

Geometric modeling

Introduction

Olivier Gourmel
Equipe VORTEX – IRIT
Université de Toulouse

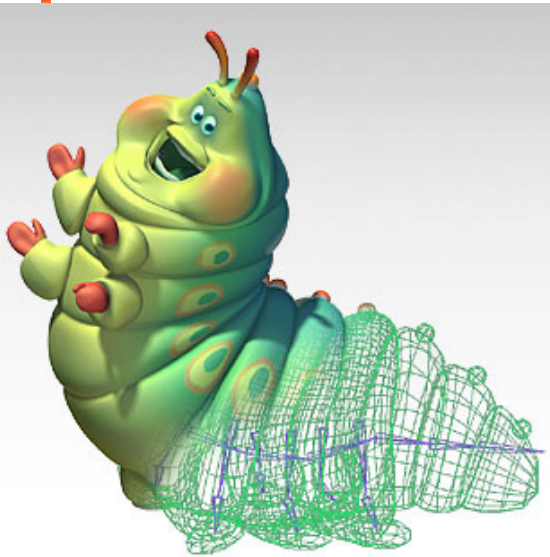
olivier.gourmel@irit.fr

The needs

- Object modeling has many applications:
 - Movies, animation, special effects ...
 - Medical field
 - Cars & planes conception...
 - Natural phenomena simulation
 - Virtual reality
 - ...

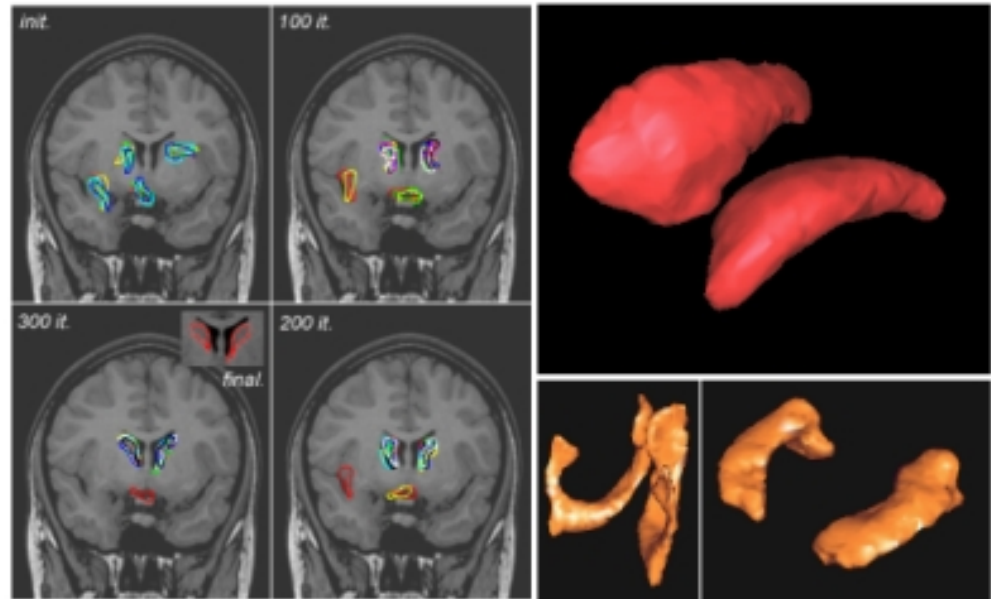
Animation

- Intuitive and interactive modeling of 3D surfaces
- Quest for visual quality
 - Continuity of surface normal: C^1
 - Continuity of surface curvature (« good looking » reflexions) : C^2



Medical field

- Visualization of scanner data
- Reconstruction of organs
- Distortion simulation (virtual surgery)
- ...

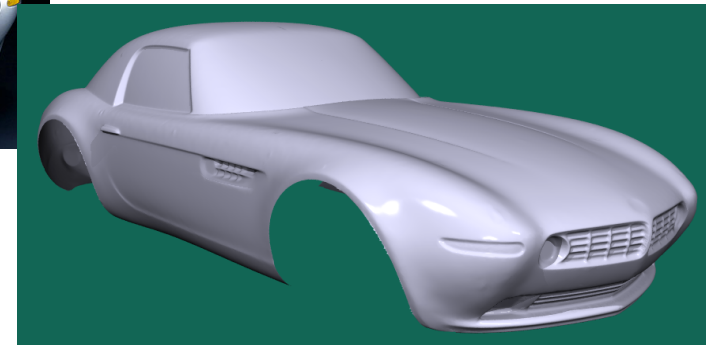


VORTEX



Construction

- Model conception
- Modeling softwares: from conception to manufacturing
 - Surface representation must be precise and adapted to the manufacturing process (continuity, carving, assembly...)
 - Must be compatible with simulation (rigidity tests...)
- ...

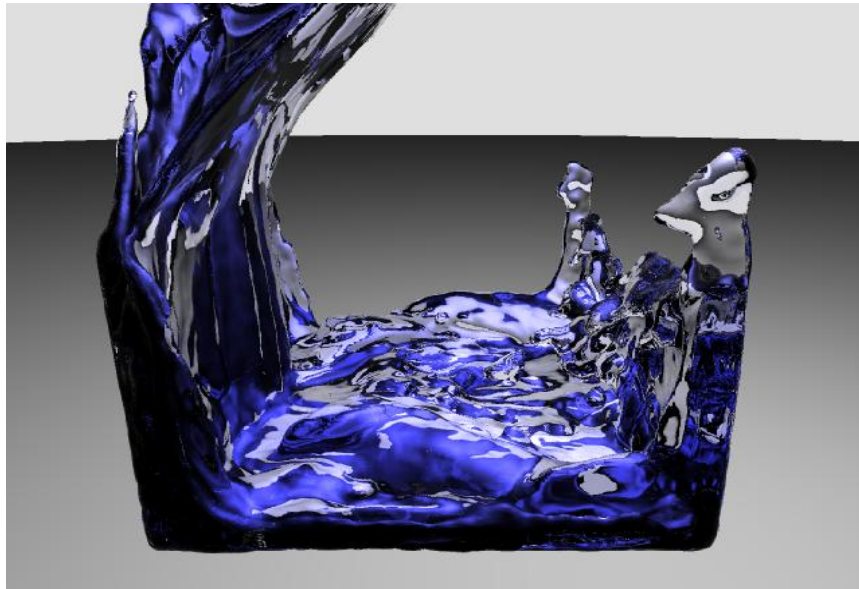


VORTEX



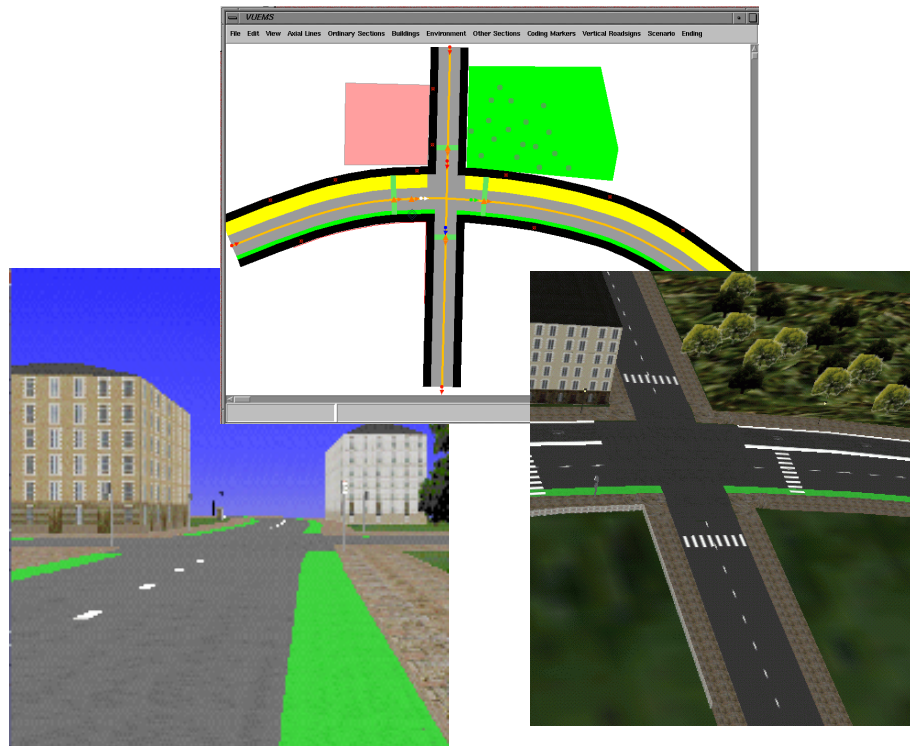
Simulation of natural phenomena

- The modeling depends on the interactivity degree of the simulation
- Adapted to the solutions of physical equations for precise simulations
- Simple to compute and visually plausible for real time simulations
- ...



Virtual reality

- Modeling of real or imaginary worlds
- Adapted to real time animation and navigation
- Depends on the nature of the simulation (city, museum...)



VORTEX



Illustration with pictures

- Video games
- Photo realistic rendering
- Animation

Video games



VORTEX



Video games

- 60 images per second needed for a good gameplay quality (30 a minimum)
 - Animation + 3D rendering + special effects + AI in real time

=> computations needs to be done quickly !!!!!

Video games

- How characters are represented in this video game ?



Video games

- How the environment is represented in video games?



VORTEX



Photo realistic rendering



VORTEX



Photo realistic rendering

- One picture can take several hours to render
 - 3D objects are very precise
 - Materials are very precise
 - Lighting must be realistic (sun, lights, shadows, reflexions).
 - The air has to be taken into account as well (fog, clouds...)

What differences do you see ?



VORTEX



Animated movies



VORTEX



Animated movies

- Consists in rendering pictures that are printed on a film afterwards so as to be seen in theaters (DVD, TV, etc). Everything is precomputed and recorded.

Films d'animation

Video sample

The Story Board



Invent and convince



Write a little script



Create a comic strip



Record voices



Time sequences

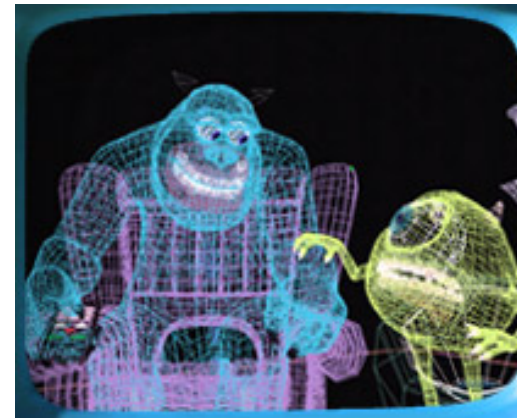


The look of characters



Modeling characters + their environment

- 3D objects are represented by meshes => sets of triangles or quads.



Characters are then animated

- Using, for instance, motion capture



VORTEX



Final rendering + special effects



VORTEX



Rendering each frame...



VORTEX



Let's observe...

- The fur
- The snow
- The grass
- The wind
- Motion effects (motion blur)

Animated movies

- Time is not a high constraint : a frame can be rendered in a few seconds or minutes.

=> The rendering quality is better than a video game, but less realistic than a photo.

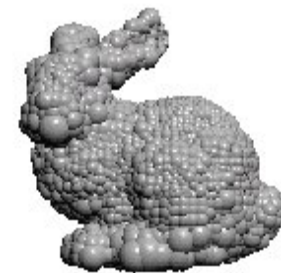
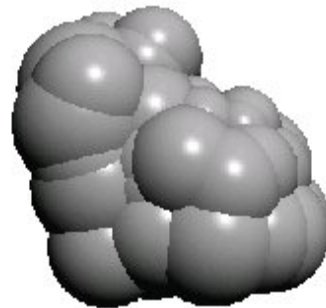
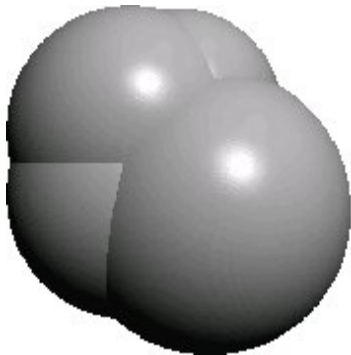
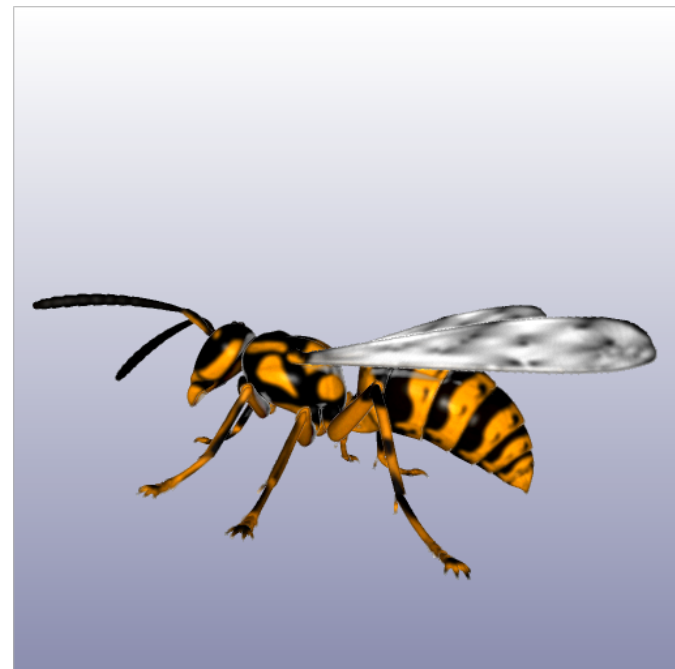
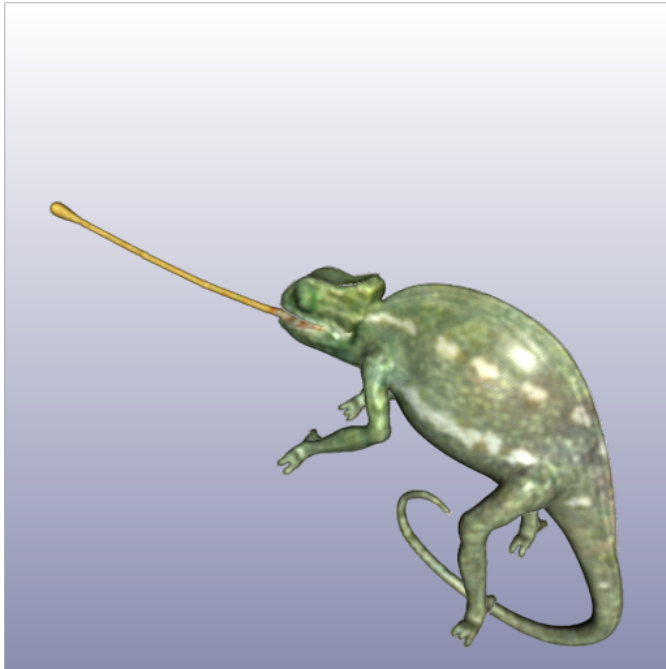
Some models

Giving a representation of 3D objects

- Points
- Polygons
- Equations
- Ellipses
- Hybrid representations
- ...

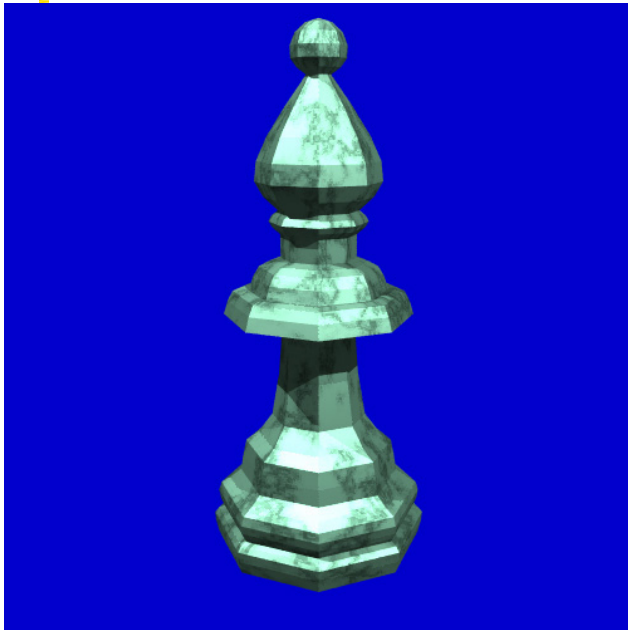
Points

- Simplest 3D primitive
- A set of points represent the geometry of an object

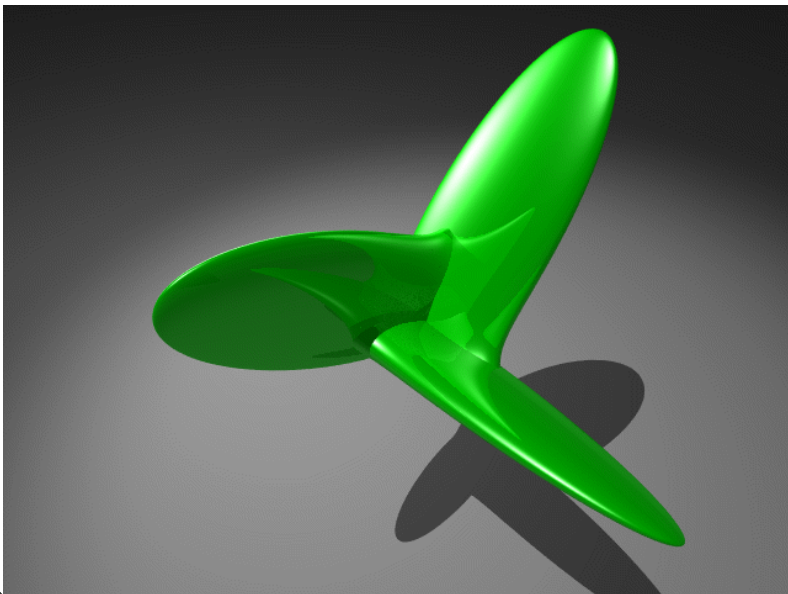
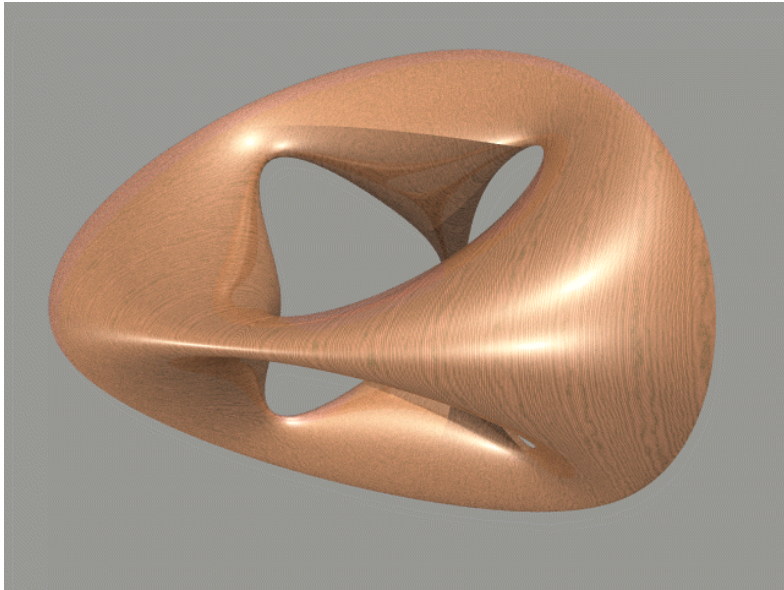


Polygons

- A set of polygons (the mesh) represents the geometry and the topology of an object



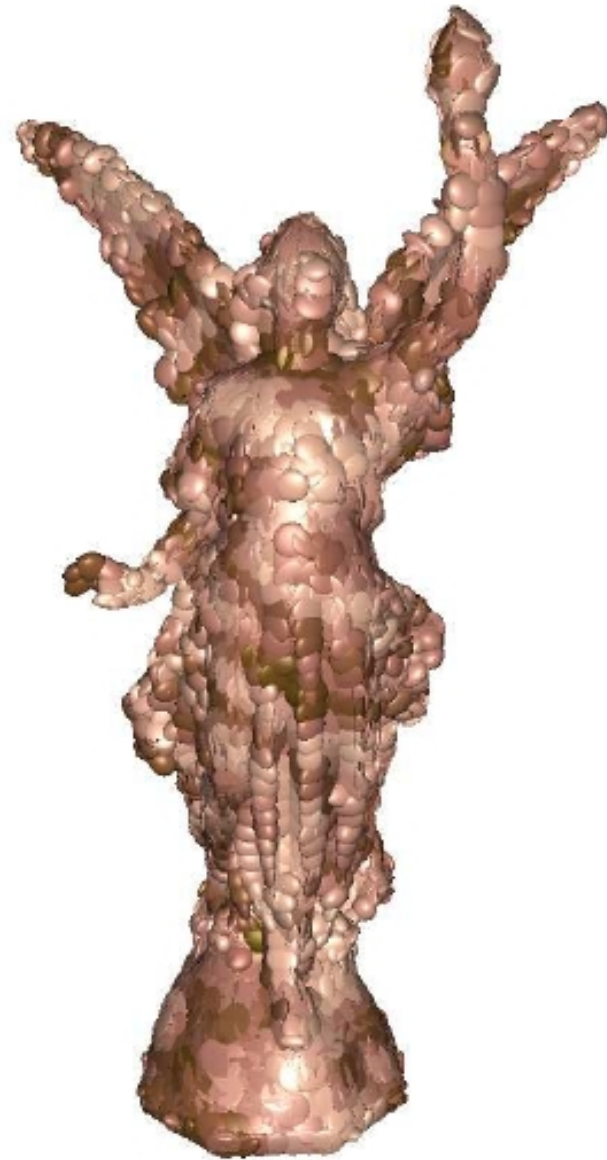
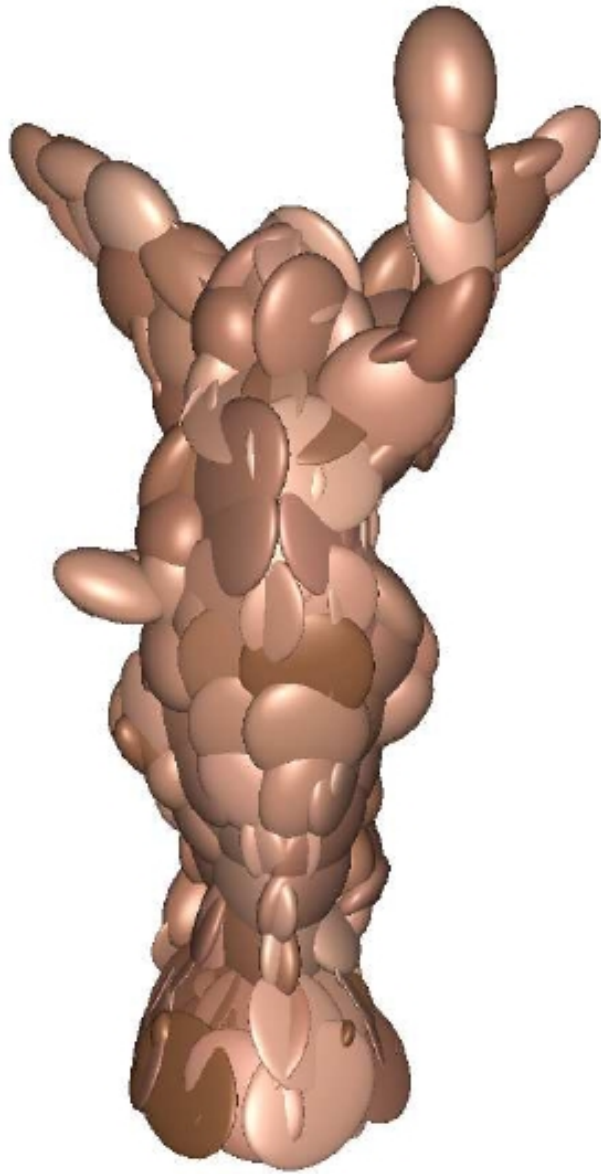
Equations



VORTEX



Ellipses

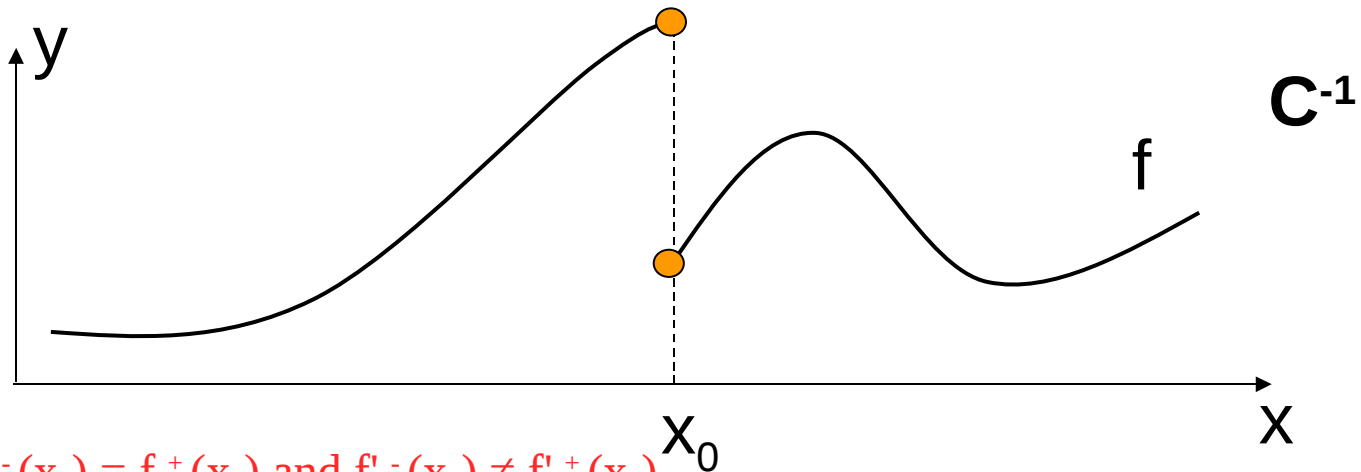


VORTEX

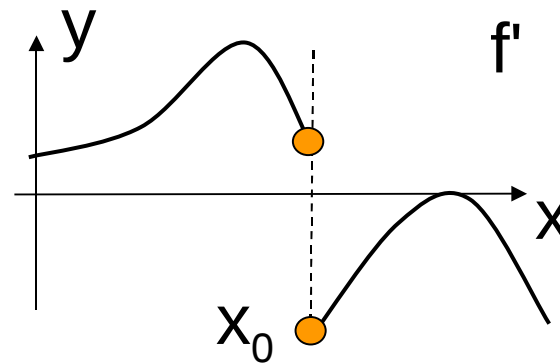
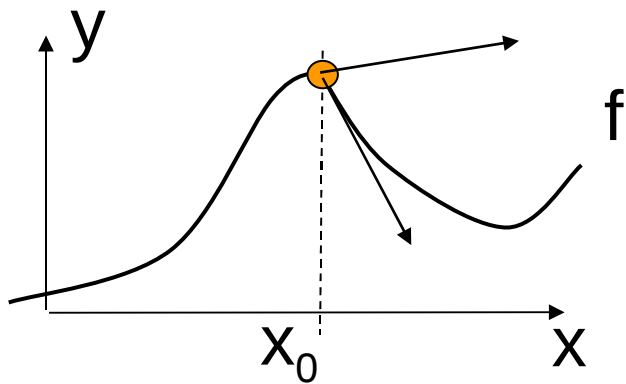


Continuity of a curve

- Let $f: \mathbb{R} \rightarrow \mathbb{R}$
 - If at point $x=x_0$ $f^-(x_0) \neq f^+(x_0)$ the curve is discontinuous at point x_0

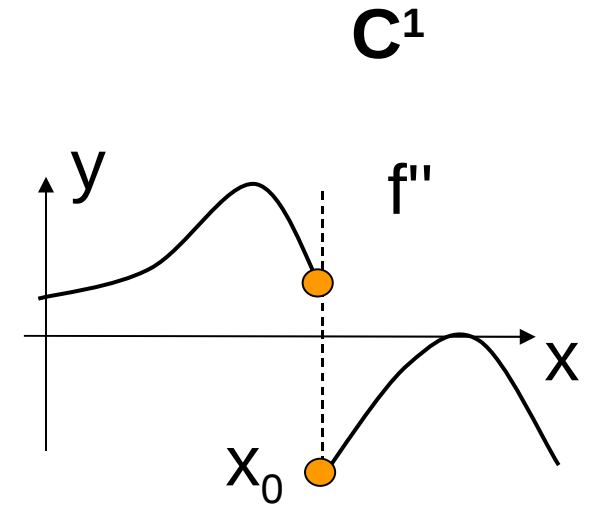
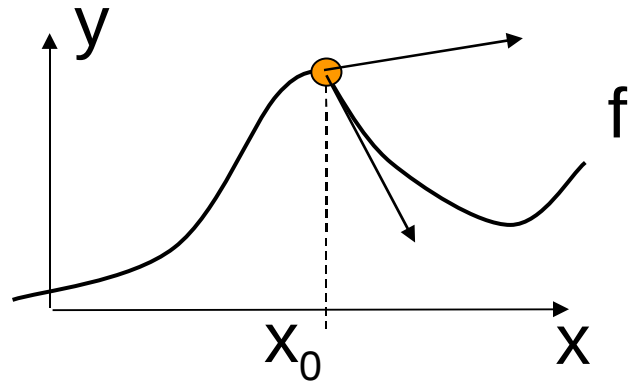
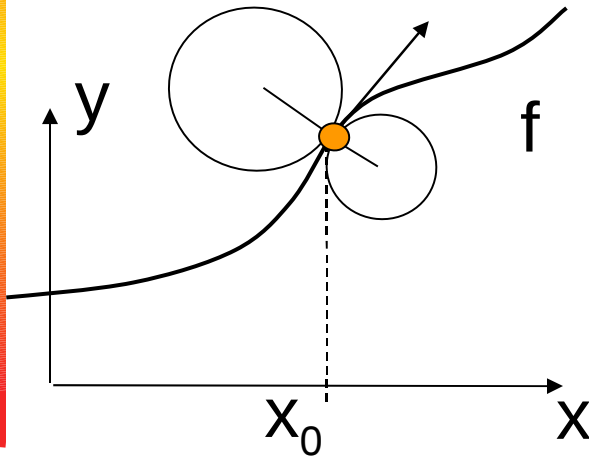


- If $f^-(x_0) = f^+(x_0)$ and $f'^-(x_0) \neq f'^+(x_0)$



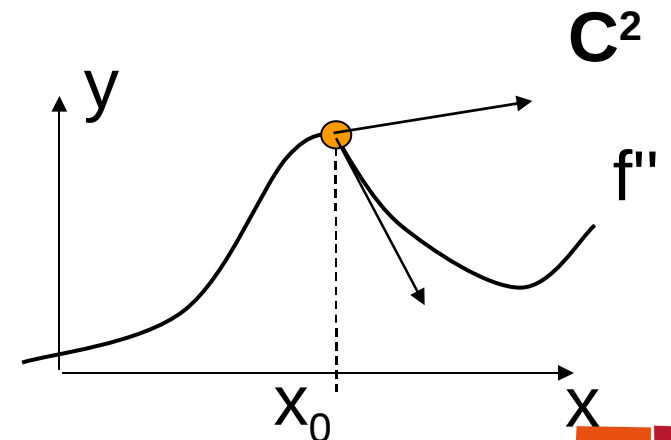
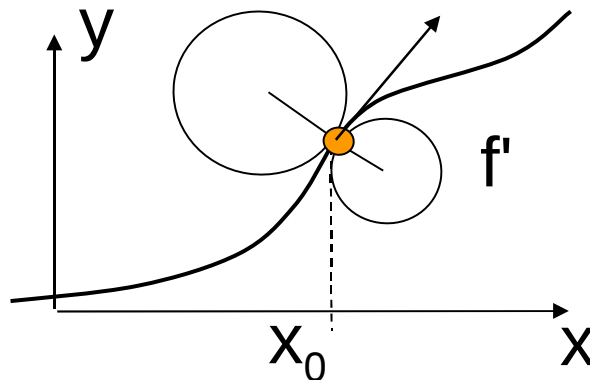
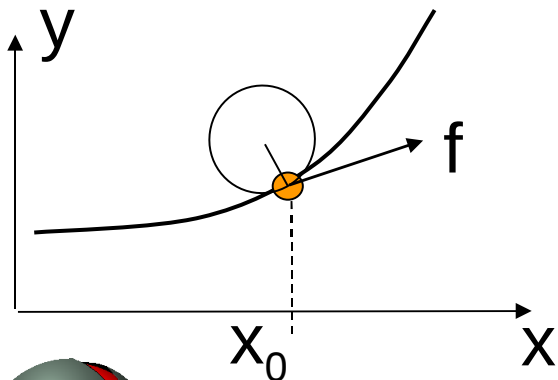
Continuity of a curve

- If $f^-(x_0) = f^+(x_0)$, $f'^-(x_0) = f'^+(x_0)$ et $f''^-(x_0) \neq f''^+(x_0)$



C^1

- If $f^-(x_0) = f^+(x_0)$, $f'^-(x_0) = f'^+(x_0)$, $f''^-(x_0) = f''^+(x_0)$ et $f'''^-(x_0) \neq f'''^+(x_0)$



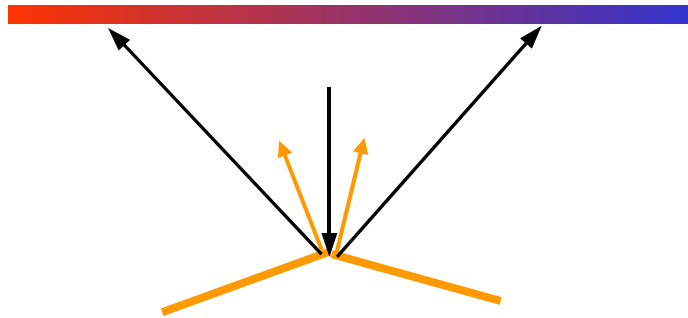
C^2



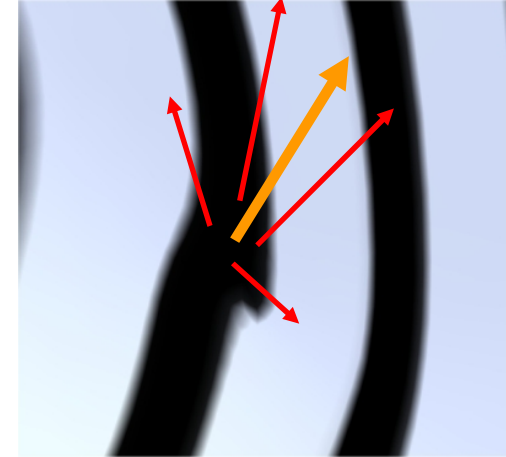
VORTEX



Continuity of reflexions



C^0 surface, discontinuous reflexion (C^{-1})

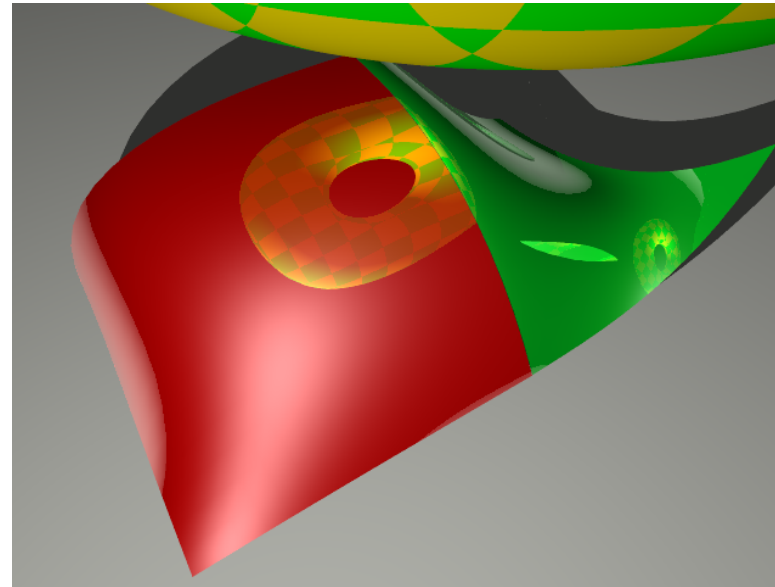
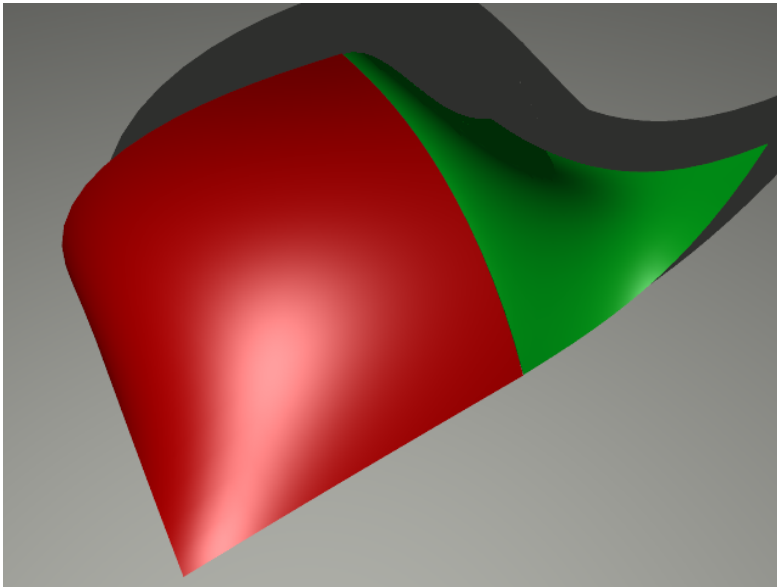
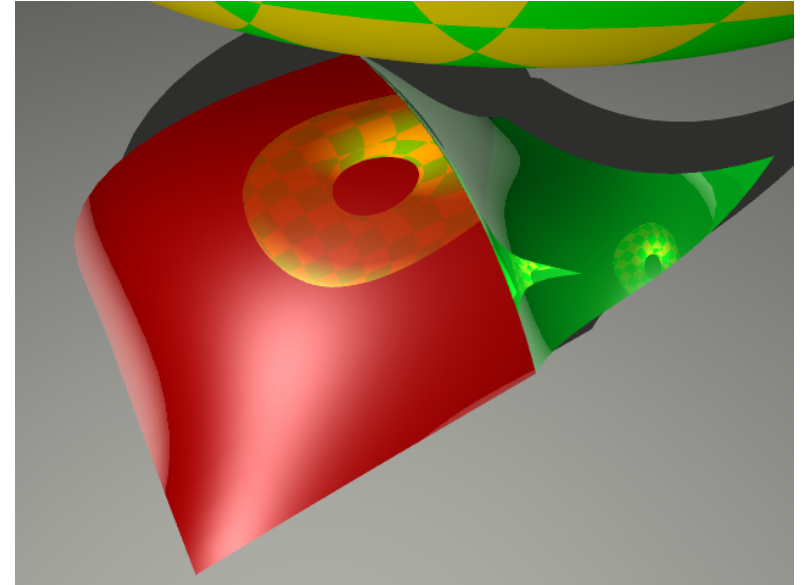
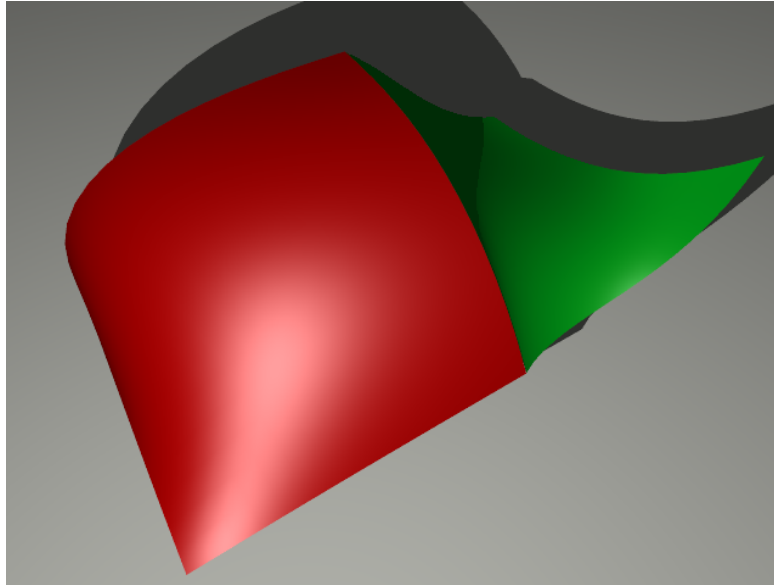


C^1 surface, C^0 reflexion: the curvature has different values around the central point

- The continuity class of the reflexions equals the one of the surface minus 1 (surface of class C^2 \Rightarrow reflexions of class C^1).
- Therefore, in animation, we would like to produce C^2 curves only in order to have C^1 reflexions.

Continuity of reflexions

- C^0 surface
- Discontinuous reflexion



- C^1 surface
- C^0 reflexion



Continuité des reflets

- C^2 surface
- C^1 reflexion

