CMPUT 307 – 2024 Winter

3D Modeling & Animation Concepts

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3D Modeling & Animation

Course Objectives:

- Understanding 3D Modeling & Animation concepts
- Having some theoretical background in this area
- Learning how to write some simple programs

History of Animation

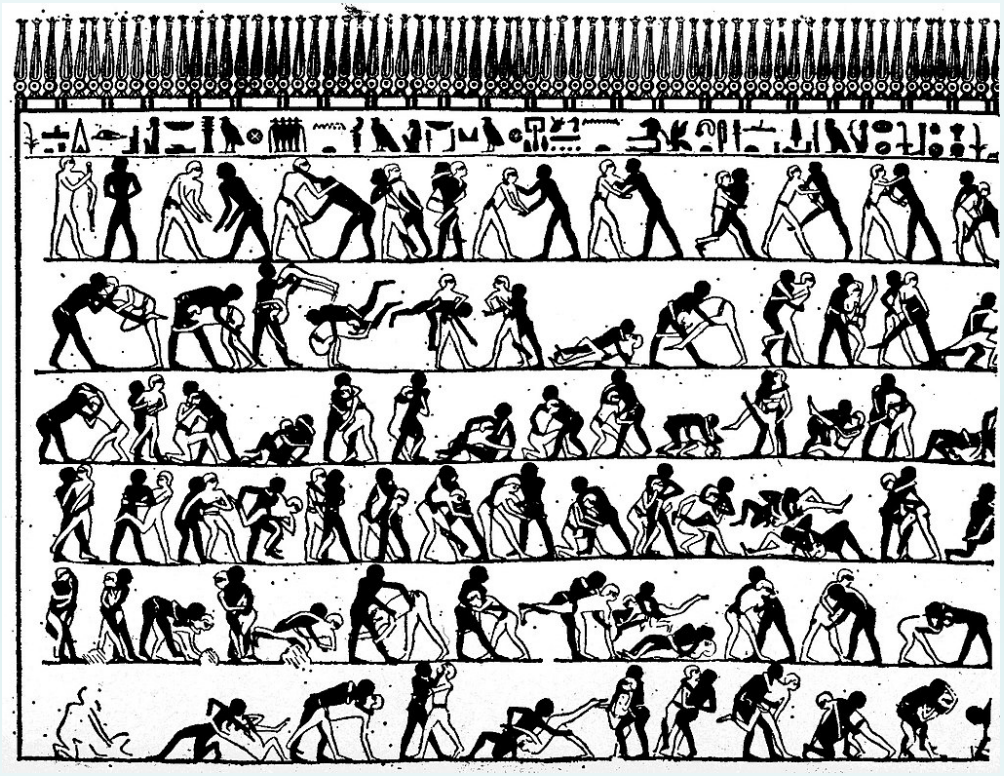
- Animation is a graphic representation showing character movement or interaction in a sequence of frames.
- The character pose is changed slightly between frames.
- When played back rapidly (24 – 30 frames per second), smooth movement is perceived.
  - Illustration: flipping a stack of images; production was labor intensive back in 1910

Example: https://www.youtube.com/watch?v=7n2YF7mfP5s

First Animations

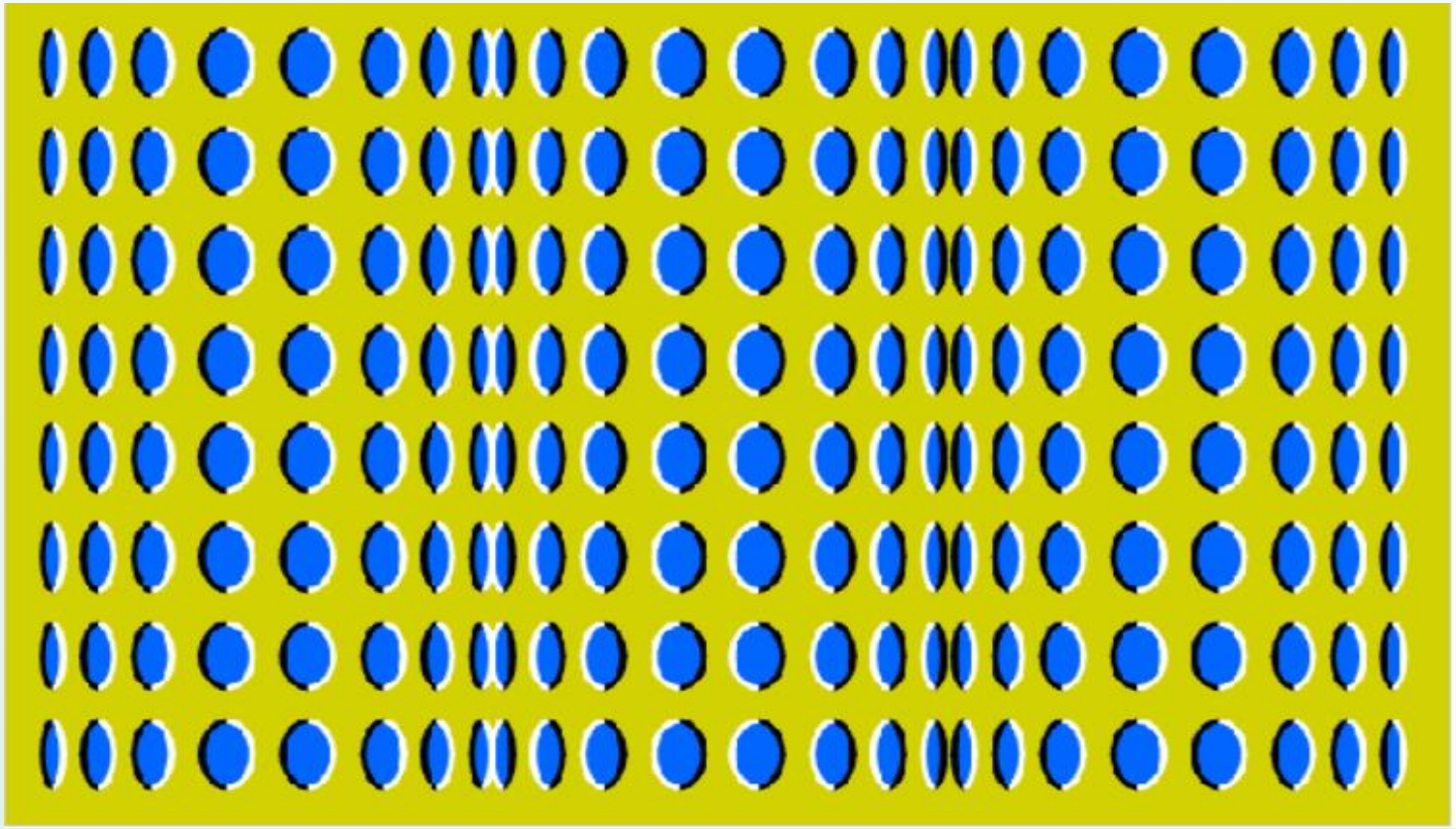
Can be traced to 4000 years ago in Eygpt!

- Sequence of images to show wrestling:



Animation by Rotating a Still Image

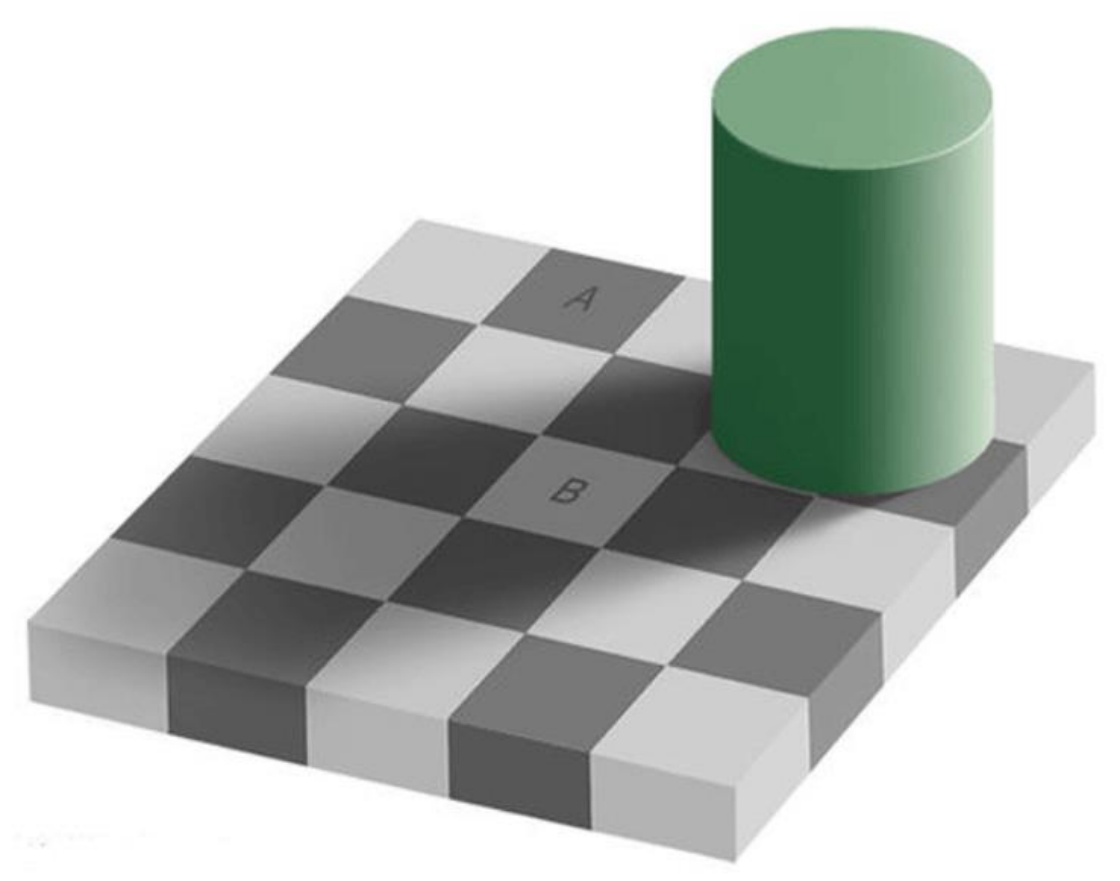
Human Perception and Illusion



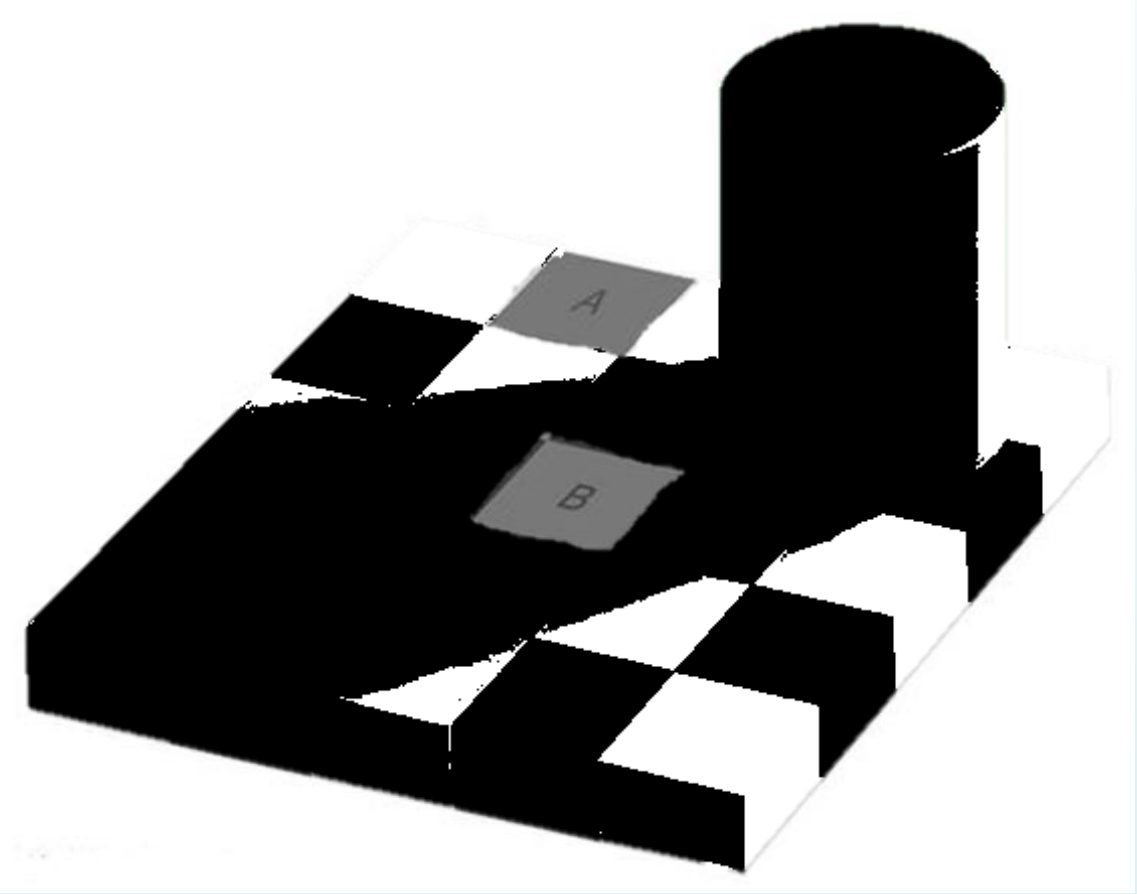
- No, this is not an animation! The image is really static.

Static
Motion

Checker Shadow Illusion



Checker Shadow Illusion



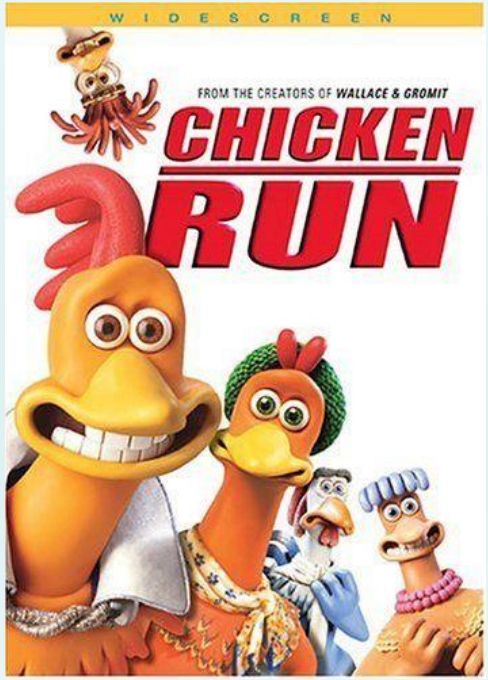
Disabling the effect of shading

A Brief History of Animation

https://www.youtube.com/watch?v=mbpLpxi9rJY

Clay Animation

- The idea is to use various Clay Models to create animations.
- Each model represents a different Pose or Facial Expression in a Character



CHICKEN RUN is one of the most well known animated movies made using stop-motion clay animation:

http://entertainment.time.com/2013/10/15/10-great-stop-motion-animation-movies/slide/chicken-run/

History of Animation

- Walt Disney took animation to a new level: (1928) animated feature film, *Snow White and the Seven Dwarfs*.

*Note the importance of a **story**, in addition to the **artistic** characters design and **appealing** animation*

*New animation techniques, e.g. **color and sound**, have evolved over the years in later versions*

History of Animation

- Computer technologies expanded the horizon of animation with special effects: e.g.
  - *Star Wars* by George Lucas
  - *Toy Story*, produced by Walt Disney Productions and Pixar Animation Studios (1995)
  - Towards 3D animation: mid-70s to 80s

With modern **desktop publishing software** animation is no longer monopolized by large corporations.

3D Graphics & Animation
(6 Basic Production Steps)

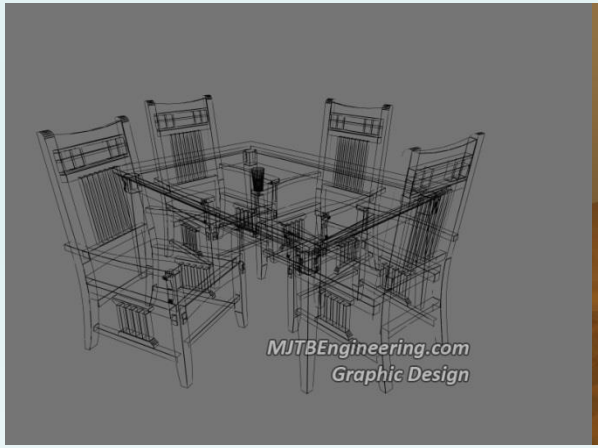
1. **Storyboard** – A good story is often behind a successful 3D movie. Tell the story by “scenes” & “camera angles.”
2. **Modeling** –Scan, construct or import.
3. Surface **material** – Color shading or texture mapping
4. **Animation** – Key-frame or Rigging (Biped, control points & constraints); bring life to objects.
5. **Special effects**, e.g. lighting.
6. Final **Rendering** – Incl. sound, trailer, etc.

Step 1: Storyboard

1. Create a story
2. Based on the story, design characters
3. Interaction between characters
4. Divide into scenes
5. Continuity between scenes

Step 2: Modeling

1. Sketch model
2. Choose surface material
3. Design animation
4. Construct mesh
5. Texture mapping or color shading



Modeling – 3D mesh

- Manually creating complex objects can be a Time Intensive and Tedious Process.
- Thus more and more complex 3D Capture Devices are being developed.
- Some scan Static Objects only, others can scan Moving Objects (with less precision, of course).

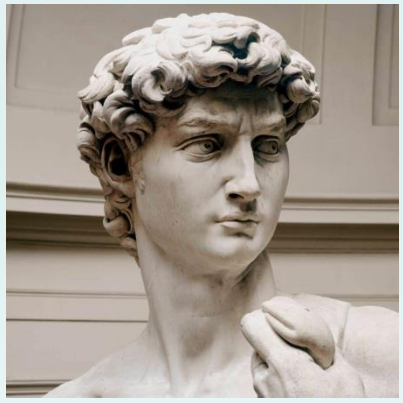
https://www.artec3d.com/3d-models

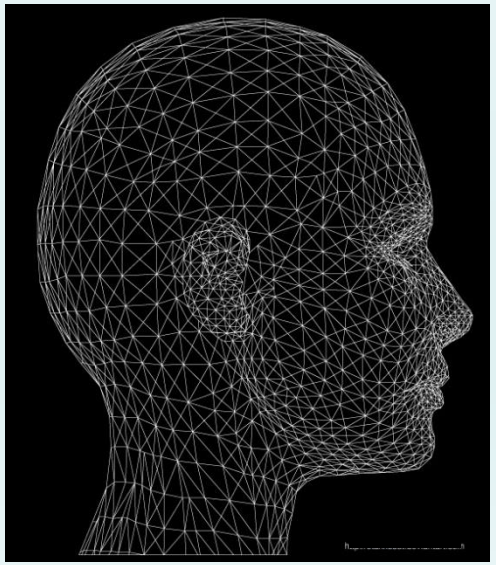
Modeling – 3D mesh

- Creating **geometry** – vertices, edges, faces (triangle) and patch
- **Mesh** (wireframe) vs. **Point Cloud**
  - With vs. without Connectivity
  - mesh file format example: .OBJ

Over 5 meters
1 billion triangles

scanner





Step 3: Model Surface Material

- Elaborate texture mapping
  - Unwrap uvw
- Shading: Color per vertex
  - Interpolation

- Bump mapping vs. geometry displacement

Step 4: Animation

- Rigging – creating a skeleton & fitting into a model

- Biped (humanlike limbs)
- Control points to associate a group of vertices on the skin surface

  (be aware that biped penetrates skin)

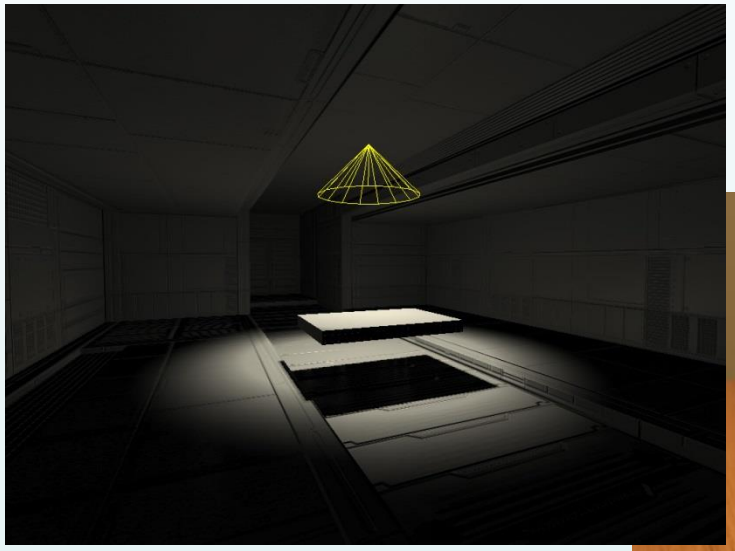
- Apply motion to control points
- Constraints to animate realistic movements
- Grouping related components & set up a hierarchy

Step 4: Animation (cont.)

- Key-frame setting
  - Animation Tools fills in the gaps using Interpolation (Parametric Curves and Splines)
- Morphing
- Motion capture

Demo4 by Ansun

Step 5: Special Effects, e.g. lighting, fire, water, …



Lighting create the mood

Lighting type examples:

- Spotlights – single point source
- Omni lights – best for an overall scene light
- Directional lights – ideal for outdoor scenes
- Area lights –

  cast from an area, rather than from a point
- Skylights
- Mental ray lights
- Global illumination
- Caustics

Step 6: Scene Rendering & Audio

Rendering takes time

Various Radiosity Algorithms try to make the scene as natural as possible by modeling how various sources of light bounce of surfaces

Did we Miss a Step?

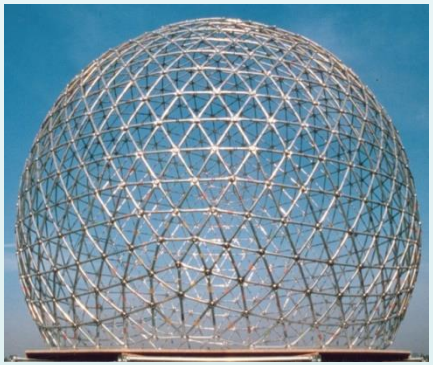
Something that often people remember after a movie (animated or not)

MUSIC!

https://frozen.disney.com/sing-along-songs

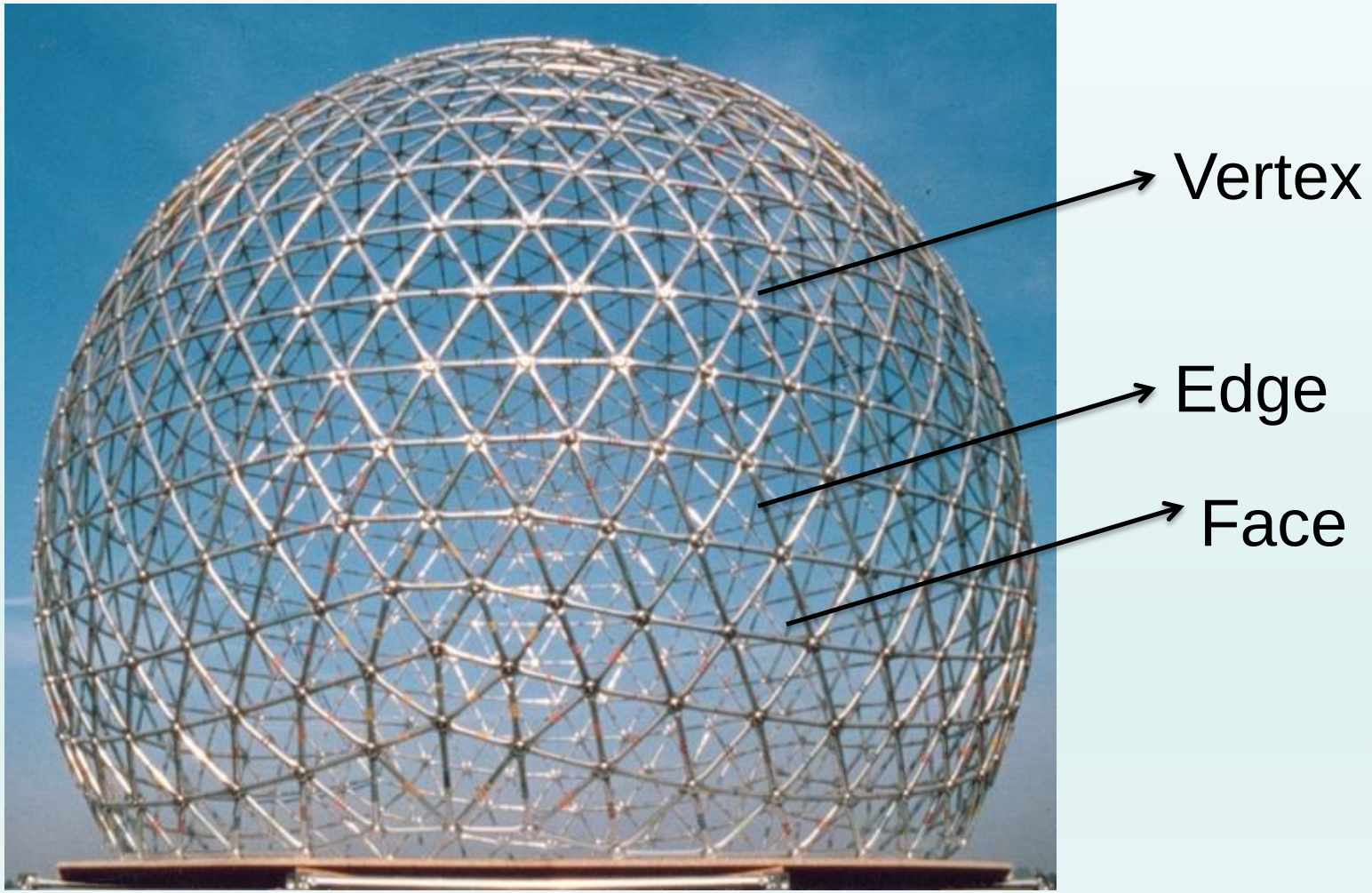
Components of a 3D Object

- Geometry:
  - Gives us the Structure of an Object
  - Represented by a Mesh (Vertices, Edges, Faces) or Point Clouds (collection of 3D points)



- Texture:
  - Images on Faces of a Mesh
  - Can be Colors on Vertices
  - For Point Clouds we can have Splats, which are oriented 2D patches (circles, ellipses etc. at each 3D point)

Components of a 3D Object



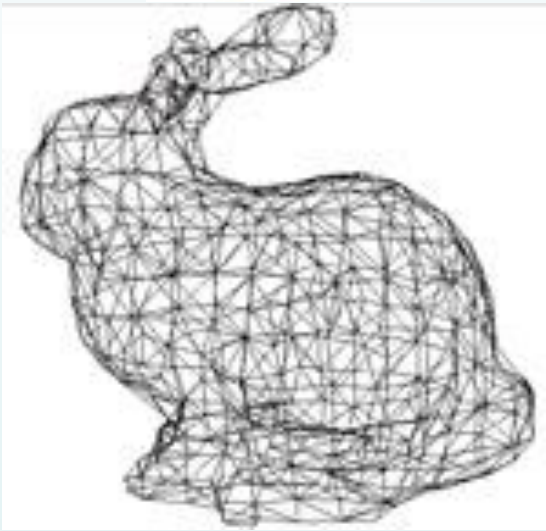
Animating 3D Objects

- We also need to define how each vertex Moves Over Time
- Motion on Objects (Humans, Animals, Plants & In-animate things) are usually represented through MoCap (Motion Capture) data

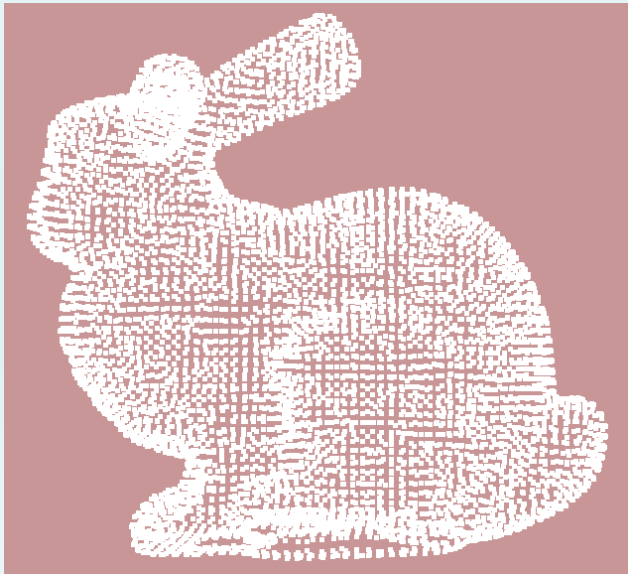
3D Object Construction

General terms in graphics:

- Mesh (Wireframe): composed of vertices (x,y,z) connected with edges; it denotes the geometry of a model



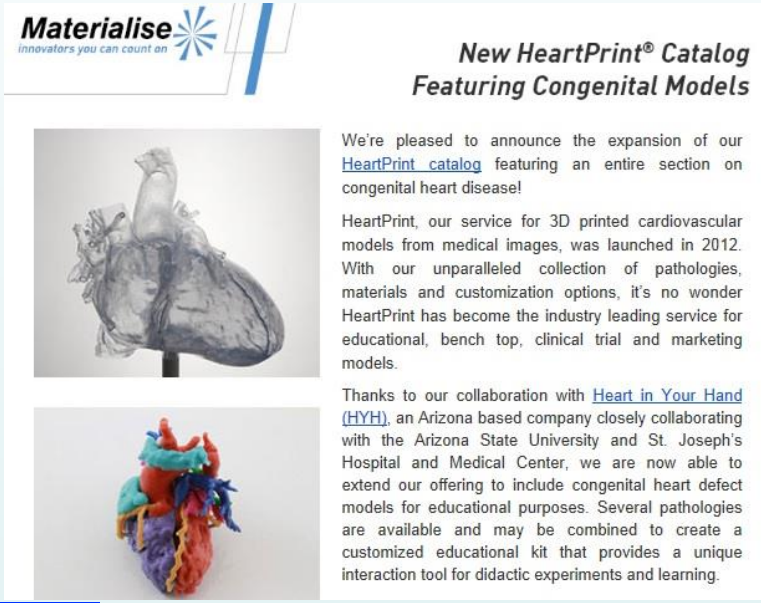
- Point cloud: composed of discrete vertices only; there is no edge (no connectivity)



3D Object Construction

General terms in graphics:

- 3D Volume, e.g. DICOM data in medical imaging: composed of voxels; it has a solid interior while a mesh and point cloud defines only the surface.



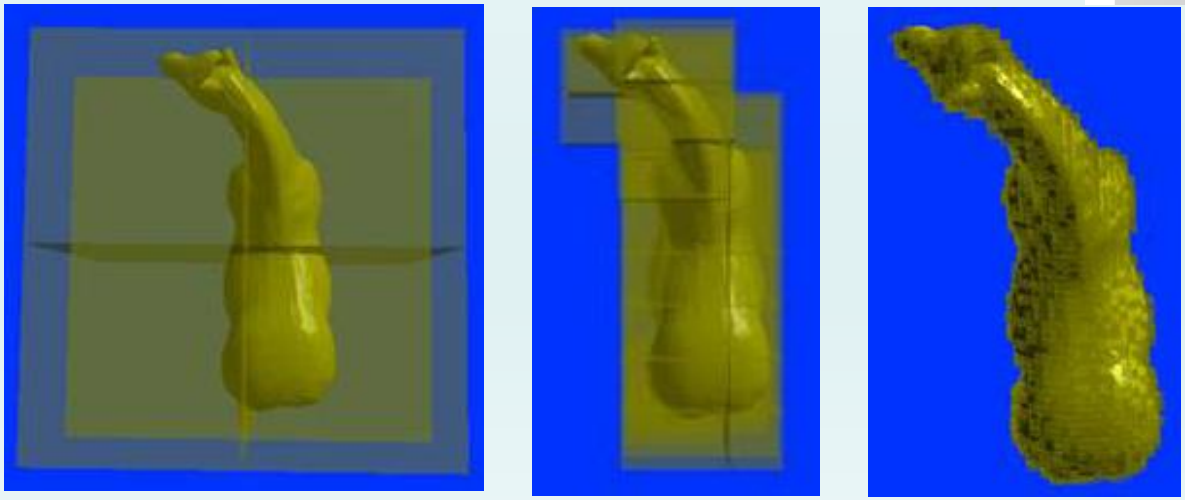
Materialise
innovators you can count on

New HeartPrint® Catalog Featuring Congenital Models

We're pleased to announce the expansion of our HeartPrint catalog featuring an entire section on congenital heart disease!

HeartPrint, our service for 3D printed cardiovascular models from medical images, was launched in 2012. With our unparalleled collection of pathologies, materials and customization options, it's no wonder HeartPrint has become the industry leading service for educational, bench top, clinical trial and marketing models.

Thanks to our collaboration with Heart in Your Hand (HYH), an Arizona based company closely collaborating with the Arizona State University and St. Joseph's Hospital and Medical Center, we are now able to extend our offering to include congenital heart defect models for educational purposes. Several pathologies are available and may be combined to create a customized educational kit that provides a unique interaction tool for didactic experiments and learning.



Approximate a 3D model using cubes (voxels)

Acquire 3D Data using scanner

http://graphics.stanford.edu/projects/mich/





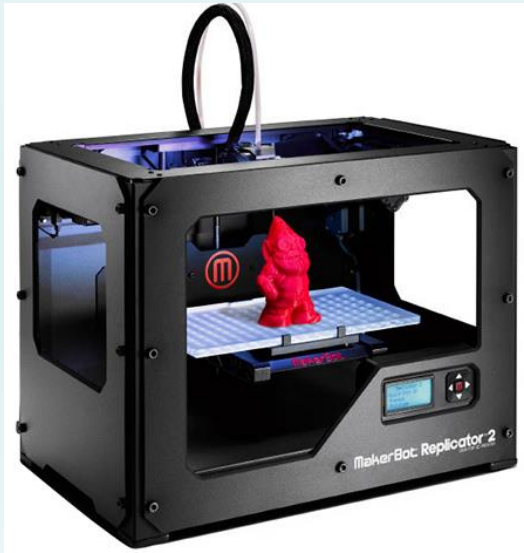


1992-3

David (23 ft)
- 1M poly
- 10 Mega Bytes

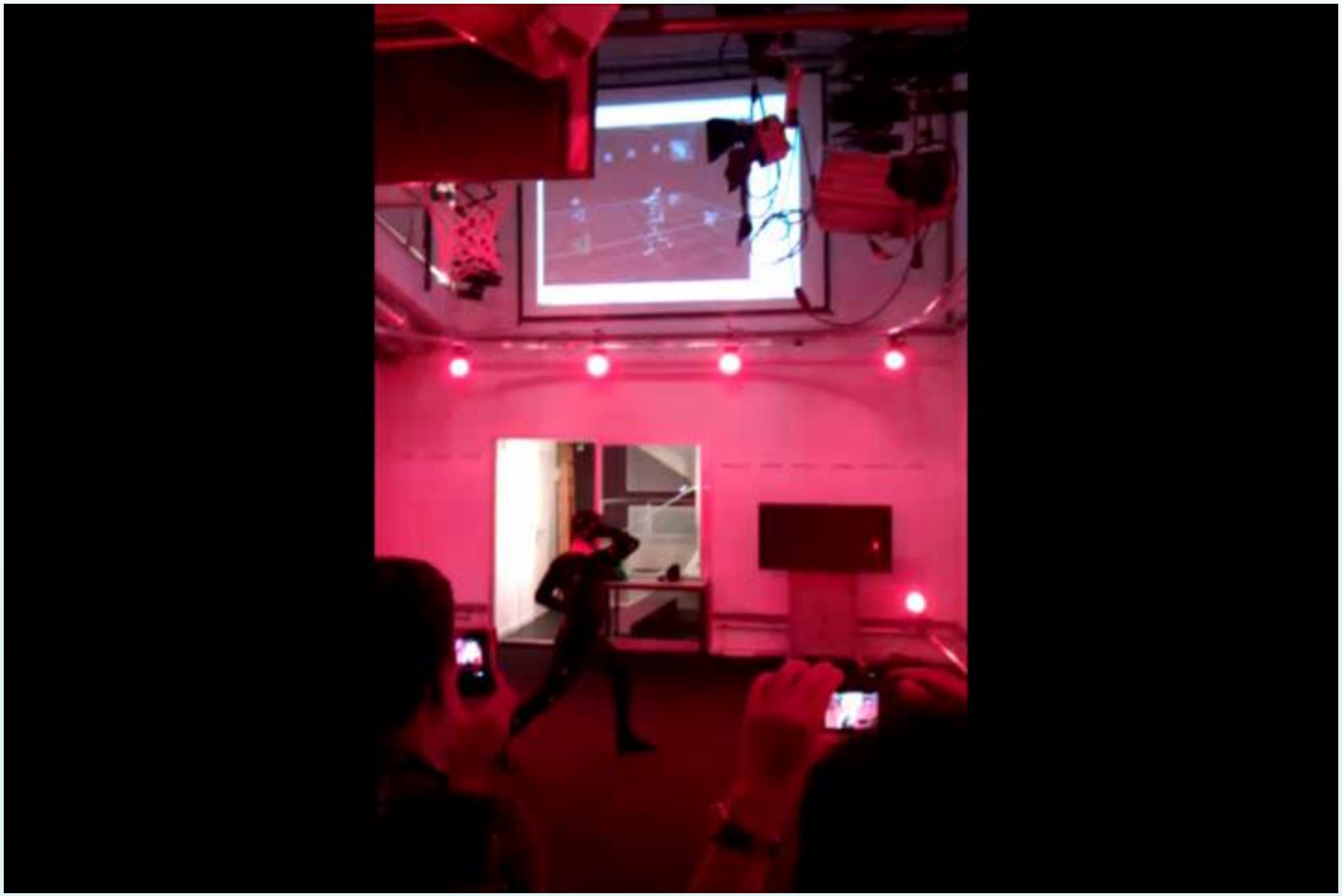
St. Matthew
- 372 M poly
- 3.7 Giga Bytes


3D scanner (continued)



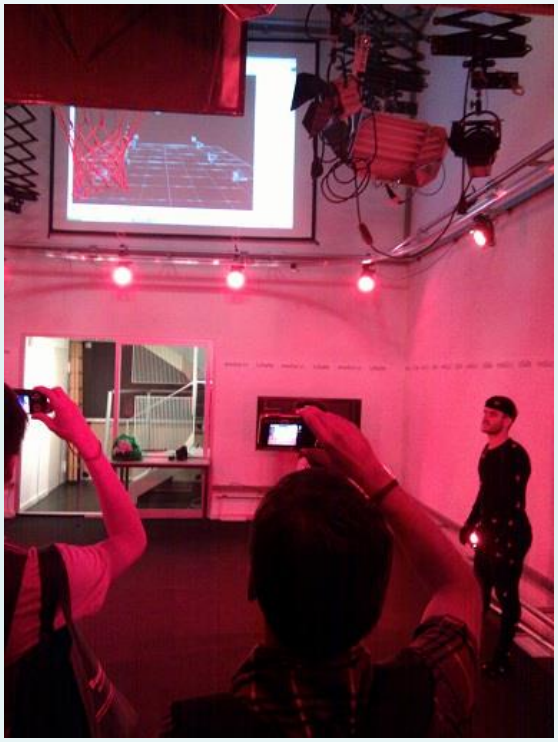
From static to dynamic:

Capture motion data using markers



From markers to multi-views

Traditional approach with markers is costly which may not be easily accessible by most.



LaSalle facility in Barcelona (2011) – one of the biggest in Europe

Special Effects with Multi-view Video

https://www.youtube.com/watch?v=rQmHFb4rd6U

3D data

What is the additional component in 3D data that is missing from 2D data?

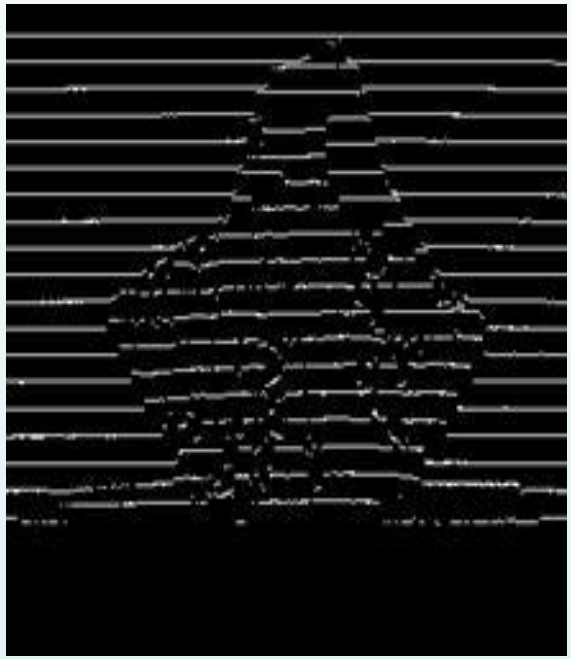
3D data

What is the additional component in 3D data that is missing from 2D data? Depth

(a temporal component is needed for dynamic data, i.e., a sequence of frames.)

How to obtain this 3rd component?

Laser scanned image example: use 3d points to construct faces



Compute **depth** (z) information based on scanner calibration parameters (e.g. focal length) and scanned images.

A mesh is generated by Triangulation based on sampling the scanned points (vertices).

Depth Map (e.g., from Infrared or time-of-flight)

A depth map is an image composed of pixels at various gray levels which represent different depths in 3D space.

Each depth sensor has a defined interaction space.

Depth map example: Kinect tracking

IR

ToF

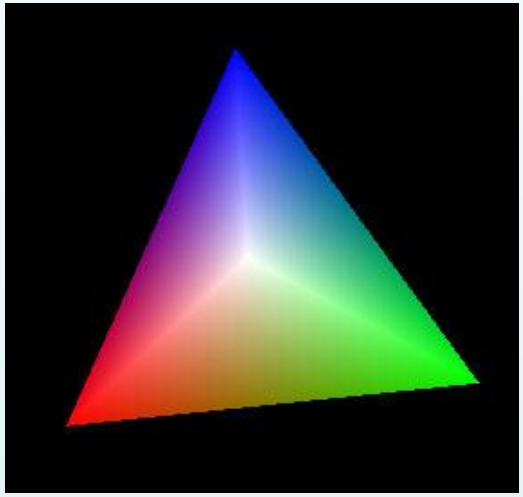
Why is there so much effort dedicated to 3D data acquisition?

Applications?

Why are there so much efforts dedicated on 3D data acquisition?

- Entertainment, e.g. Hollywood movies, games
- Art & Manufacturing Design (CAD)
- Medical Imaging & Rehabilitation
- Scientific Visualization, e.g. DNA sequence, Physics, molecules, ..
- Archaeological and Heritage Preservation,
  e.g. Machu Picchu, Bayan Temple
- Education, e.g. Second life (English Village)
- Self-driving cars (using LIDAR scanners)
- and others ..

Color Interpolation between vertices: Color Per Vertex



Compared with texture mapping

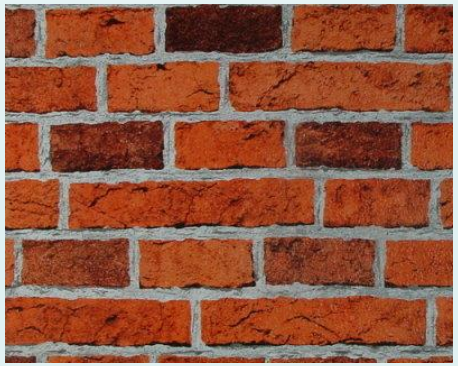
v -0.427599 0.557786 -0.000541 red green blue

- Each color is composed of 3 channels (red, green, blue), with value ϵ [0, 255]

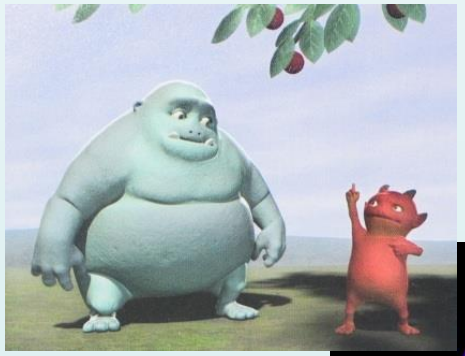
Surface Material

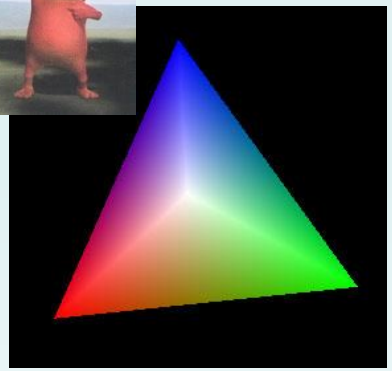
Need to use a large # of vertices if the color per vertex approach is adopted

- Realistic texture mapping
- Bump mapping
- Color interpolation (color per vertex)



Surface appears rough but no vertex displacement



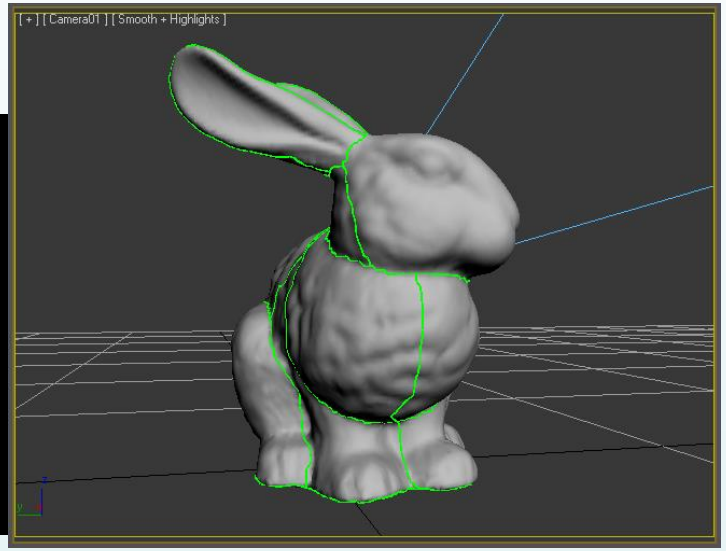


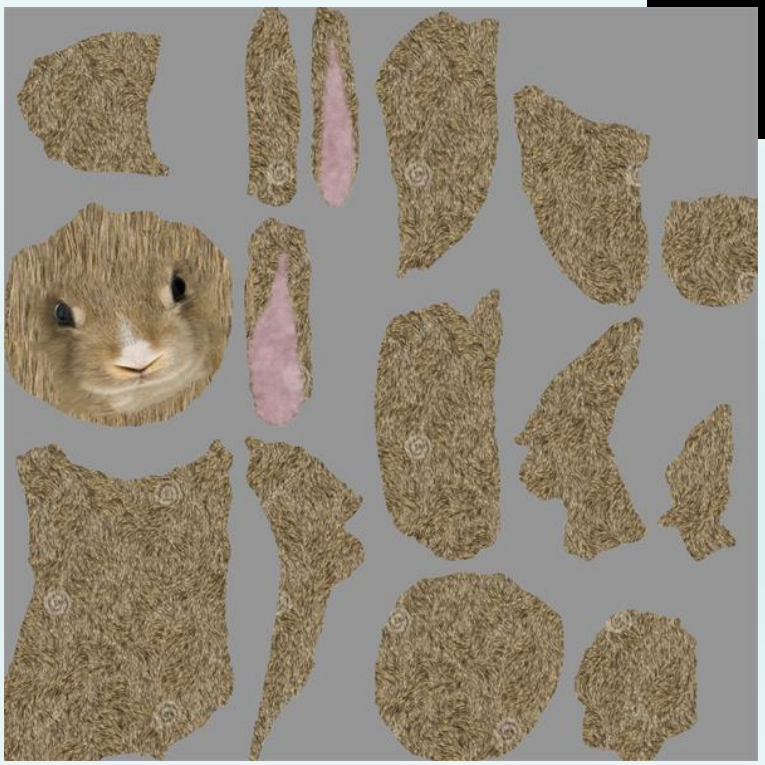
Bump Mapping

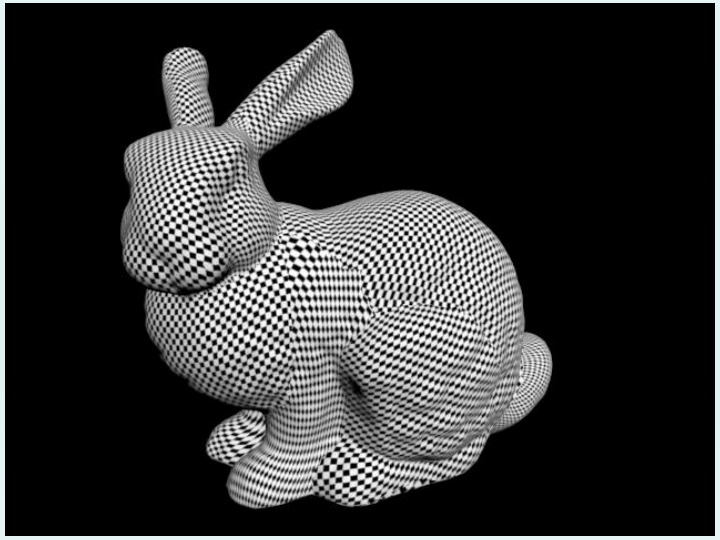
- *Bump mapping* uses intensities in the map to affect the perceived material on the surface.
- There is no geometric displacement.

Texture Mapping

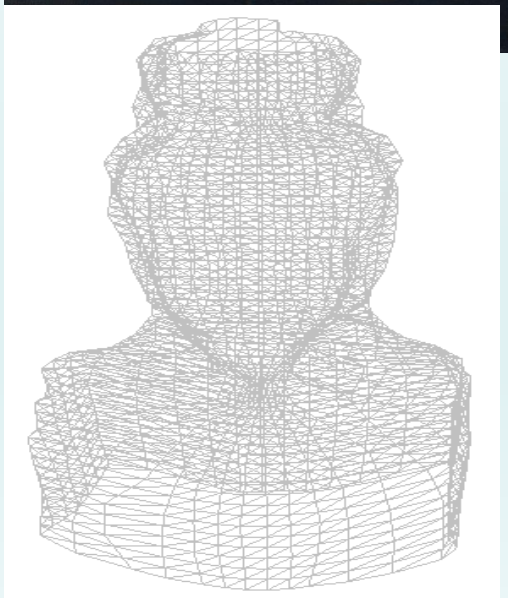
Separate patches

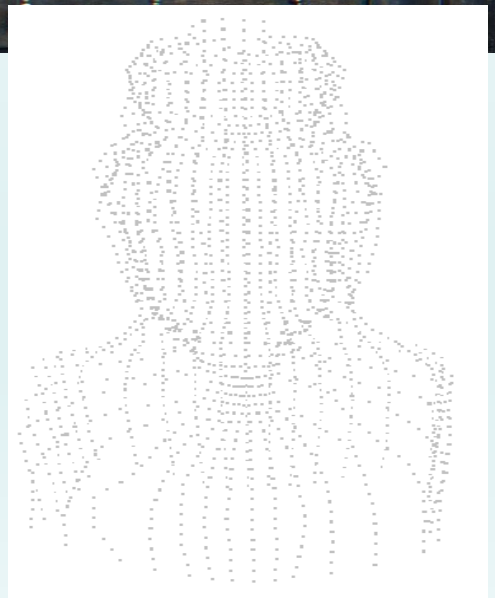






Texture Mapping (continuous patch)





Point Cloud vs. Textured mapped Mesh

More points does not mean better quality

233,216 points

10,000 points using Mesh + Texture Mapping (less vertices are needed if texture mapped)

512,000 point-cloud (redundant)

Are there Other ways of Creating Special Effects?

- Creating Special Sets
- Creating Special Automobiles
- Creating Fires, Floods in a controlled way
- …

Closing Thoughts

- Many components involved in Creating Impressive Models and Animations
- Many applications benefit from these areas
- Many Representations & Techniques can be adopted depending on Applications, Resources and Environment