Computer Graphics

Lecture 13

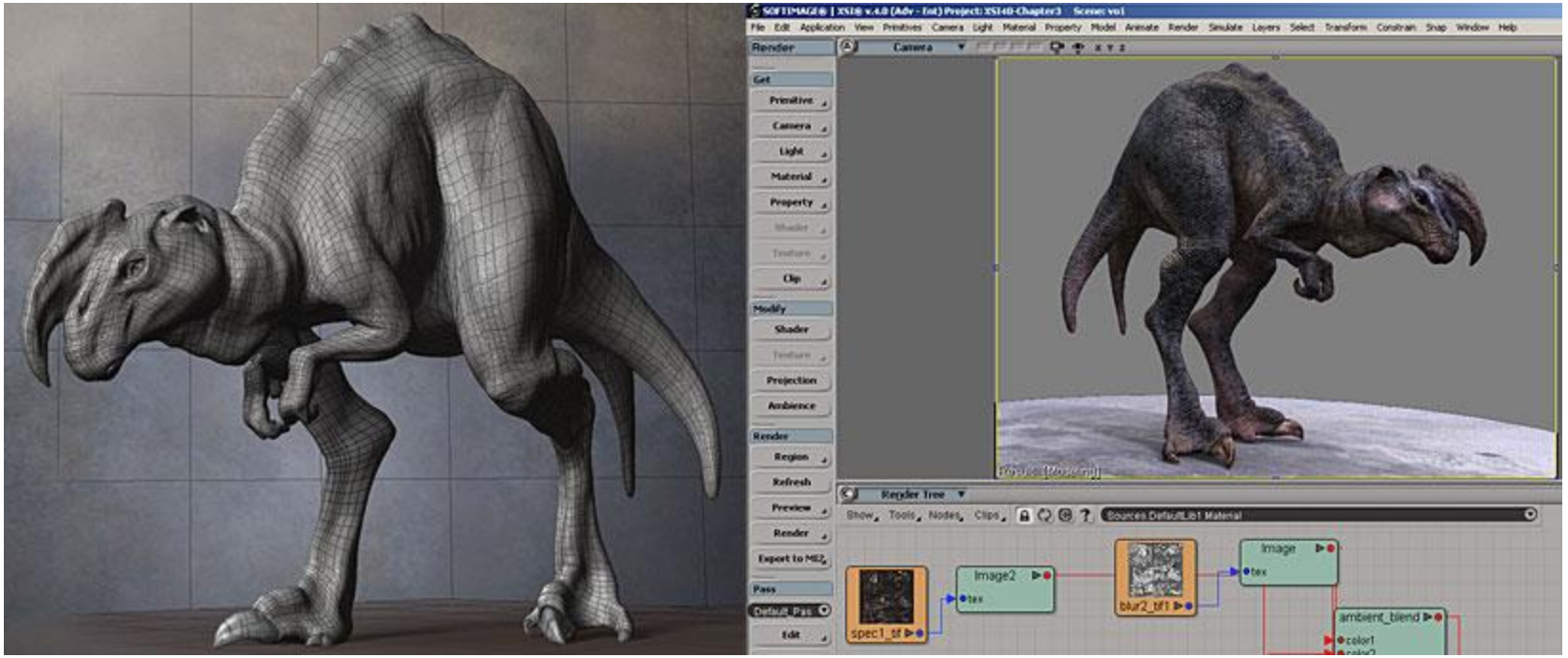
Building 3D Models

- What is 3D model?

- 3D object using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc.

https://cdn3.artstation.com

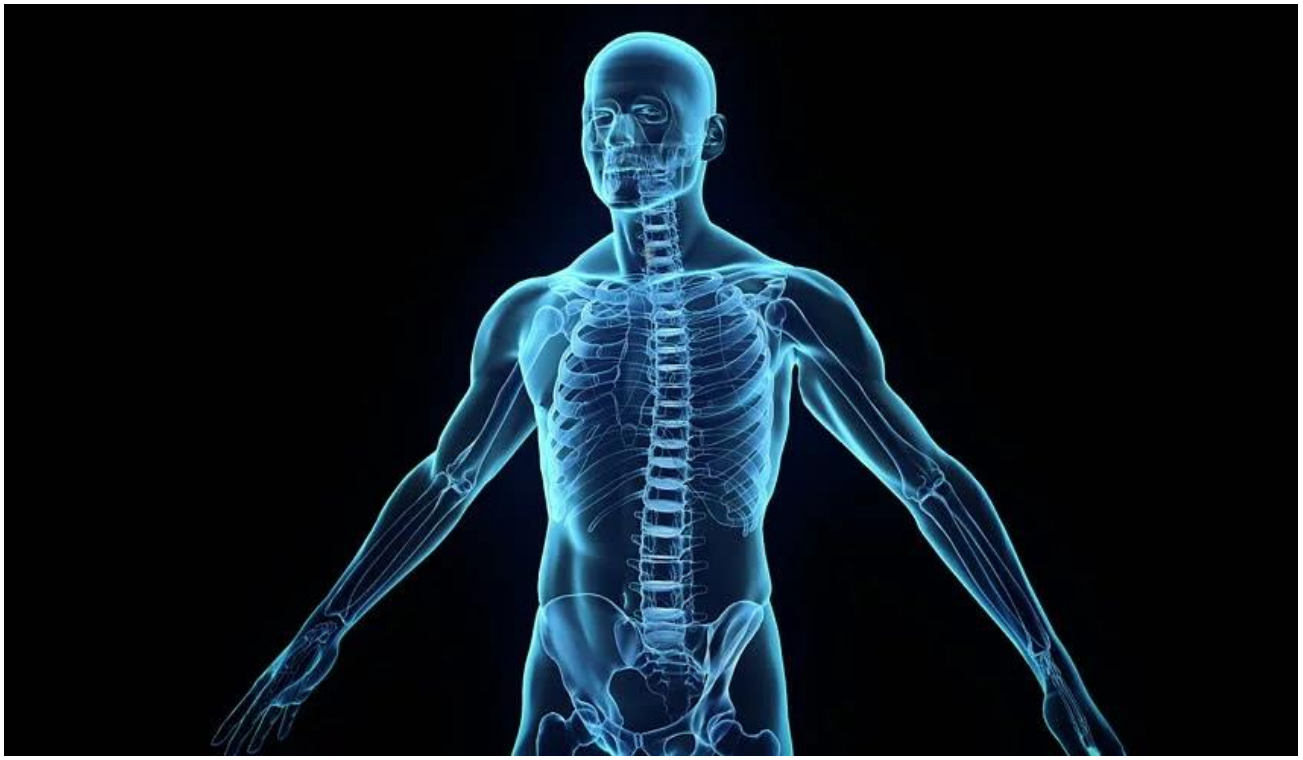
- Representation of 3D model
  - The process of developing a mathematical representation of any three-dimensional surface of object via specialized software



https://xsisupport.files.wordpress.com/2016/08/ex1.jpg

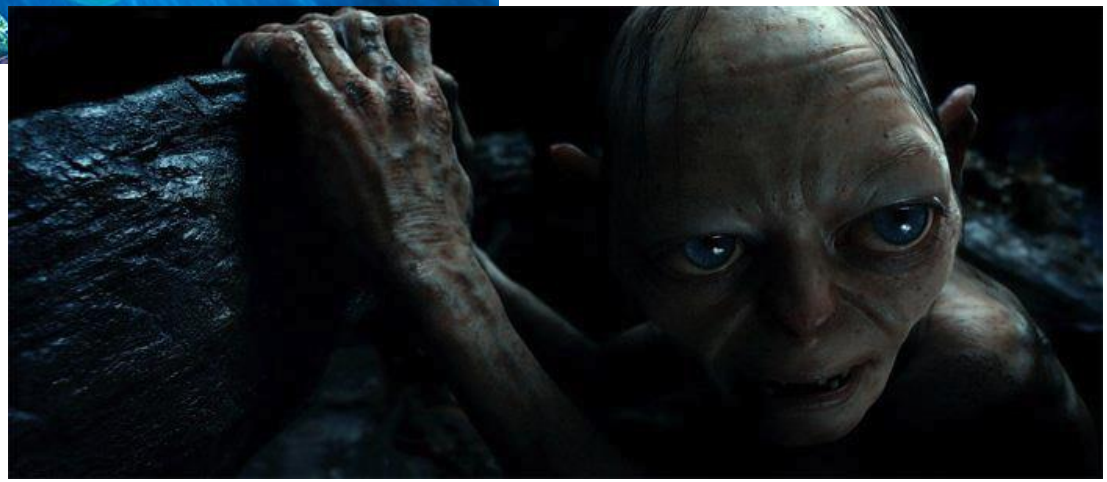
Usage of a 3D model

- Medical
  - The medical industry uses detailed models of organs



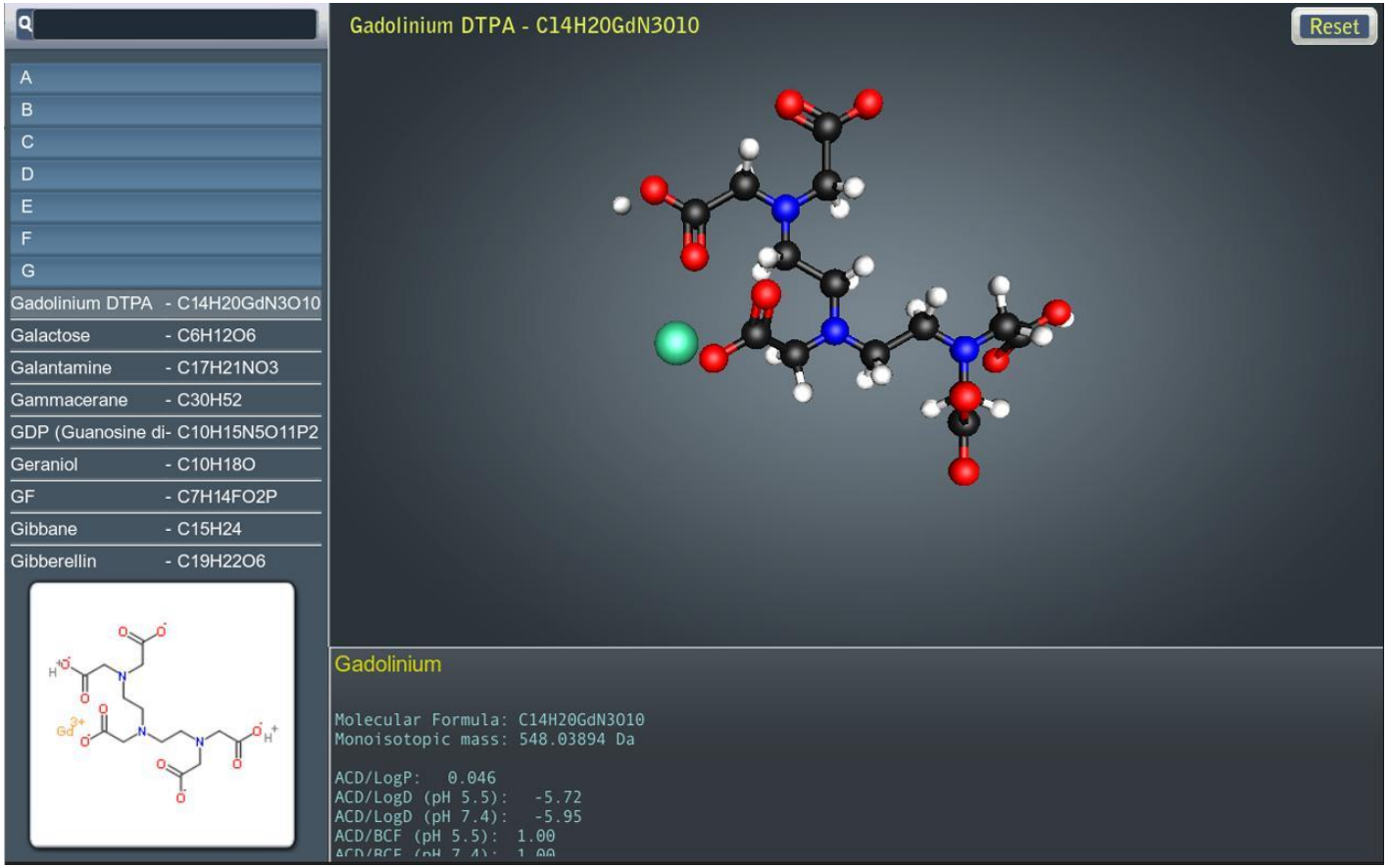
http://il2.picdn.net/shutterstock/videos/3058408/thumb/1.jpg

- Movies
  - The movie industry uses them as characters and objects for animated and real-life motion pictures



http://frpnet.net/wp-content/uploads

- Science
  - The science sector uses them as highly detailed models of chemical compounds



- Architecture
  - The architecture industry uses them to demonstrate proposed buildings and landscapes through Software Architectural Models

http://s1.thingpic.com/images/Jx/zCYDjZ3xcRi5QsA6MVBpC3o3.jpeg

- Engineering
  - The engineering community uses them as designs of new devices, vehicles and structures as well as a host of other uses

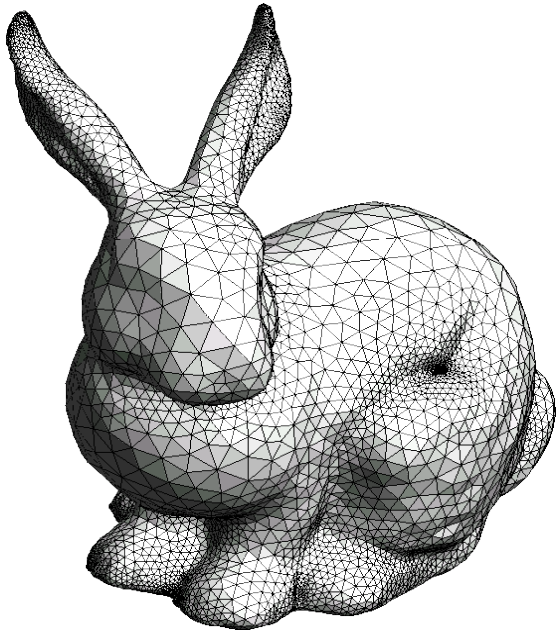
http://bioage.typepad.com/.a/6a00d8341c4fbe53ef01bb08417cc0970d-550wi

Classic models in CG

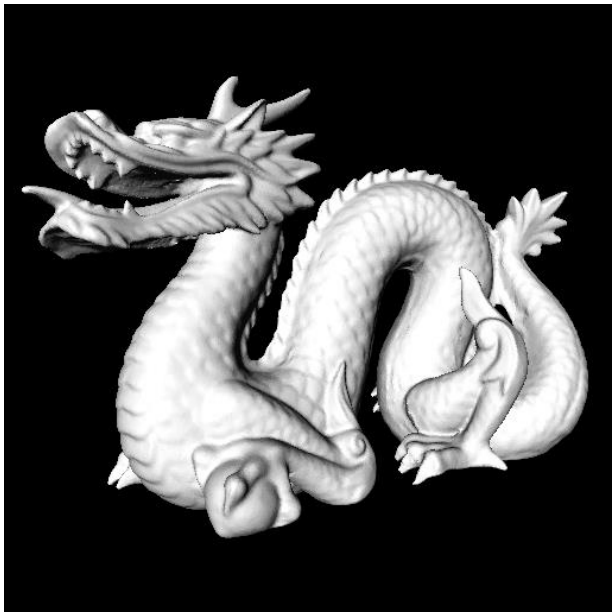
- Most common models use around the Graphics community for their research
  - The Utah Teapot
  - A mathematical model of an ordinary teapot, which appears solid, cylindrical and partially convex.
  - Created in 1975 by Martin Newell, a member of the pioneering graphics program at the University of Utah

http://mech.fsv.cvut.cz/~dr/papers/Habil03/img989.gif

- The Stanford Bunny
  - The Stanford Bunny is a computer graphics test model developed by Greg Turk and Marc Levoy in 1994 at Stanford University.
  - The Bunny consists of data describing 69,451 triangles determined by 3D scanning a ceramic figure of a rabbit.



- The Stanford Dragon
  - The Stanford Dragon is a computer graphics test model created with a Cyberware 3030 MS at Stanford University.
  - The Dragon consists of data describing 871,414 triangles determined by 3D scanning a real sculpture

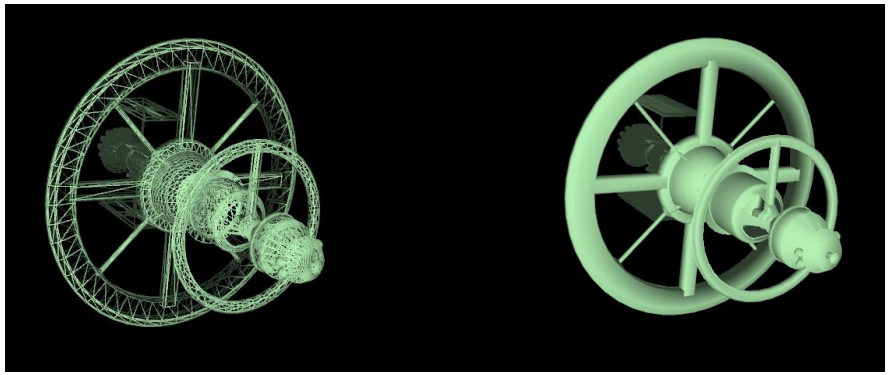


What is a mesh model

- Model represent by set of connected polygons (usually triangles)
- Can Represent by Vertices and Indexed Face Set
- Meshes are flexible and computers can render them so quickly. So the vast majority of 3D models today are built as textured polygonal models
- Since polygons are planar, curved surfaces can represent only by using many polygons

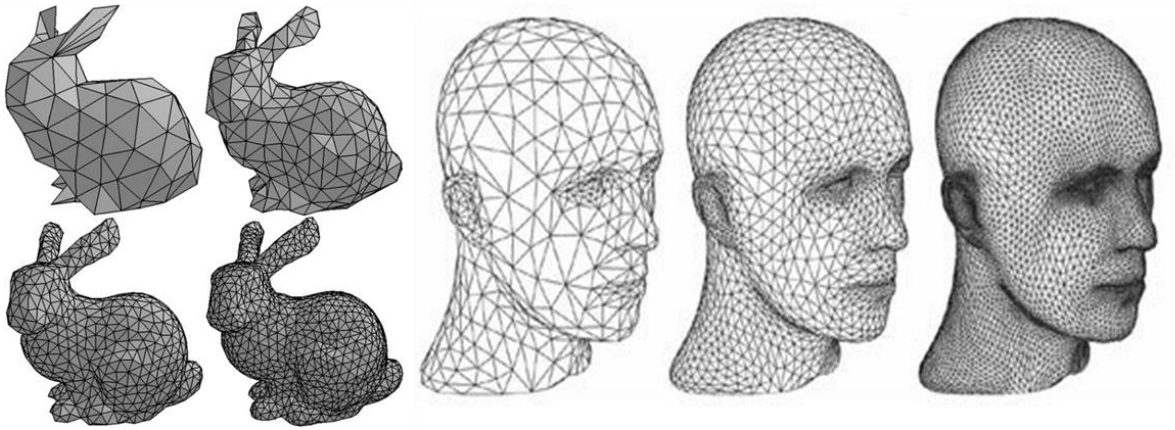
Modeling

3D Model with Triangles



12,000 – 15,000 Wireframe of Triangles

More triangles show fine details



Building a 3D model

```
# Blender v2.78 (sub 0) OBJ File: ''
# www.blender.org
mtllib cube.mtl
o Cube
v -1.000000 -1.000000 1.000000
v -1.000000 1.000000 1.000000
v -1.000000 -1.000000 -1.000000
v -1.000000 1.000000 -1.000000
v 1.000000 -1.000000 1.000000
v 1.000000 1.000000 1.000000
v 1.000000 -1.000000 -1.000000
v 1.000000 1.000000 -1.000000
vn -1.0000 0.0000 0.0000
vn 0.0000 0.0000 -1.0000
vn 1.0000 0.0000 0.0000
vn 0.0000 0.0000 1.0000
vn 0.0000 -1.0000 0.0000
vn 0.0000 1.0000 0.0000
usemtl None
s off
f 1//1 2//1 4//1 3//1
f 3//2 4//2 8//2 7//2
f 7//3 8//3 6//3 5//3
f 5//4 6//4 2//4 1//4
f 3//5 7//5 5//5 1//5
f 8//6 4//6 2//6 6//6
```

Wavefront object file of a Cube

Wavefront .obj file

Vertex:

A vertex can be specified in a line starting with the letter "v". That is followed by (x,y,z[,w]) coordinates. W is optional and defaults to 1.0

```
v -1.000000 -1.000000 1.000000
v -1.000000 1.000000 1.000000
v -1.000000 -1.000000 -1.000000
v -1.000000 1.000000 -1.000000
v 1.000000 -1.000000 1.000000
v 1.000000 1.000000 1.000000
v 1.000000 -1.000000 -1.000000
v 1.000000 1.000000 -1.000000
```

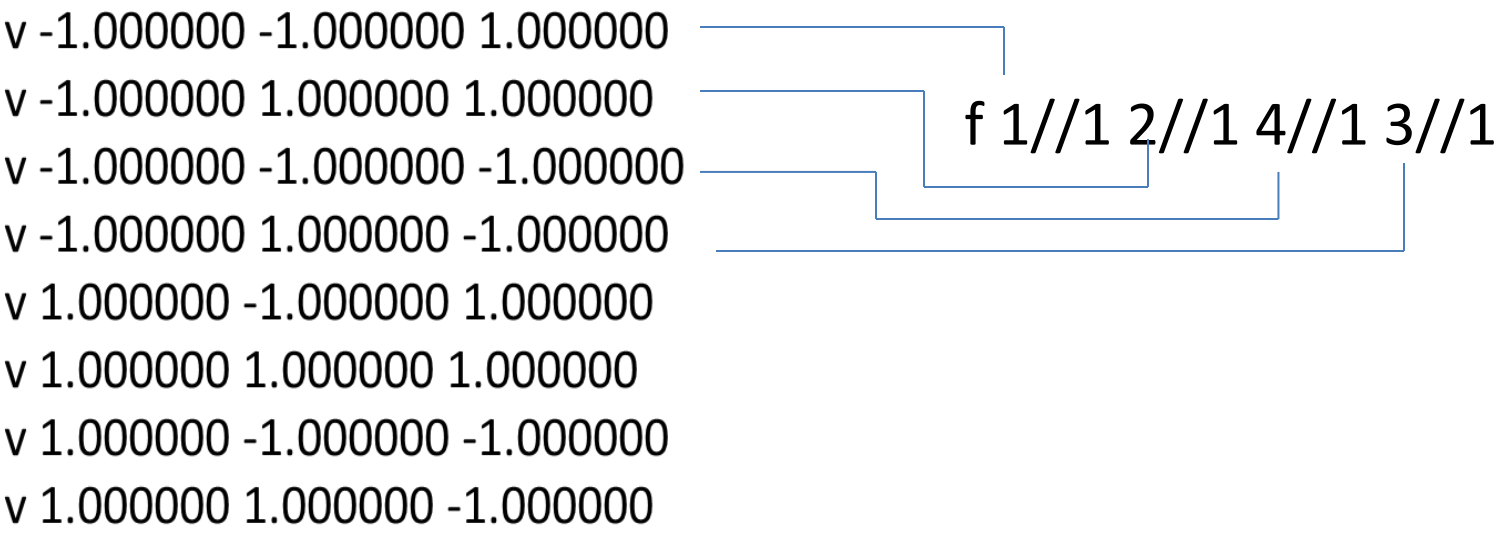
Faces:

Faces are defined using lists of vertex, texture and normal indices. Polygons such as quadrilaterals can be defined by using more than three vertex/texture/normal indices.

```
usemtl None
s off
f 1//1 2//1 4//1 3//1
f 3//2 4//2 8//2 7//2
f 7//3 8//3 6//3 5//3
f 5//4 6//4 2//4 1//4
f 3//5 7//5 5//5 1//5
f 8//6 4//6 2//6 6//6
```

Vertex Indices:

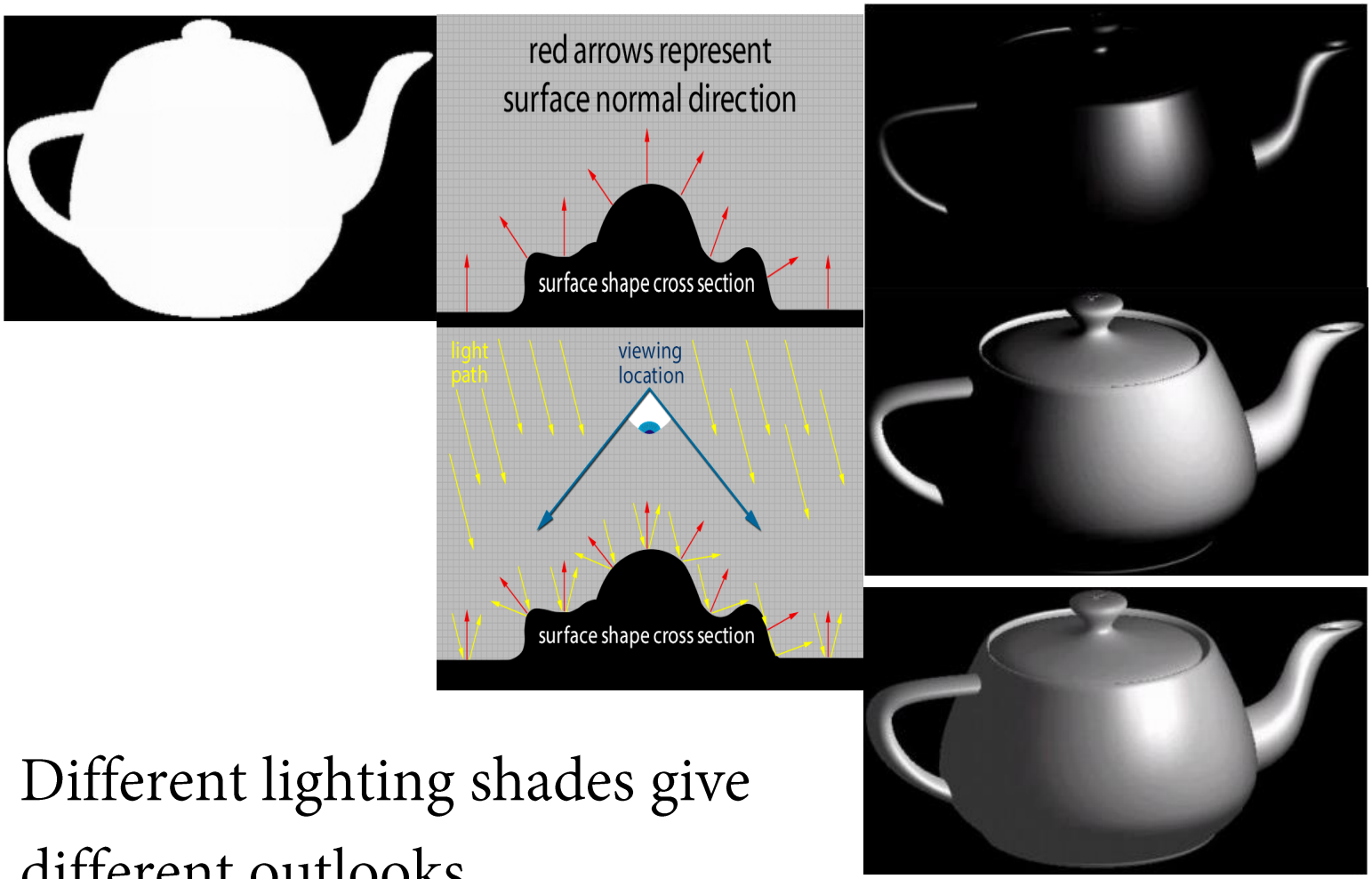
A valid vertex index matches the corresponding vertex elements of a previously defined vertex list.



Vertex Normal Indices:

- A vertex can be specified in a line starting with the letter "vn".
- Optionally, normal indices can be used to specify normal vectors for vertices when defining a face.
- To add a normal index to a vertex index when defining a face, one must put a second slash after the texture coordinate index and then put the normal index.
- A valid normal index starts from 1 and matches the corresponding element in the previously defined list of normals. Each face can contain three or more elements.

Model surface normal

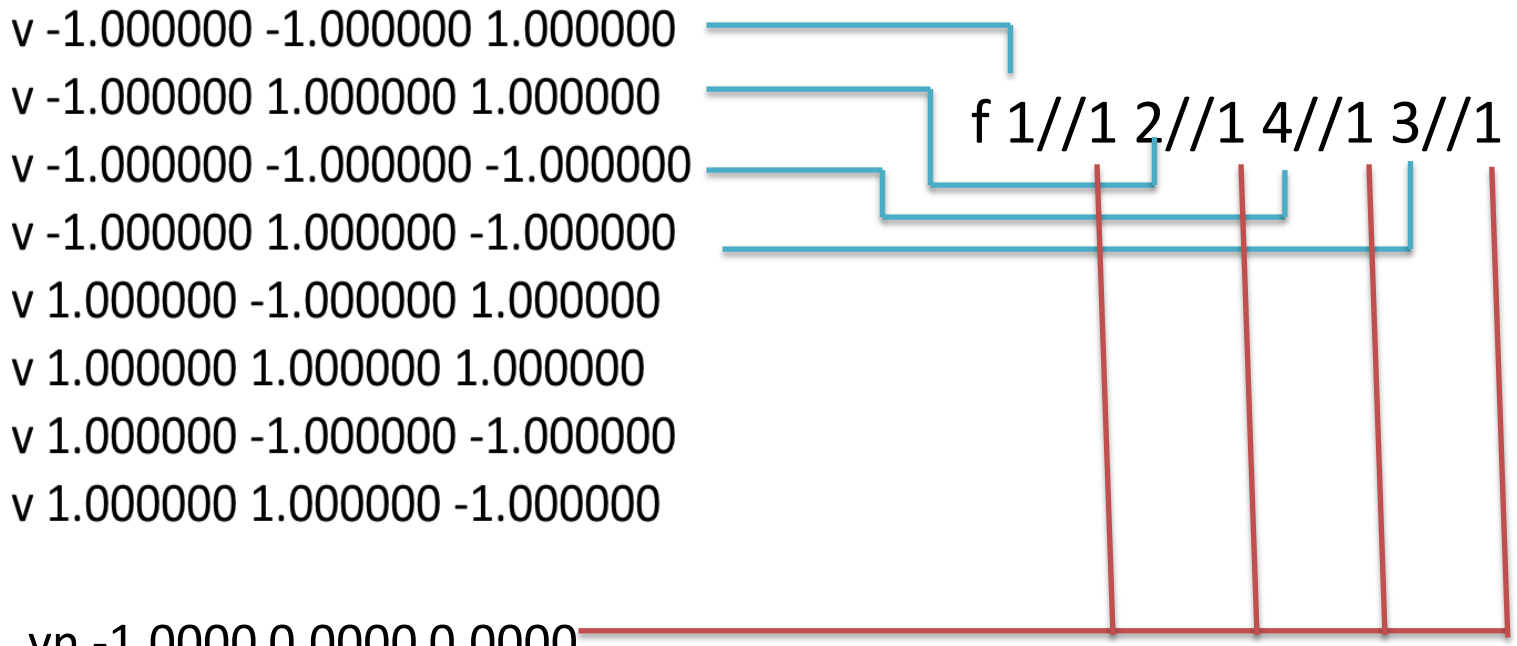


Different lighting shades give different outlooks

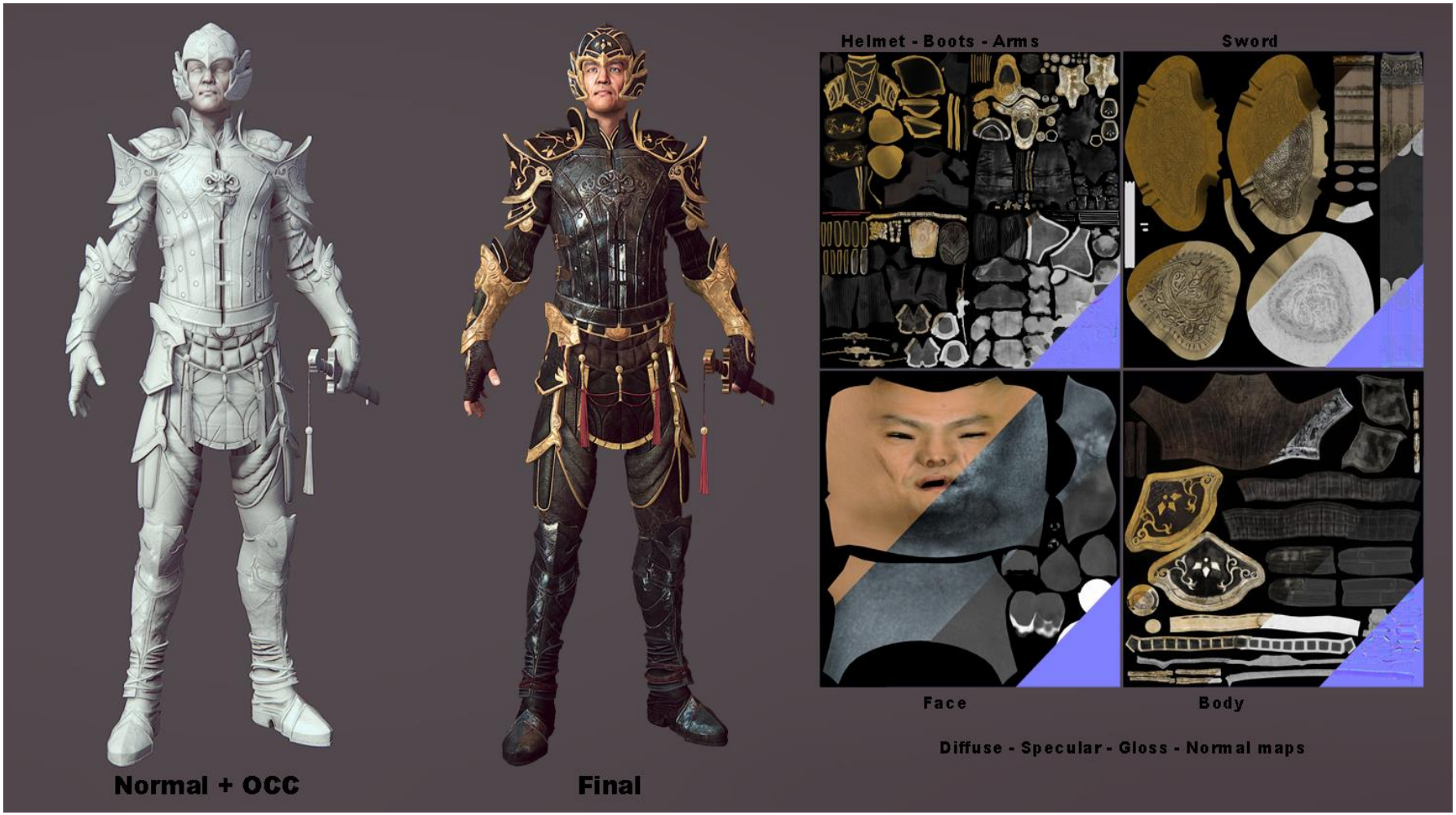
v -1.000000 -1.000000 1.000000
v -1.000000 1.000000 1.000000
v -1.000000 -1.000000 -1.000000
v -1.000000 1.000000 -1.000000
v 1.000000 -1.000000 1.000000
v 1.000000 1.000000 1.000000
v 1.000000 -1.000000 -1.000000
v 1.000000 1.000000 -1.000000

f 1//1 2//1 4//1 3//1

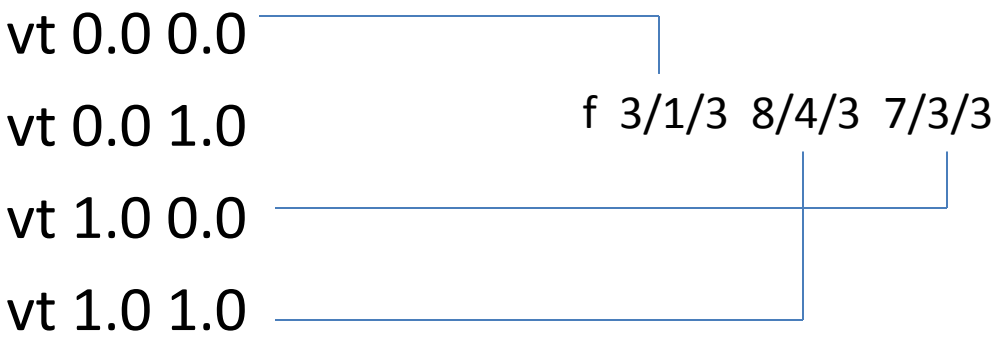
vn -1.0000 0.0000 0.0000
vn 0.0000 0.0000 -1.0000
vn 1.0000 0.0000 0.0000
vn 0.0000 0.0000 1.0000
vn 0.0000 -1.0000 0.0000
vn 0.0000 1.0000 0.0000



Texture maps



Face format



Each face can contain three or more elements with the format of

f v1/vt1/vn1 v2/vt2/vn2 v3/vt3/vn3 ....

Summary
cube.obj with materials and documentation
#
mtllib cube-textures.mtl
g cube
v1 is origin: back lower left (bll)
v2=fll, v3=bul, v4=ful, v5=blr, v6=flr, v7=
v 0.0 0.0 0.0   v1 = back lower left (origin)
v 0.0 0.0 1.0   v2 = front lower left
v 0.0 1.0 0.0   v3 = back upper left
v 0.0 1.0 1.0   v4 = front upper left
v 1.0 0.0 0.0   v5 = back lower right
v 1.0 0.0 1.0   v6 = front lower right
v 1.0 1.0 0.0   v7 = back upper right
v 1.0 1.0 1.0   v8 = front upper right

vn 0.0 0.0 1.0
vn 0.0 0.0 -1.0
vn 0.0 1.0 0.0
vn 0.0 -1.0 0.0
vn 1.0 0.0 0.0
vn -1.0 0.0 0.0

vt 0.0 0.0 # vt=1 is upper left of texture
vt 0.0 1.0 # vt=2 is lower left of texture
vt 1.0 0.0 # vt=3 is upper right of texture
vt 1.0 1.0 # vt=4 is lower right of texture

```
# remember, syntax is v/vt/vn
g back face
usemtl buffy-gray
f  1/4/2  7/1/2  5/2/2
f  1/4/2  3/3/2  7/1/2
g left face
usemtl buffy-blue
f  1/2/6  4/3/6  3/1/6
f  1/2/6  2/4/6  4/3/6
g top face
usemtl buffy-red
f  3/1/3  8/4/3  7/3/3
f  3/1/3  4/2/3  8/4/3
g right face
usemtl buffy-green
f  5/4/5  7/3/5  8/1/5
f  5/4/5  8/1/5  6/2/5
g bottom face
usemtl buffy-red
f  1/2/4  5/4/4  6/3/4
f  1/2/4  6/3/4  2/1/4
g front face
usemtl buffy-gray
f  2/2/1  6/4/1  8/3/1
f  2/2/1  8/3/1  4/1/1
```


T-rex low poly game version
Tris : 11,700
Arun aggarwal