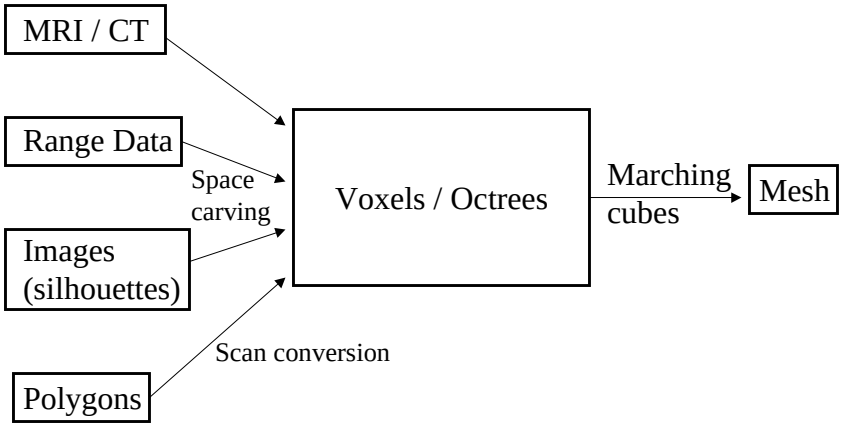
Reconstruction of Voxels from Sensor Data

Geometric Modeling
COS 598d Fall 2000

Volume Representations

- Voxels = uniform, orthogonal grid
  - Binary (empty/full)
  - Float : density / color / distance to surface, etc.
    0^{th} (nearest) vs. 1^{st} order (tri-linear) interpolation
  - Can be RLE'd
- Octrees = hierarchical space subdivision
  cube nodes: black/ white/ gray (split 1-to-8)

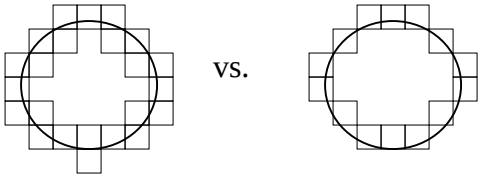
Data acquisition / conversion



3D “Scan-Conversion”

- Binary vs. anti-aliased
- Extension of scanline filling
- Scan-convert boundary, then flood fill

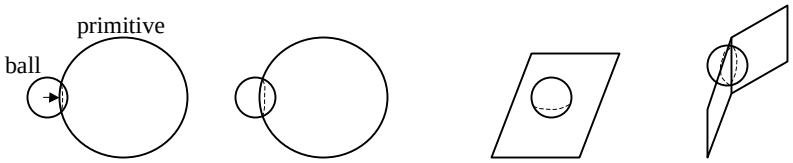
Problems



- “simple” and “separating”
- In 2D: 4/8-adjacency :
  neighbors share edges / edges OR vertices
  4-connected is 8-separating and vice-versa
- 3D: 6/18/26-adjacency

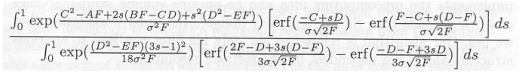
3D Antialiasing

- [Wang & Kaufman’93]
  - weighted integral of “stuff” inside ball
  - radius 3 voxels => filtering
  - weight function = cone (“hat”)
  - precompute for all primitive types & discrete set of distances



3D Antialiasing

[Oomes et al.'97]

- sample implicit function defined on volume
  - point => gaussian fall-off blob
  - line => "cylinder", radial e^{-d} fall-off, *erf* for ends
  - triangle => 
- Expensive but solves some problems.

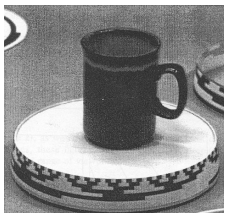
Space Carving

- Done hierarchically using octrees
- Cubes can be "maybe full" / mixed / empty
- Start w/ whole volume presumed full
- "Carve" away portions of "seen" space
- If cube partially empty, subdivide
- Carve 1 level using all views before subdiv.

Octrees from silhouettes

- [Szeliski ’93]
  - Map cube to image & see if full
  - Fast test on square bounding box (could use summed area tables too)
  - Subdivide after full rotation

  + Simple & fast
  - Result is “line hull”



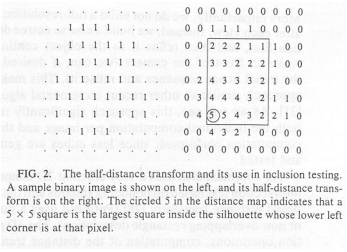
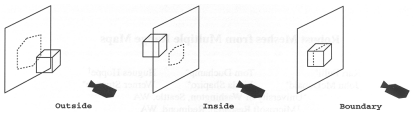
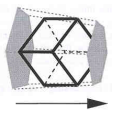


FIG. 2. The half-distance transform and its use in inclusion testing. A sample binary image is shown on the left, and its half-distance transform is on the right. The circled 5 in the distance map indicates that a 5×5 square is the largest square inside the silhouette whose lower left corner is at that pixel.

Octrees from range data

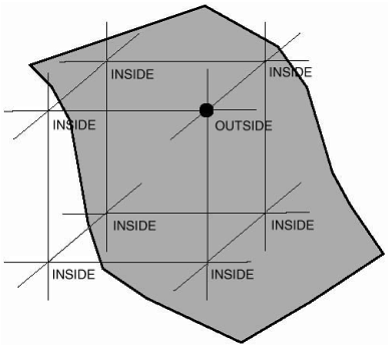
- [Pulli et al. ’97] Project cubes to depth map

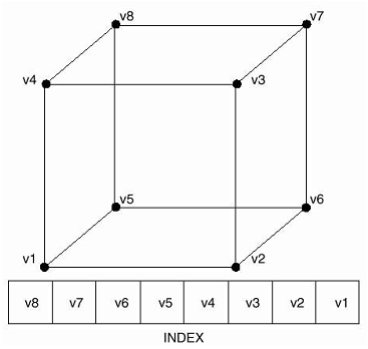




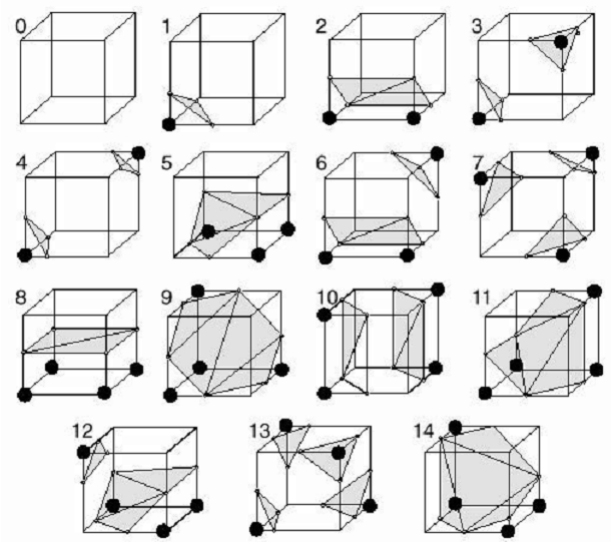
  - All points in hex. behind far cube vtx => empty
  - If points in hexagon in front => cube inside obj
  - Else, cube is boundary (subdivide)
  - Can accelerate using 2D min/max quadtrees.
  - Hint for voxel grid resolution

Marching Cubes





Cases



Matching up neighboring voxels