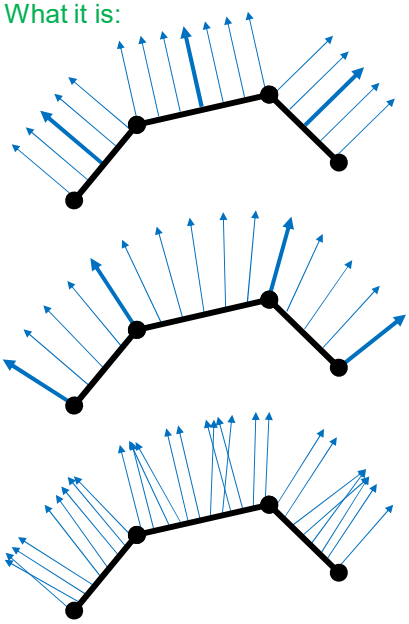
Marco Tarini - Computer Graphics 2020/2021
Università degli Studi di Milano

Surface smoothness

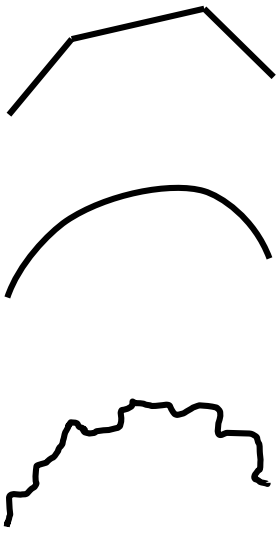
1

Surfaces and Normals for meshes (recap)

What it is:



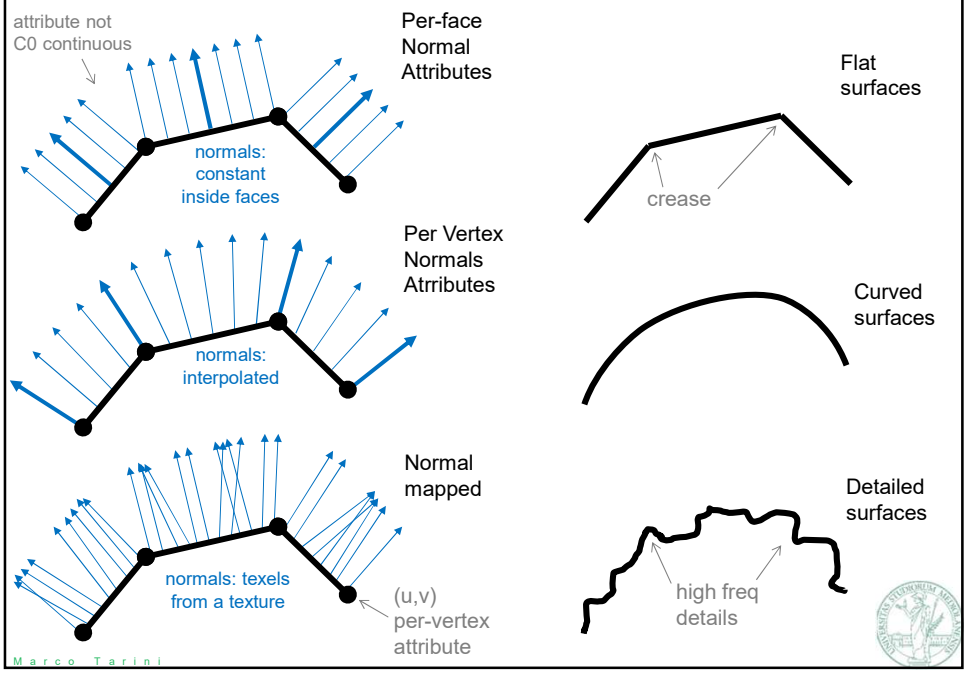
What it looks like:



Marco Tarini

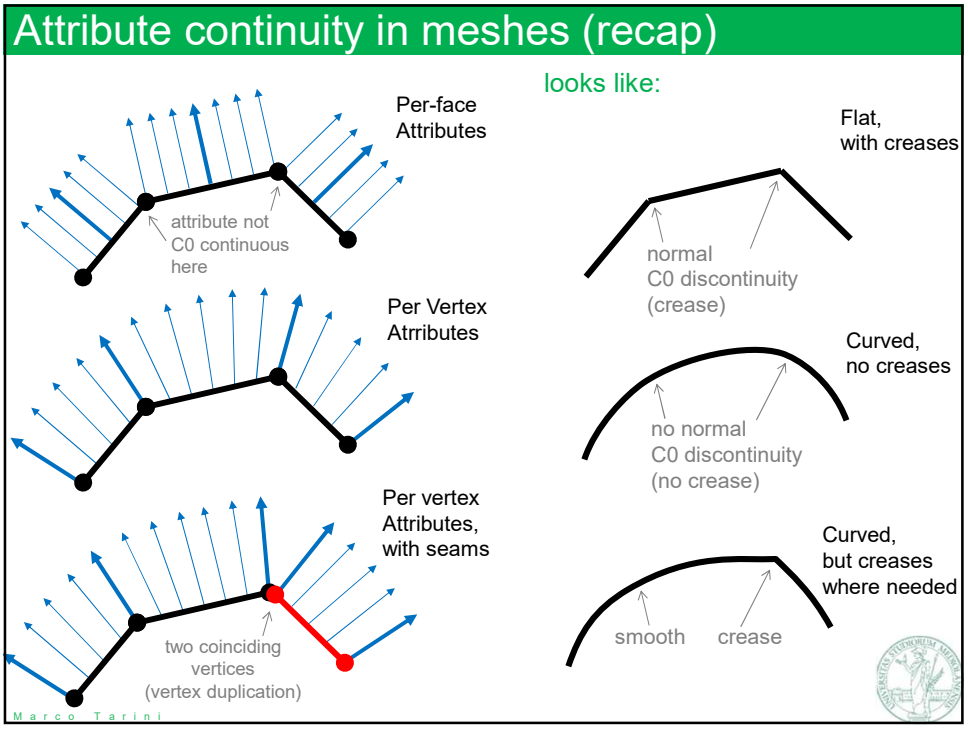
4

Surfaces and Normals for meshes (recap)



5

Attribute continuity in meshes (recap)



6

Mesh = Flat surfaces

- ✓ Tri-meshes are always piecewise linear 3D surfaces
  - ⇒ i.e. made of flat faces, with creases (“hard”, “sharp” edges)
  - ⇒ not “curved” -- not “smooth”
- ✓ Curvature can only be “faked” by lighting
  - ⇒ using normal interpolation
  - ⇒ note: eyes believes lighting more than shape!
  - ⇒ example: normal-maps = “fake” but convincing small details
- ✓ How to model “real” curved / smooth surfaces?
- ✓ We will see three different answers:
  - ⇒ 1) subdivision surfaces ← this today
  - ⇒ 2) parametric surfaces
  - ⇒ 3) implicit models
- ✓ First: what curvature, smoothness even is?

Marco Tarini

7

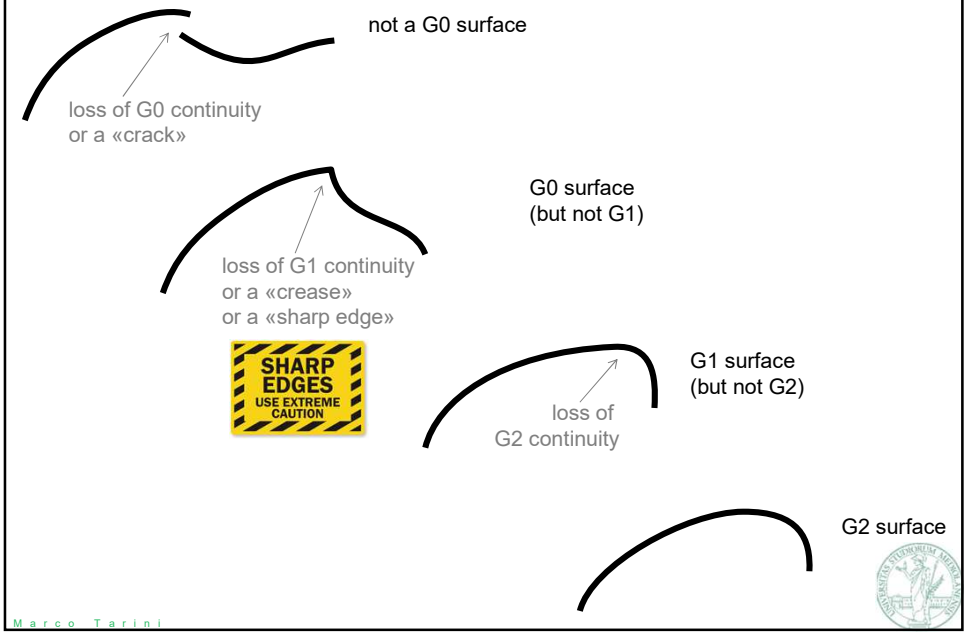
Surfaces: definitions and intuitive concepts

- ✓ normal ≙ surface orientation (around a point)
  - ⇒ how the position of a point P of surface varies, if I move around P while staying on the surface
  - ⇒ akin to: 1st derivative of surface position (more precise relationship later). Think of coefficient *a* of a line in 2D ($y = a\,x + b$)
- ✓ curvature ≙ normal variation (around a point)
  - ⇒ e.g.: zero curvature = no normal variation = flat
  - ⇒ e.g.: high curvature = normal varies a lot around a point
  - ⇒ different precise mathematical definitions are possible (not in this course)
  - ⇒ akin to derivative of surface normal, i.e. to 2nd derivative of surface position
- ✓ smoothness ≙ continuity of normal or curvature (around a point)
  - ⇒ “G1 smooth” surface ≙ surface with continuous normal = no sudden “jump” in surface normal = no creases
  - ⇒ “G2 smooth” surface ≙ surface with continuous curvature = no sudden “jump” in surface curvature Akin to: vanishing 3rd derivative of surface position

Marco Tarini

8

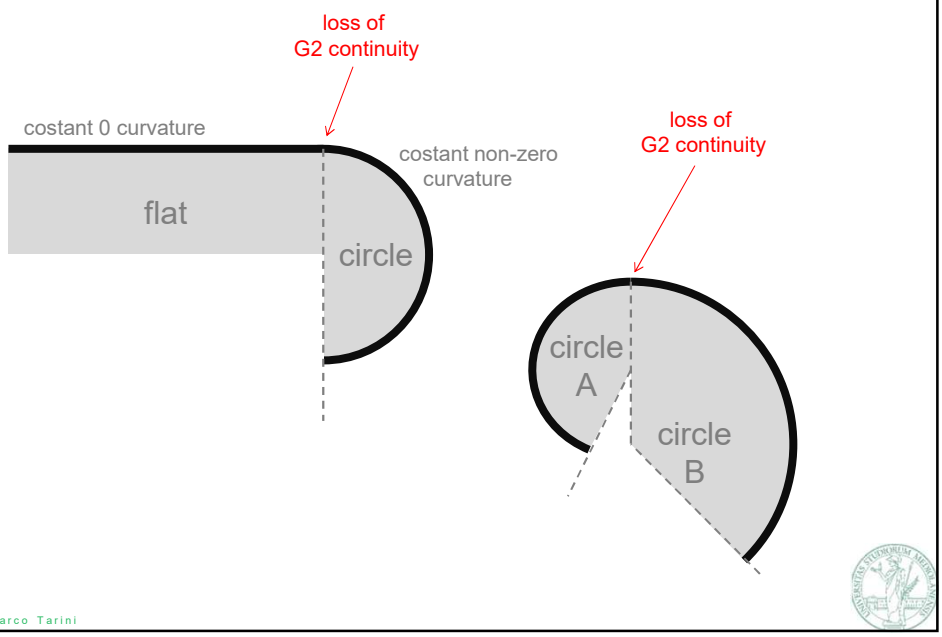
Surface smoothness



Marco Tarini

9

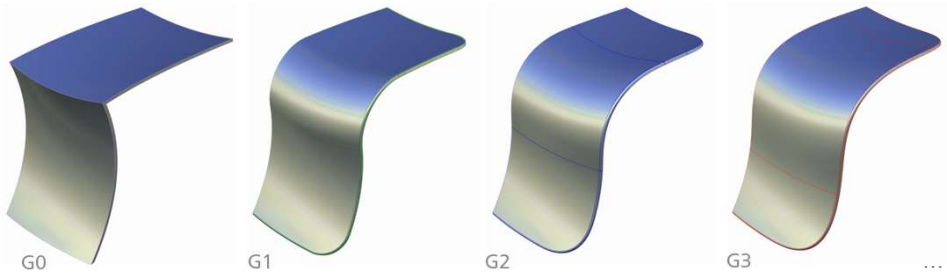
Examples of «G1 but not G2» surface (or lines)



Marco Tarini

10

But, clearly, in 3D



continuity of position	continuity of normals	continuity of curvature	continuity of derivative of curvature

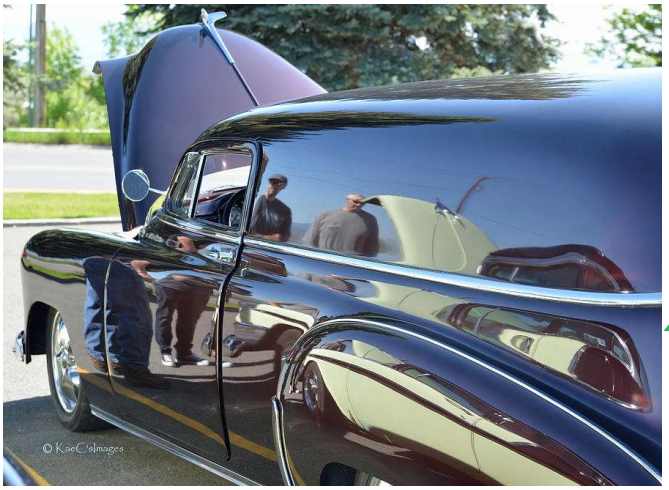
high quality,
«good looking» surfaces
(e.g. for car industry)

Marco Tarini

11

Smoothness can be important

✓ Reflections / highlights reveal surface smoothness



:)

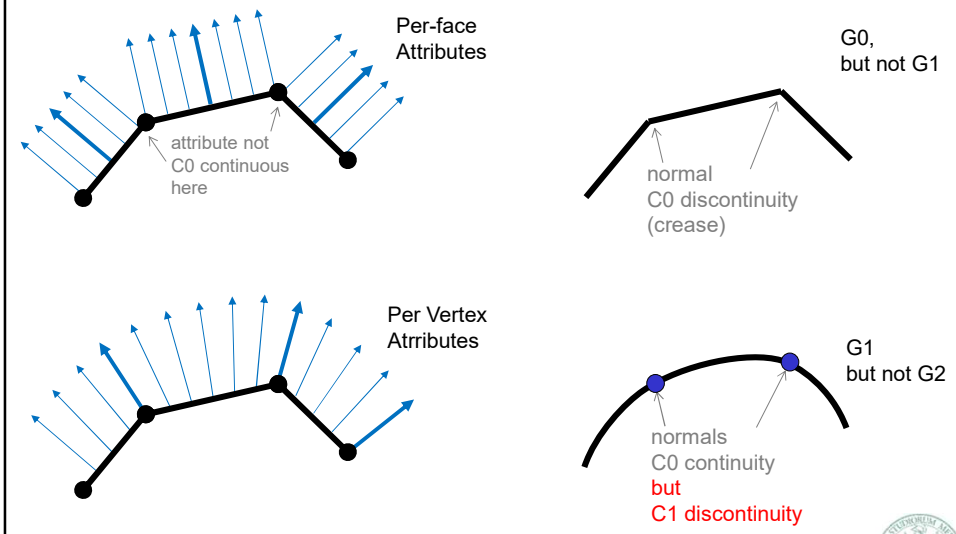
✓ In c.g. and reality alike

Marco Tarini

12

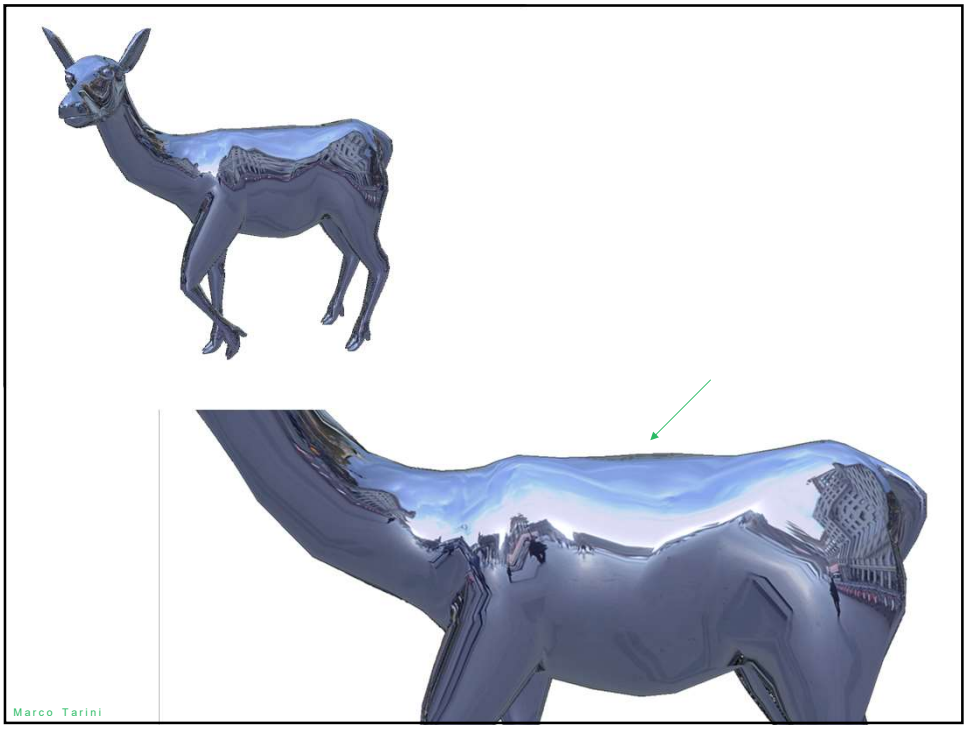
Meshes are G0 , can “fake” G1 , but not G2

looks like:



BUT: magnitude of discontinuities go down with mesh resolution

13



15