3D Graphics

Class 2

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http://www.simulationfirst.com/ein5255/

Refresher

- Many examples in Military and Medical communities
- Live Simulation: Real Person interacting with real world entities
- Constructive Simulation: The user is a group leader or commander who construct the simulation in a computer and let it run.
  - It can be interactive as in JCATS, where the user can add new entities during the game. http://www.llnl.gov/nai/group/JCATSHome.htm
- Virtual Simulation: Real person interacting with non real world entities (computer entities)

Virtual Reality

- Virtual Reality is a Media
- Virtual Reality is the use of computer technology to create the effect of an interactive three-dimensional world in which the objects have a sense of spatial presence

3D computer Graphics

- Modeling
- Polygons
- Colors
- Transforms
- Lights
- Z-Buffer
- Collision
- Level of Details
- SVS Demo
- Human Animation Demo

Model

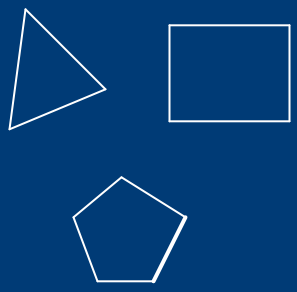
- A Model may be defined as a representation of some or all of the properties of a device, system, or object.
- A Model is a mathematical or physical system, obeying certain specific conditions, whose behavior is used to understand a physical, biological, or social system to which it is analogous in some way.

Modeling

- Modeling is the Process of making Models. The Blender Project.
- Physical modeling is done by carving, assembling …
- 3D Computer Modeling is also done by different techniques (carving, assembling…)
- No matter what method is used, a 3D Computer Model is made of a set of connected Polygons **(In Most Cases)**

Polygons

- A Polygon is a flat surface that consists of a set of vertices connected by lines called edges. can be divided into three basic types:
- **Convex** polygons are the simplest type of polygon. To determine whether or not a polygon is convex, ask the following question: Does a straight line connecting ANY two points that are inside the polygon intersect any edges of the polygon?

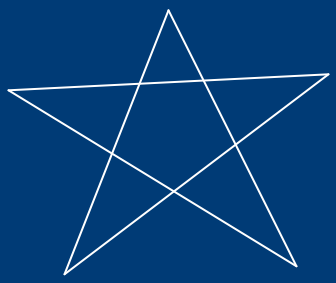


Polygons

- **Concave** polygons have fewer restrictions than convex polygons. The line connecting any two points that lie inside the polygon may intersect more than two edges of the polygon.

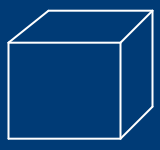
Polygons

- **Complex** polygons are just what their name suggests: complex. Complex polygons are basically concave polygons that may have self-intersecting edges. The complexity arises from distinguishing which side is inside the polygon when filling it.



Modeling

- How many polygons a Cube is made of?
- 6 ?
- 12 ?
- It depends of the base polygon used: a Triangle, Quad ?



Modeling

- Vertex and Triangle Tables, Page 30, Figure 3.2
- Triangulation, Page 31, Figure 3.3
- Extruding, Page 33, Figure 3.7
- Sweeping a Contour, Page 33, Figure 3.8
- Geometric Primitives, Page34, Figure 3.9

Colors

- Keep in mind we are trying to replicate real life processes
- Real Objects have colors → Virtual objects should have colors
- Computer Technology uses mixture of Red, Green and Blue to describe colors.
- Values of these parameters range from 0 to 1
- Therefore the triplet (0,0,0) represents black, and (1,1,1) represents white.
- (1,0,0) ??

Transforms

- Each object in Real World holds a position, orientation, and scale so should each object in the Virtual World
- Common Transforms:
  - Translation
  - Rotation
  - Scaling
  - Shearing
- Using Matrix Multiplications

Lights

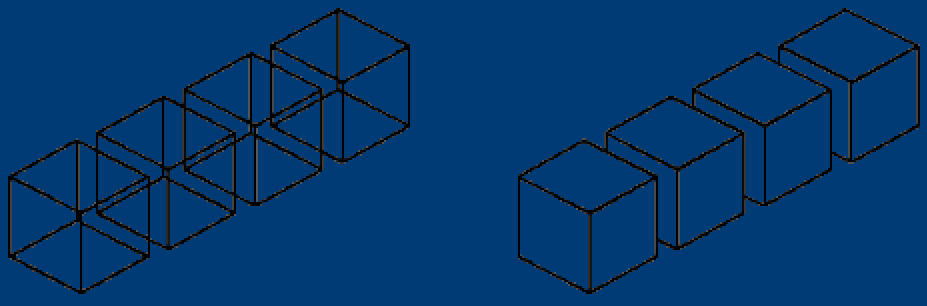
- Keep in mind we are trying to replicate real life processes
- You can't see anything without light
- Therefore in your virtual world, Light shall exist
- Four different light can be used:
  - Ambient, it has no direction (moon light)
  - Spotlight, it has a position, direction, and angle
  - Fixed Point, (light bulb) it radiates light in all directions
  - Parallel, (sun light) it shine light in one direction

Z-Buffer

- Surfaces normally invisible from a certain point, should be also invisible in the computer generated image
  - Visible-surface problem (determining the surfaces that are visible)
  - Hidden-surface problem (determining those that are invisible)
- Z-Buffer is the simplest algorithms for visible surface determination

Z-Buffer

- Eliminate, erase, or draw over all surface that should not be visible



Z-Buffer

- For each pixel on the display:
  - we keep a record of the depth of the object in the scene that is closest to the viewer
  - plus a record of the intensity that should be displayed to show the object
- When a new polygon is to be processed, a z-value and intensity value are calculated for each pixel that lies within the boundary of the polygon

Z-Buffer

- If the z-value at a pixel indicates that the polygon is closer to the viewer than the -value in the z-buffer, the z-value and the intensity values recorded in the buffers are replaced by the polygon's values
- After processing all polygons, the resulting intensity buffer can be displayed

Collision

- Once these objects are modeled and put in a virtual environment, they have to interact with other objects in the same manner as in real life.
- For example: two objects that touch each others are in a collision state.
- Once they collide, then their trajectories changes

Collision

- Collision detection is the process of determining if two objects have collided, and where the collision occurs
  - Collision detection is a field by itself, and numerous methods exists
  - Bounding Spheres
  - Bounding Boxes
- Collision Response is the process of changing the objects attributes in response to the collision (velocity, direction, ...)

Level of Details

- Realistic looking 3D models need a lot of polygons.
- The more polygons you have, the longer it takes to your computer to compute and draw
- To keep the Real Time aspect of the virtual simulation, we need to lower the process time.
- Therefore, we need low polygon counts for our 3D models

Level of Details

- As objects gets closer, they become clearer (in Real World). You can't see details when objects are far.
- We can use the same analogy for Virtual World, by having multiple models for the same object with different polygon counts.
- Then, we can switch between models of greater details as they get closer.