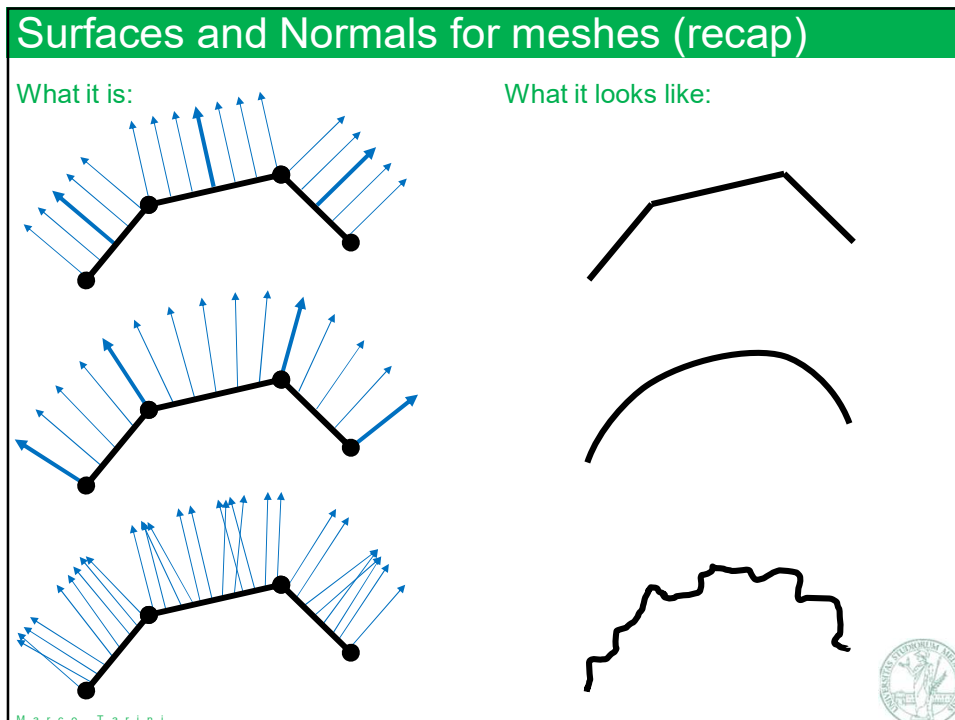




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Surfaces and Normals for meshes (recap)

Per-face Normal Attributes

attribute not C0 continuous

normals: constant inside faces

Per Vertex Normal Attributes

normals: interpolated

Normal mapped

normals: texels from a texture

(u,v) per-vertex attribute

Flat surfaces

crease

Curved surfaces

Detailed surfaces

high freq details

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Attribute continuity in meshes (recap)

Per-face Attributes

attribute not C0 continuous here

Per Vertex Attributes

Per vertex Attributes, with seams

two coinciding vertices (vertex duplication)

looks like:

Flat, with creases

normal C0 discontinuity (crease)

Curved, no creases

no normal C0 discontinuity (no crease)

Curved, but creases where needed

smooth crease

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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?

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Surfaces: definitions and intuitive concepts

- ✓ **normal** \triangleq 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 ($y = ax + b$)
- ✓ **curvature** \triangleq 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** \triangleq continuity of normal or curvature (around a point)
 - ⇒ “G1 smooth” surface \triangleq surface with continuous normal = no sudden “jump” in surface normal = no creases
 - ⇒ “G2 smooth” surface \triangleq surface with continuous curvature = no sudden “jump” in surface curvature
 - Akin to: vanishing 3rd derivative of surface position

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Surface smoothness

The diagram shows four curves representing different levels of surface smoothness:

- not a G0 surface:** A curve with a sharp corner. An arrow points to the corner with the text "loss of G0 continuity or a «crack»".
- G0 surface (but not G1):** A curve with a sharp peak. An arrow points to the peak with the text "loss of G1 continuity or a «crease» or a «sharp edge»". Below this curve is a yellow warning sign that reads "SHARP EDGES USE EXTREME CAUTION".
- G1 surface (but not G2):** A curve with a smooth transition but a change in curvature. An arrow points to the transition with the text "loss of G2 continuity".
- G2 surface:** A smooth curve with constant curvature.

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

The diagram illustrates two examples of G1 but not G2 surfaces:

- Example 1:** A flat surface (constant 0 curvature) transitioning to a circular surface (constant non-zero curvature). A dashed vertical line marks the transition, with a red arrow pointing to it labeled "loss of G2 continuity".
- Example 2:** Two circular surfaces, labeled "circle A" and "circle B", meeting at a point. A dashed line marks the junction, with a red arrow pointing to it labeled "loss of G2 continuity".

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But, clearly, in 3D

G0 G1 G2 G3 ...

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

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

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Smoothness can be important

- ✓ Reflections / highlights reveal surface smoothness

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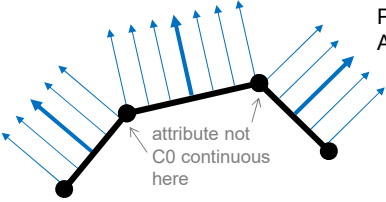
- ✓ In c.g. and reality alike

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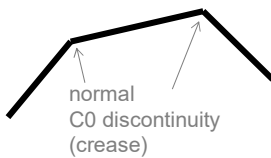
Meshes are G0 , can “fake” G1 , but not G2

looks like:



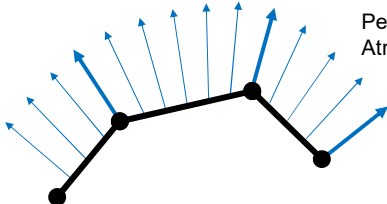
Per-face Attributes

attribute not C0 continuous here

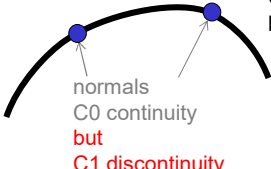


G0, but not G1

normal C0 discontinuity (crease)




Per Vertex Attributes



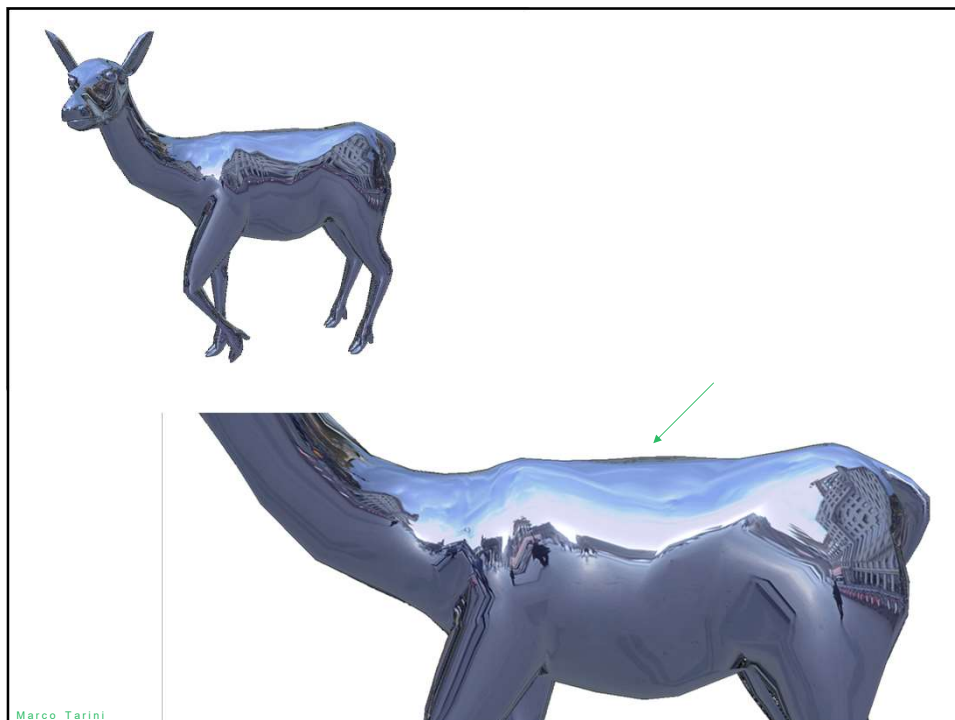
G1 but not G2

normals C0 continuity
but
C1 discontinuity

BUT: magnitude of discontinuities go down with mesh resolution



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