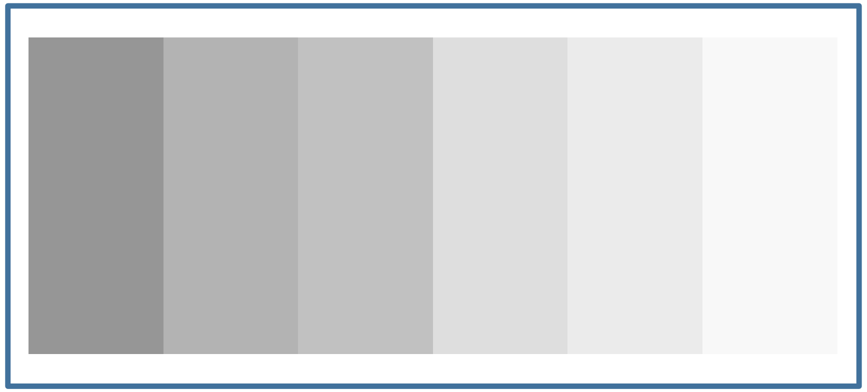
Vertex Normals

CS418 Computer Graphics

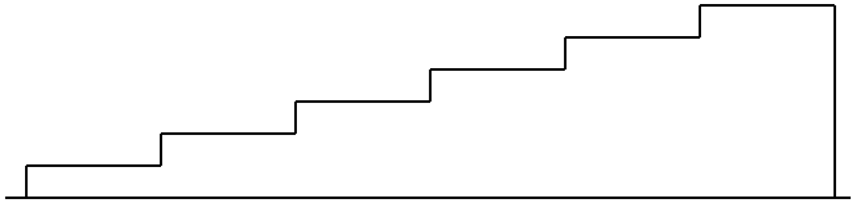
John C. Hart

Mach Bands

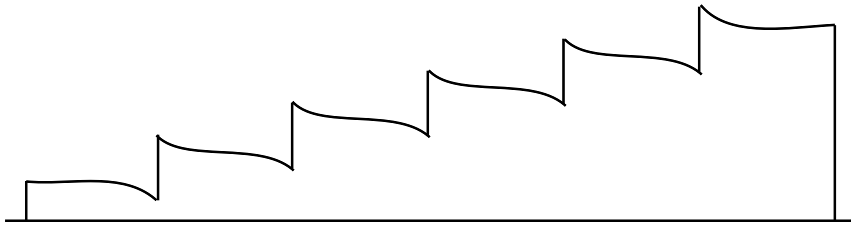
- Adjacent solid gray quads in increasing brightness



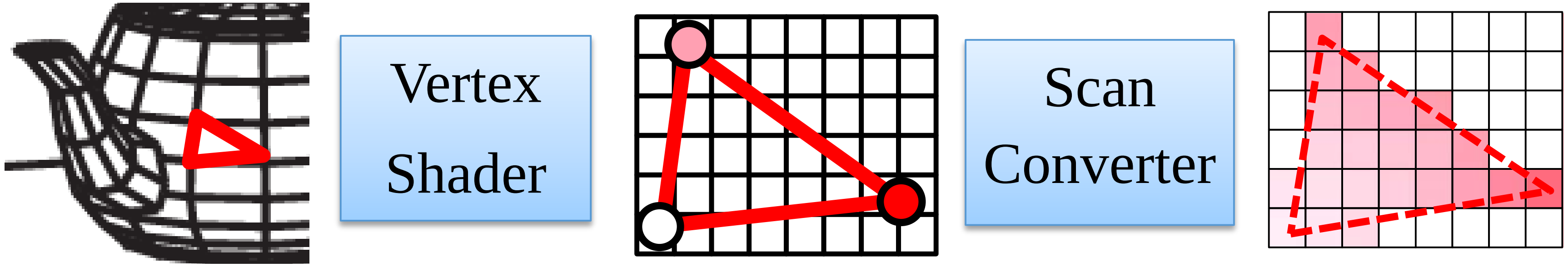
- Intensity on the retina



- Intensity perceived



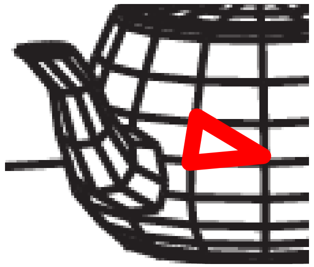
Color Interpolation

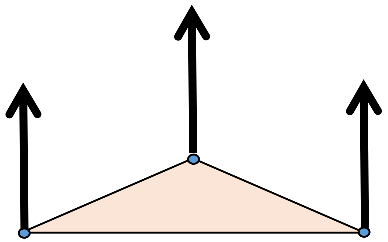


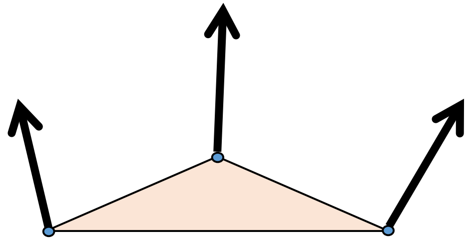
- Vertex shader computes positions of vertices
(in viewport coordinates)
- Vertex shader also computes colors of vertices
(result of vertex lighting)
- Scan converter fills triangle with fragment positions
- Scan converter interpolates vertex colors across fragments

Gouraud Shading

- Vertex shader computes color based on vertex data
  - material color
  - vertex position
  - vertex normal
- Using the same “face” surface normal for all three triangle vertices yields faceted shading
- Using independent vertex normal yields smooth (Gouraud) shading





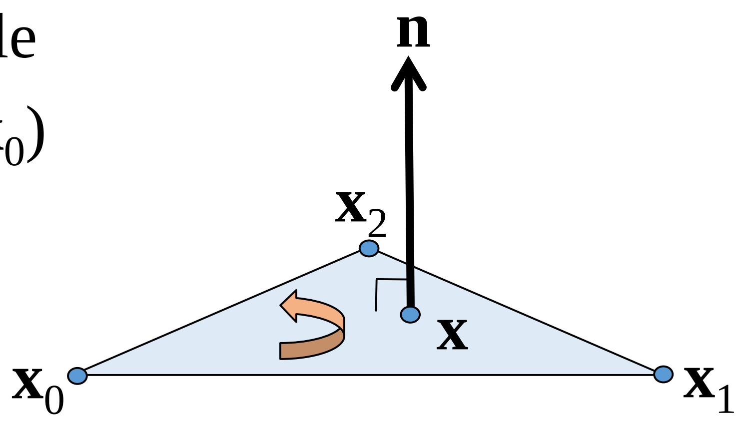


Computing Normals

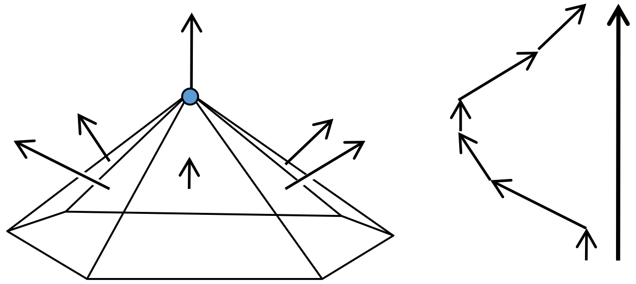
- Face normal of triangle

  $$\mathbf{n} = (\mathbf{x}_1 - \mathbf{x}_0)\times(\mathbf{x}_2 - \mathbf{x}_0)$$

  – Needs to be normalized

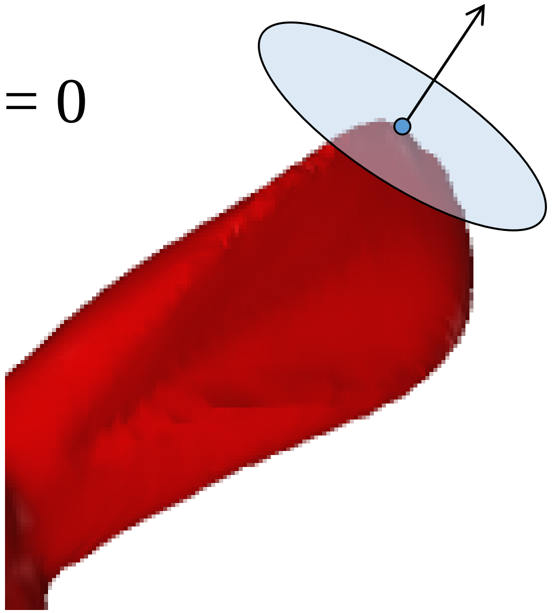


- Per vertex normal
  – Sum of normals of triangle faces that share the vertex
  – Needs to be normalized



Transforming Normals

- First order neighborhood of a point on a surface described by a tangent plane
- Plane equation: $Ax + By + Cz + D = 0$
- Plane normal: (A, B, C)



$$\begin{bmatrix} A & B & C & D \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = 0$$

Transforming Normals

- Plane equation: **n x** = 0
- Let M be an affine transformation
- Transformed geometry **x'** = M **x**
- New normal **n'** such that **n' x'** = 0

$$\mathbf{n}' M \mathbf{x} = 0$$

$$\mathbf{n}\,\mathbf{x} = 0$$

$$\mathbf{n}' M = \mathbf{n}$$

(not really, but at least their parallel)

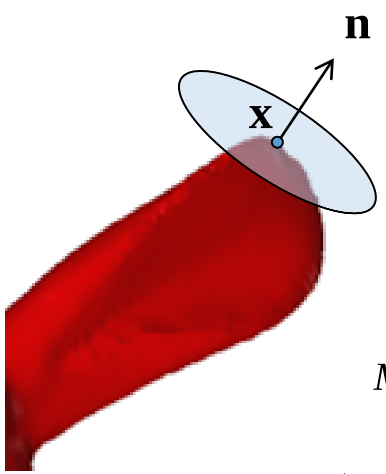
$$\mathbf{n}' = \mathbf{n}\, M^{-1}$$

- **n'** needs to be normalized

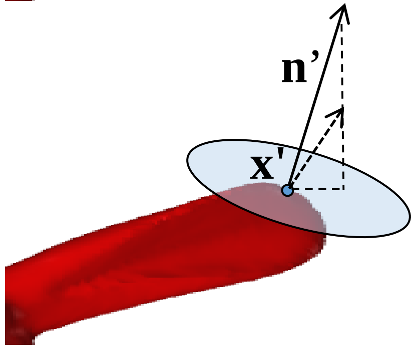
$$\mathbf{n}' = (M^{-1})^T \mathbf{n}$$

- $(M^{-1})^T$ is called the Normal Matrix

$$\begin{bmatrix} A & B & C & D \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = 0$$



$$M = \begin{bmatrix} 1 & & & \\ & \frac{1}{2} & & \\ & & 1 & \\ & & & 1 \end{bmatrix}$$



Vertex Pipeline