CSE 167 (FA22)
Computer Graphics:
Non-photorealistic Rendering

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Non-photorealistic rendering

- Most rendering seeks to emulate real world
- However, not all uses of computer graphics call for realism
Celluloid (Cel) Animation

- First, draw each frame on paper
- Transfer the outline to transparent sheets (called cels)
- Paint the color on the opposite side of the cel
- Overlay the cell on painted static background
Toon shading / cel shading

- Give 3D scene a cartoon-style look
- Main feature
  - Emphasize silhouettes (outlines)
  - Piecewise constant colors (discretized diffuse + highlights)
Discretized shading

Intensity input

Output color

Intensity input
Geometry outlines

- The outline curves include
  - Silhouette
  - Surface boundary
  - Creases
  - Self-intersections
  - Surface curves (e.g. coordinate lines)
Silhouette

- Silhouette consists of curves on the surface where front-face transitions to back-face

\[
\begin{align*}
\text{A point on the surface is in} & \\
& \begin{cases}
\text{front face} & \text{if } \text{normal} \cdot \text{viewdir} > 0 \\
\text{silhouette} & \text{if } \text{normal} \cdot \text{viewdir} = 0 \\
\text{back face} & \text{if } \text{normal} \cdot \text{viewdir} < 0
\end{cases}
\end{align*}
\]
Silhouette

- Approximating silhouette curve on a discrete surface
  - Evaluate \((\text{normal} \cdot \text{viewdirection})\) per vertex
  - Per edge, if there is sign change, find silhouette point by linear interpolation
  - Visit all triangles and connect silhouette point into curve
Silhouette

- Break the curve where visibility of the curve may change
- Assign visibility on each connected piece
Potential visibility changes of silhouette curve:
① Passing under another boundary or silhouette curve
② Intersect with another boundary or silhouette curve
③ Cusp
Efficient hack

- Direct approach in fragment shader
  \[ \text{edge} = \text{true if } \max(n \cdot v, 0) < 0.01 \]
Another technique: post processing

(discretized shading)  Depth map  Normal in the world space

Image processing
edge detection
(Sobel filter)
Another technique: post processing