Shading Interpolation

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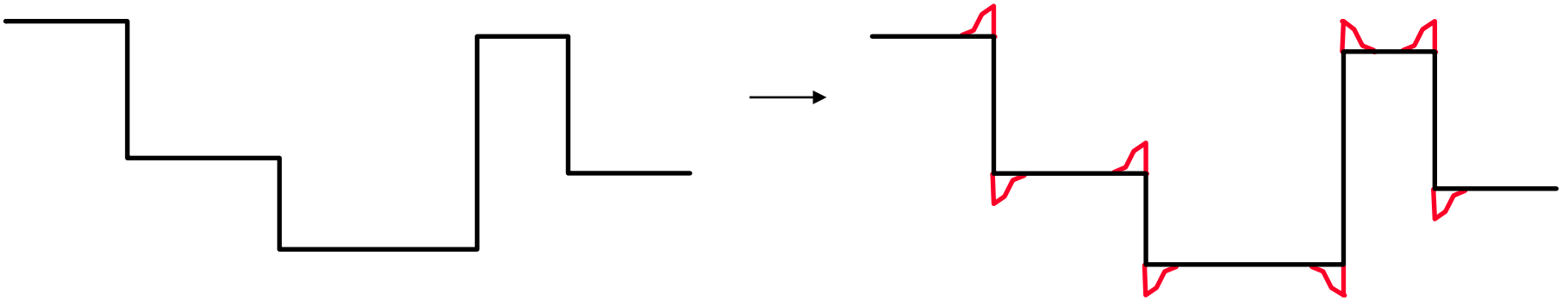
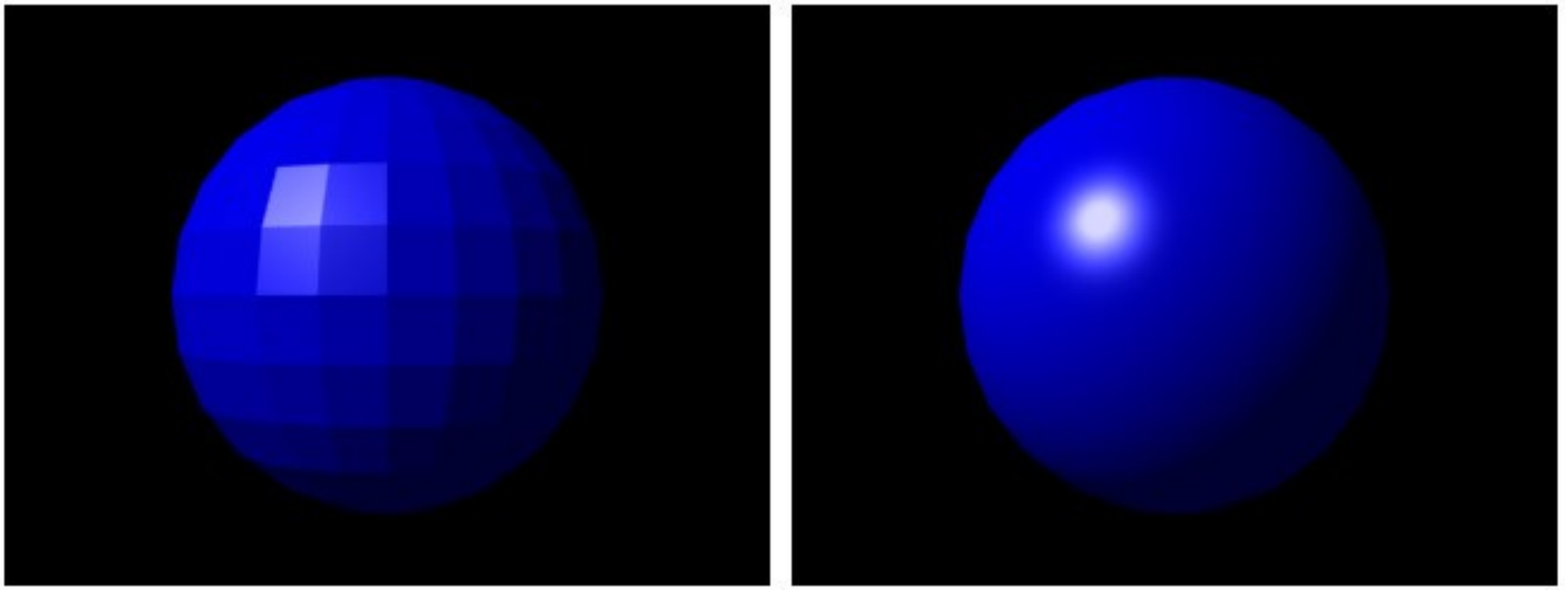
Shading Interpolation

- Methods to **apply shading algorithms** when displaying surfaces (B-rep):
- **Constant shading**
- **Continuous shading**
  - Gouraud interpolation (colours)
  - Phong interpolation (normals)

Constant Shading

- Compute **E** once for each polygon (e.g. in the center), and fill the polygon with **a single colour**
- Works well for **polygonal solids**
- **Curved surfaces** that are approximated via polygons:
  - Artificial edges of the solid are highlighted
  - This is made worse by the **Mach effect** (a human visual system feature)





FLAT SHADING

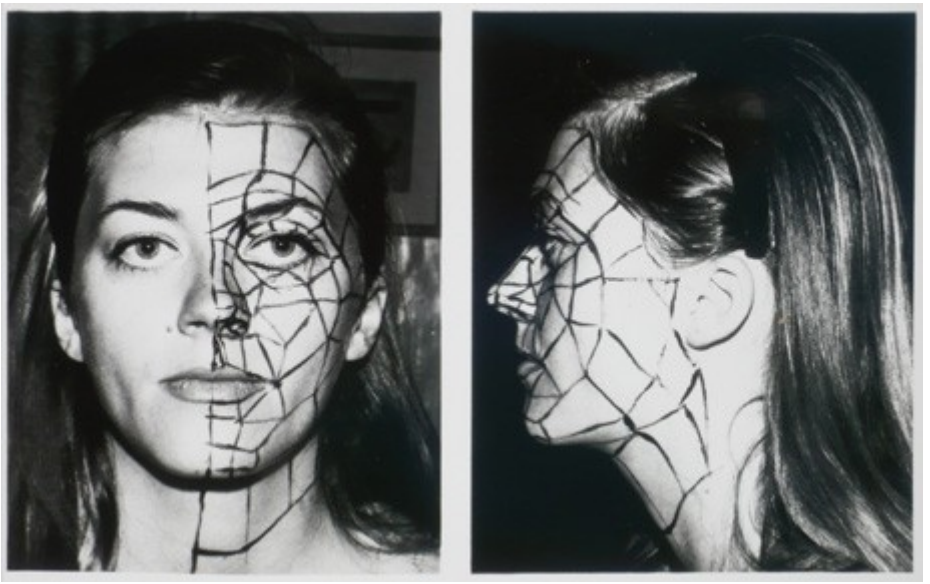
PHONG SHADING

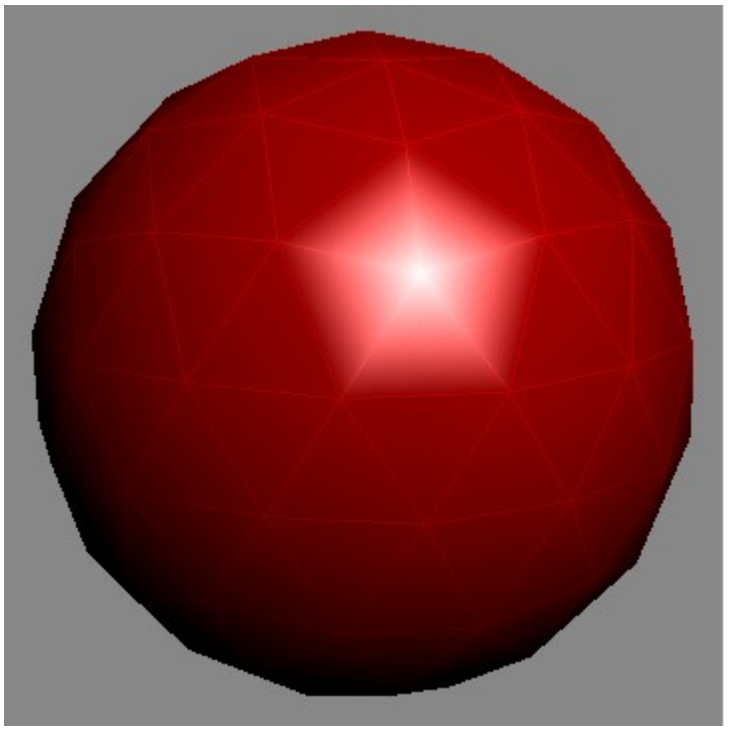
Continuous Shading

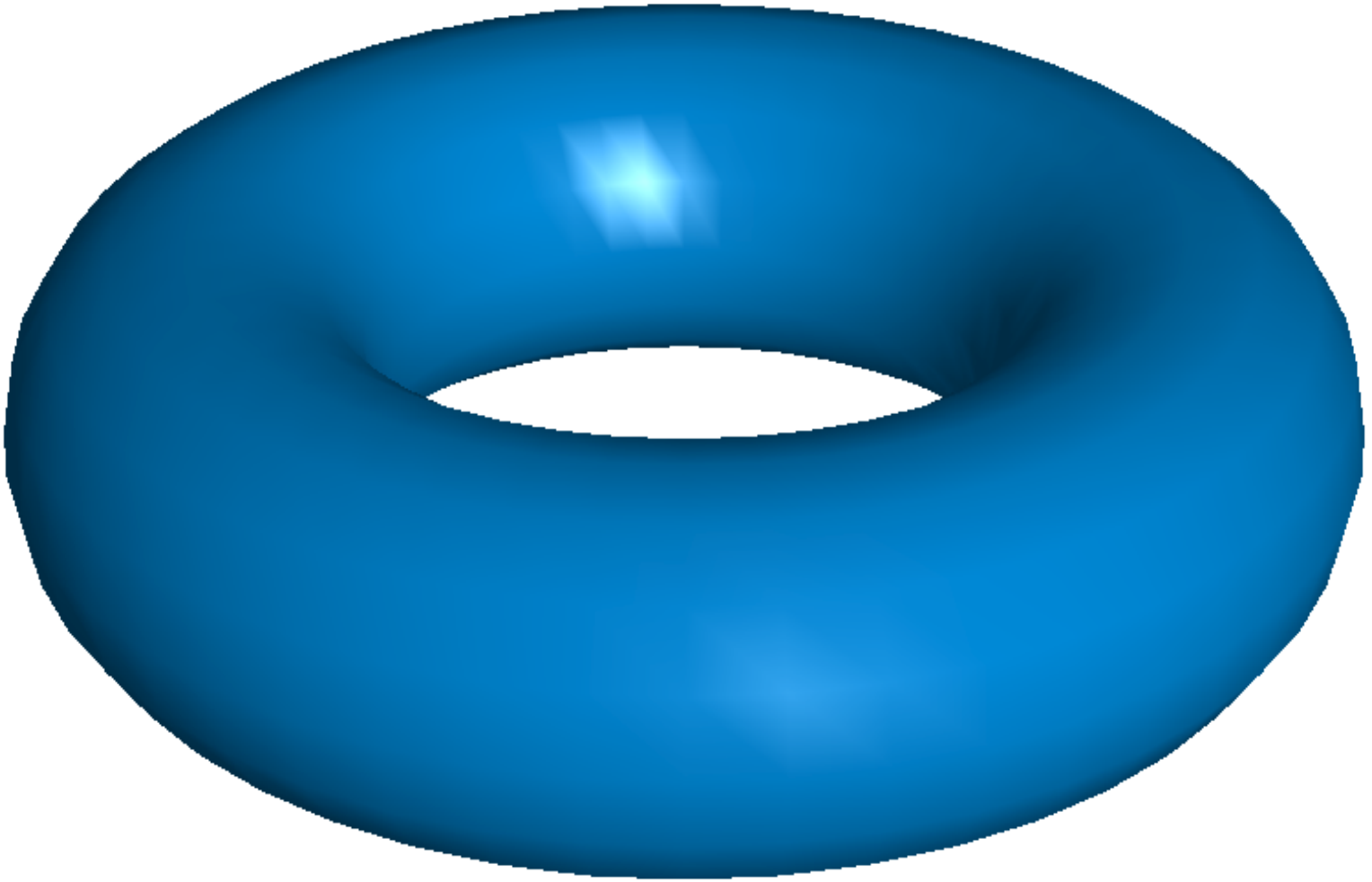
- Colour interpolation – **Gouraud shading**
  - Faster, more suited for diffuse surfaces
  - HW implentations available early on (Silicon Graphics)
- Normal interpolation – **Phong shading**
  - Slower, more accurate
  - Nowadays, also available in hardware - everywhere

Gouraud Shading

- At **polygon vertices**, we calculate the normal vector, and the **colour** that results from shading
  - Any shading model can be used
- **Inside the polygon**, we only interpolate these colour values bi-linearly
  - This is done during polygon filling

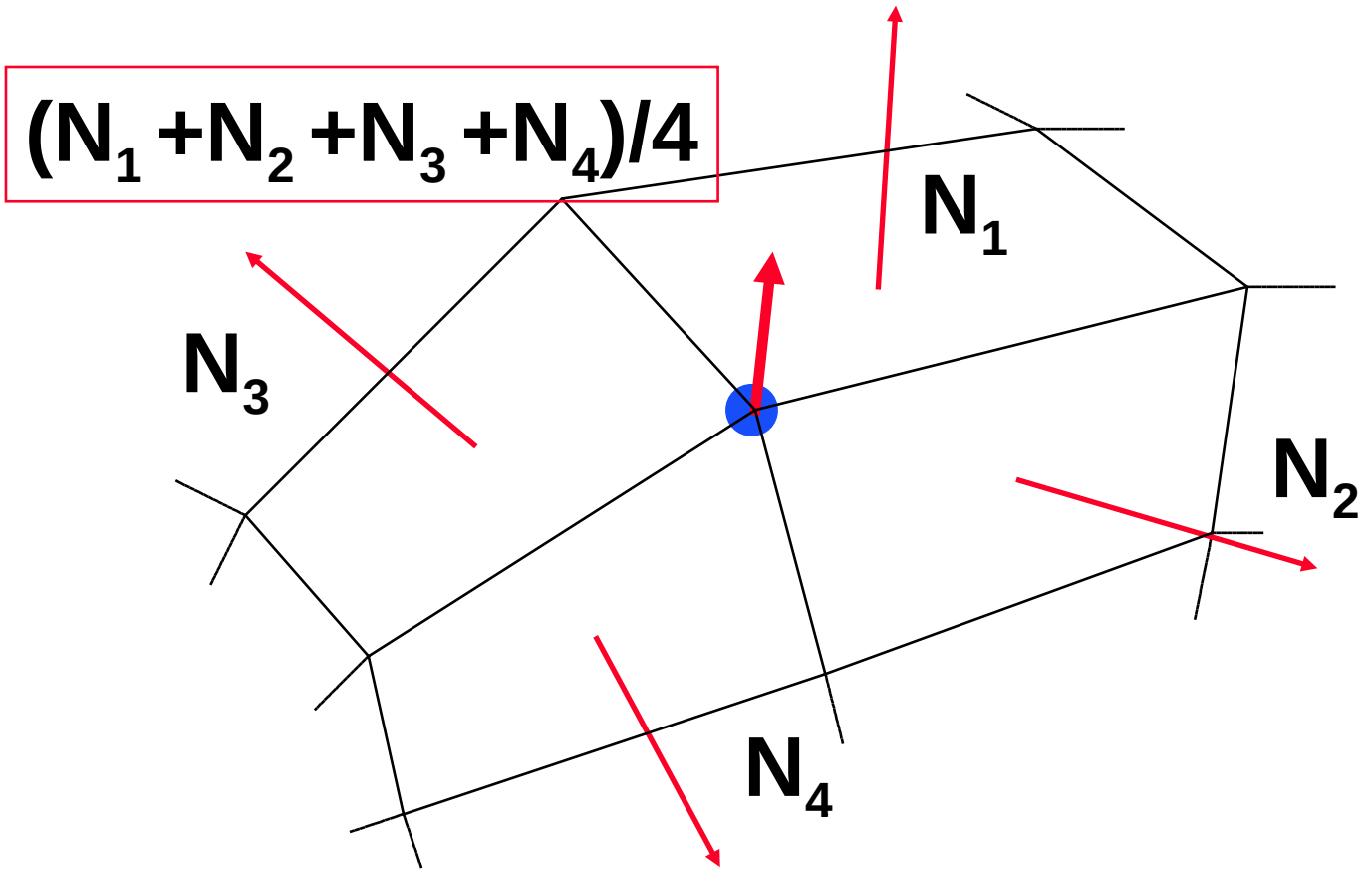




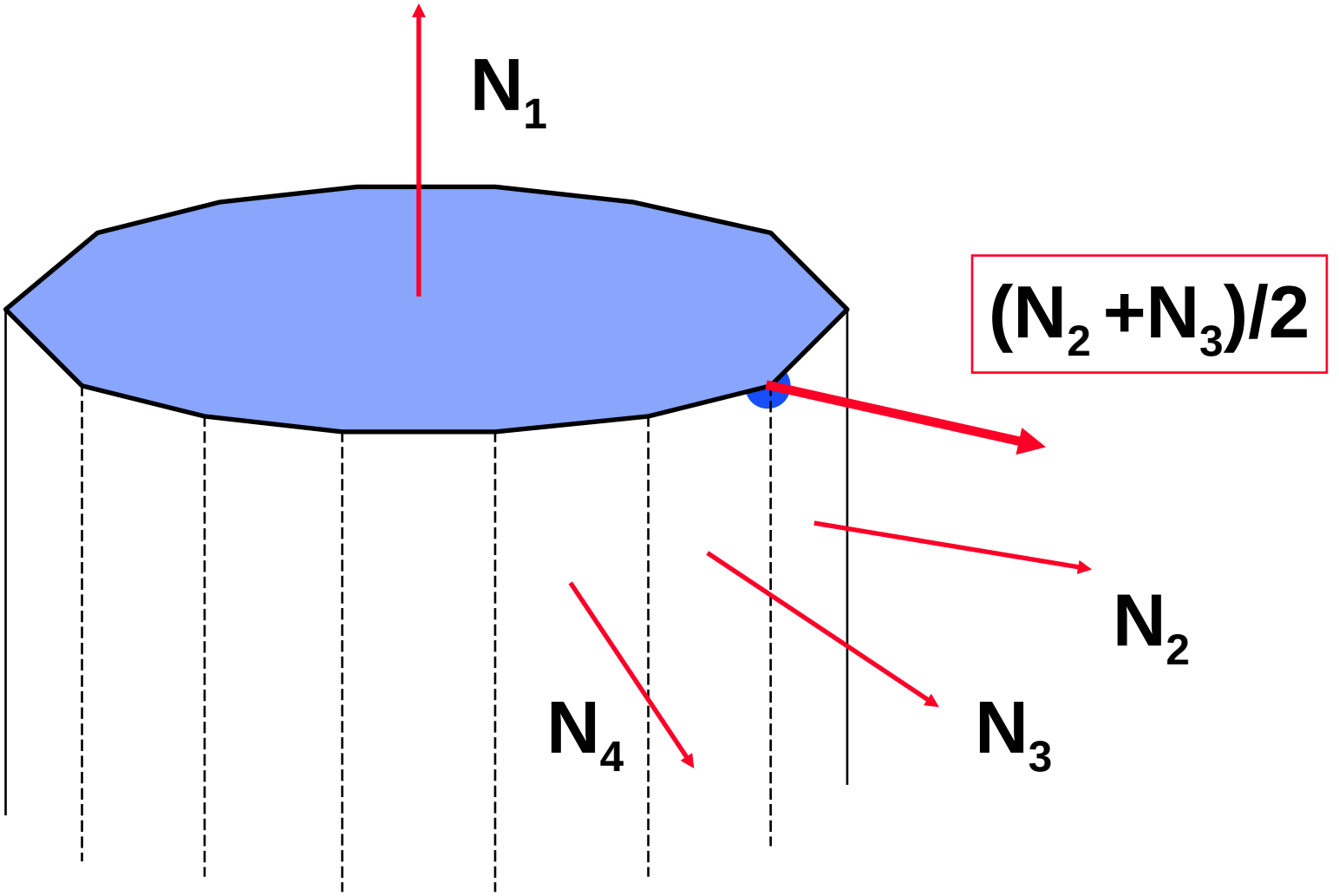


Calculation of Vertex Normals

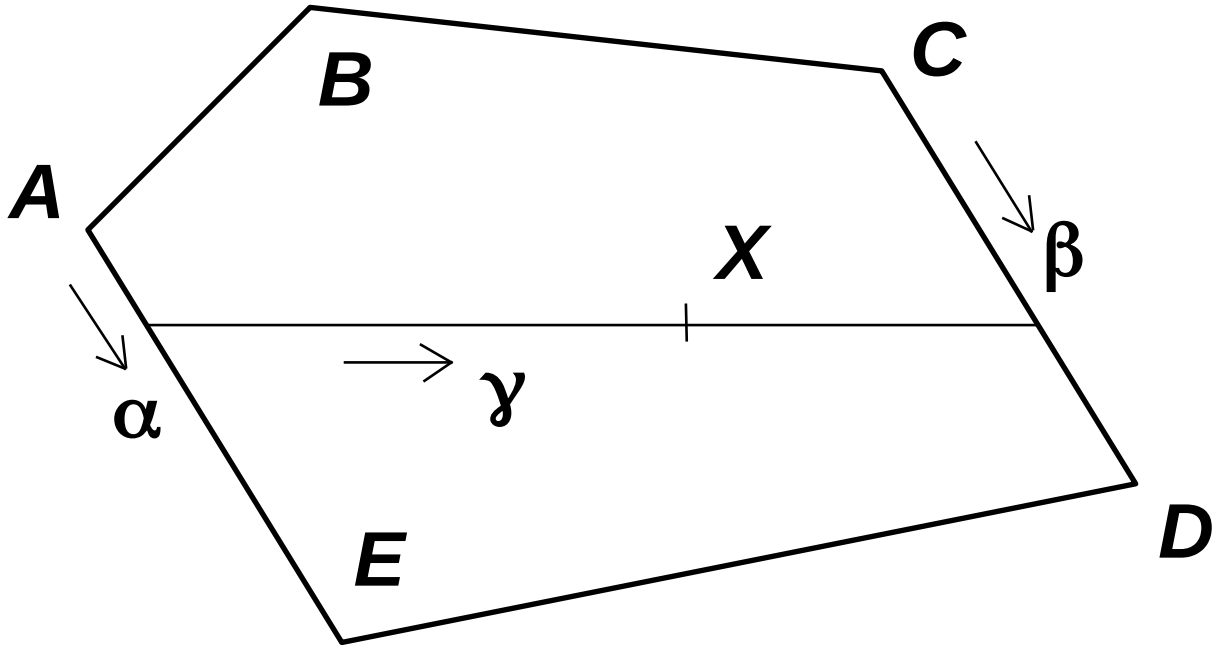
1. **Analytically** – according to neighbour polygon area
2. **Aproximative** – normal average of neighbours:



Real and Internal Edges



Bi-linear Interpolation

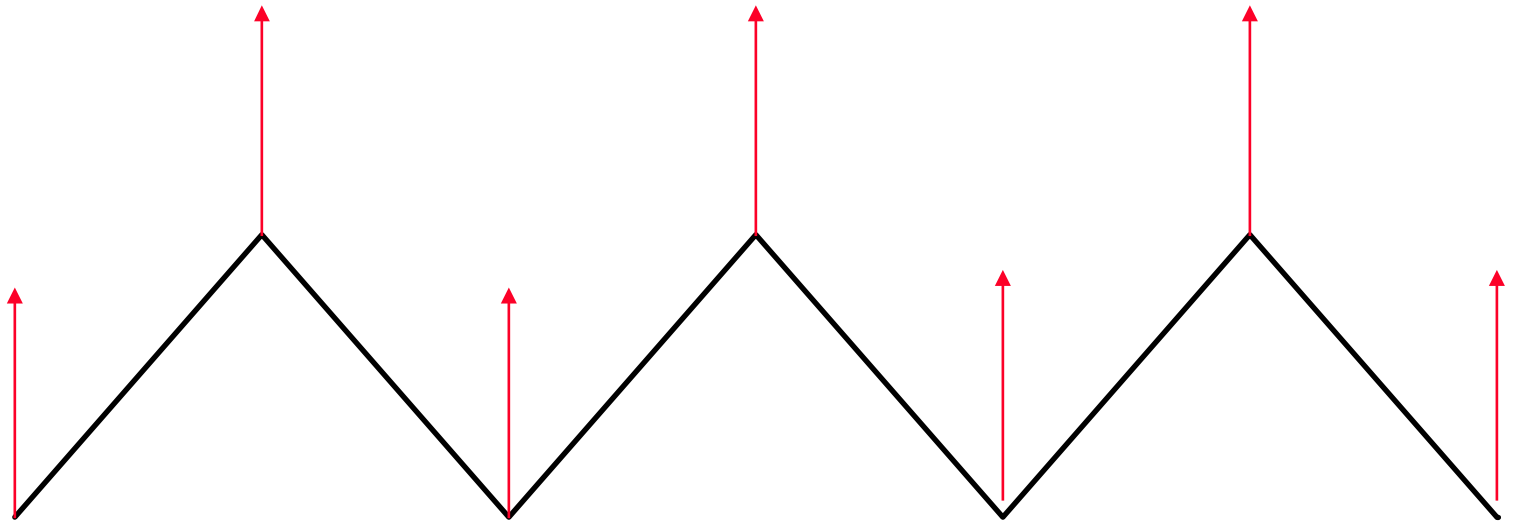


$$f_X = (1-\gamma) \cdot [(1-\alpha) \cdot f_A + \alpha \cdot f_E] +$$

$$+ \gamma \cdot [(1-\beta) \cdot f_C + \beta \cdot f_D]$$

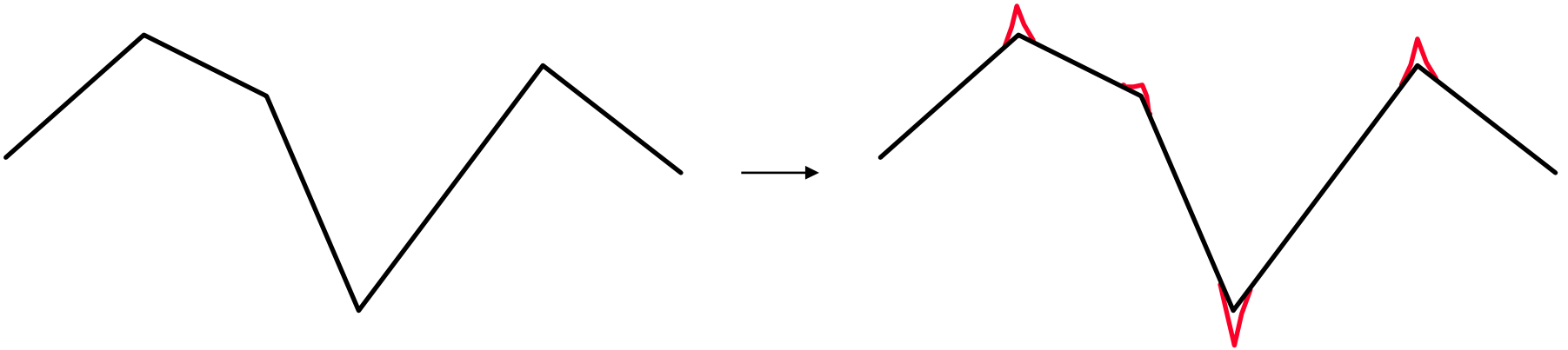
Interpolation Issues (colour)

- Poorly captures **highlights** (particularly for mirror surfaces)
- Not **rotationally invariant!**
- Possibility of **badly calculated normals**!



The Mach Effect (1865)

- Highlight discontinuities due to **intensity** – or its **derivation**!
- This is caused by **lateral inhibition** of the photoreceptors in our retina
  - Excited cells lower the sensitivity of neighbouring cells



Phong Shading (Interpolation?)

- At the polygon vertices, we determine the correct (interpolated?) normal vectors
- Inside the polygon, we interpolate the normal vectors via bi-linear interpolation for each pixel
  - This is done in parallel with polygon filling
- For **each internal pixel** we compute the shading (colour)
  - According to the chosen shading model

Larger Computational Cost

- Normals are computed for each pixel
  - Bi-linear interpolation and normalisation – this needs a square root calculation
  - There exist approximate interpolations w/o square root
- In each pixel, we compute the shading model
  - Scalar product, square of floats, division

End

Further Information:

- **J. Foley, A. van Dam, S. Feiner, J. Hughes**: ***Computer Graphics, Principles and Practice***, 734-741
- **Jiří Žára a kol.**: ***Počítačová grafika***, principy a algoritmy, 355-361