Image-Space Algorithms

- goal: extract significant edges from a model
- utilization of traditional rendering techniques
- usage and manipulation of rendered G-buffers

→ application of algorithms from image processing

→ in particular, image filtering for edge detection

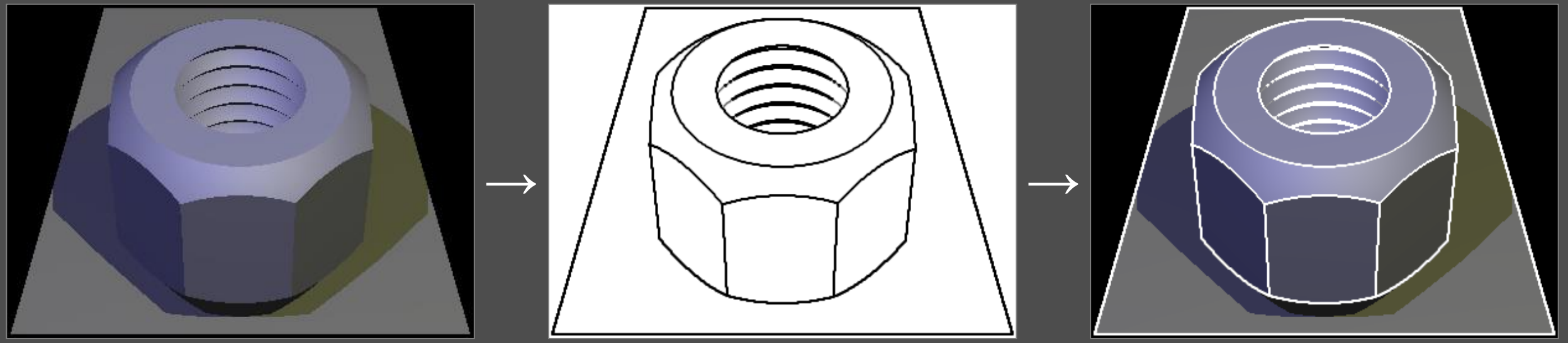
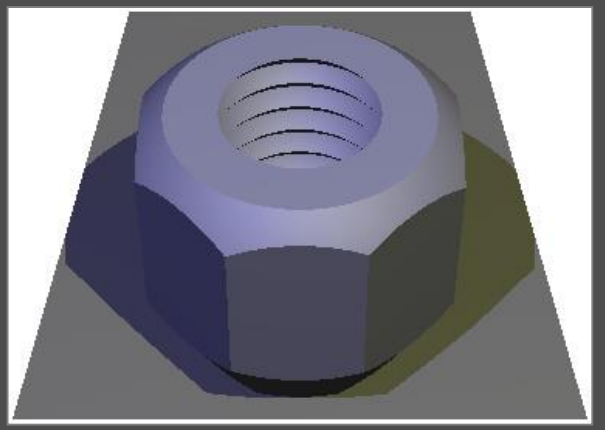
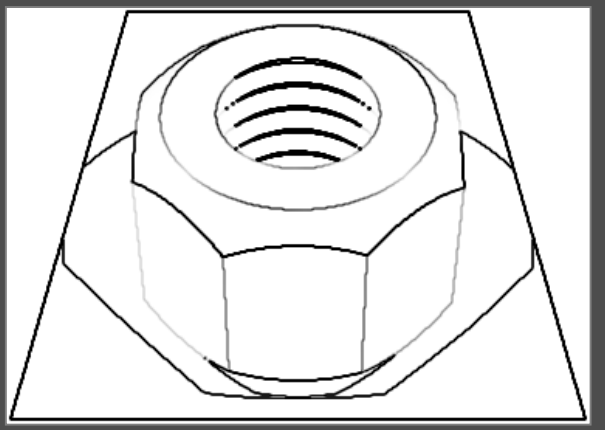


Image-Space Algorithms

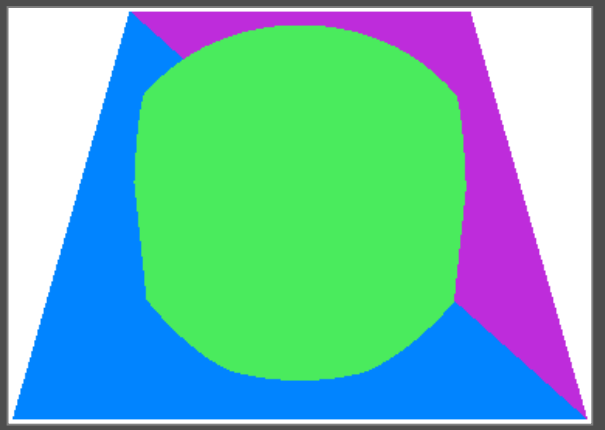
- discontinuities in the frame buffer
  - not well suited for silhouette detection
  - unwanted edges detected at discontinuities; e.g., due to textures, shadow, or shading
  - some essential edges not detected, e.g., due to shadows
- discontinuities in object ID buffer
  - yields only contour/outline of objects
  - potential artifacts if model erroneous e.g., one object modeled in two parts with two different object IDs



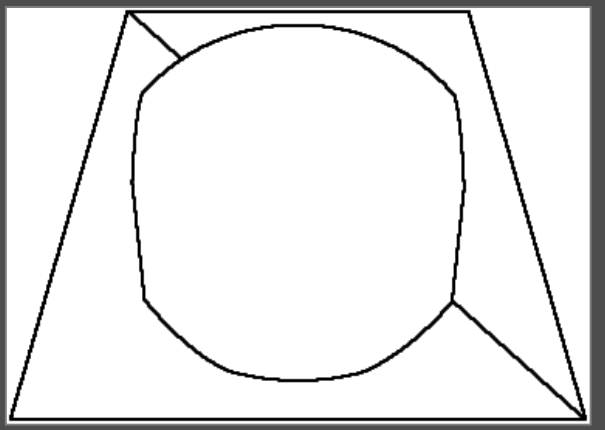
frame buffer



edges



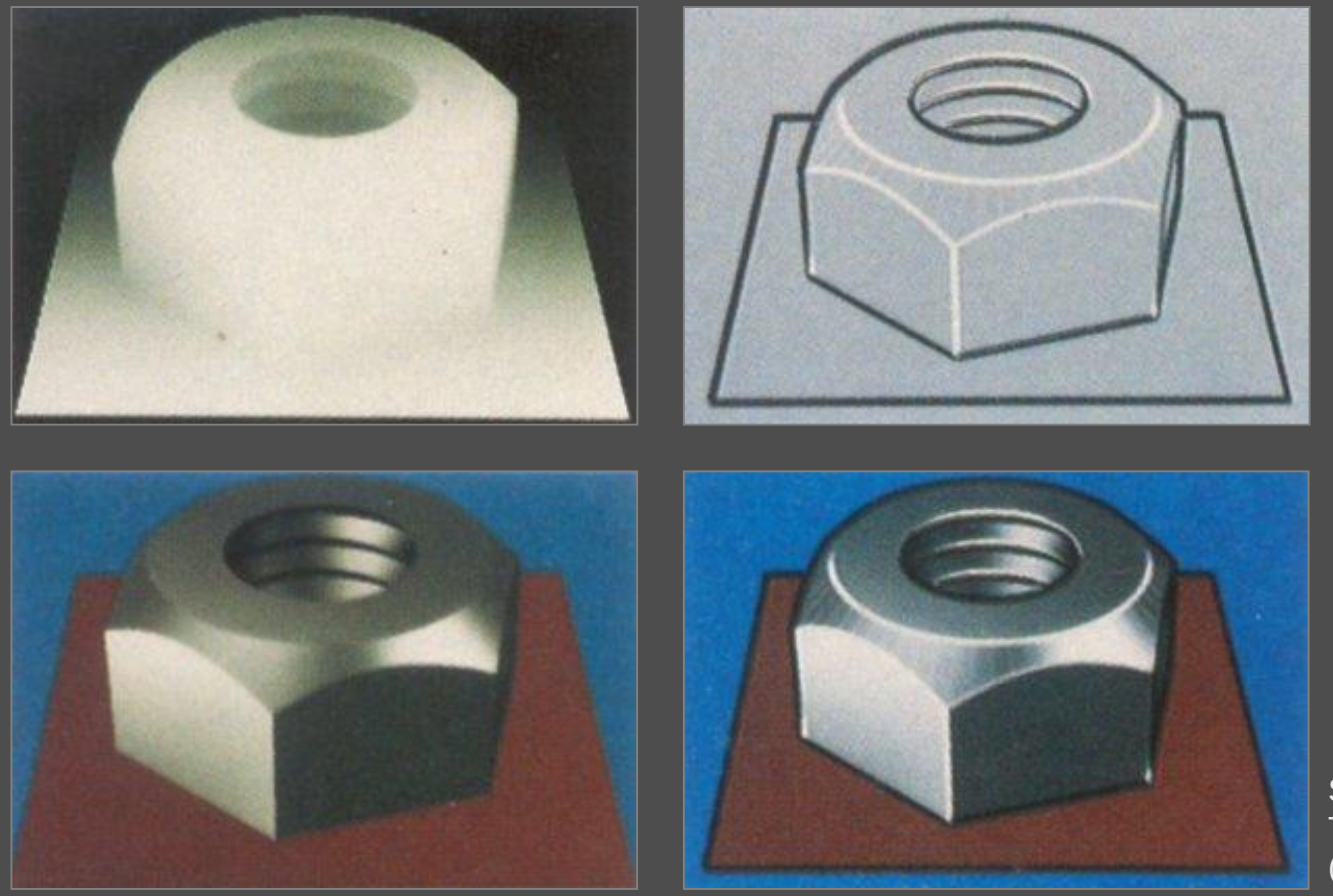
object ID buffer



edges

Image-Space Algorithms: z-Buffer

- Saito & Takahashi (1990): edge detection in the z-buffer
  ⇒ only looking at discontinuities of depth values

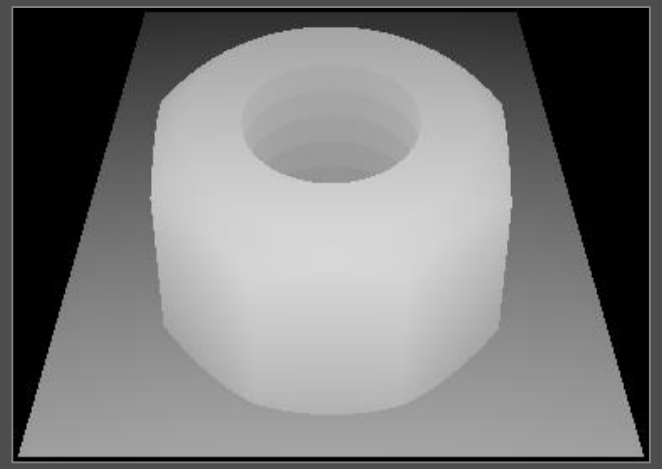


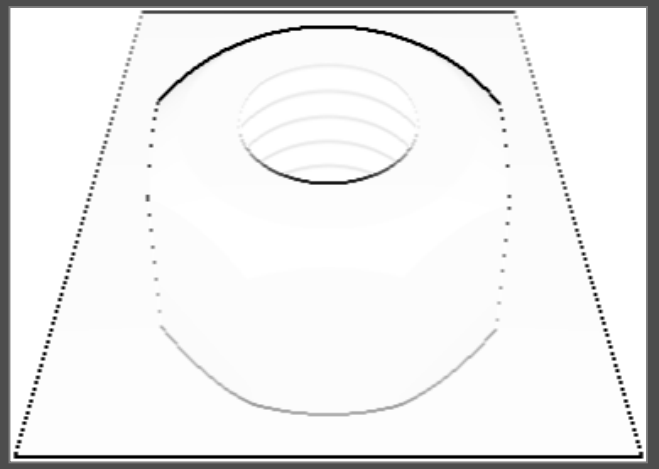
Saito & Takahashi (1990)

Image-Space Algorithms: z-Buffer

- edge detection operators from image processing
  - Sobel operator (1st derivative), e.g.,

$$\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \qquad \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$





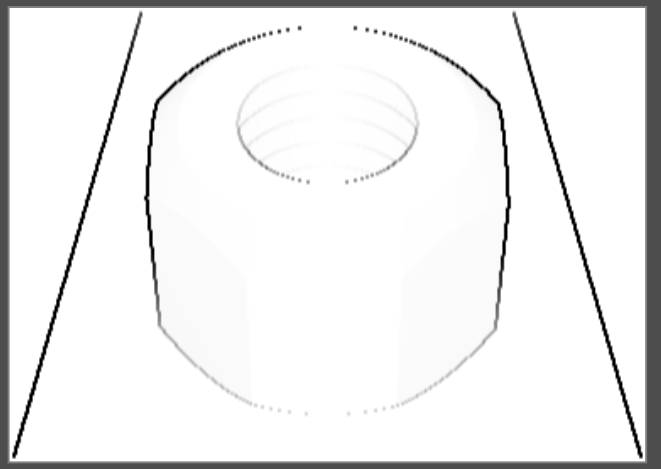


Image-Space Algorithms: z-Buffer

- edge detection operators from image processing
  - Laplace operator (2nd derivative), e.g.,

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \quad \begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 2 & 1 \\ 2 & -12 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

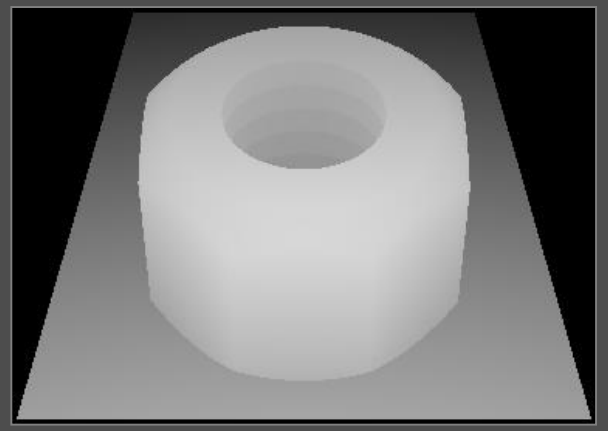
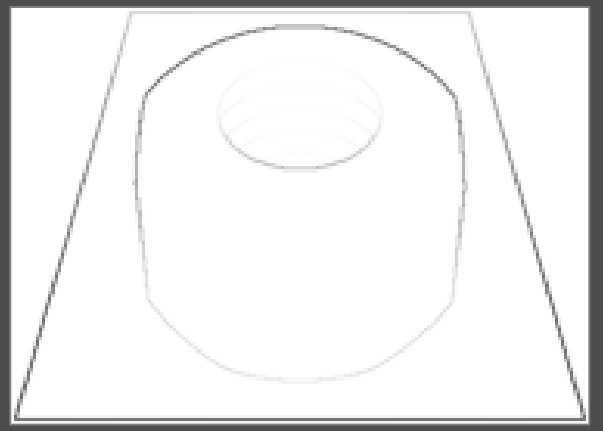
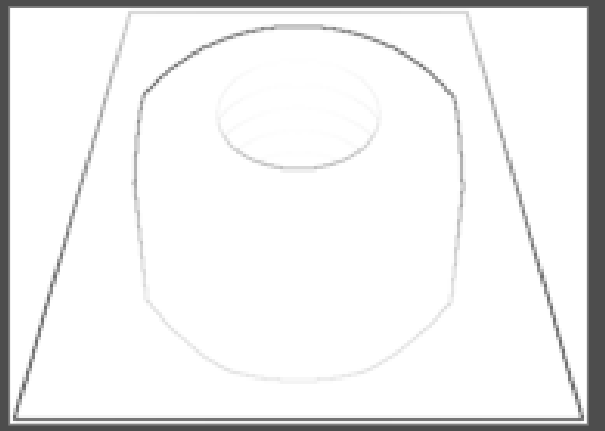
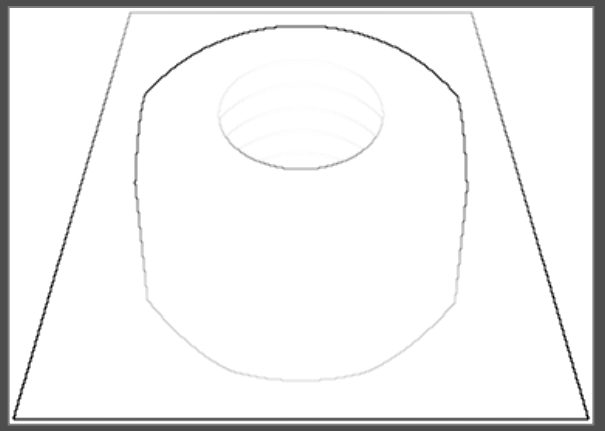
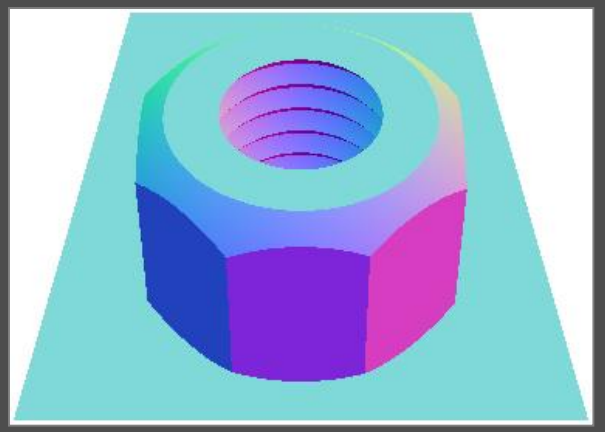
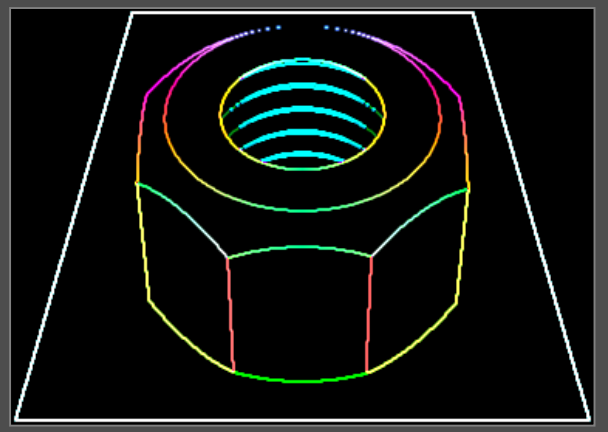





Image-Space Algorithms: Normal Buffer

- extension of the principle to normal buffer
  - Decaudin (1996) & Hertzmann (1999)
- normal buffer contains normal direction
  - x-, y-, and z-components as RGB values
- edge detection operator on normal buffer (e.g., Laplace)
- application of edge detection operator
  - individually per RGB channel or gray value derived from maximum RGB color





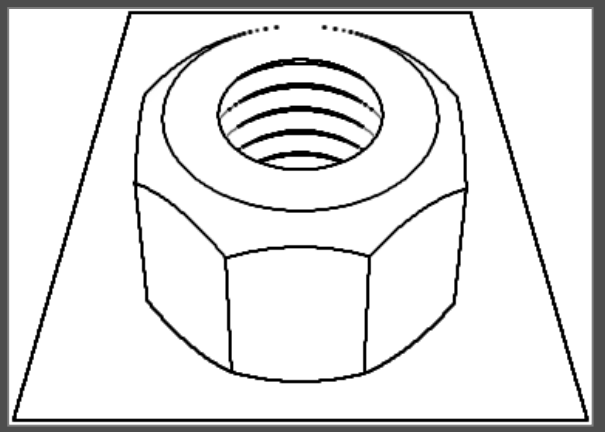


Image-Space Algorithms: Combination

- all edges neither through z-buffer nor normal buffer algorithm
  ⇒ combination both z-buffer and normal buffer edge detection
  → combination of the buffers with edges into one image
- all desired edges are present in the combined buffer

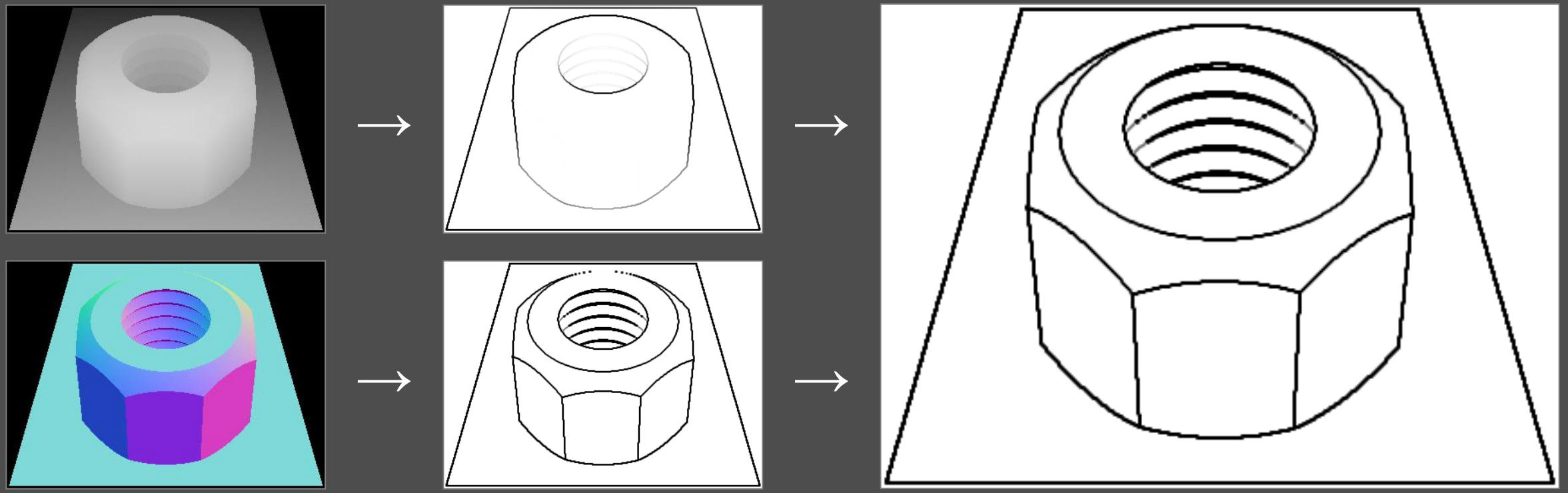
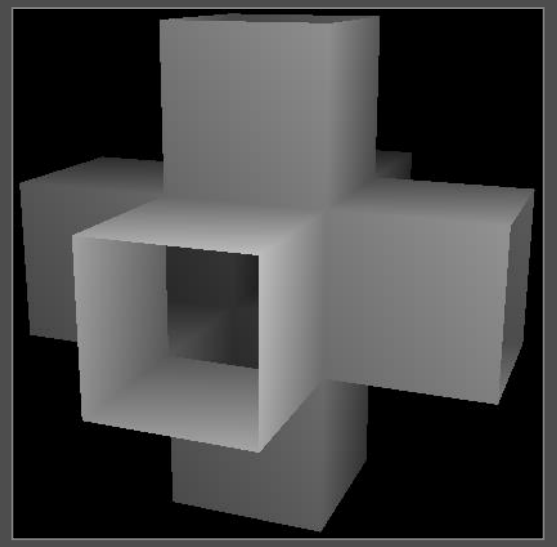
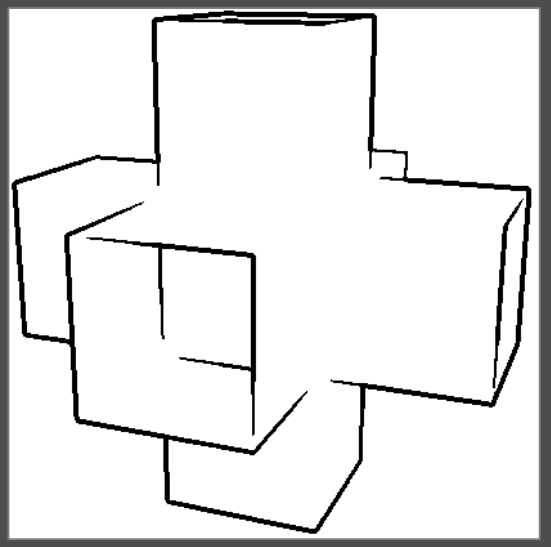
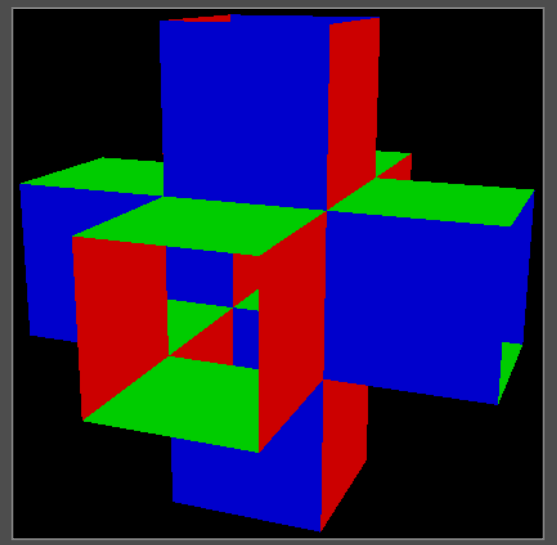
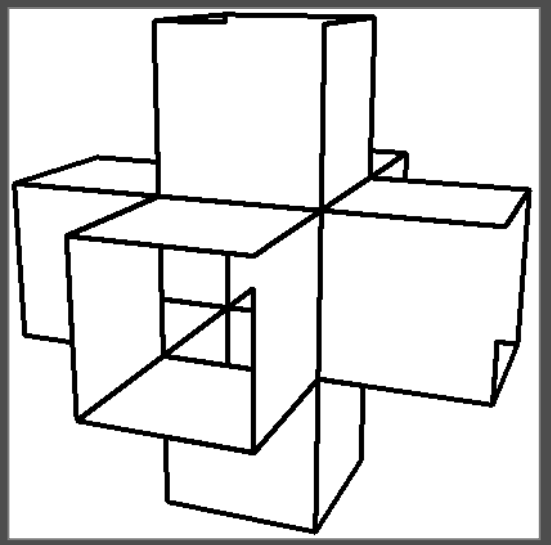


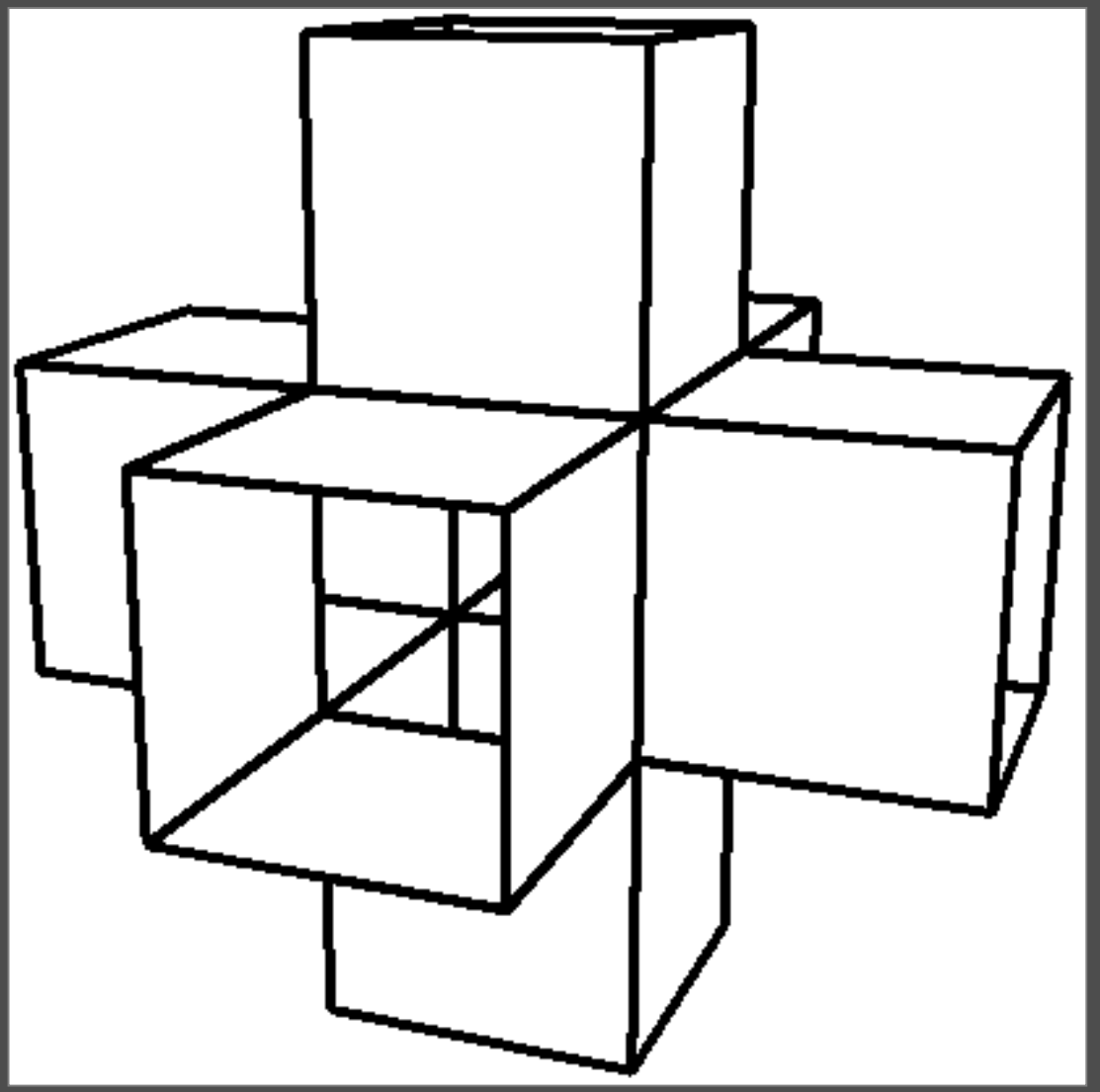
Image-Space Algorithms: Example











Hertzmann (1999)