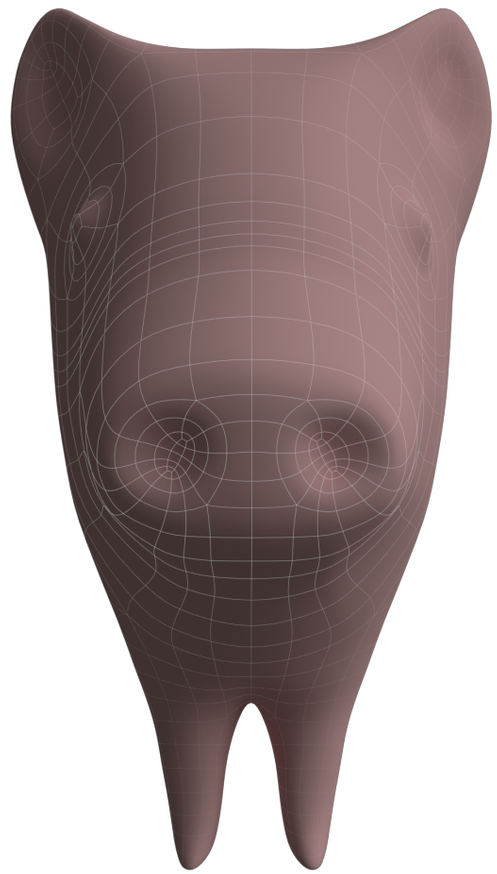

Geometria 3D per Programmatori

develer

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Geometria 3D per Programmatori

- Introduzione
  - computer graphics 3D e geometria computazionale
- Modelli 3D
  - rappresentazioni matematiche di un oggetto tridimensionale
- Algoritmi e Strutture Dati
  - elementi costitutivi di un modello 3D
  - elaborare/modificare un modello 3D

3D Computer Graphics

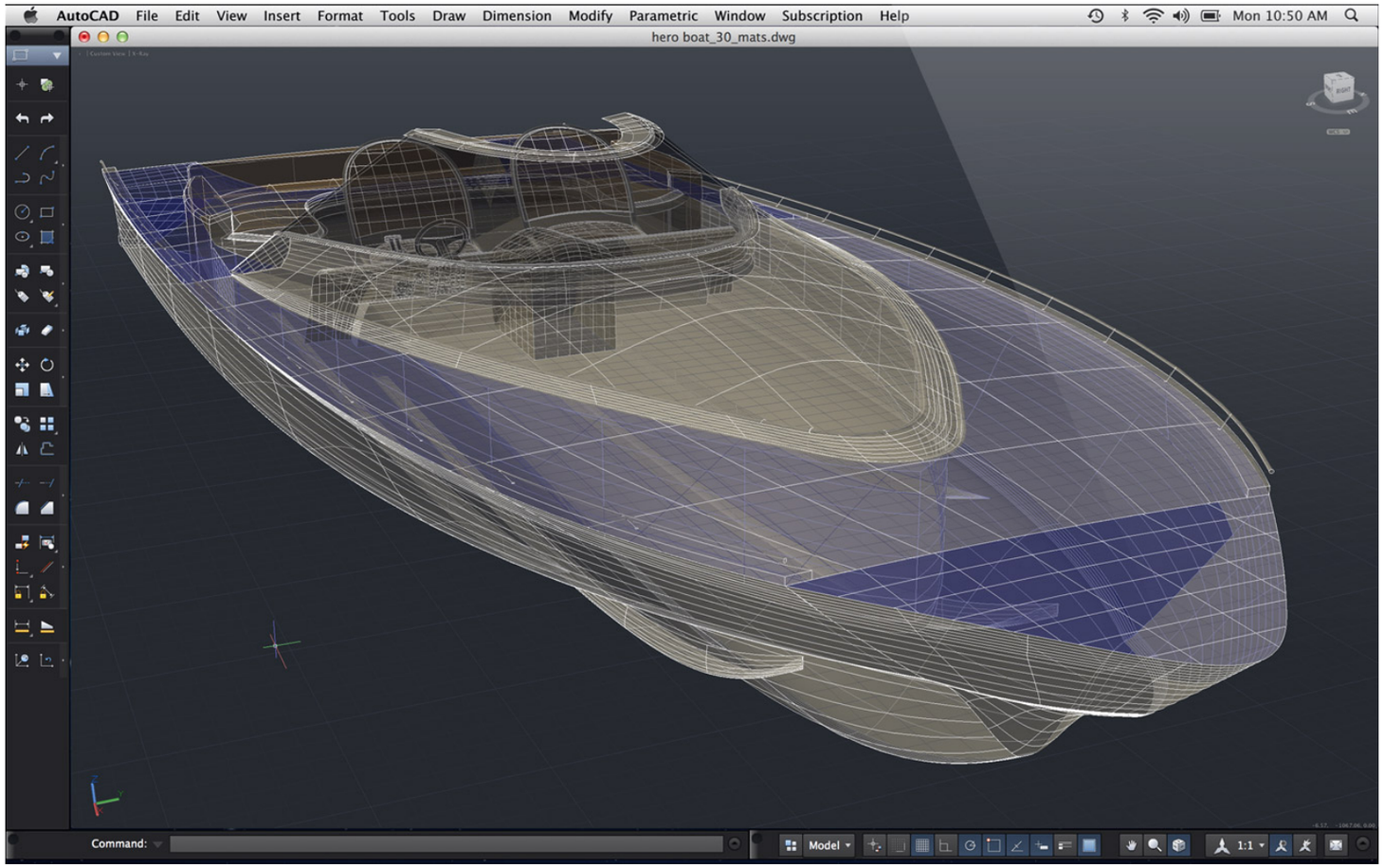
metodi e tecnologie per elaborare dati geometrici tridimensionali allo scopo di eseguire calcoli e produrre visualizzazioni (2D rendering, 3D printing, …)

1. modeling — acquisizione/definizione dati
2. animation — elaborazione/modifica dati
3. rendering — visualizzazione

3D Computer Graphics

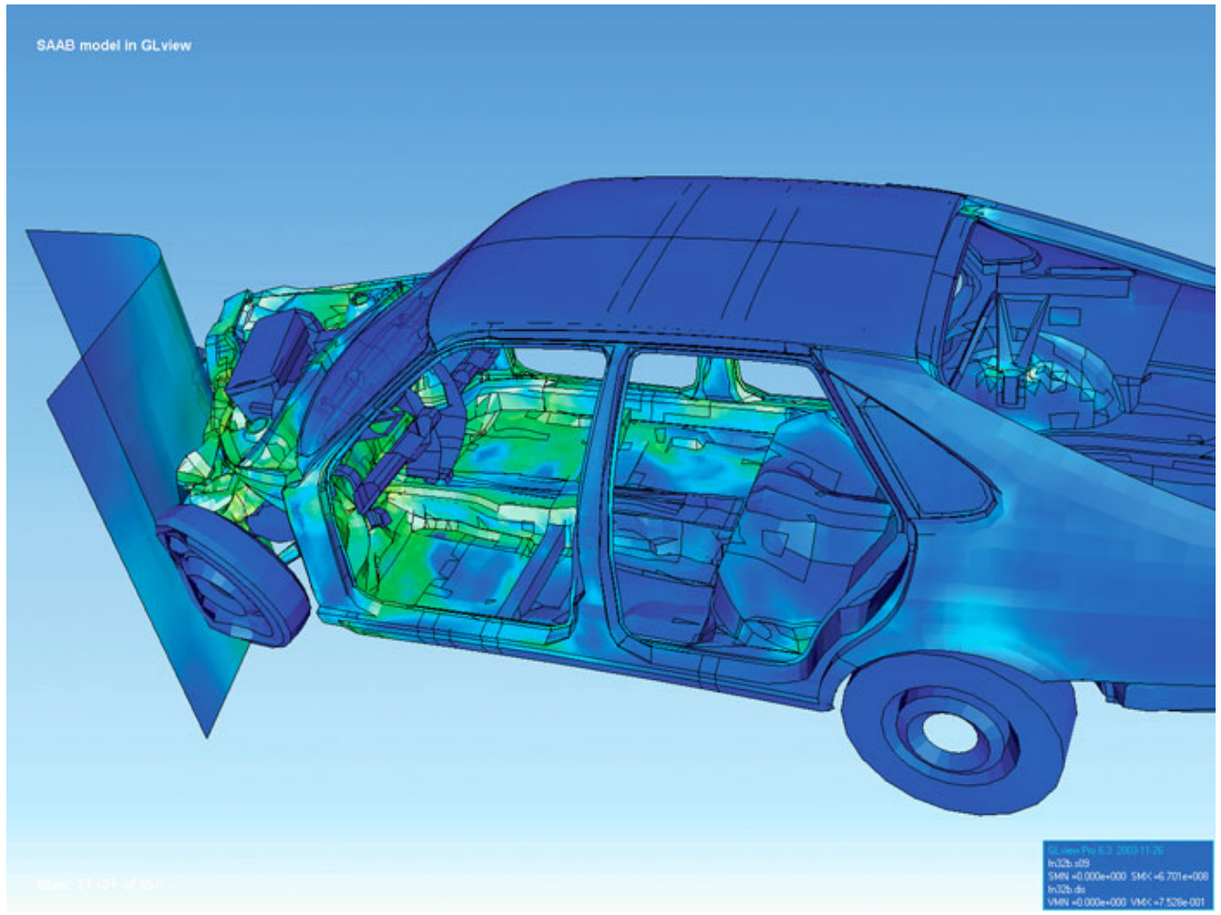
3D Computer Graphics

- progettazione industriale (CAD, …)



3D Computer Graphics

- progettazione industriale (CAD, …)
- simulazione fisica computerizzata



3D Computer Graphics

- progettazione industriale (CAD, …)
- simulazione fisica computerizzata
- videogiochi

3D Computer Graphics

- progettazione industriale (CAD, …)
- simulazione fisica computerizzata
- videogiochi
- animazione ed effetti visivi

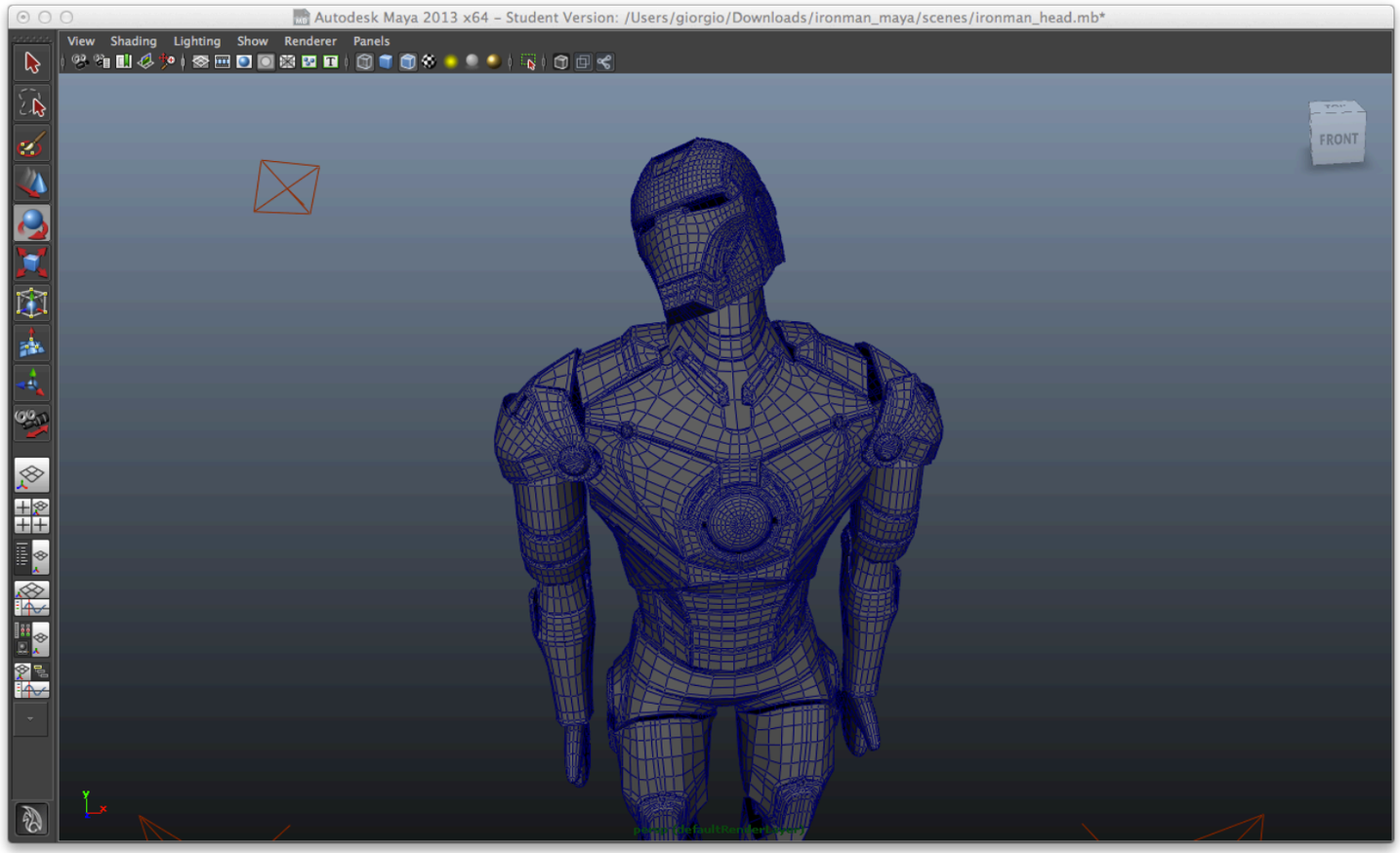
Modeling

il processo di definizione e sviluppo della rappresentazione matematica della geometria di un modello 3D

Modeling

il processo di definizione e sviluppo della rappresentazione matematica della geometria di un modello 3D

1. “a mano”
   tramite software interattivi (es. Maya, Blender, …)



Modeling

il processo di definizione e sviluppo della rappresentazione matematica della geometria di un modello 3D

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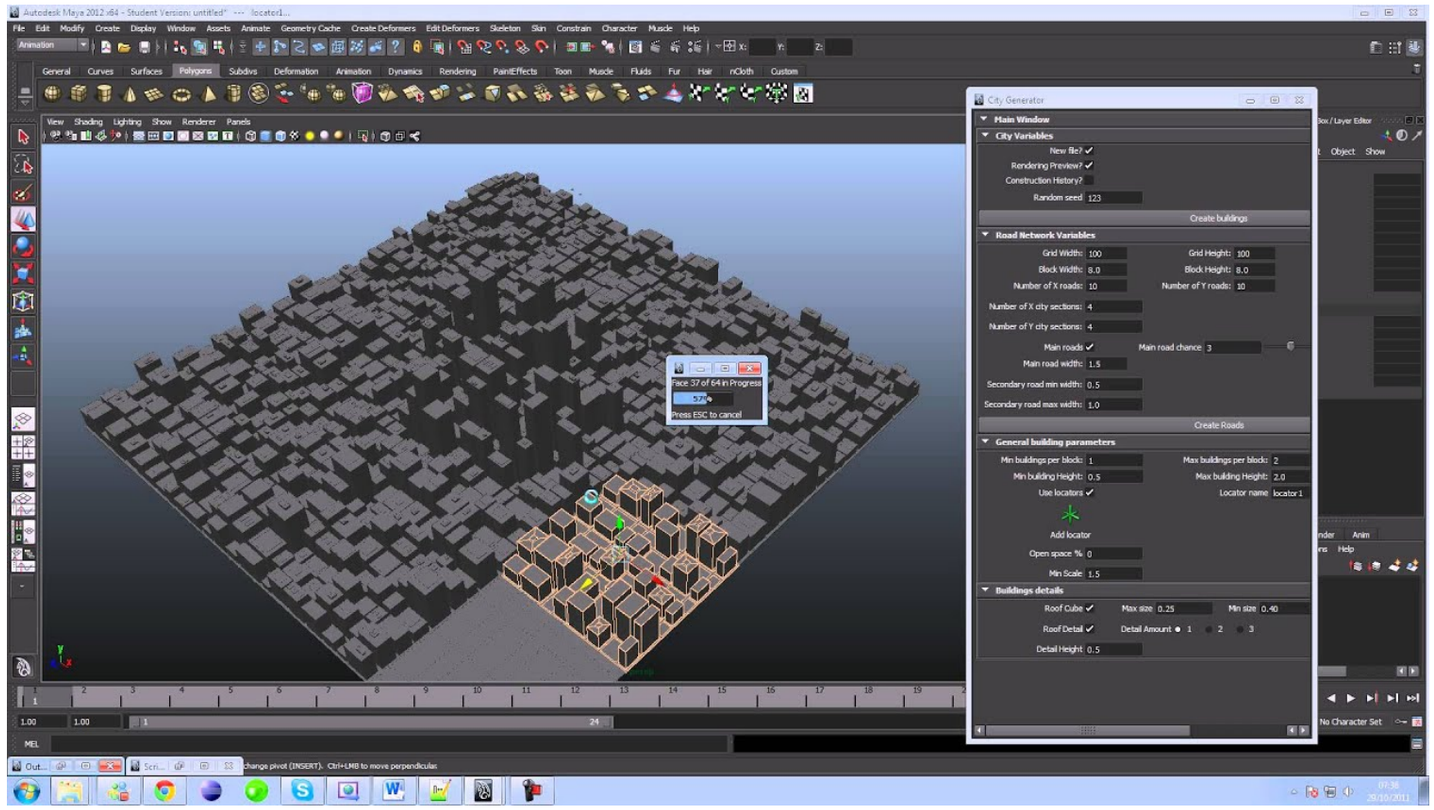
   tramite software interattivi (es. Maya, Blender, …)

2. procedurale
   definizione algoritmica



Modeling

il processo di definizione e sviluppo della rappresentazione matematica della geometria di un modello 3D

1. “a mano”
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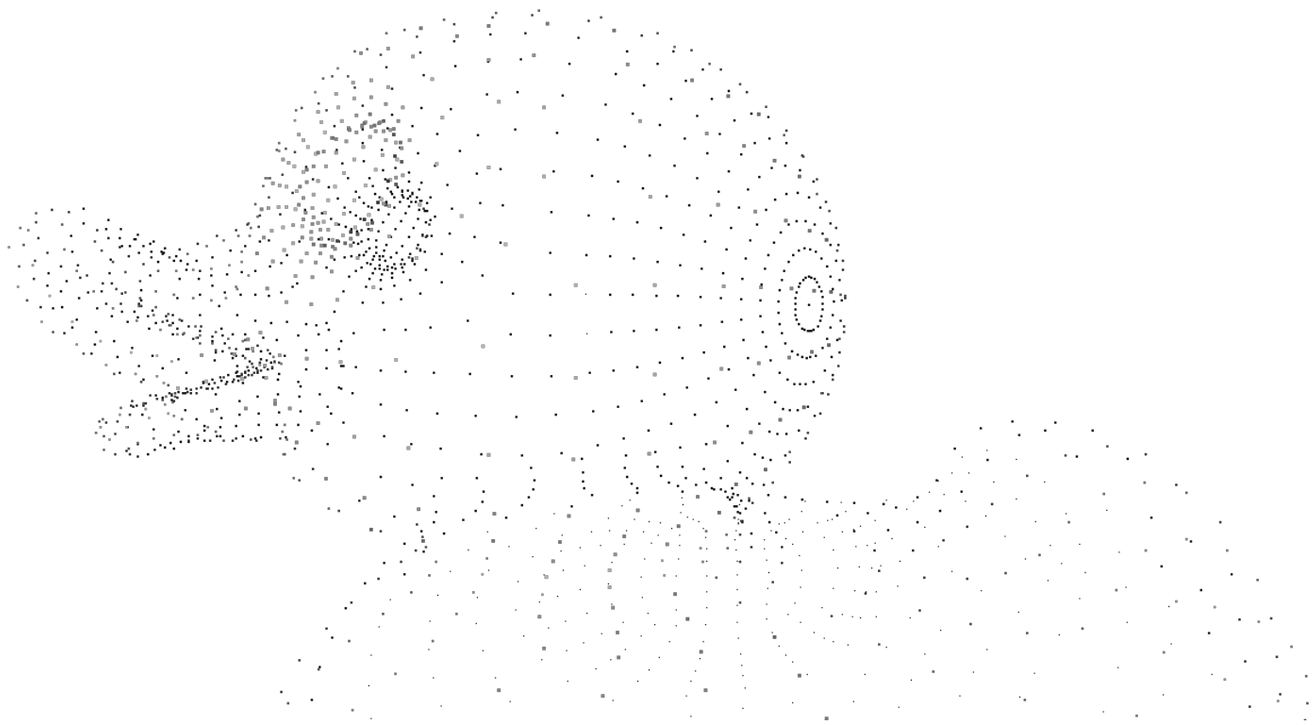
2. procedurale
   definizione algoritmica

3. acquisizione
   via scanning



Modeling

il processo di definizione e sviluppo della rappresentazione matematica della geometria di un modello 3D

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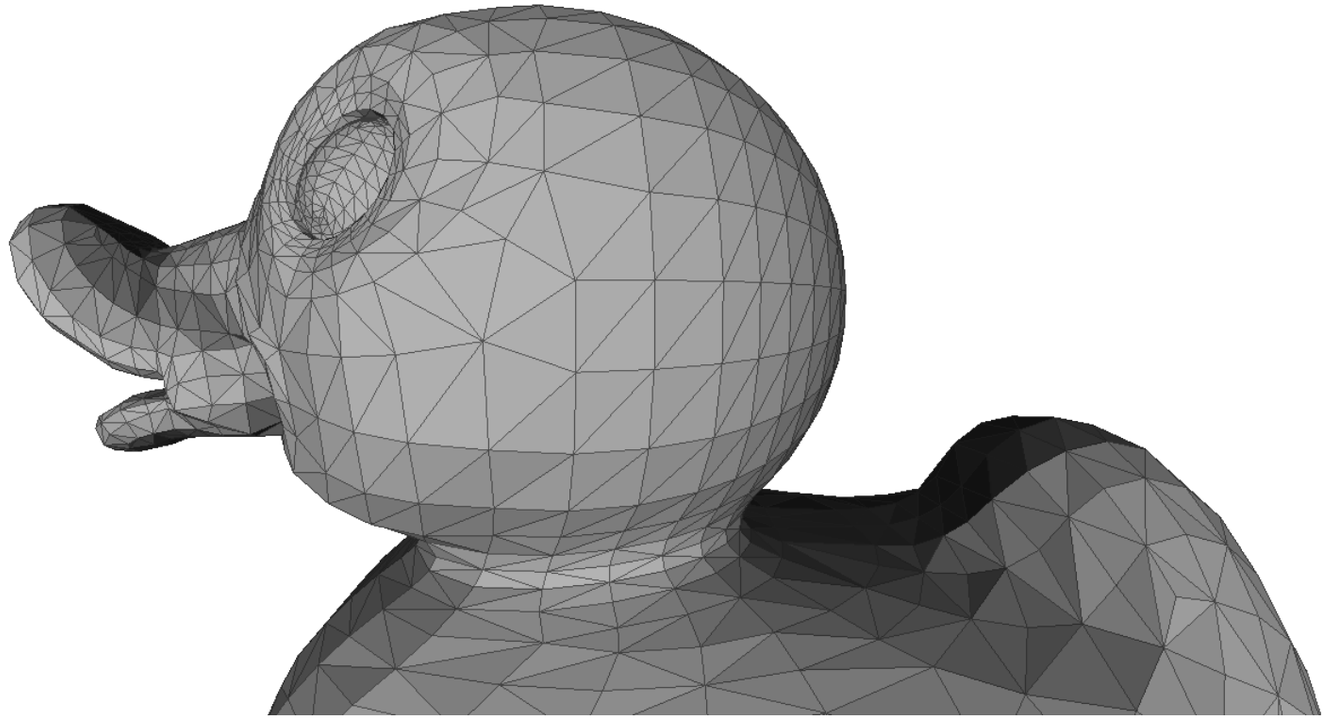
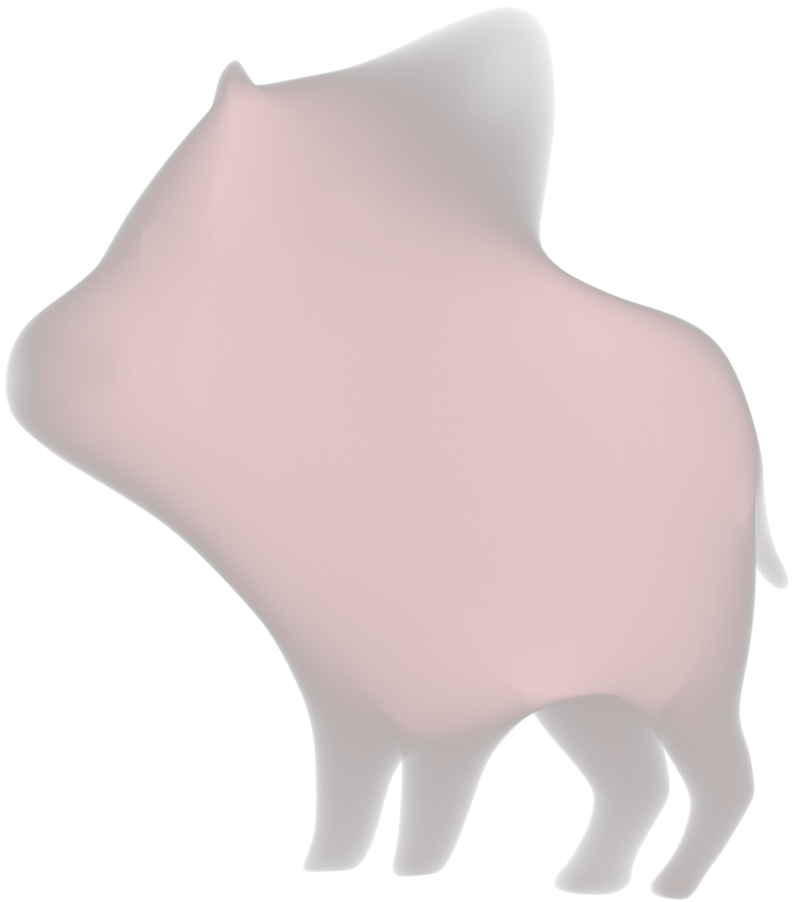
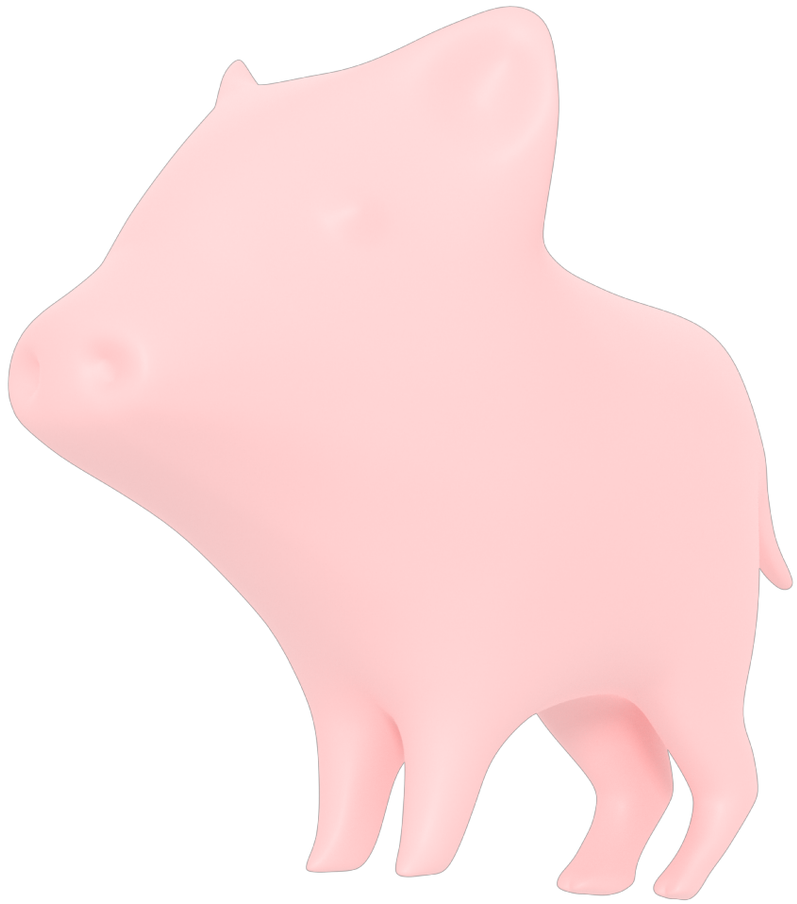


Il Modello 3D

come si rappresenta?
volume vs superficie



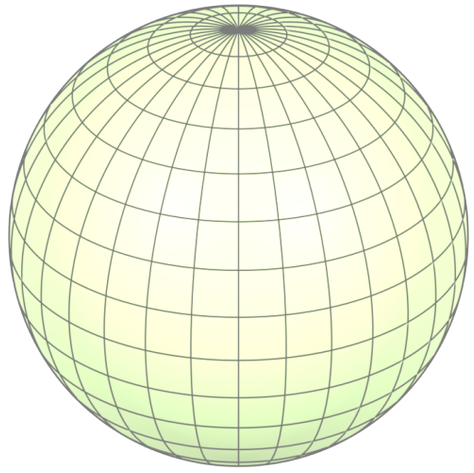


Superfici

parametriche *vs* implicite

$$f : \mathbf{D} \subset \mathbb{R}^2 \mapsto \mathbf{I} \subset \mathbb{R}^3 \qquad F(x, y, z) = 0$$

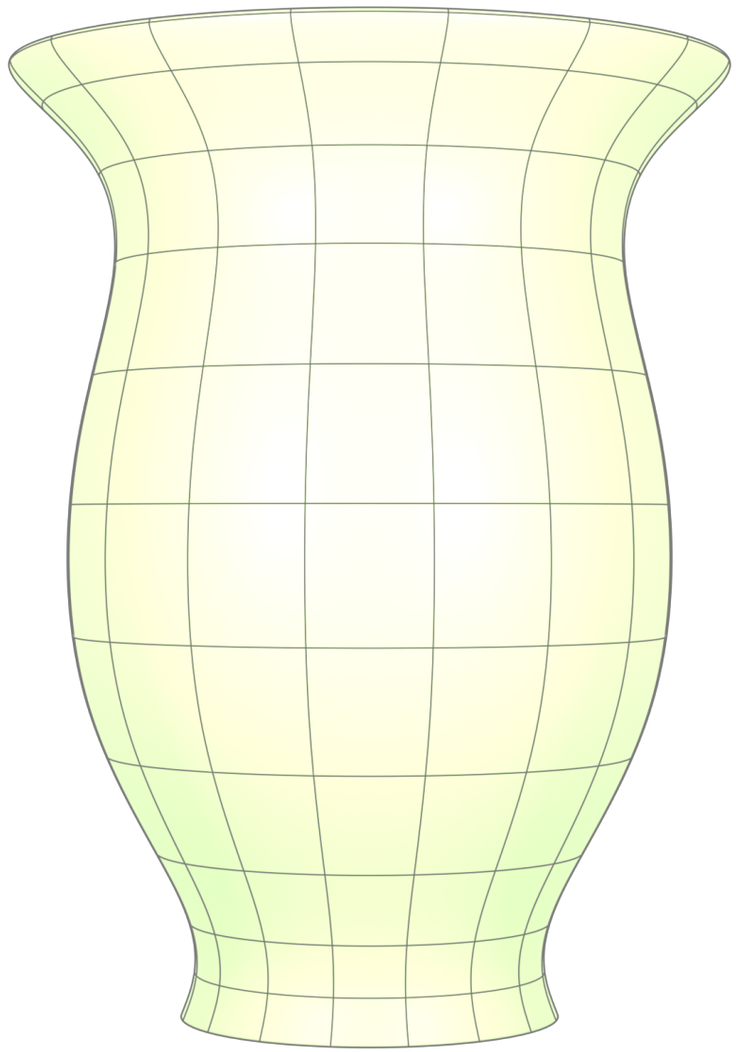
$$f(\alpha, \beta) = \begin{pmatrix} sin(\beta)cos(\alpha) \\ sin(\beta)sin(\alpha) \\ cos(\beta) \end{pmatrix} \qquad x^2 + y^2 + z^2 - 1 = 0$$



Superfici a tratti

- difficile rappresentare superfici complesse con singole funzioni matematiche

- campionamento



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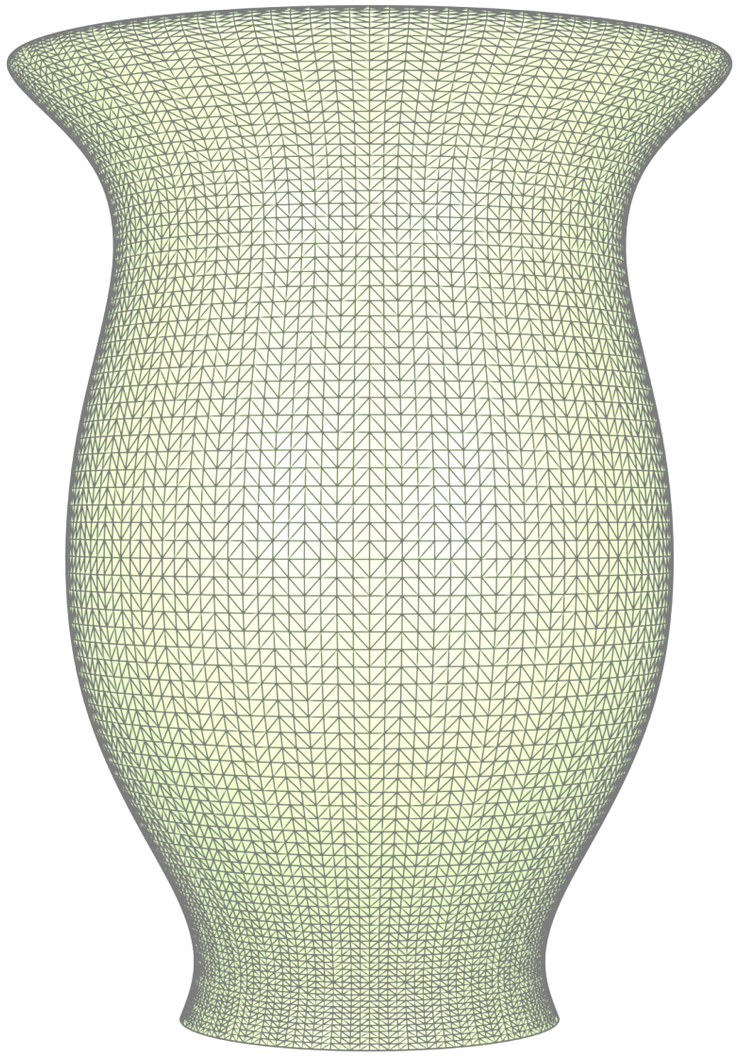
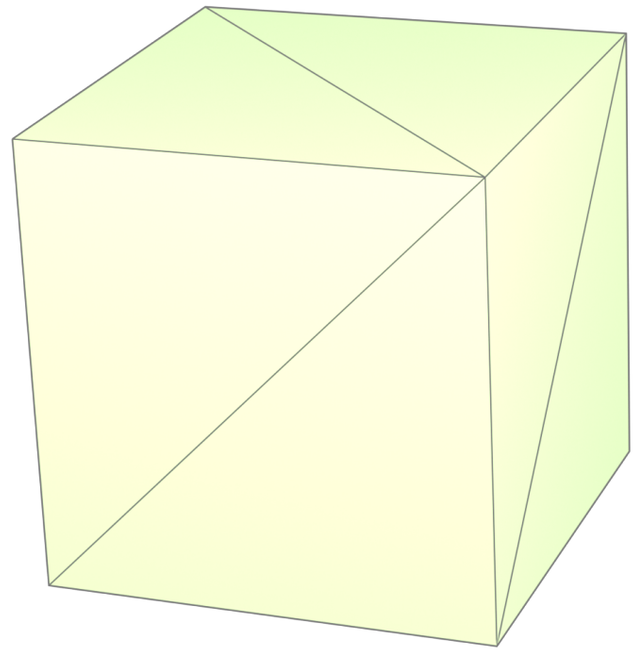
Superfici a tratti

- una superficie complessa è suddivisa in porzioni di superfici più semplici, unite ai bordi (mesh)

- es. porzioni di piani (mesh poligonali)
  - caso particolare: triangoli

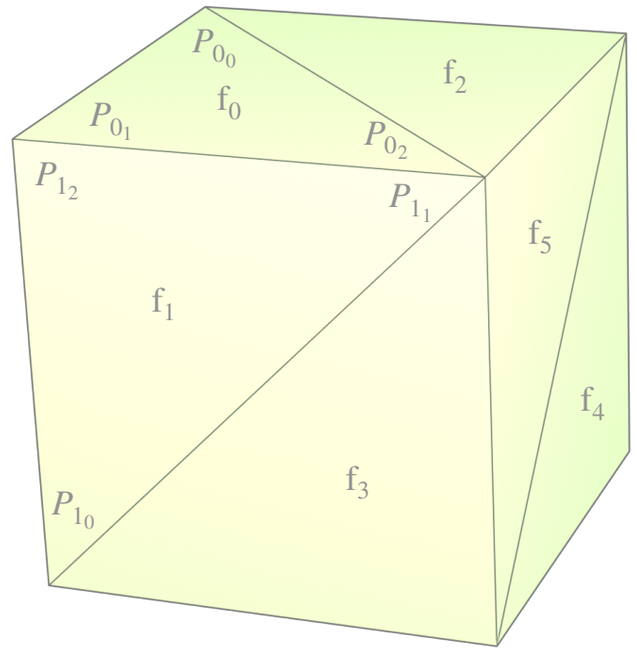


Mesh di triangoli: struttura dati semplice

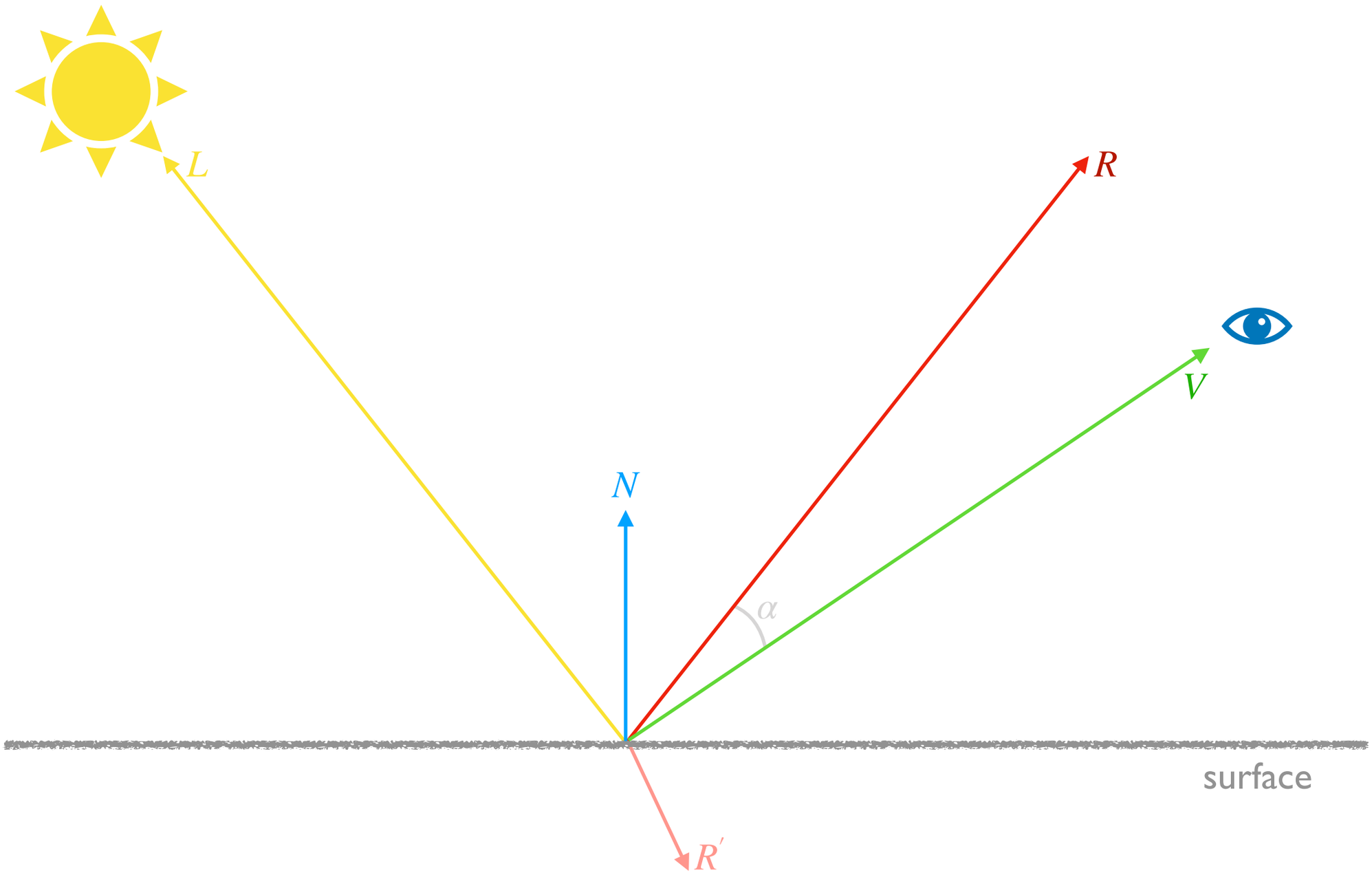


Mesh di triangoli: struttura dati semplice

face 0	$P_{0_0}\begin{pmatrix}x_{0_0}\\y_{0_0}\\z_{0_0}\end{pmatrix}$	$P_{0_1}\begin{pmatrix}x_{0_1}\\y_{0_1}\\z_{0_1}\end{pmatrix}$	$P_{0_2}\begin{pmatrix}x_{0_2}\\y_{0_2}\\z_{0_2}\end{pmatrix}$
face 1	$P_{1_0}\begin{pmatrix}x_{1_0}\\y_{1_0}\\z_{1_0}\end{pmatrix}$	$P_{1_1}\begin{pmatrix}x_{1_1}\\y_{1_1}\\z_{1_1}\end{pmatrix}$	$P_{1_2}\begin{pmatrix}x_{1_2}\\y_{1_2}\\z_{1_2}\end{pmatrix}$
face 2	$P_{2_0}\begin{pmatrix}x_{2_0}\\y_{2_0}\\z_{2_0}\end{pmatrix}$	$P_{2_1}\begin{pmatrix}x_{2_1}\\y_{2_1}\\z_{2_1}\end{pmatrix}$	$P_{2_2}\begin{pmatrix}x_{2_2}\\y_{2_2}\\z_{2_2}\end{pmatrix}$
face 3	$P_{3_0}\begin{pmatrix}x_{3_0}\\y_{3_0}\\z_{3_0}\end{pmatrix}$	$P_{3_1}\begin{pmatrix}x_{3_1}\\y_{3_1}\\z_{3_1}\end{pmatrix}$	$P_{3_2}\begin{pmatrix}x_{3_2}\\y_{3_2}\\z_{3_2}\end{pmatrix}$
...			



Illuminazione



Richiami di Geometria

- somma di vettori

$$\mathbf{v} = \mathbf{v}_1 + \mathbf{v}_2 = \begin{pmatrix} x_1 + x_2 \\ y_1 + y_2 \\ z_1 + z_2 \end{pmatrix}$$

- prodotto tra vettore e scalare

$$\mathbf{v} = a\mathbf{v}_1 = \begin{pmatrix} a x_1 \\ a y_1 \\ a z_1 \end{pmatrix}$$

- norma di un vettore

$$l = \|\mathbf{v}_1\| = \sqrt{x_1^2 + y_1^2 + z_1^2}$$

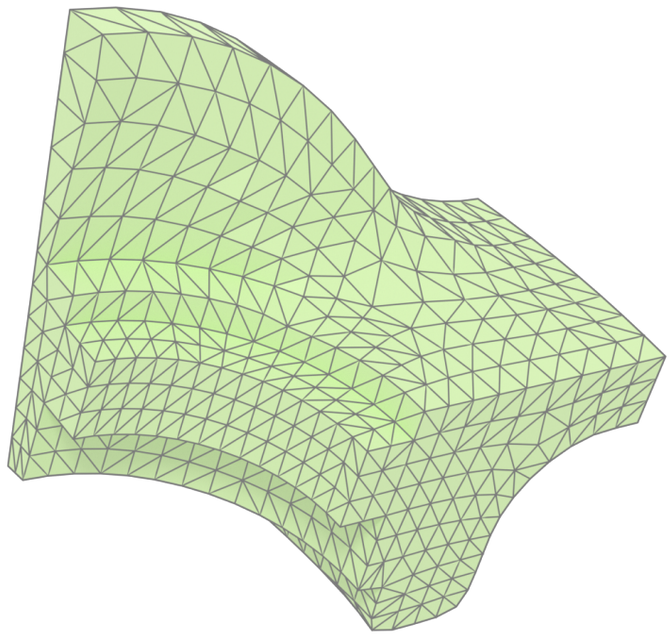
- prodotto scalare

$$\begin{aligned} a &= \mathbf{v}_1 \cdot \mathbf{v}_2 \\ &= x_1 * x_2 + y_1 * y_2 + z_1 * z_2 \\ &= \|\mathbf{v}_1\| \|\mathbf{v}_2\| \cos(\mathbf{v}_1 \angle \mathbf{v}_2) \end{aligned}$$

- prodotto vettoriale

$$\begin{aligned} \mathbf{v} &= \mathbf{v}_1 \times \mathbf{v}_2 \qquad \mathbf{v} \perp (\mathbf{v}_1, \mathbf{v}_2) \\ \|\mathbf{v}_1 \times \mathbf{v}_2\| &= \|\mathbf{v}_1\| \|\mathbf{v}_2\| \sin(\mathbf{v}_1 \angle \mathbf{v}_2) \end{aligned}$$

Superfici: shading



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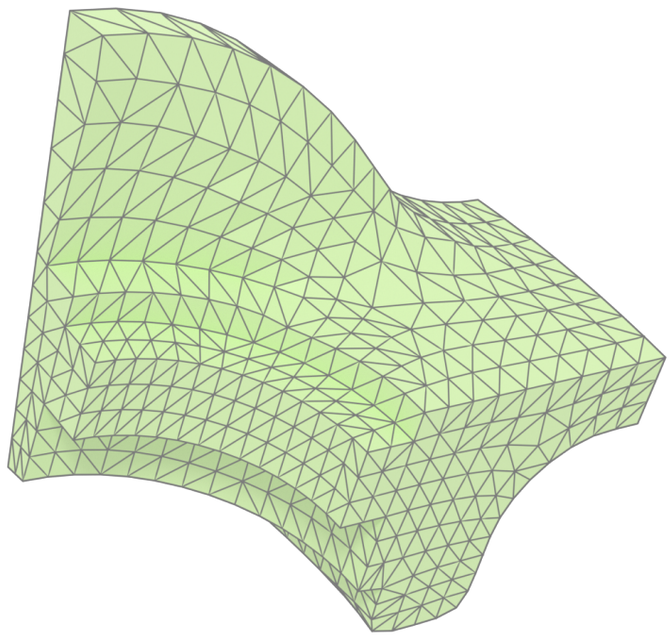
Superfici: shading

- flat shading



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Superfici: shading

- flat shading

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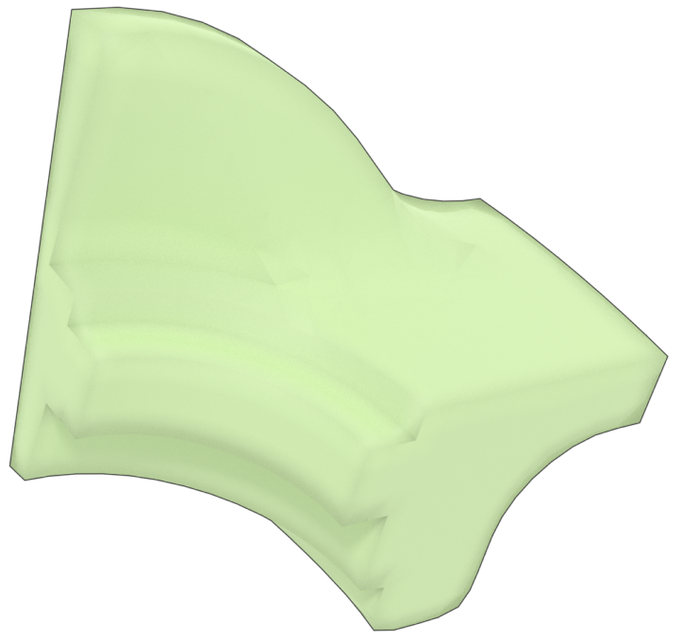
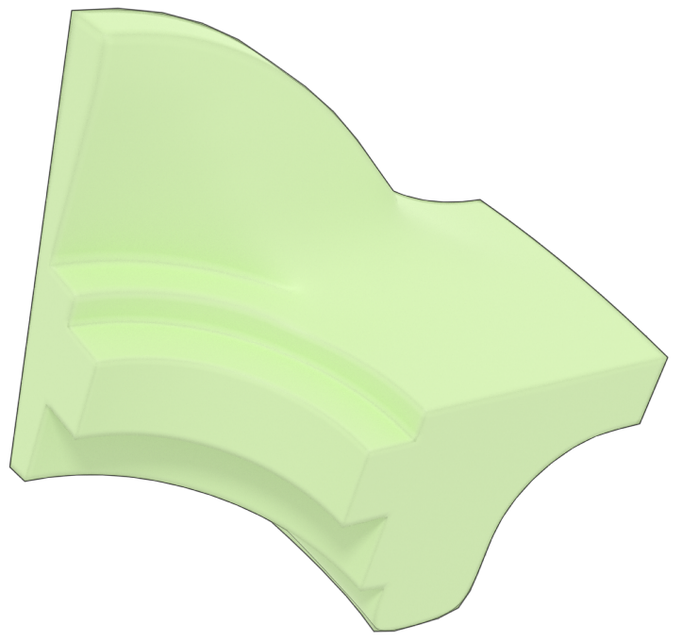
Superfici: shading

- flat shading
- smooth shading

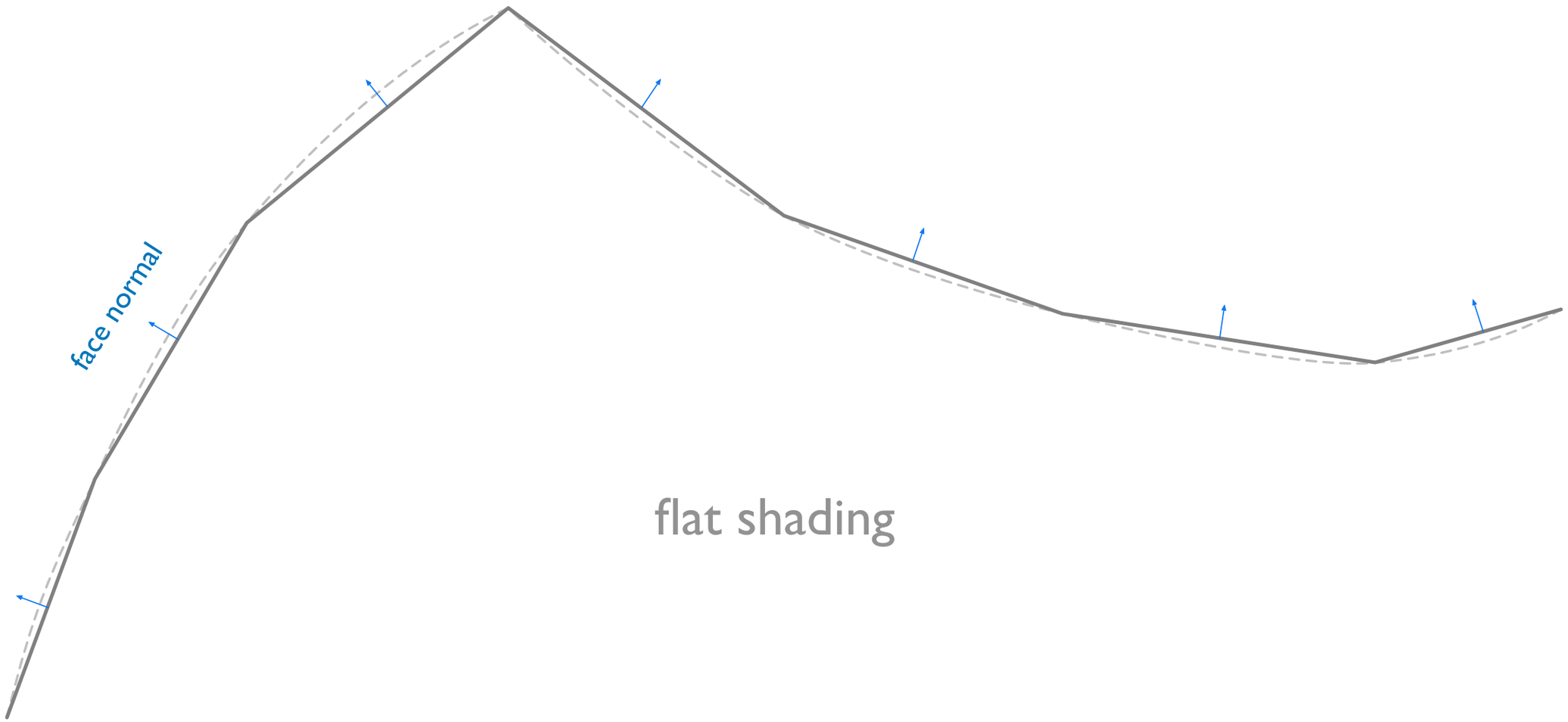


Superfici: shading

- flat shading
- smooth shading
- smooth + spigoli



Surface: shading



flat shading

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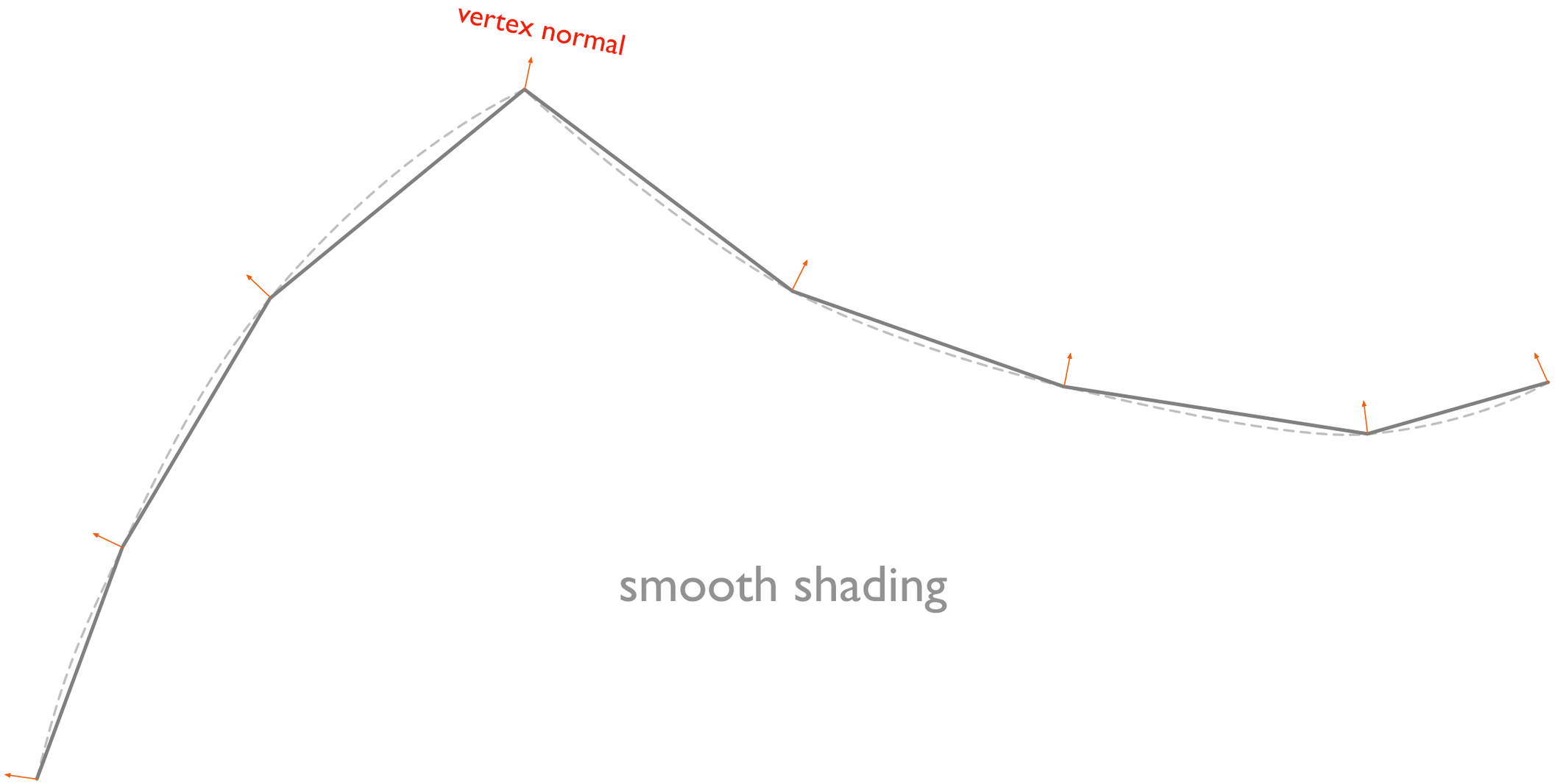
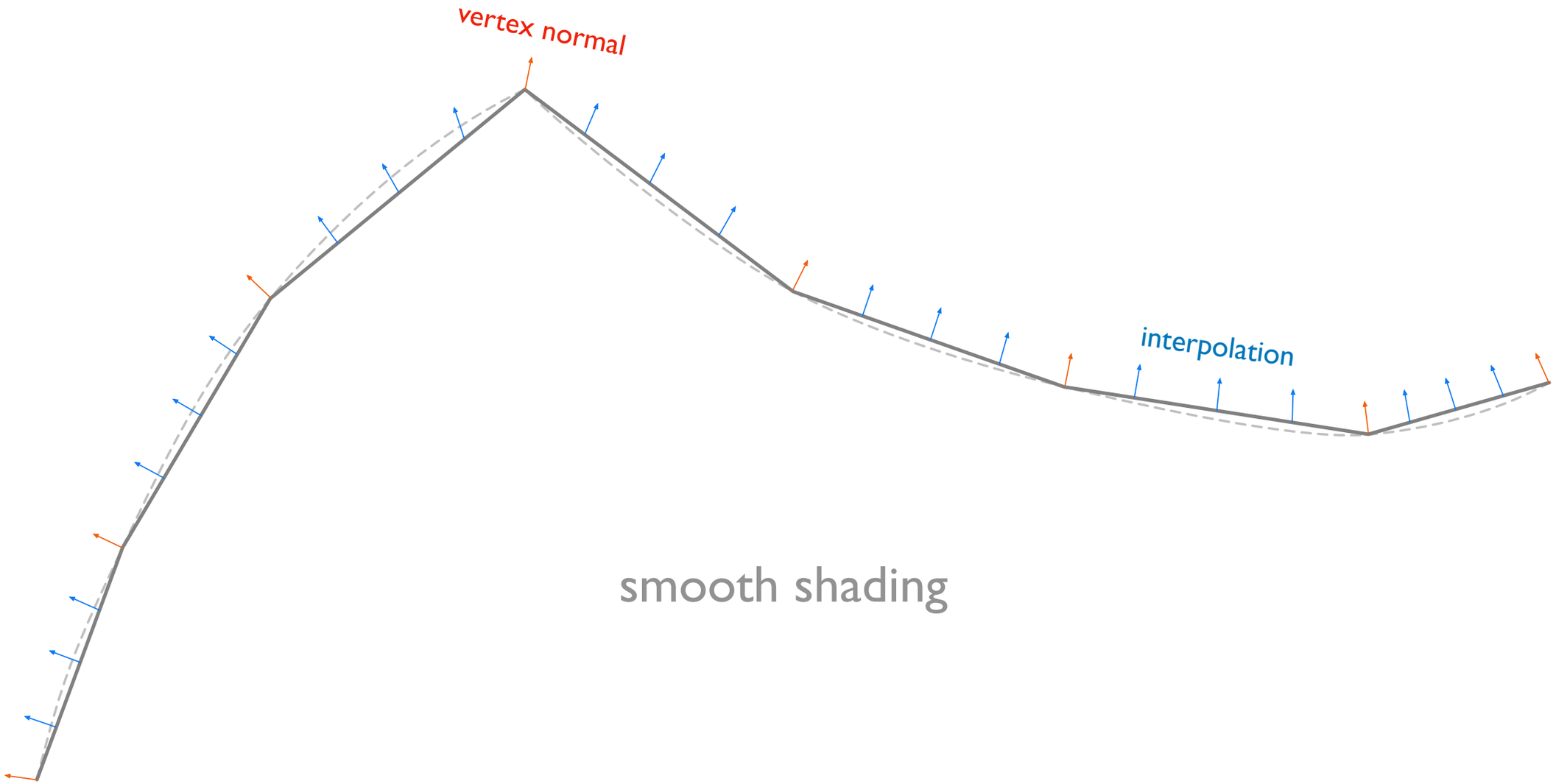
Surface: shading



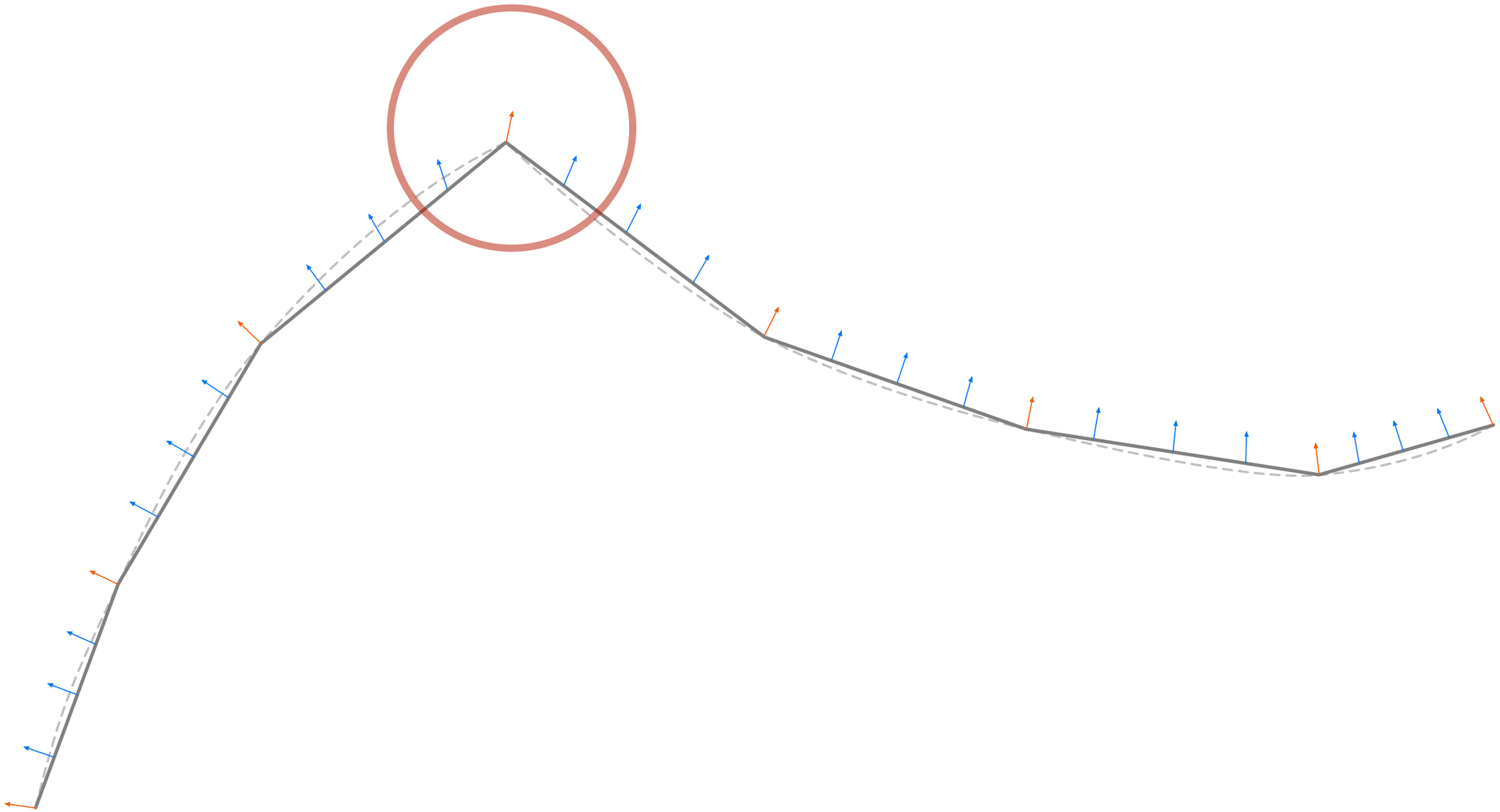
smooth shading

Surface: shading



smooth shading

Surface: shading



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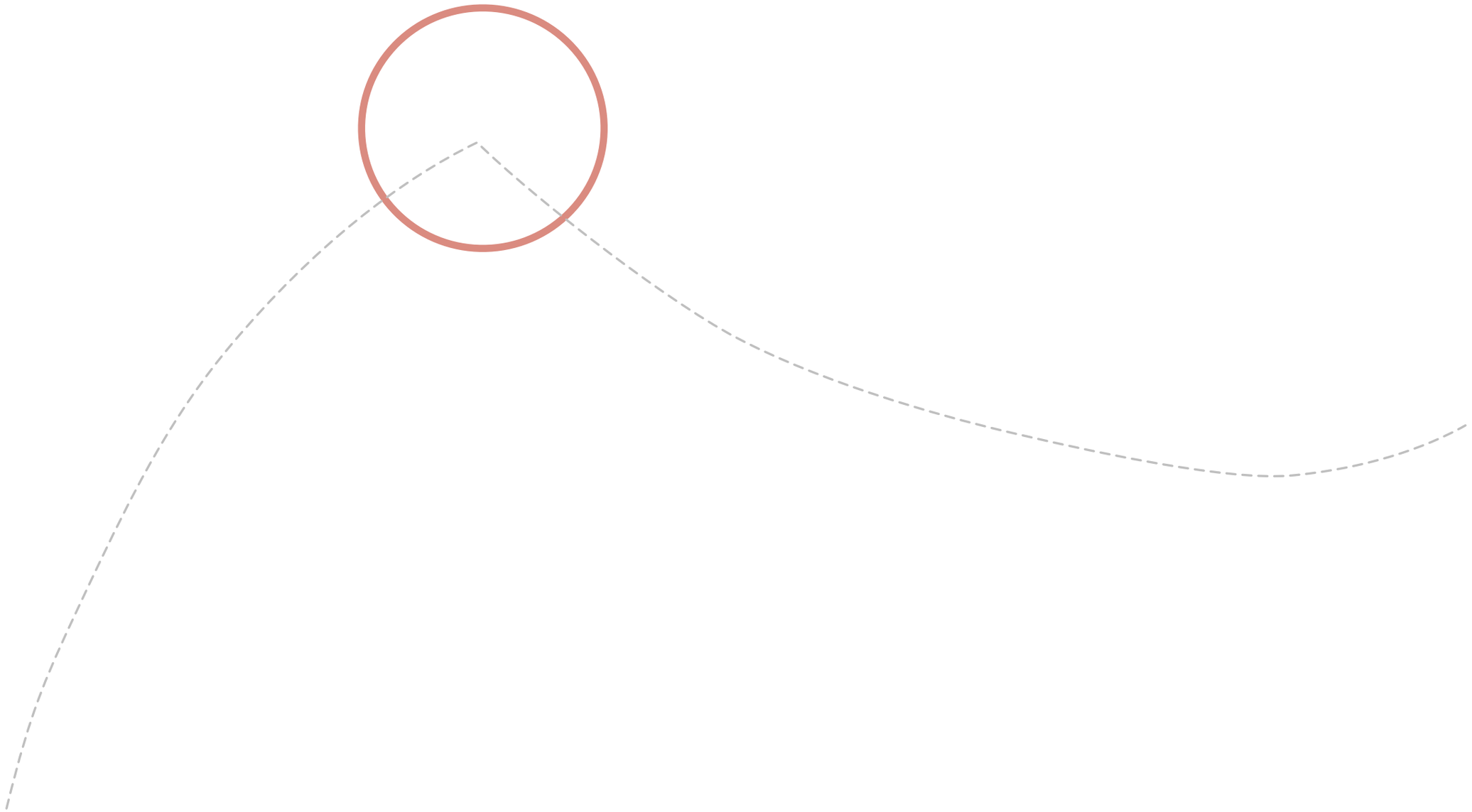
Surface: shading



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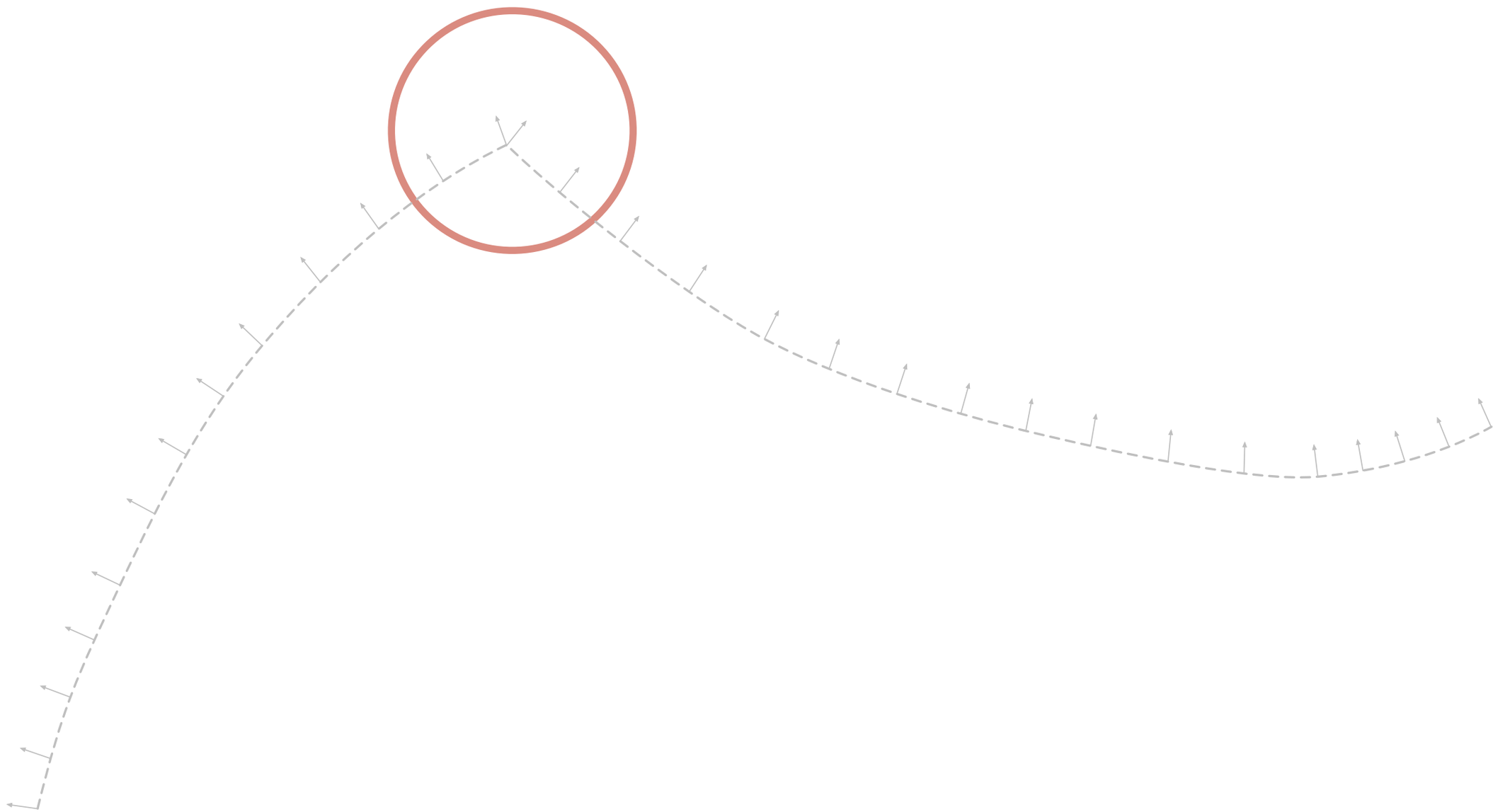
Surface: shading



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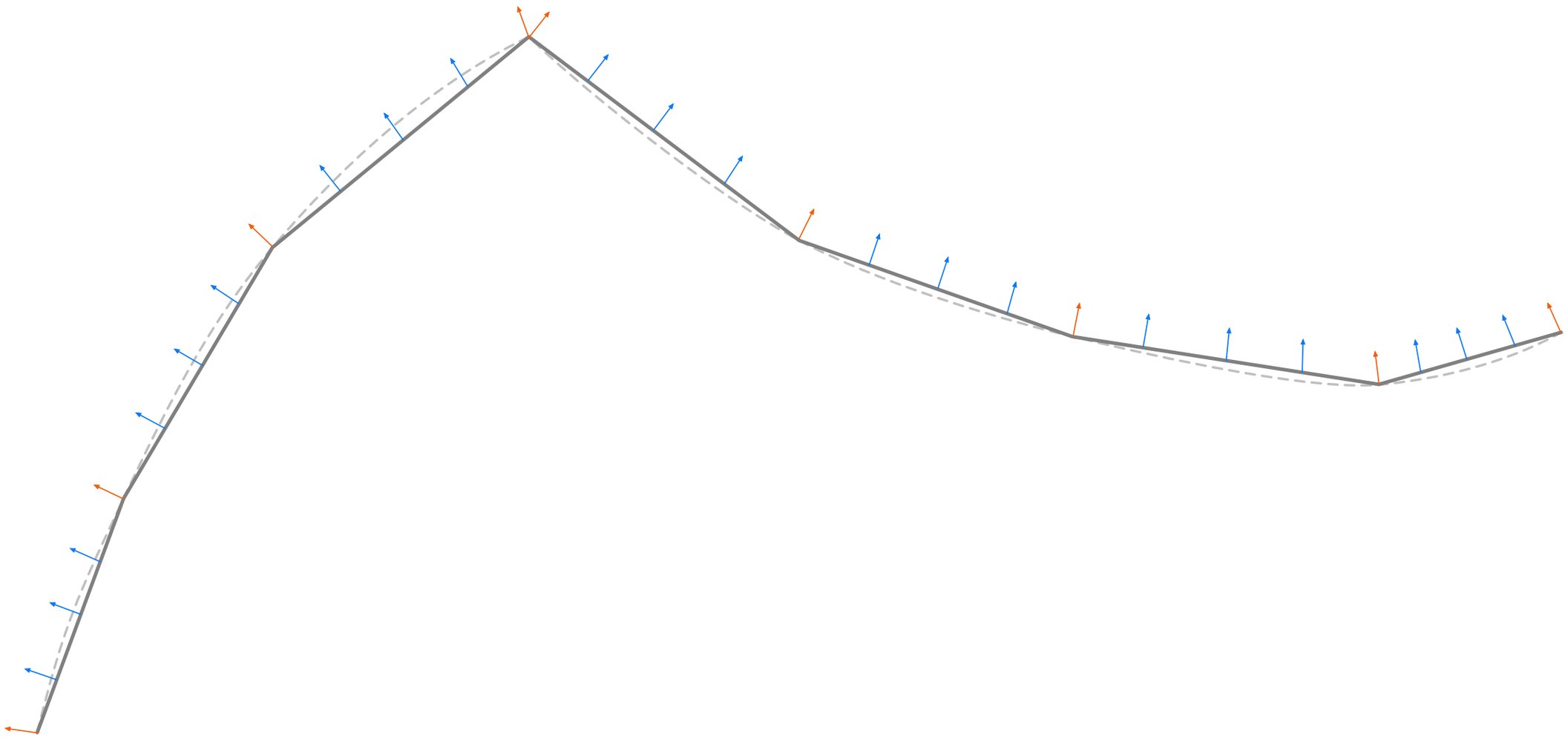
Surface: shading



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Codice e Librerie

- repo: https://github.com/giorgiomarcias/WS_geo_3D

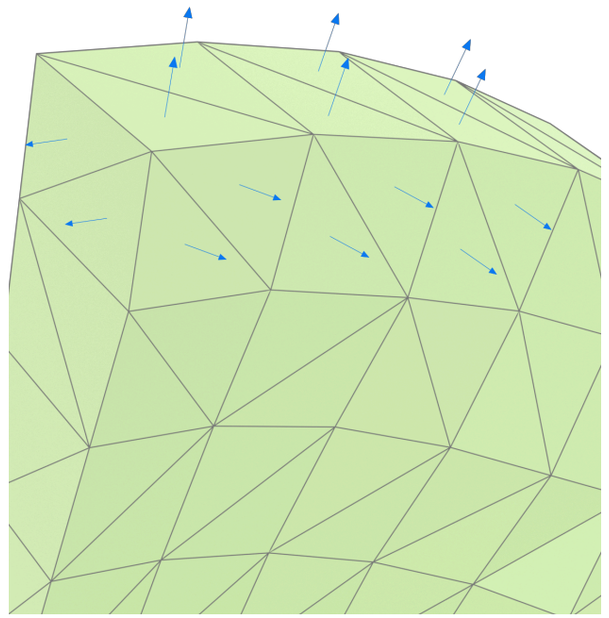
  - ```
    git clone --recurse-submodules https://github.com/giorgiomarcias/WS_geo_3D.git
    cd WS_geo_3D
    mkdir build
    cd build
    cmake ..
    make
    ```

- **libIGL** https://libigl.github.io
  viewer e geometry processing

- **eigenlib** http://eigen.tuxfamily.org
  algebra lineare e calcolo matriciale
    ```

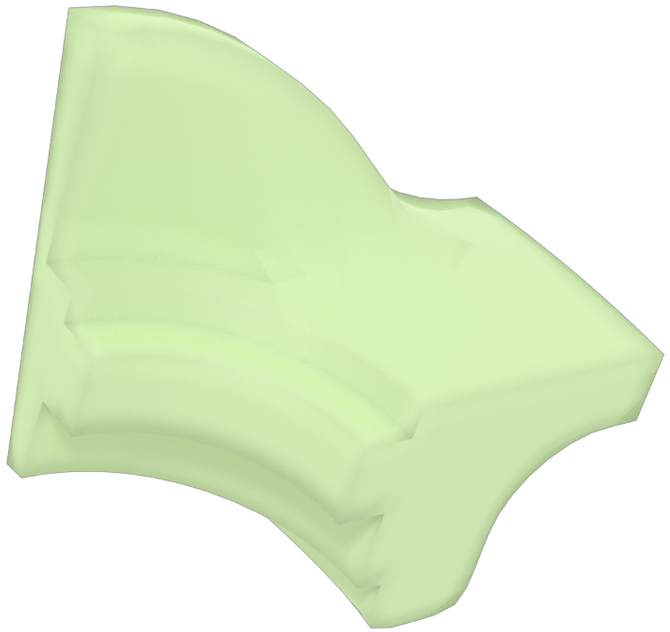
Esercizio 1

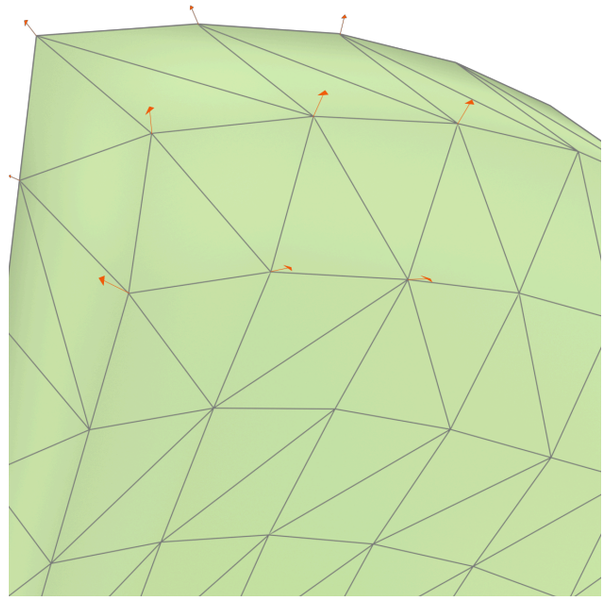
flat shading: calcolare le normali dei triangoli



Esercizio 2

smooth shading: calcolare le normali dei vertici





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Esercizio 3

smooth & sharp shading: calcolare le normali dei vertici e dei triangoli