Computer Graphics

COMP3421/9415
2021 Term 3 Lecture 10

What did we learn last lecture?

A Deep Dive into Design and Art

- Some thoughts of Graphics and Art in general
- How Games are designed (and where graphics fits in)
- A look into the Art pipeline for digital assets

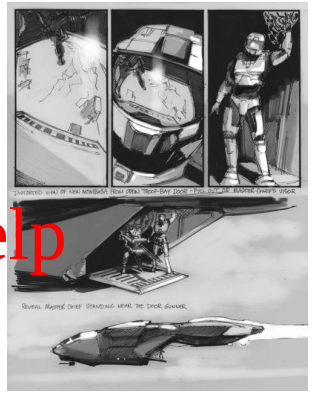
What are we covering today?

More detail on the Art Pipeline

- Continuing our overview of the Art Pipeline
- Going into a little more detail on:
- Modelling
- Rigging
- Animation

Developing a Character

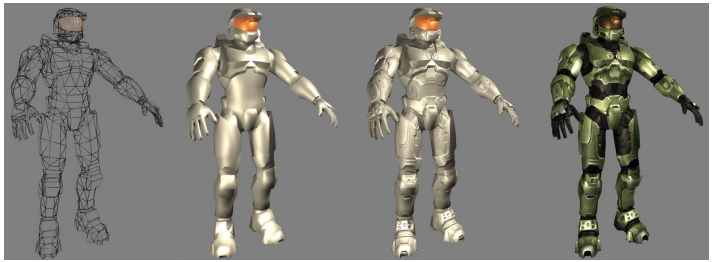
Computer Games Art Pipeline

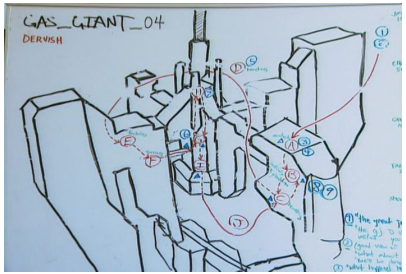


It's a long process from idea to polygons

- Concept
- Design
- Pre-Production (Technical Graphics appears here)
- Post-Production (iteration may involve redoing earlier steps)

Today, we're looking at Concept and Design





Various Production Images from Halo and Halo 2 (Bungie Studios and Microsoft 1999-2002)

Concept

We should have an idea of this now

- Have we given them a name? Should they have one?
- Is there any visual information yet? (probably not)
- Start doing research
- Visual References (start a pinterest board?)

Concept Art

Visual representations of ideas

- An early step in the design of a character (or location or vehicle etc)
- A lot of work will come from references here
- Very much the domain of the traditional sketcher/painter

Sculpting

Most likely digital sculpting

- Initial ideas going from concept art to 3D model
- Options for sculpting in clay and the 3D scanning
- More often sculpted and modelled digitally
  - This work will be done in a 3D modelling and/or 3D sculpting program
- Unlikely to be game ready at this point
  - Too many polygons to run efficiently
  - Only vertices, no other important information

Programmers working with artists

In the meantime, us, the programmers are also working

- We'll establish a scale for the game world
- And most likely set up our source control (not always git when working alongside artists)

- Artists will provide us with a sample object (like a cube)

- We'll set up correct transforms for this and start building up graphics engine capabilities

Optimisation and Texturing

Getting a model ready for use

- If a model has been sculpted, it might have a lot of extra polygons
- It will either be remodelled or optimised to remove vertices
- Then it must be UV mapped

- This is the process of adding texture coordinates to the vertices
  - Texture coords are usually called (u,v)

- Then once mapped, actually "painting" the textures
  - Creating the 2D images, usually in a digital painting program
  - This also means adding other maps which we haven't learnt about yet in this course
  - Artists might refer to these as "materials"

Polygon Reduction Optimisation

Image credit: Wikipedia

Rigging and Animation

Skin and Bones

- Animation in games is usually done via an internal bone system
- Artists will create a skeleton
- And "rig" the mesh to the skeleton
- With a rigged skeleton, animations can be created
- Animations are dependent on game needs, so they might not all be planned in advance

What ends up in the game?

As programmers we receive:

- A 3d model (vertex and index buffers)
- with textures and other maps (materials)
- and a set of animations

We will then:

- Make sure these are imported and handled in our engine correctly
- Transform the model into its correct place in the world
- Write code to activate its animations at the right time

How many artists was that?

There are many specialisations in this pipeline

- Concept Artists
- Sculptors
- 3D Modellers
- Texture Artists
- Riggers
- Animators
- Depending on the project, these might all be different people!

Modelling

Creating 3D Models

A big collection of vertices

- Models are essentially a bunch of verts
- (also textures and other maps/materials)
- Picking numbers for vert coordinates could be a very painstaking task
- So certain techniques are used to create multiple verts
  - Box modelling
  - Digital Sculpting
  - 3D Scanning and Photogrammetry

Image credit: Stanford University

Box Modelling

Start with a box, add verts

- Start with some kind of primitive object (cube/cylinder are common)
- Add vertices in between
  - Usually take a quad and turn it into 4 quads
- Move vertices around to create rough shapes
- The more verts you add, the more detail you create
- Common technique used in Maya, 3DS Max, Blender etc

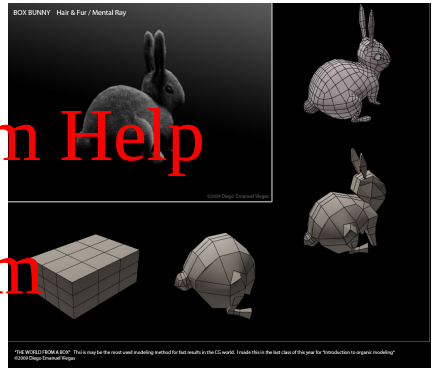


Image credit: Diego Emanuel Viegas

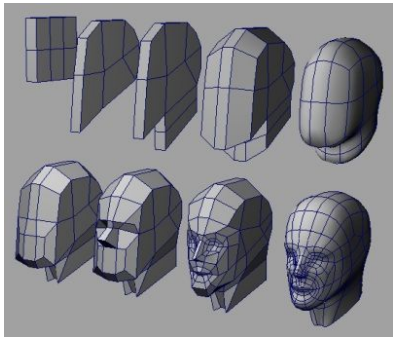


Image credit: Don College

Digital Sculpting

Treating a 3D model like a solid substance

- Initially an attempt to give traditional sculptors a way to create digital models
- Adding and subtracting "chunks" of the model and smoothing with tools replicating real materials
- The concept of polygons and vertices does not drive the process
  - but it will be a part of it eventually
- Used in Zbrush, Blender and others

Image credit: blenderartists.org user: 0rAngE

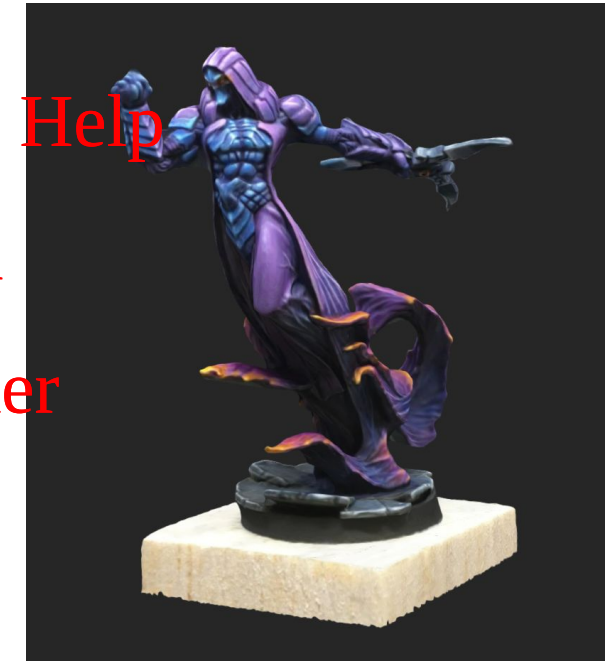
3D Scanning and Photogrammetry

Using technology to acquire surface information

- Laser scanners for detailed surface topography
- Cheaper and reasonably accurate results from photogrammetry

- Builds up 3D model automatically using relative viewpoints

- Usually very high complexity, would need significant reduction in polygons for use
- Marc's example: https://p3d.in/Ekkiv



Painting and Photogrammetry by Marc Chee

Break Time

The joys of creation

- Highly recommended to partake in art
- No limitations on what kind of art you want to do
- Something that takes you away from your "day job"
- Can be very valuable for stress relief and fulfilment
- Marc paints little toys in his spare time

Animation

What is animation?

A series of still images, an illusion of motion

- Oldest use of this is in zoetropes (1300s or possibly 1st Century BC)

- The advent of film cameras and projectors brought the film industry to life (around 1895)

- We already understand the idea of frames and us drawing each frame as a separate still image
- But how do we decide how much our geometry should change between frames?

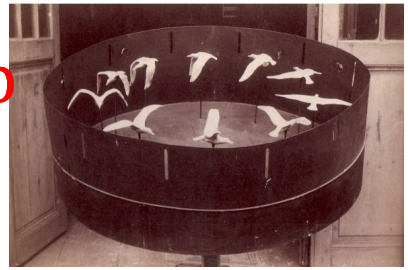


Image credit: William George Horner 1887

Image credit: Eadweard Muybridge 1887

Frame by Frame Animation

Doing it by hand

- The simplest way to understand
- Vertices are in a particular position in one frame
- They are in a new position in the next frame
- Hand drawn cel animation works in this way

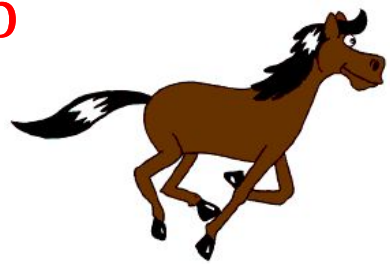


Image credit: Jan-Eric Nyström, Helsinki, Finland

Doing this in Graphics?

- While possible, it's incredibly time consuming, considering the number of vertices
- There must be a way of bulk editing multiple verts

Vertices aren't alone!

Animation by objects

- We could animate by changing transforms!
- Each object can have its transform "lerped" maybe along a curve
- We could animate by changing some transforms within a scene graph
- This way, we could have different objects move relative to each other
- You may remember this from Tutorial 4 . . .

Animation by objects

What are the downsides to this approach?

- Forced separation of objects based on movement
- An artist will have to separately model fingers, lower arms, upper arms, shoulders etc.

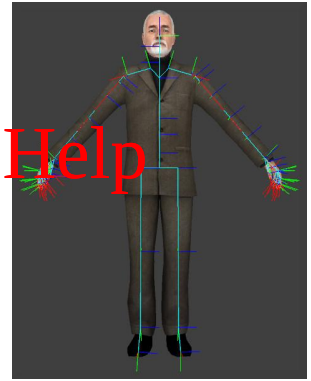
- Models will start to look like deconstructed action figures

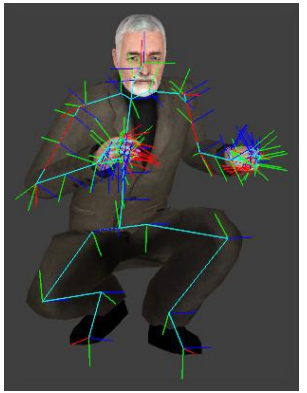
- Highly complex scene graphs and tiny separate pieces
- Computers can handle this, but can we?
- Also, how good is this method for say, an organic creature or cloth?

Skeletal Animation

An In-between solution

- What if we have ways of affecting sections of an object, but not the whole thing?
- Treat the mesh as the "skin" and build a skeleton inside the model
- The skeleton is a series of abstract positions that are linked together with a scene graph-like hierarchy of transforms





Images credit: Valve Developer Community

Details of Skeletal Animation

How do bones affect the mesh?

- Each vertex in the mesh is affected by some bone(s)
- We do this via a weighted list of bones in each vertex
- A simple rigid object might have a single bone and all verts are affected 100% by that bone
- A flexible are like the skin around an elbow will have partial weight from the lower arm and partial weight from the upper arm
- When a bone moves, it will alter the mesh
- The higher the weight, the more the mesh will follow the bone movement

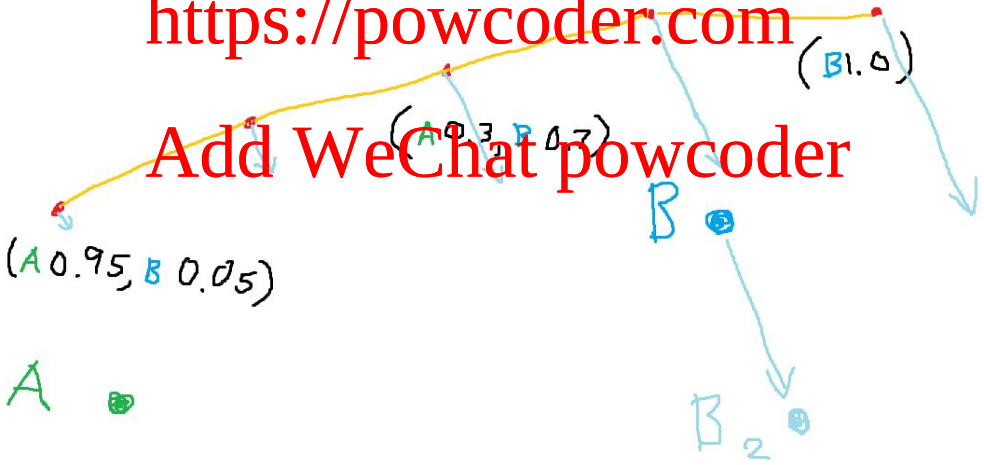
Rigging

Rigging involves building a logical skeleton

- For something like a human, this is going to look reasonably familiar
- But for more abstract models, it's harder to predict
- Skeletons and bones don't have to be inside the mesh, they just control its movement and are hierarchically organised
- Each bone is intended to control some movement
- Vertices that are near that point of movement will be mapped to that bone
- Vertices further away will have less connection to the bone, or won't be connected at all

Rigging

Different weights will allow bones to have more influence over different parts of a mesh



Animation

Animate the Skeleton

- If we use the object based animation we talked about earlier
- But this time with the transforms in a rigged skeleton
- Our model will follow that skeleton

- It will also morph and stretch where there are partial weights
- It also means an animator is moving say 20-30 bones, not 500+ vertices

Keyframe Animation

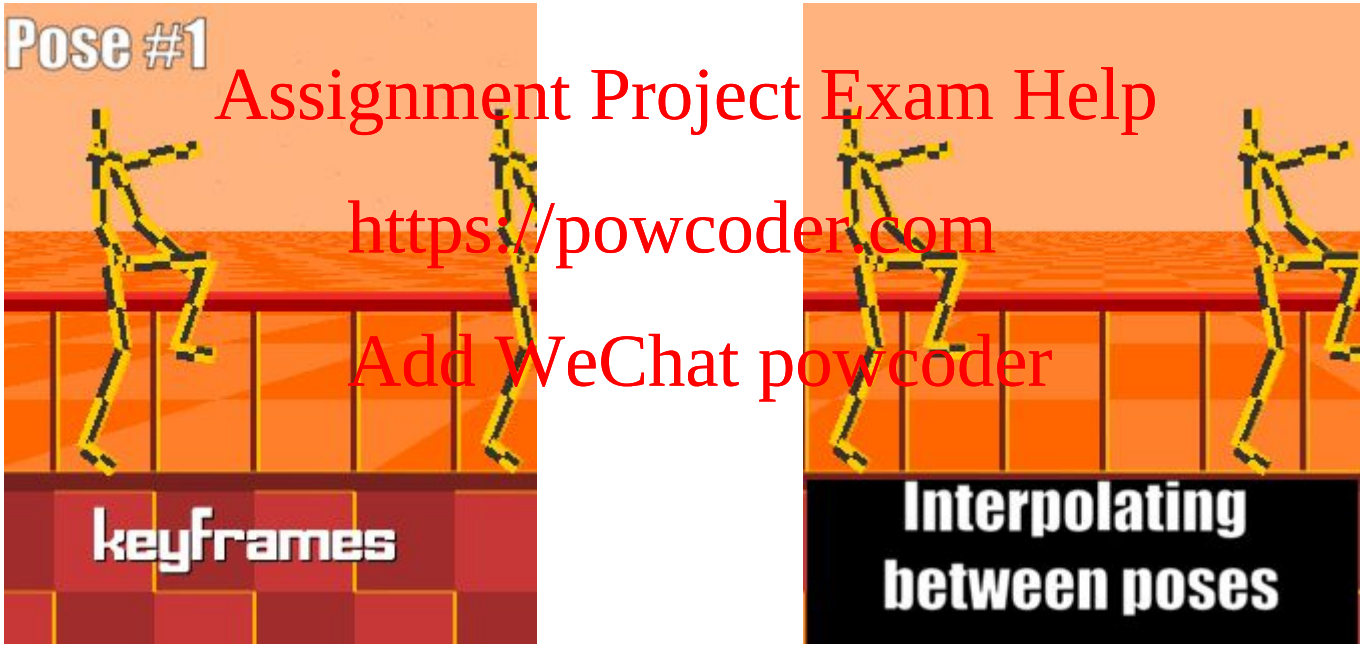
Do animators specify positions for every frame?

- We've reduced the number of vertices, but not frames!
- Skeletons usually only have translation and rotation relative to other bones

- Often animators will only set joint positions made up of rotation angles

- These poses can be used as "keyframes" and can be as little as one every 30-40 actual screen frames
- The frames in between can be determined by lerping the joint orientations

Keyframing Images



Images credit: Learnopengl.com

In OpenGL

Animating in OpenGL

- Import a model with animations, bone and weights
- Transform verts to their correct positions relative to bones
- Animations will have keyframe information
- As well as timings: How long in real time in between each keyframe
- To play an animation, we interpolate bone positions between keyframes depending on how long the animation has been running
- We transform vertices relative to wherever their bones currently are (and what weighting they have to the bones)

What did we learn today?

The Art Pipeline

- Overview of the entire art pipeline for something like a character
- Detail on 3D Modelling
- Detail on Animation and Rigging