

# Modeling 3D objects with polygons



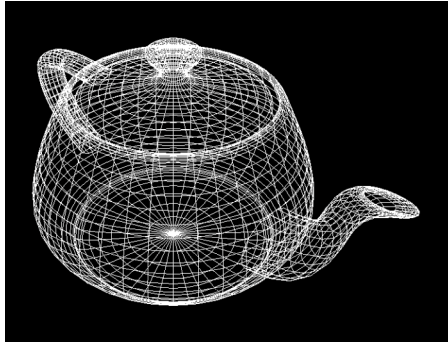


## Why polygons?

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- Simple mathematical description
- Standard 3D graphics primitive
- All graphics packages optimized for polygon throughput
- Most 3D graphics algorithms assume a polygon-based scene
- Common polygon algorithms implemented in hardware
- In the end, everything (well, almost everything) is a polygon

## Terminology



- *Polygon soup*: a general set of unstructured polygons used to define a scene
- *Polygonal mesh*: a set of connected polygons that together form a surface



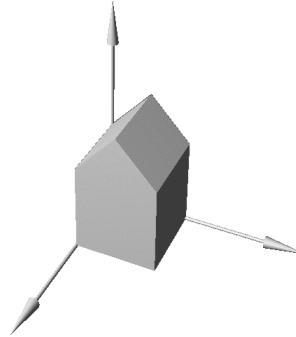
## More terminology

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- *3D polygonal model*: a 3D object made up entirely of polygons
- *3D polygonal modeling*: the process of building a 3D object by specifying the polygons that make up that object
  - NOTE: you can build a 3D polygonal model without using 3D polygonal modeling!

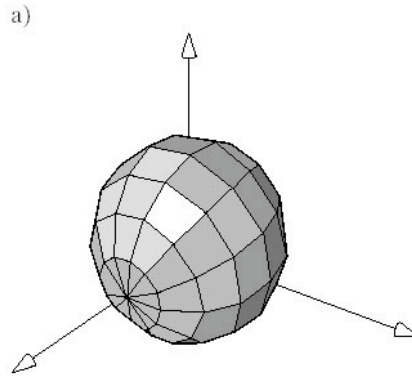
# Methods of creating polygonal meshes

- Build mesh by hand



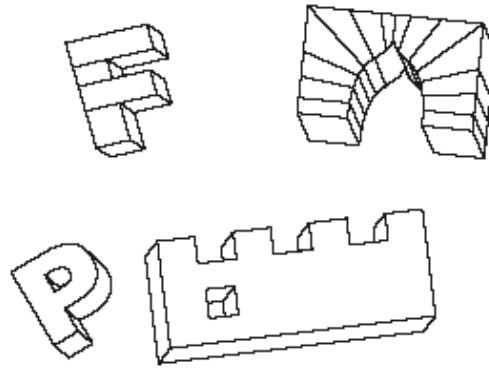
# Methods of creating polygonal meshes

- Tessellate a theoretical smooth surface
  - Tessellation: the process of creating a polygonal approximation from a smooth surface

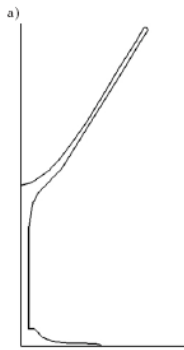


# Methods of creating polygonal meshes

- Extrude a 2D polygon, curve, etc.
  - Extrusion: the process of moving a 2D cross-section through space to create a 3D solid



# Methods of creating polygonal meshes



- Revolve/sweep a 2D polygon or curve
  - Revolution: the process of rotating a 2D cross-section about an axis to create a 3D solid



## Problems with polygonal models

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- They approximate smoothly curving surfaces
- Tradeoff between realism and efficiency
  - Lots of polygons: good approximation, slow to process
  - Few polygons: fast processing, poor approximation



## Polygonal simplification

- Decrease the number of polygons without sacrificing visual quality (meet *polygon budget*)



30944 triangles



2502 triangles



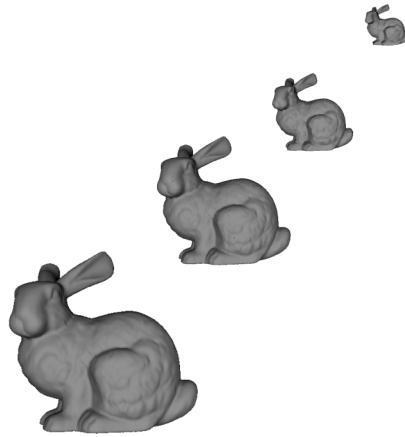
621 triangles



251 triangles

## Level of detail (LOD) techniques

- LOD: change the complexity of the model/image dynamically to maintain real-time performance
- Ex: use simplified models when objects are at a great distance
- "Popping" problem



## Texture substitution

- Textures (“imposters”) can cause objects to appear much more detailed than they actually are
- Problem: when the user is close

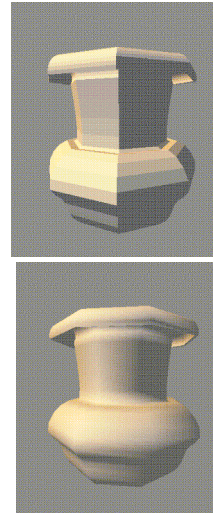
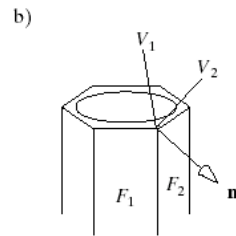
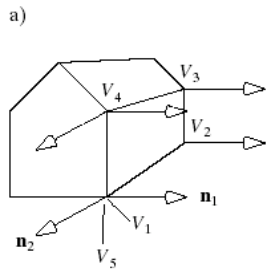




## Rendering polygonal meshes

- Simply use traditional raster graphics techniques
- Proper lighting depends on proper normals
  - Face normal: the normal to the plane in which a polygon lies
  - Vertex normal: the normal to the underlying surface (being approximated by a polygonal mesh) at a particular vertex

# Face normals vs. vertex normals





## Practical polygonal modeling

- Modeling tools
  - 3D Studio Max
  - Maya
  - AutoCAD
  - ...
- File formats
  - OBJ, DXF, 3DS, FLT, DWG, ...



## Alternatives to polygonal modeling

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- As we noted, almost everything is a polygon eventually, but the modeling process does not have to be based on polygons
- Instead, we can model objects using smooth higher-order surfaces, and only convert to polygons in order to render
- Also, we can model *volumes* instead of surfaces
- Next: modeling with curves/surfaces