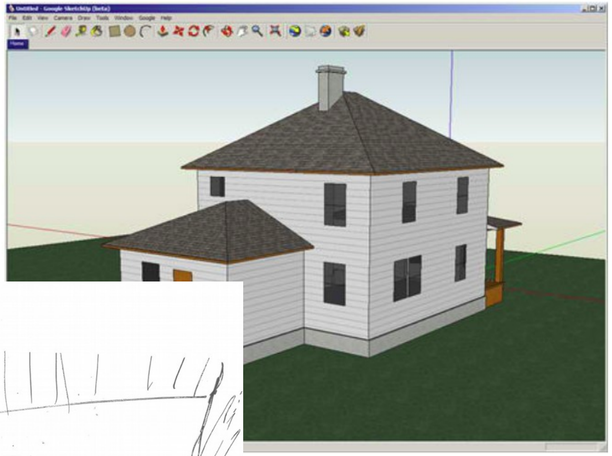
Motivation



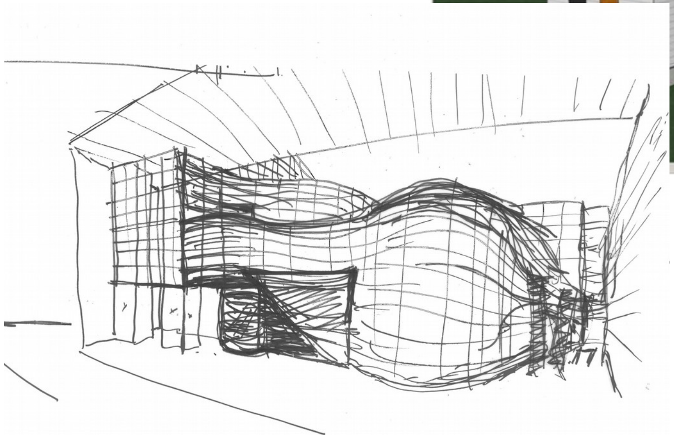
[Science’s teacher sketch]

[Blender]

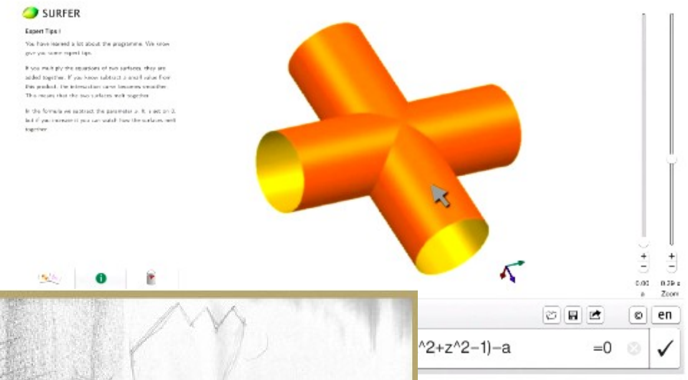




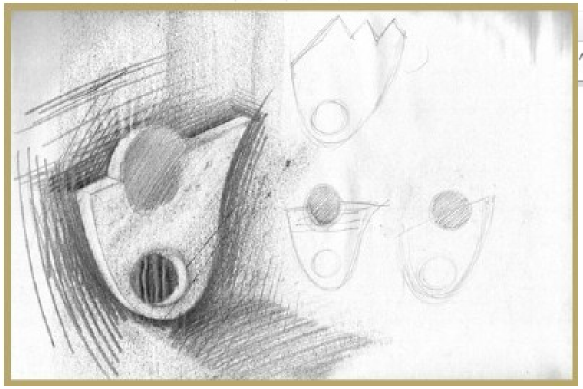
[Google SketchUp]



[SCAU sketch]



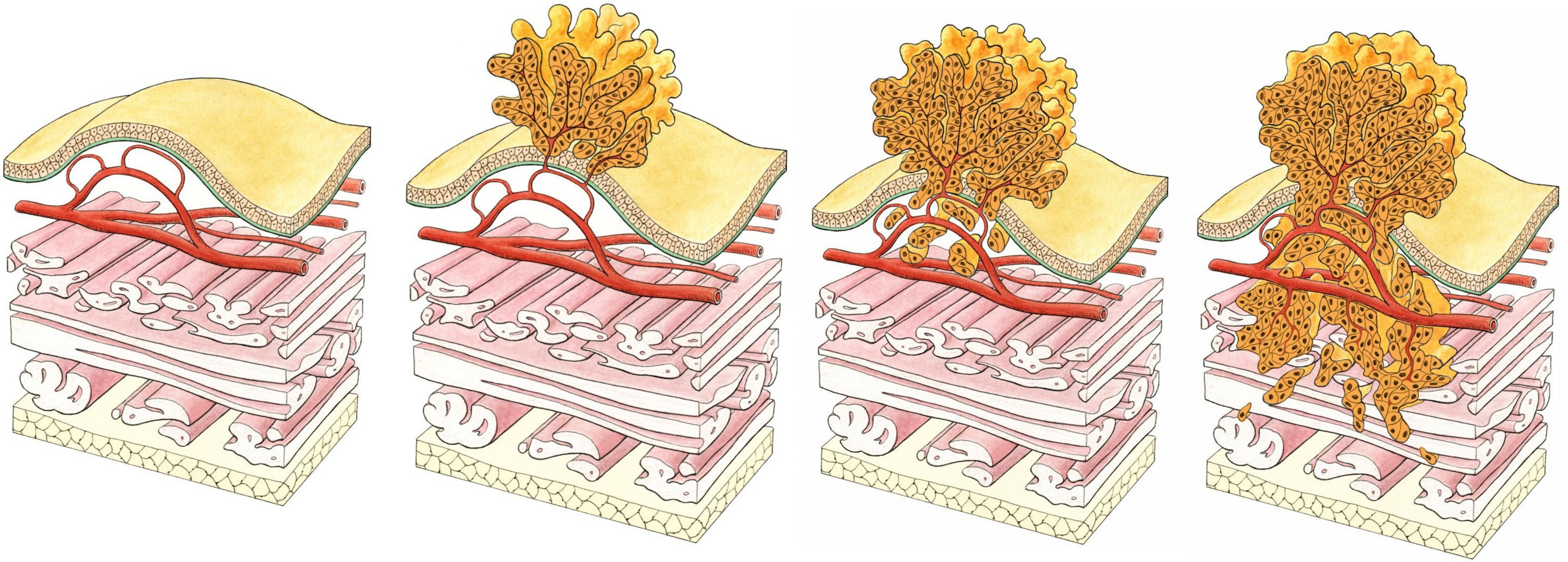
[Surfer]



[Sketch of a 3D business card]

Objectives

- General methodology
  - Fast creation + progressive refinement of 3D shapes in motion
  - Implementation in WebGL application prototype



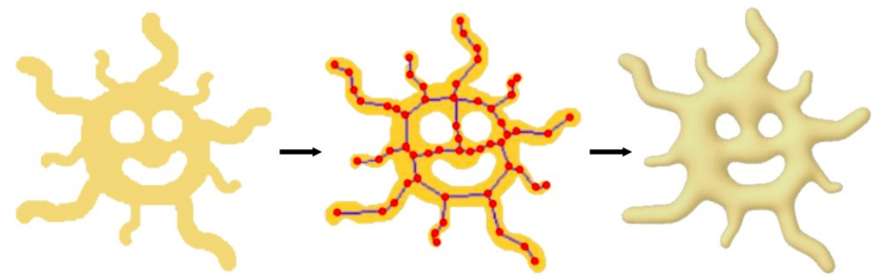
State of the art

- Modeling
  - Sketch-based modeling, Implicit surfaces
- Animation
  - Line of action, gesture-based control
- Distributions
  - Pair Correlation Function (PCF)
- Illustrative visualization
  - Non-Photorealistic rendering

State of the art : Modeling

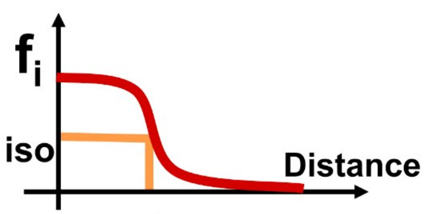
$$I = \{ P \ / \ f(P) = c \}$$

f : R³ → R scalar field

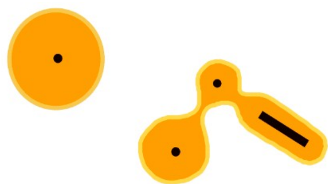


[Bernhardt et al., SBIM 2008]

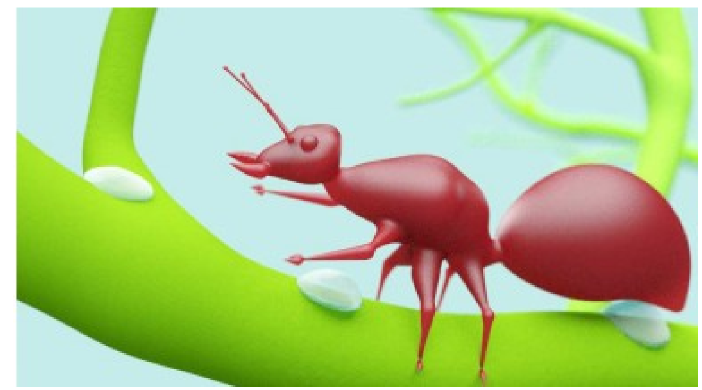
Implicit skeleton surfaces



Localité!



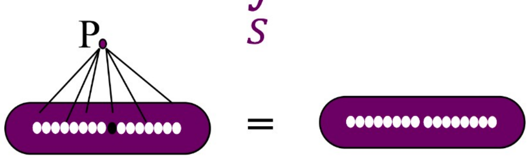
$$f(P) = \sum f_i(P) = c$$



[Zanni et al. CGF 2013]

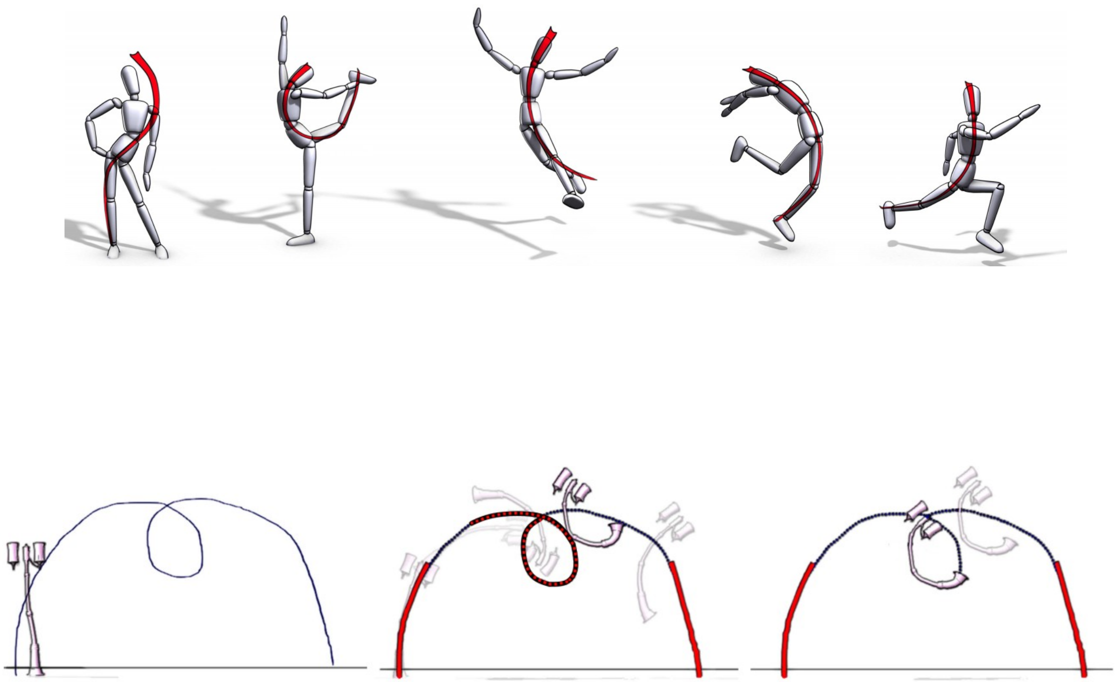
Convolution surfaces to avoid bumping effect

$$F(P) = \int_S r(s)\, f_s(P) ds$$

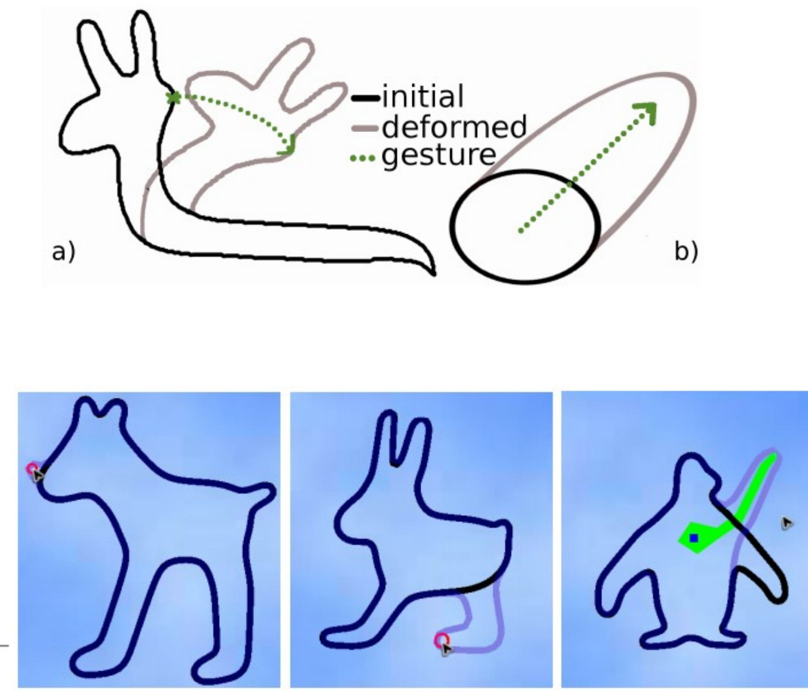


Interactive version at : *https://www.lix.polytechnique.fr/geovic/software.html*

State of the art : Animation

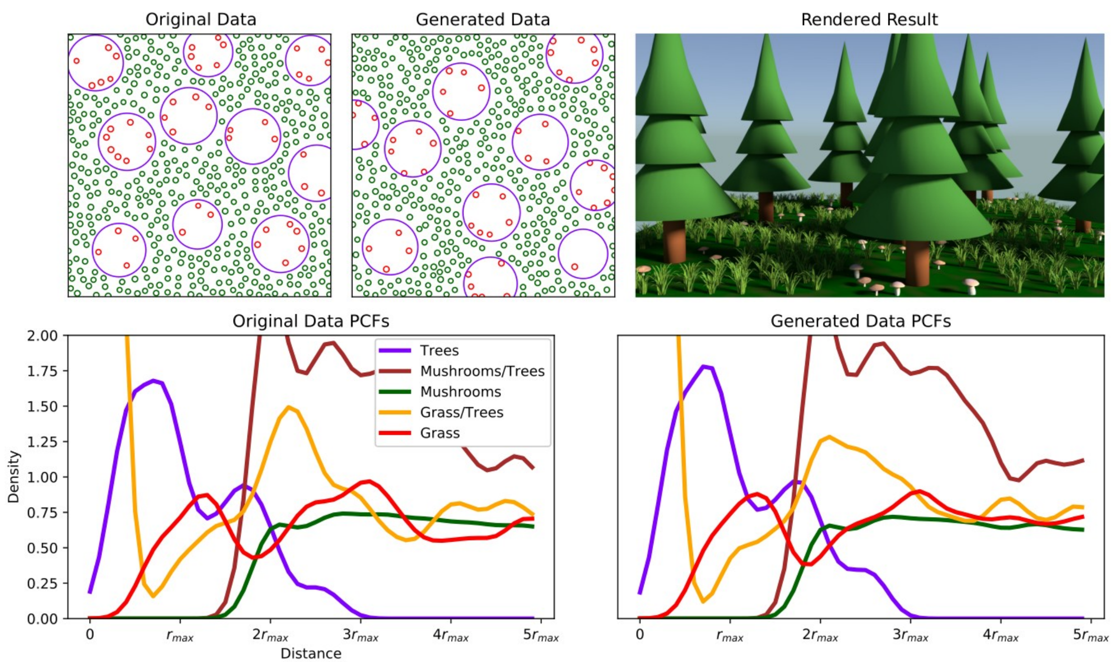


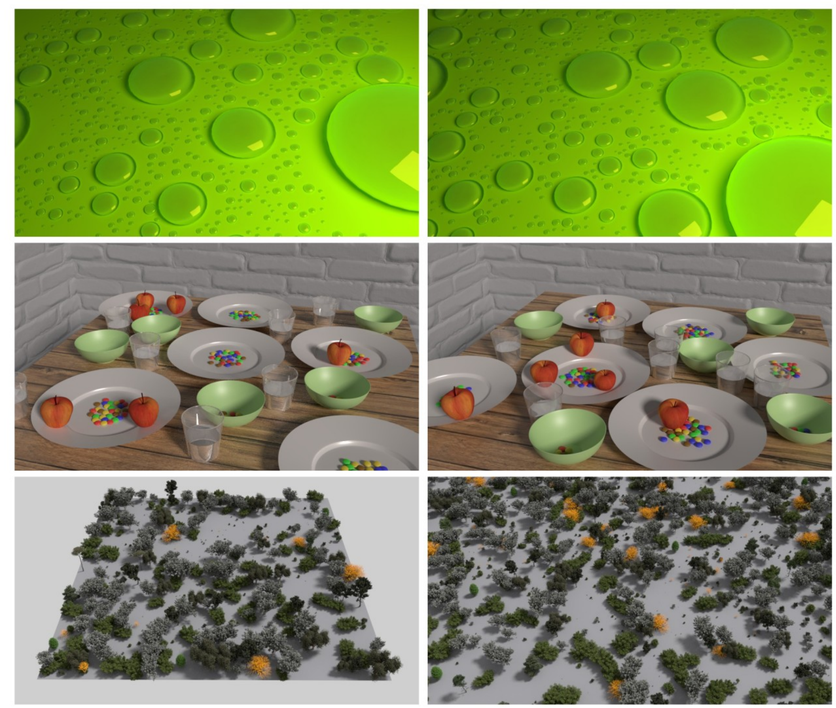
[Guay et al. 2013, 2015]



[Delame et al. 2013]

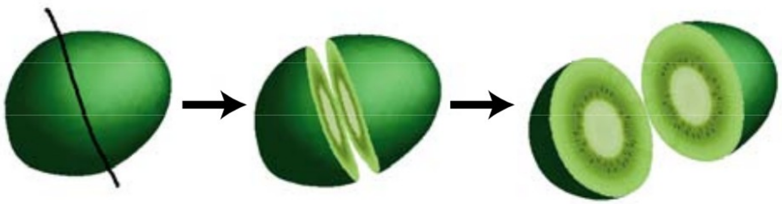
State of the art : Distributions

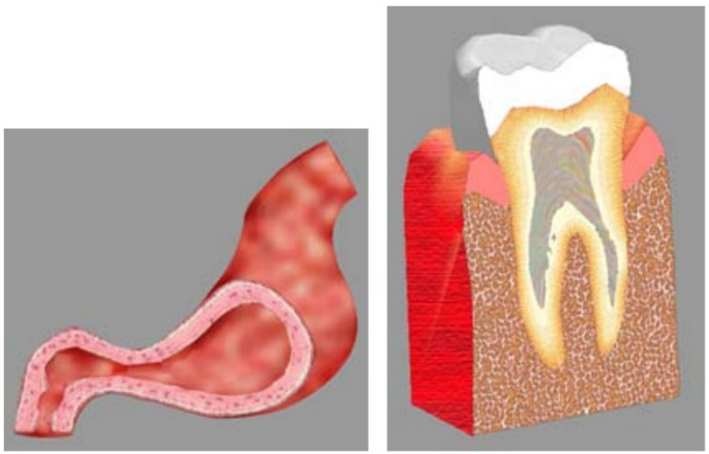




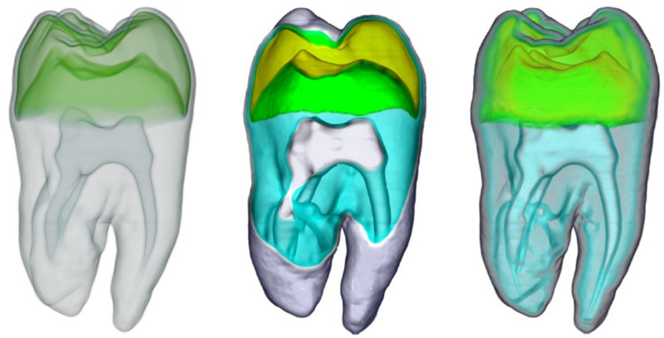
[Eccormier-Nocca et al. Eurographics 2019]

State of the art : Illustrative Rendering





[Owada et al. 2004]



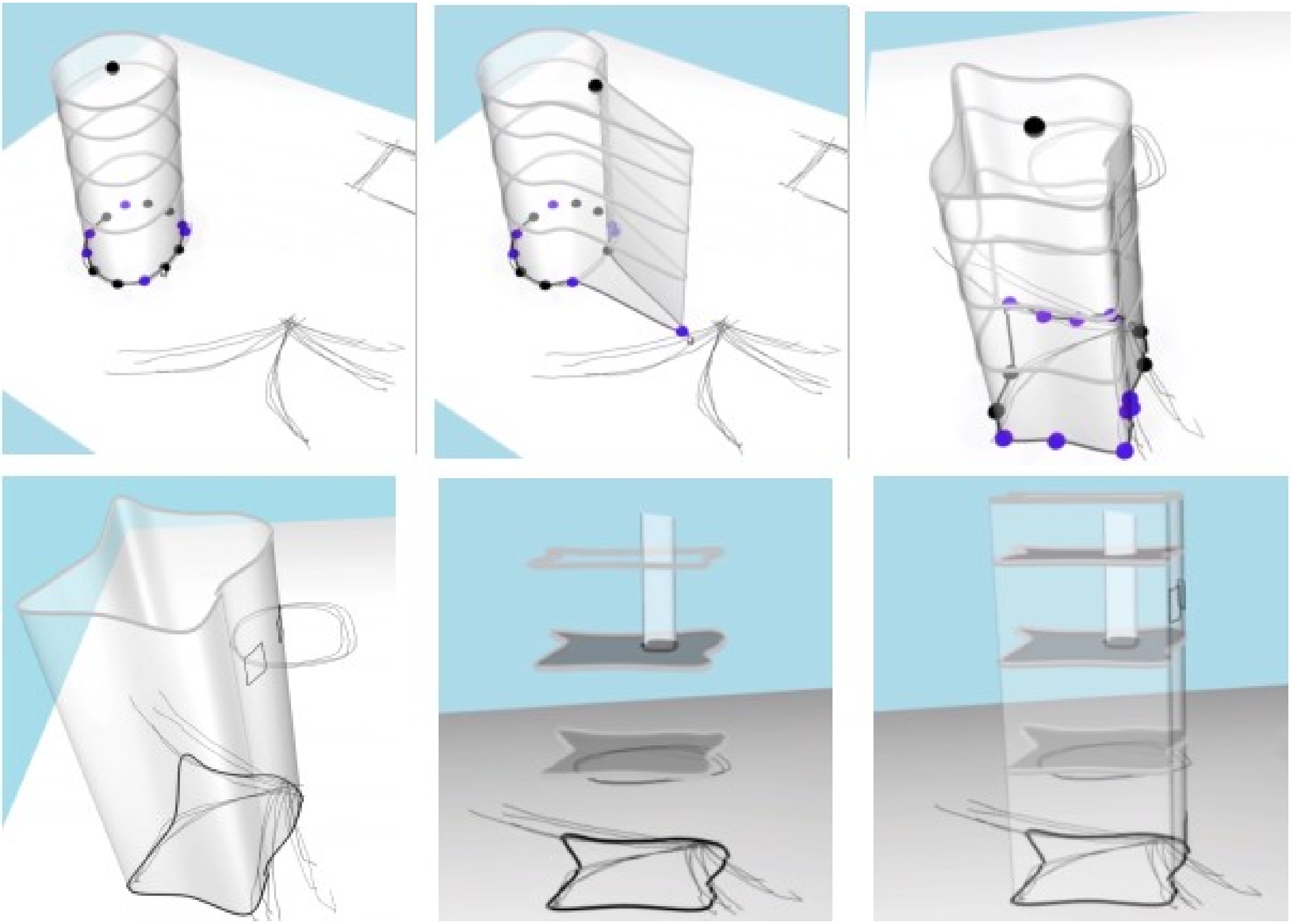
[Bruckner et al. 2005]

(a)

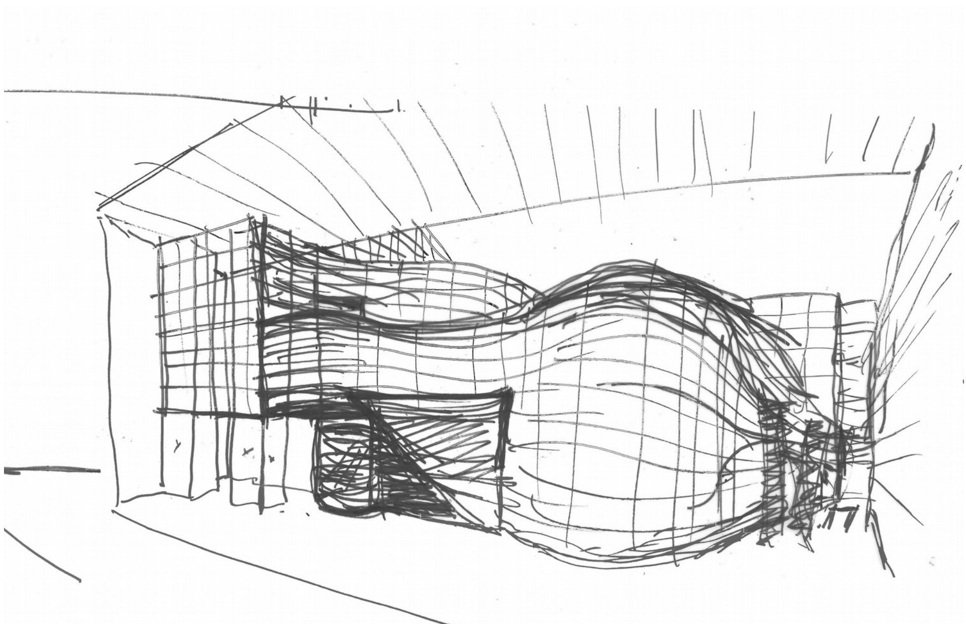
Image courtesy of Nucleus Medical Art

http://www.nucleusinc.com

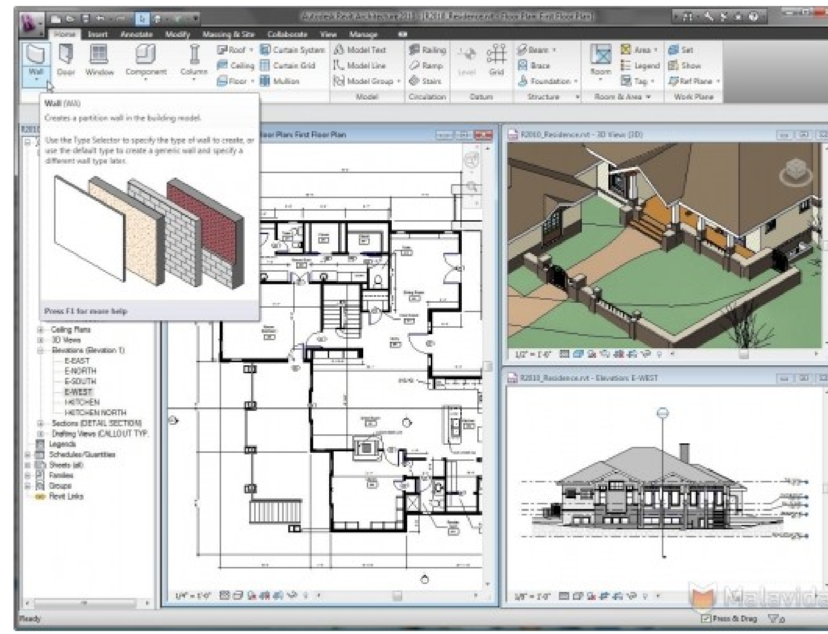
State of the project :
Expressive modeling for architecture



Motivation : Creativity in architecture



[Architect’s sketch]



[BIM - Revit of Autodesk]

2 extreme design processes

- Free-hand sketching
  suggesting 3D surfaces
  mental image of the model

- BIM (Revit)
  combination of volumes
  geometric primitives

Pre-study professional architecture agency

SCAU Paris

Main criteria :

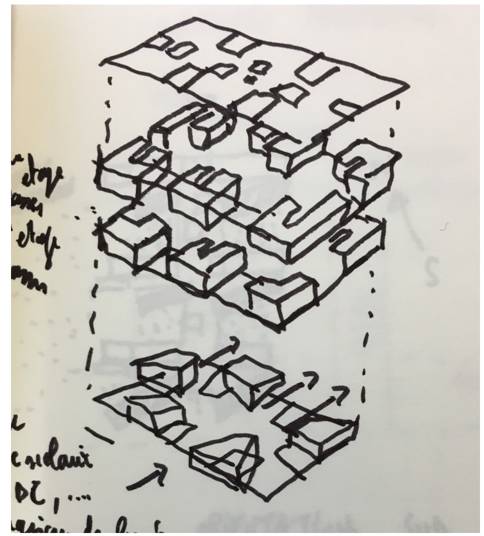
(C1) Immediate usability

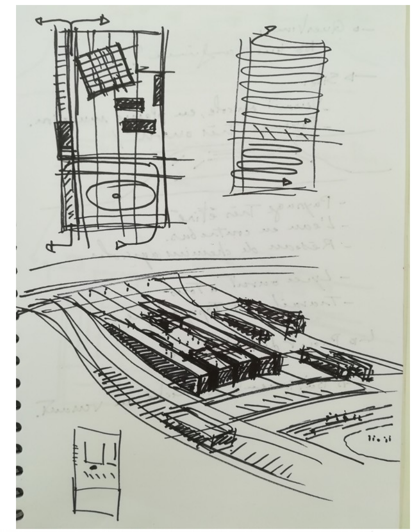
Coarse to fine design
- **(C2) Both outside and inside**

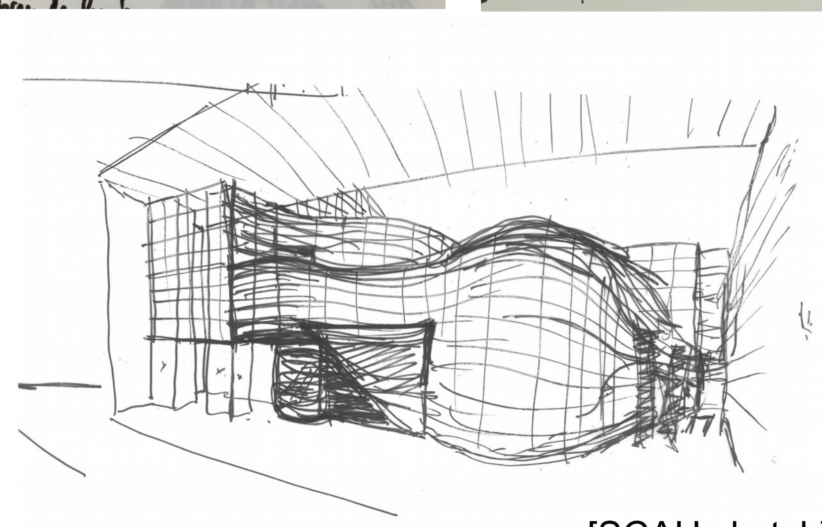
Free-form shapes
- **(C3) Keep the original strokes**

Uncertainty
- **(C4) Exploration**

3D navigation







[SCAU sketch]

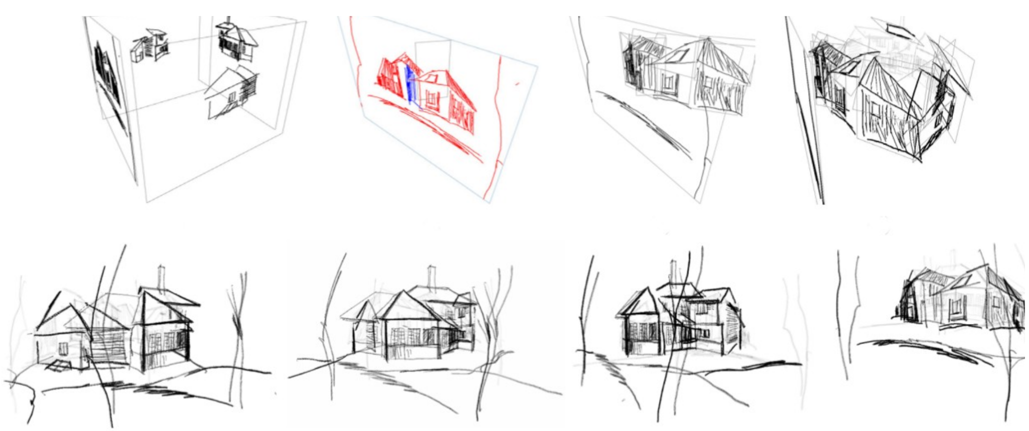
State of the art : Sketching in Computer Graphics for architecture applications

2 goals:

- Inferring a 3D model (knowledge)

Sketching Reality
[Chen et al. SIGGRAPH 2008]

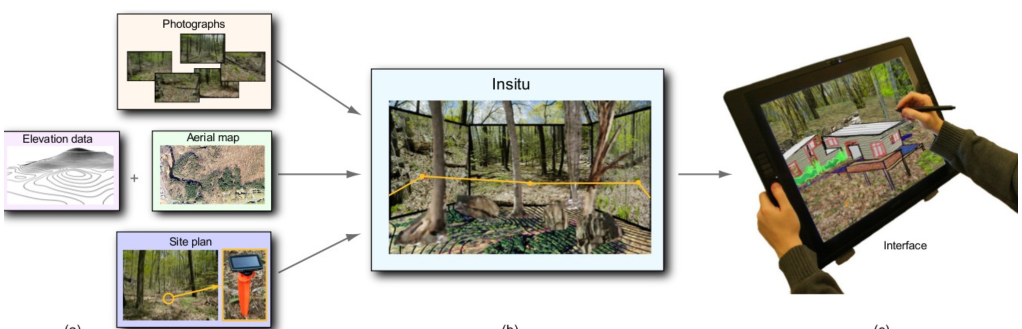
- Creating a 3D sketch (without model)



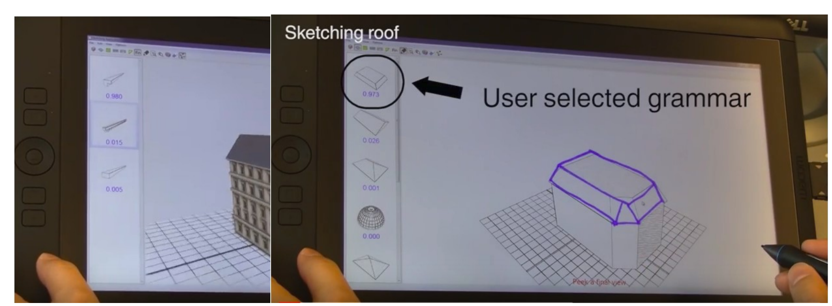
Mental Canvas
[Dorsey and al. Pacific Graphics 2007]

State of the art : Sketching in Computer Graphics for architecture applications

	C1 Immediate Usability	C2 Both inside/outside	C3 Keep original strokes	C4 Uncertainty exploration
Inferring 3D model - *Sketching Reality* -*Sketching Procedural*	O	N	N	N
3D sketch -*Mental Canvas* -*Insitu*	O	N	O	N



Insitu
[Paczkowski and al. SIGGRAPH Asia 2011]



Sketching Procedural
[Nishida et al. SIGGRAPH 2016]

Goal of our research

- Creating a 3D sketch (without model)

?

007]

Insitu
[Paczkowski and al. SIGGRAPH Asia 2011]

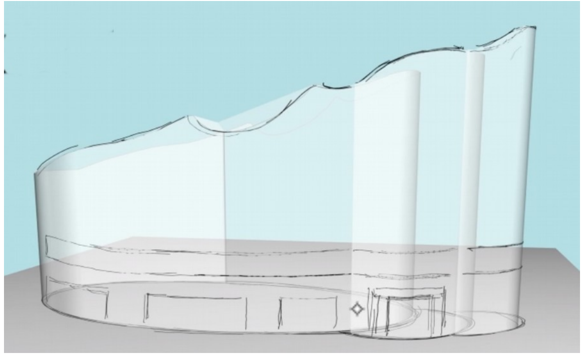
+ **(C1)** Immediate usability
+ **(C2)** Both outside and inside
+ **(C3)** Keep original user strokes
+ **(C4)** Uncertainty exploration

Our method

New concept of *Nested Explorative Maps*

Contributions

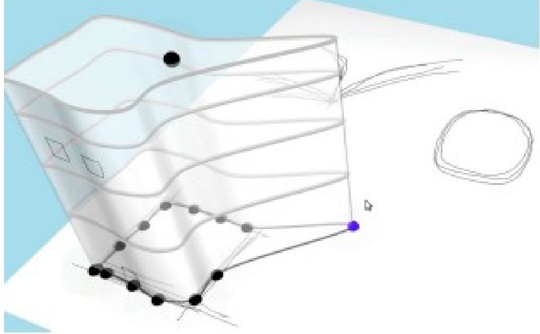
1) Nested structure for coarse to fine, free form design
- From the outside to the inside
- While keeping the original strokes



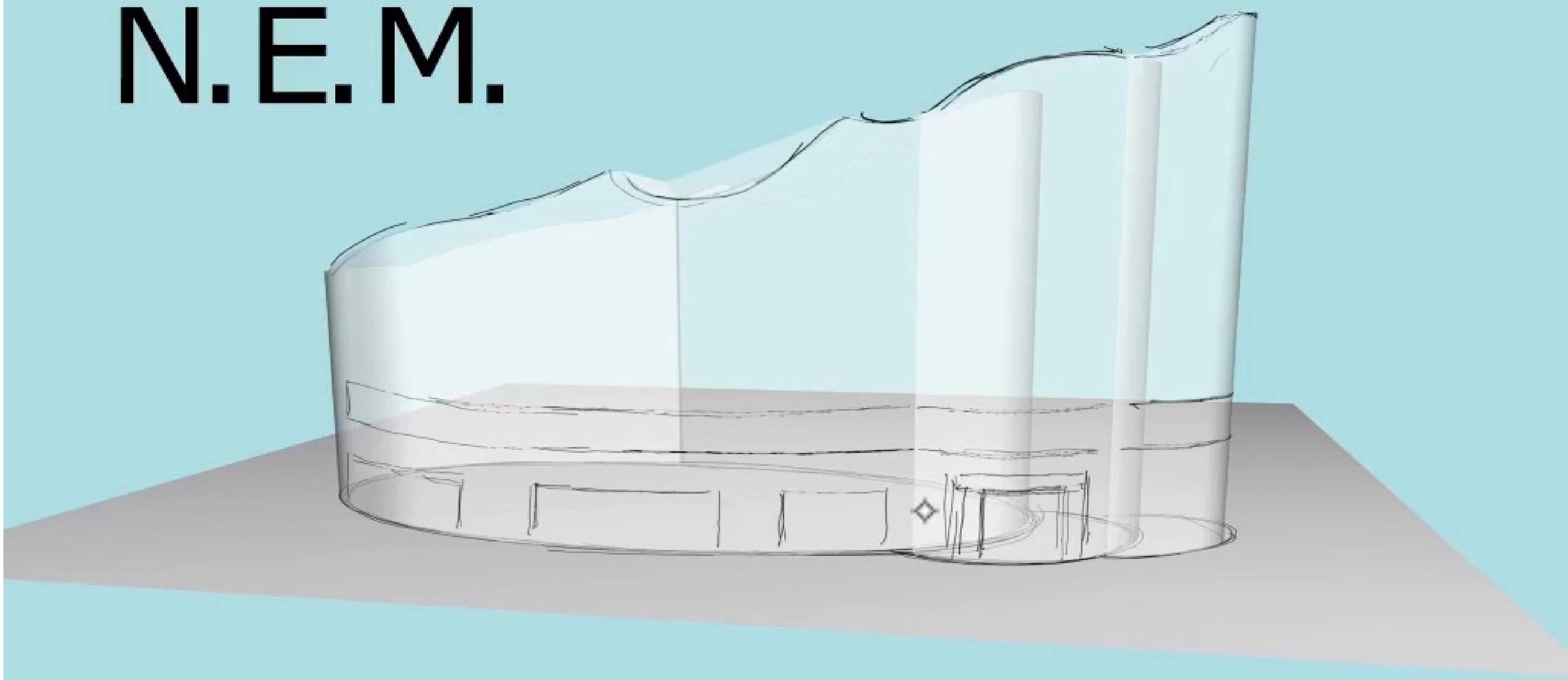
2) Uncertainty
- Interactive exploration of options

Validation

User study with professional architects



N.E.M.



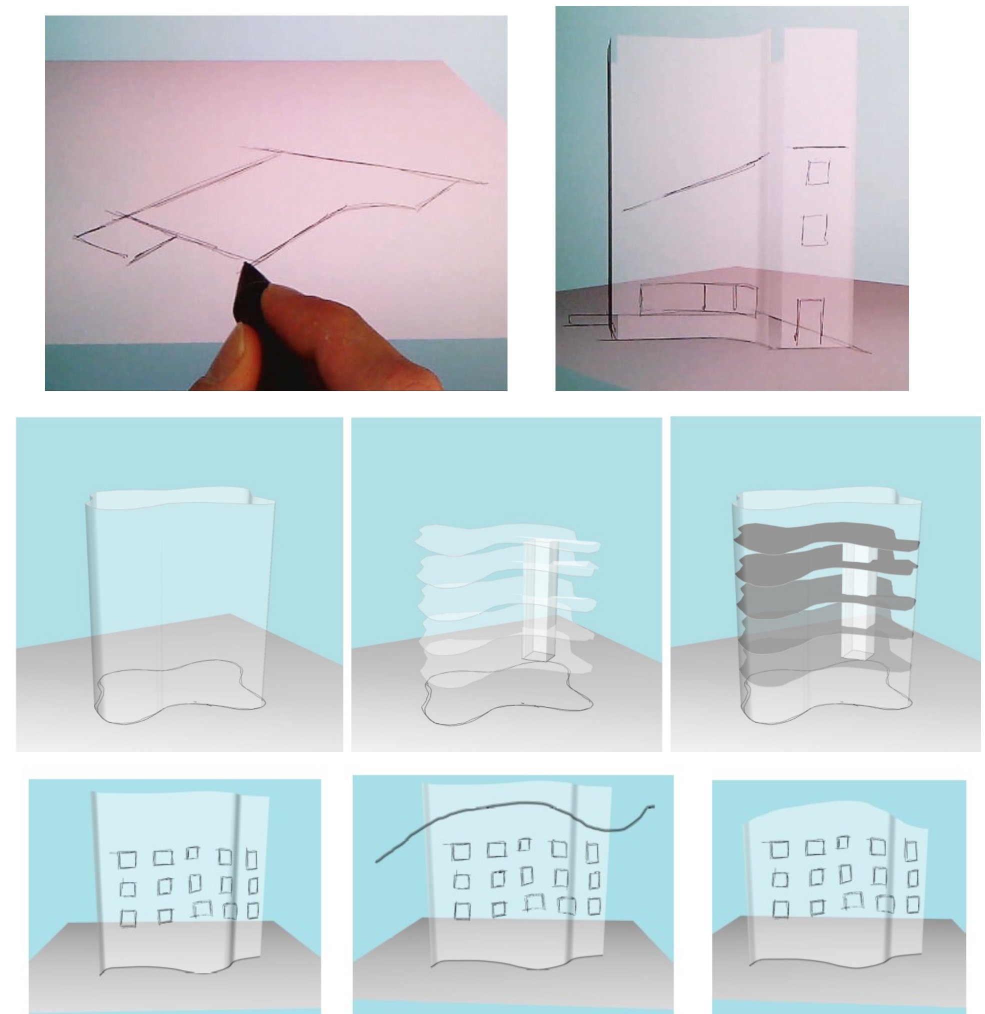
1) NEM : editing modes

Map sketching mode
- Freehand strokes

Nested footprint mode
- Spline for smooth canvas
- Play on stroke’s speed
- Volume from closed curve

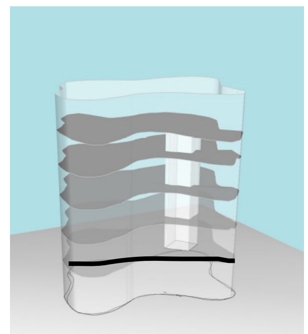
Floor mode
- Volume required

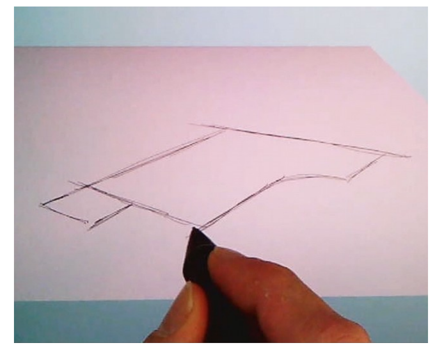
Cutting mode
- Freehand cutting line

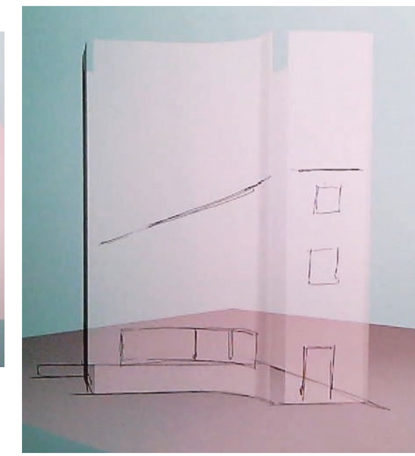


1) Nested structure

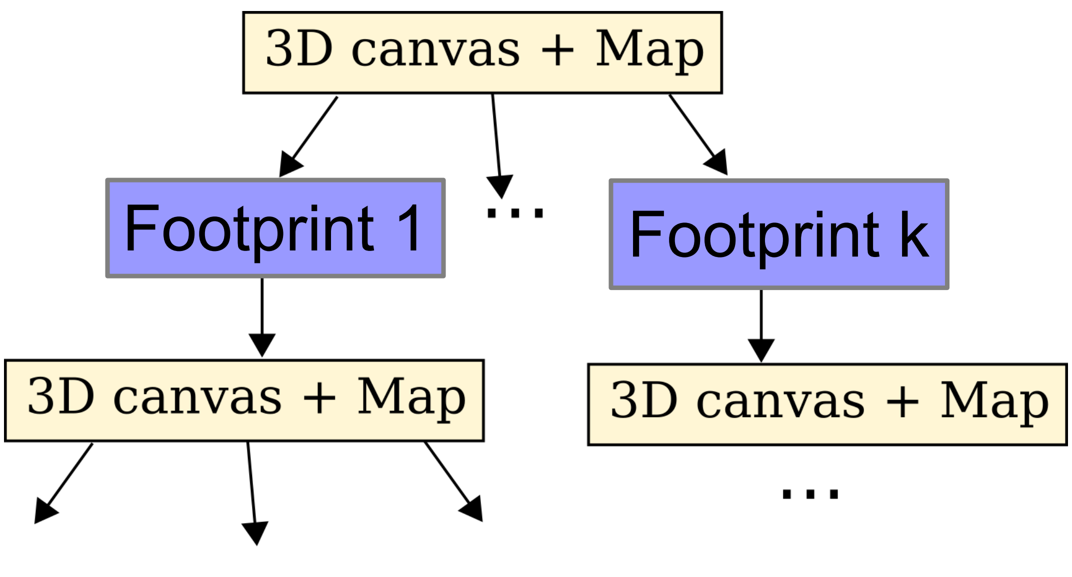
Challenge: Free form canvases
built from and carrying original user strokes







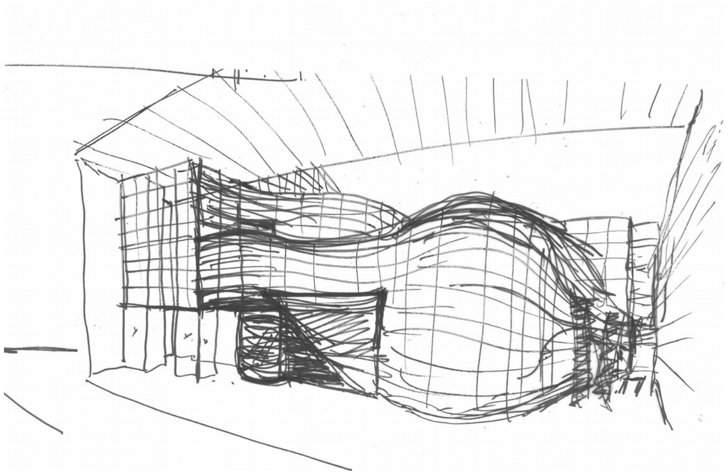
Our solution : hybrid hierarchy

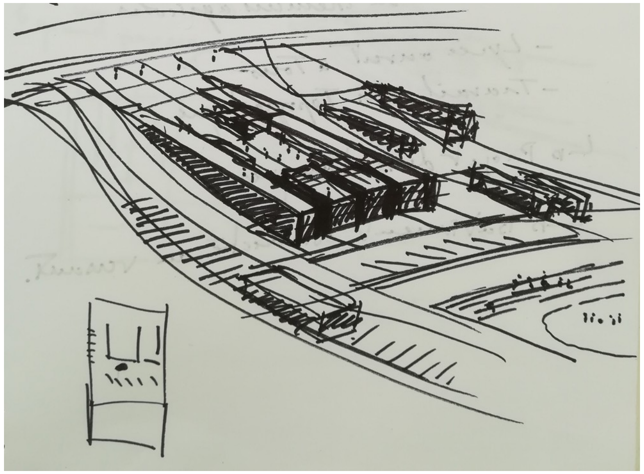


Map
- User strokes
- Texture
  expressing uncertainty

NEM = Nested Explorative Maps

2) Uncertainty: Challenges





Uncertainty represented through
- lighter strokes
- over-sketching

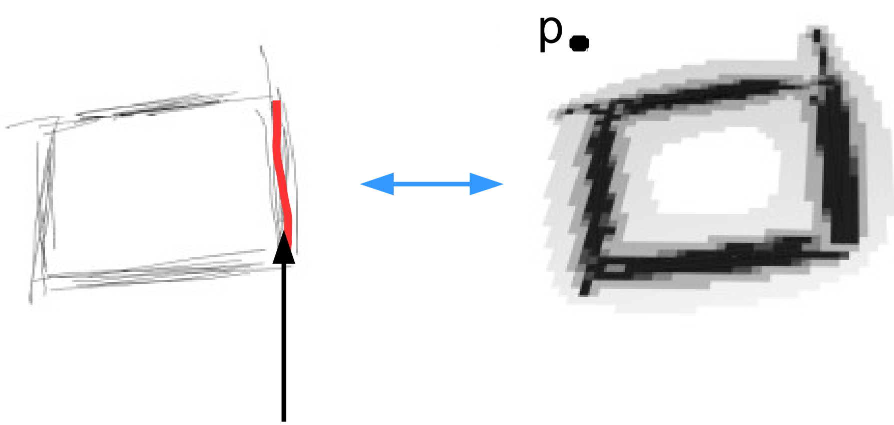
Goal: enable explorative options

No existing solution to explore options

General idea: High stroke density => confidence region

2) Uncertainty: Confidence field from a set of strokes

Solution: Creating a confidence field stored as a texture, footprints navigation



S_i, thickness α

Method

Map = set of strokes + confidence fiel

Inspired from convolution surfaces :
strokes ↔ skeletons generating a fiel

$$F_i(p) = \int_{S_i} \alpha \, \kappa(p, s) \, \mathrm{d}s$$

$$\kappa(p, s) = \frac{1}{d(p, s)^3}$$

Incremental update $F = \sum F_i$

2) Uncertainty
Plastic deformation of footprints and canvases

Input : Confidence texture

Footprint = mass-particles + plastic springs

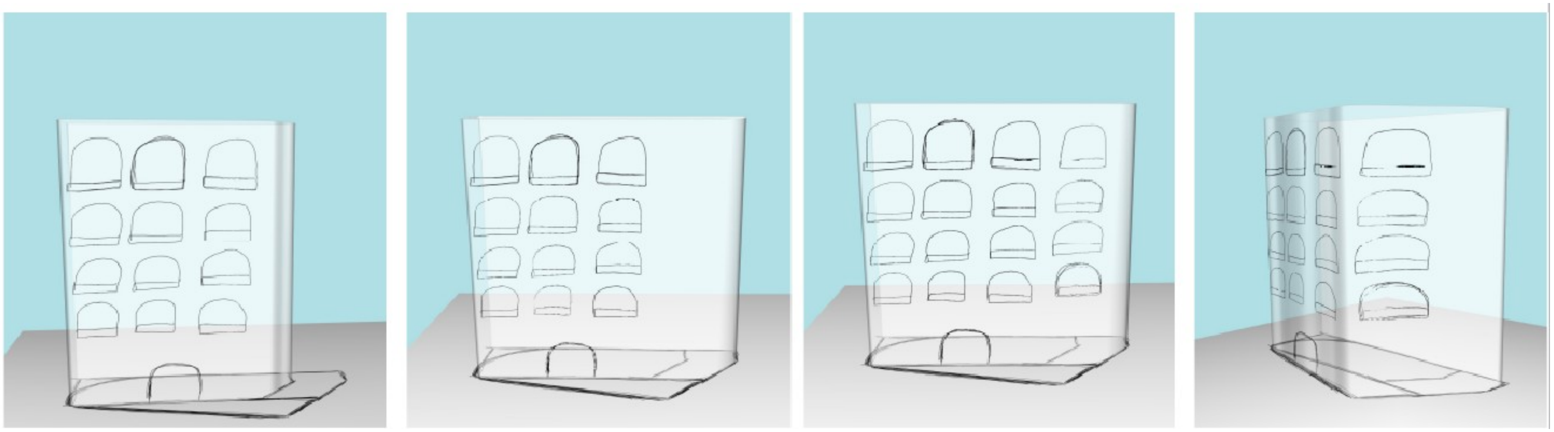
Attraction towards high confidence

$$P_{attraction}(p) = \exp\left(-(F(p)/\sigma)^2\right)$$

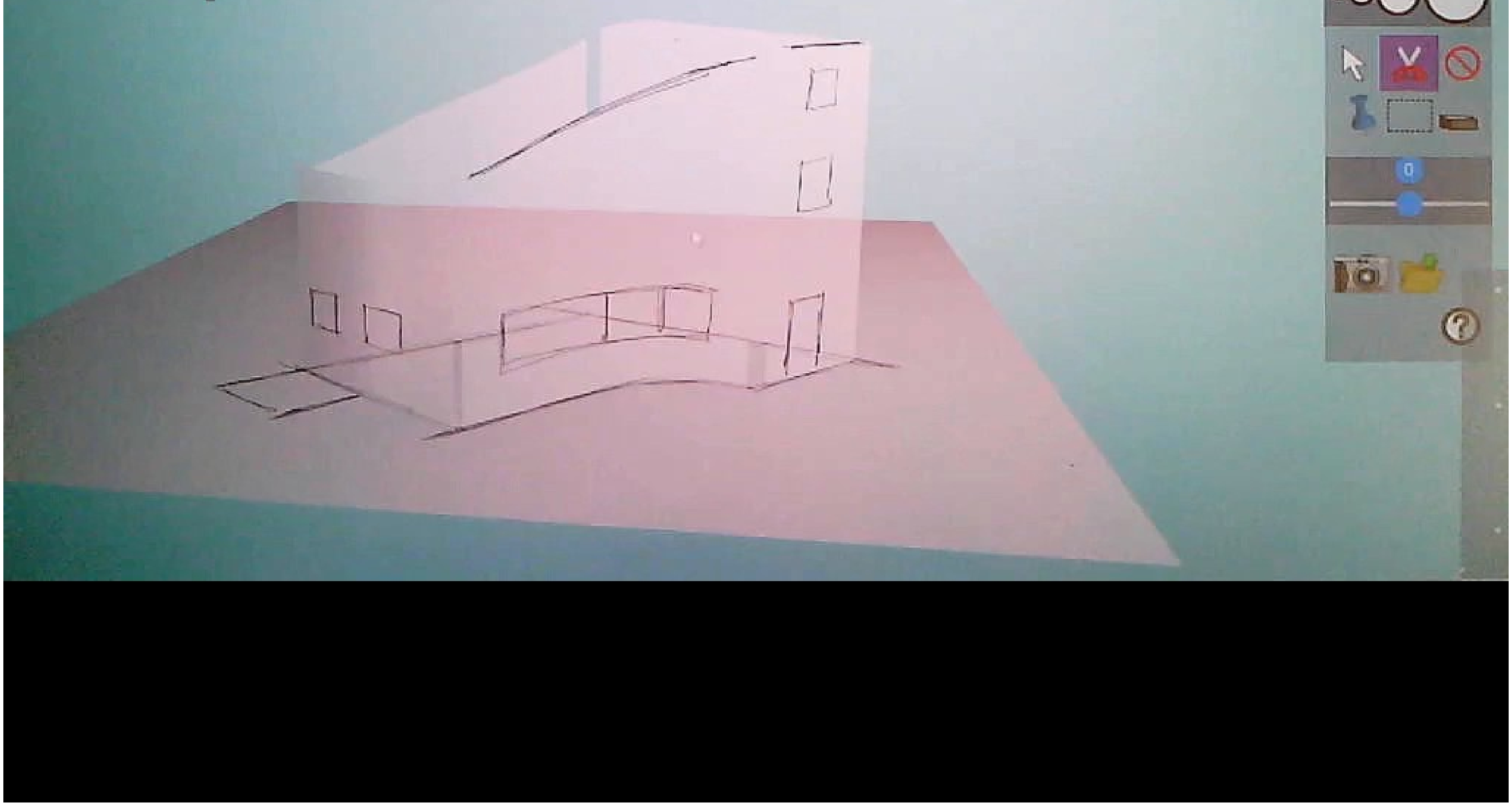
$$F_{attraction}(p) = -\nabla P_{attraction}(p)$$

Plastic spring

Small elongation	Large elongation
Elastic behavior $F = -k (L - L_o)$	Absorbs deformation (rest length changes) $L_o \leftarrow L$

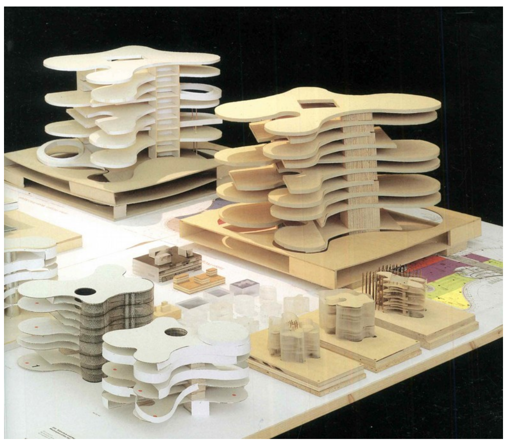


Part B: Exploration Tools

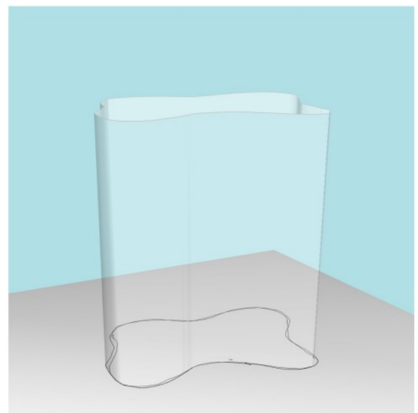


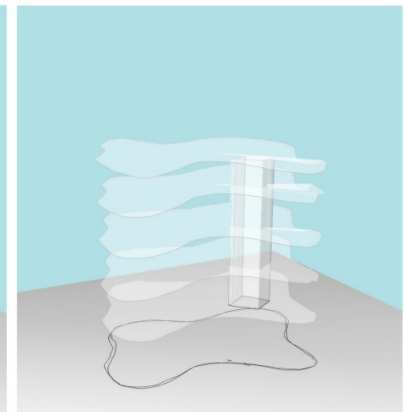
Validation: User study at the SCAU agency

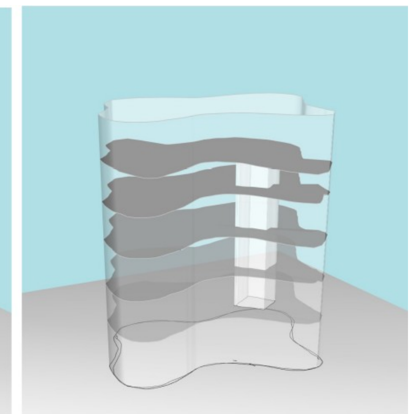
Visual references

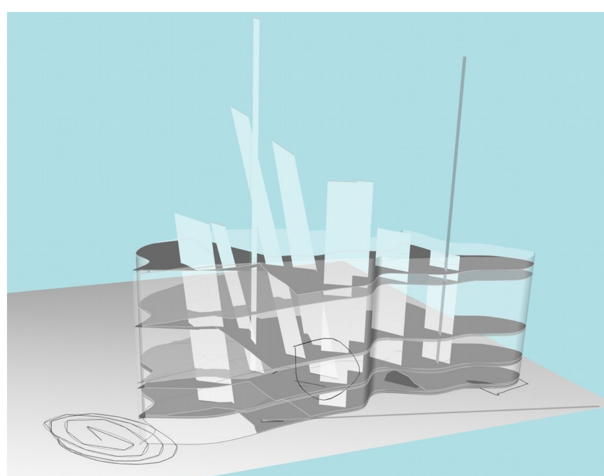


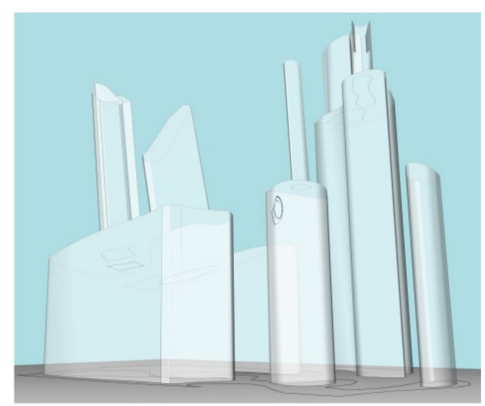
Created by professional architects
(~10 minutes, WACOM tablet)

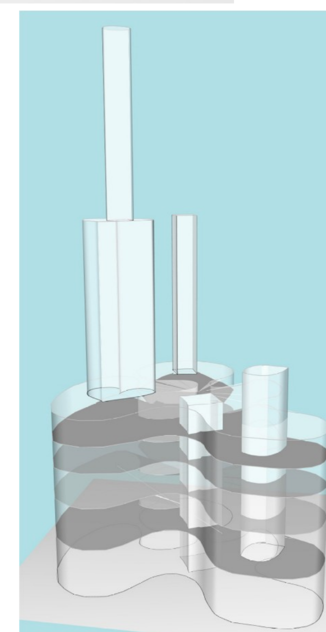






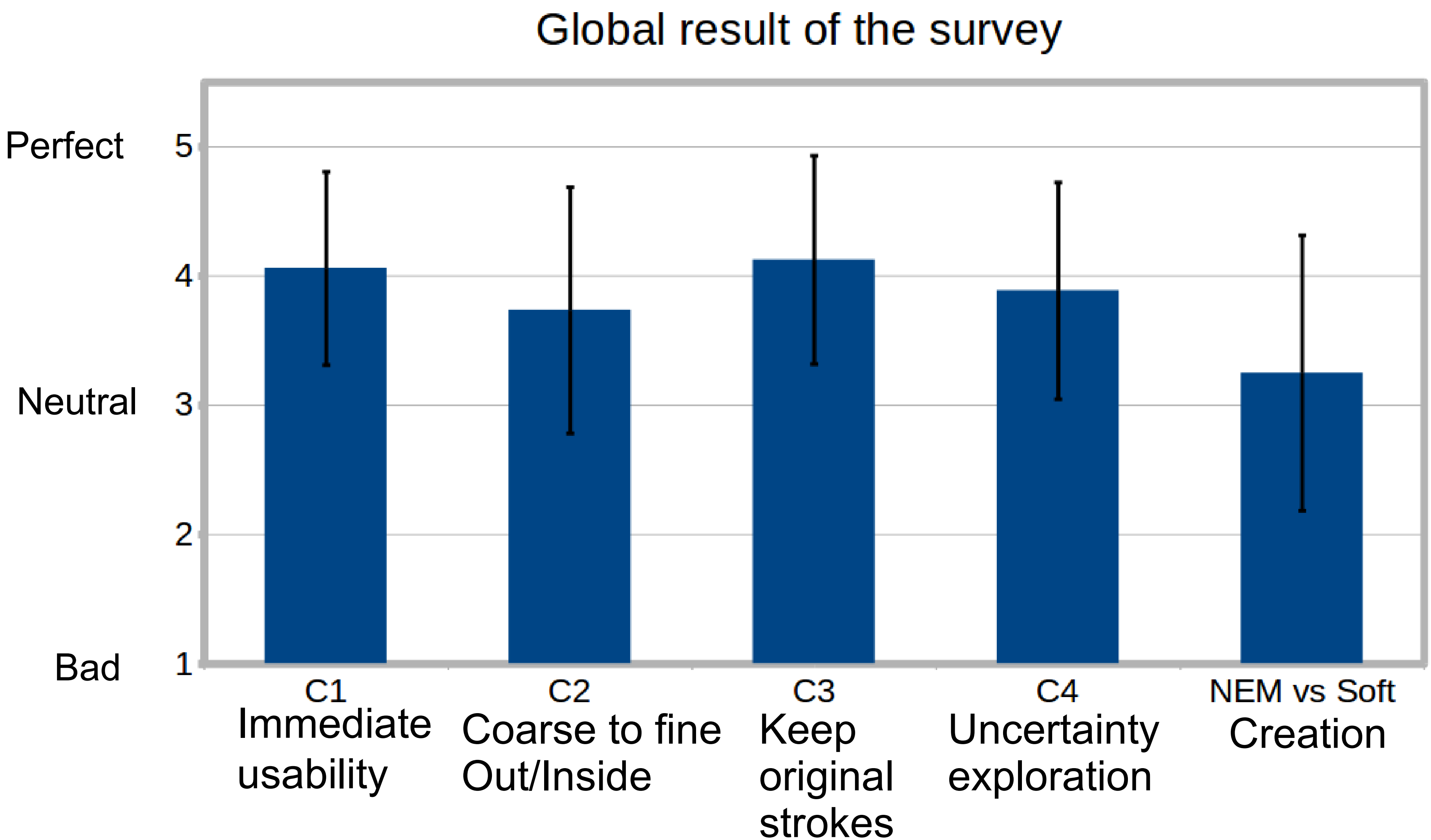




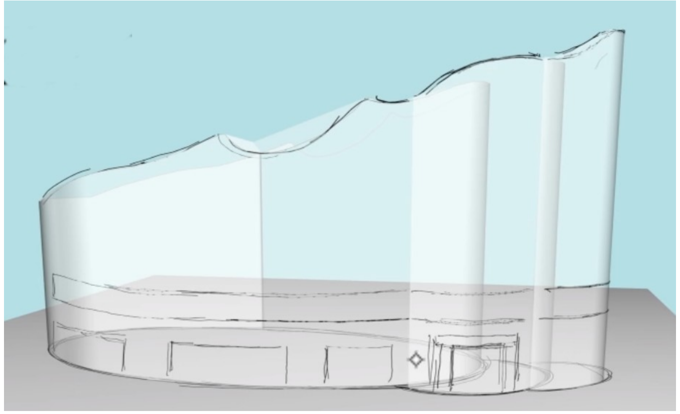


User study at the SCAU agency

17 professionals, from 6 months to 40 years of experience



Conclusion NEM

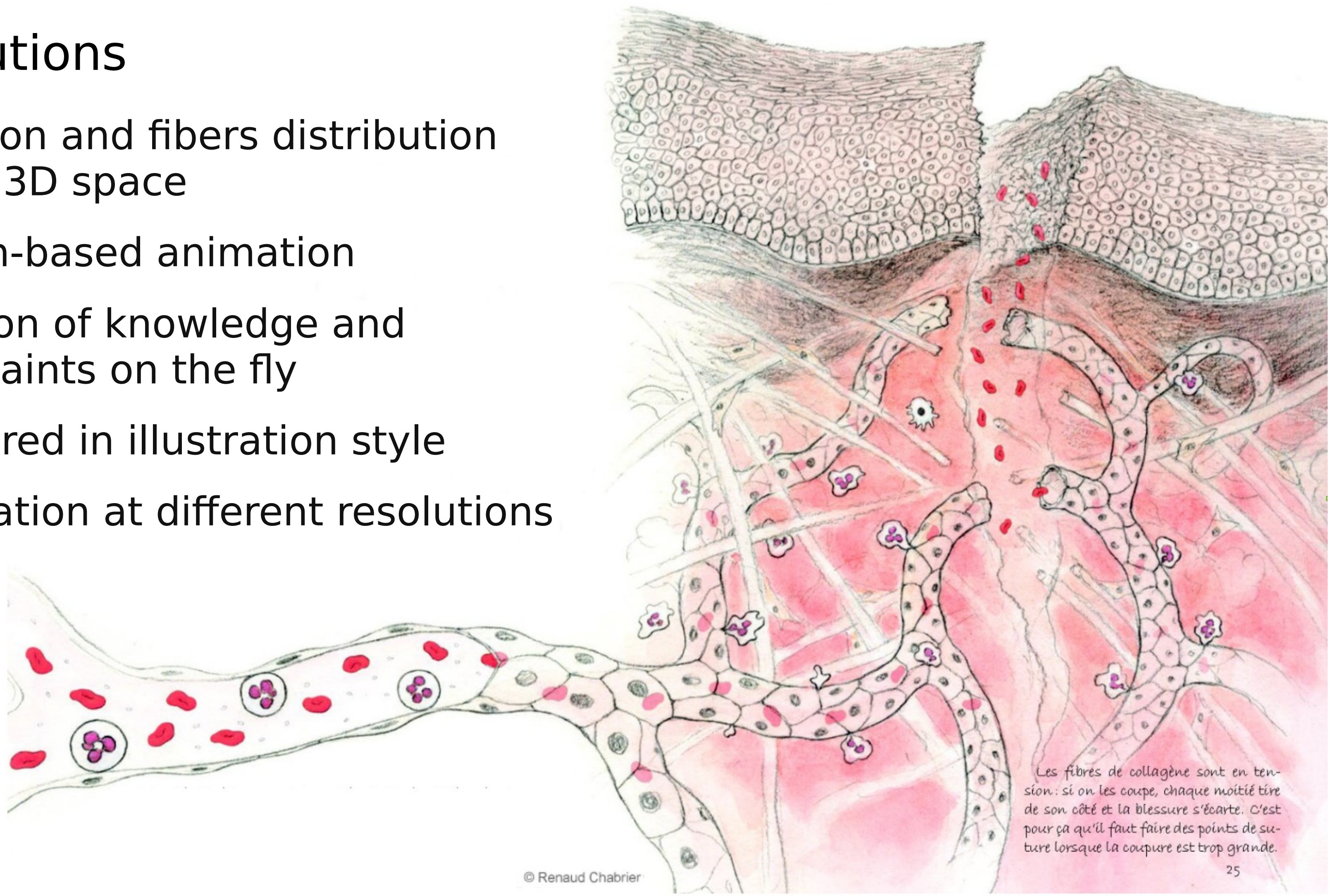


- Architects needs + state of the art
- Concept of Nested Explorative Maps :
  - Recursive creation of a 3D sketch
  - Interactive exploration of options

- Limitations
  - Limited functionnalities in our prototype
  - Not fully free form
- Future work
  - Extension to more general goals

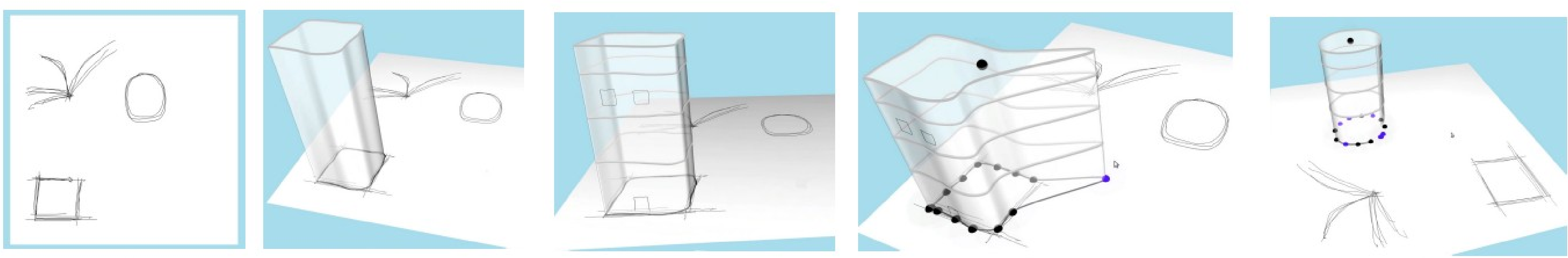
In process : General methodology

- Contributions
  - Skeleton and fibers distribution in the 3D space
  - Sketch-based animation
  - Addition of knowledge and constraints on the fly
  - Rendered in illustration style
  - Navigation at different resolutions

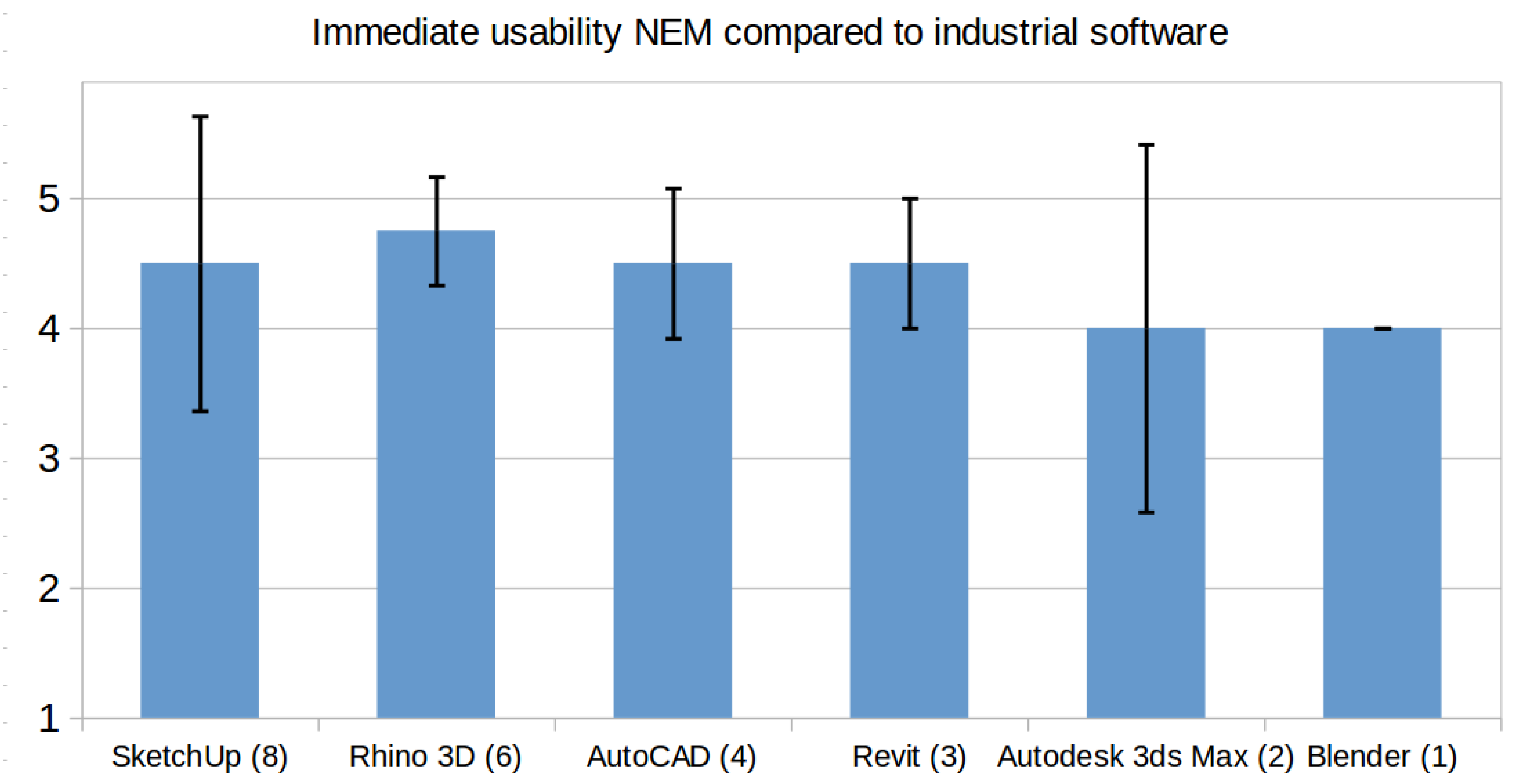


Thank you for your attention !

Code online at : *www.lix.polytechnique.fr/geovic/software.html*



User Study – Comparison Industrial software



User Study – Comparison Industrial software