



COMP220: Graphics & Simulation

1: Introduction to Graphics and Simulation

Learning outcomes

By the end of this week, you will be able to:

- ▶ **Understand** the context of computer graphics and simulation in games.
- ▶ **Recall** some of the main areas of interest in graphics and simulation.

Computer graphics

What is computer graphics?

- ▶ The process of representing 3D virtual objects on a screen.
- ▶ "The creation of, manipulation of, analysis of, and interaction with pictorial representations of objects and data using computers." – *Dictionary of Computing*
- ▶ Trying to make it look as convincing and/or interesting as possible:
 - ▶ Shape representation - **modelling**
 - ▶ How light interacts with the surface - **shading**
 - ▶ (Photo)realistic vs. stylised, e.g. cel shading
 - ▶ How light travels around the scene - **rendering**

Modelling



Image courtesy of Framestore

- ▶ Defines the outline/shape of an object, usually by identifying points or **vertices** on its surface
- ▶ Vertices can be generated by an artist using a 3D modelling package, or may be generated procedurally
- ▶ More vertices => more accurate shape => more data and longer processing times
- ▶ Algorithms can be used to reduce model complexity without compromising appearance

Shading and rendering

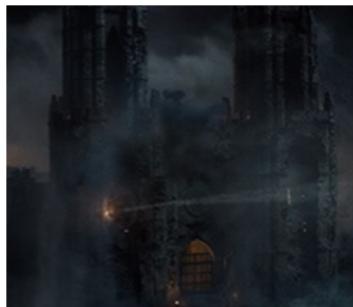


Image courtesy of Framestore

- ▶ Models are given **textures** and other surface properties as **materials**
- ▶ Use equations from physics to define how light behaves and interacts with materials
- ▶ A variety of simplifications exist that approximate (some of) the full equation, e.g. Phong shading

Simulation

What is simulation?

- ▶ Replicating (physical) behaviour using equations (e.g. Newton's Laws of Motion).
- ▶ Different kinds of objects behave differently:
 - ▶ Motion through space resulting from external forces - **particle simulation**
 - ▶ Changes in orientation resulting from external forces - **rigid body dynamics**
 - ▶ Changes in shape resulting from external *and internal* forces - **soft-body deformation**
 - ▶ Some types of object have specific techniques, e.g. **hair**, **cloth** and **fluid**
 - ▶ Automating aspects of manual animation processes - e.g. **inverse kinematics (IK)**

Particle simulation



Image courtesy of Framestore

- ▶ Used to predict the behaviour of dimensionless **point mass** objects
- ▶ Computed one frame at a time, to account for **collisions**
- ▶ Can be used for fluid-like effects such as smoke

Rigid body dynamics



Image courtesy of Framestore

- ▶ Used to predict the behaviour of **non-deformable** objects
- ▶ Global motion is computed as for particles...
- ▶ ... combined with local motion (rotation) about the object's centre of mass
- ▶ Commonly used for destruction sequences

Soft body dynamics

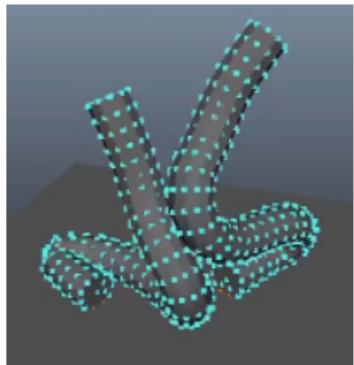
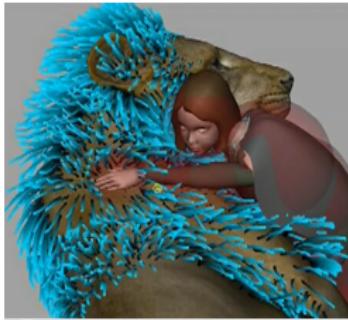


Image courtesy of Framestore

- ▶ Used to predict the behaviour of **deformable** objects
- ▶ Requires knowledge of the interior of an object (e.g. FEM): computationally very expensive
- ▶ Often approximated using **constrained rigid bodies** and other techniques

Other types of dynamic simulation



Images courtesy of Framestore

- ▶ Objects such as **hair**, **cloth** and **liquids** behave slightly differently
- ▶ These have their own equations and techniques...
- ▶ Beyond the scope of this module!

Rigging and animation

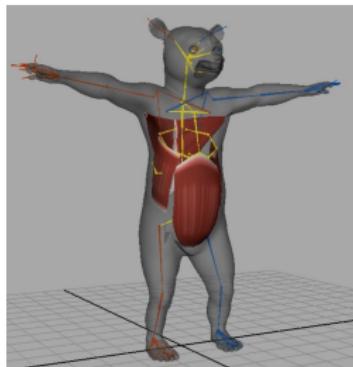


Image courtesy of Framestore

- ▶ Key characters (and objects) are hand-animated by artists using a **skeleton rig**
- ▶ Positioning each joint would be a laborious process...
- ▶ Techniques such as Inverse Kinematics (IK) have been developed to automate certain aspects.

Context and applications

Why are graphics and simulation important?

- ▶ More than 50% of the cortex, the surface of the brain, is devoted to processing visual information (David R. Williams, William G. Allyn Professor of Medical Optics at the University of Rochester; reference [here](#)).
- ▶ Most computer output appears on the screen.
- ▶ Enables intuitive observation of data, representing:
 - ▶ locations, orientations and dimensions of objects in space
 - ▶ statistical or experimental results

Applications

- ▶ Entertainment: games, virtual reality, films/TV
- ▶ Architecture and CAD
- ▶ Engineering
- ▶ Science and medicine

Challenges

- ▶ Accuracy vs. speed: complex calculations take time...
- ▶ Solution: use approximations, considering:
 - ▶ Which objects do we really need to see?
 - ▶ How much detail do we need to see them in?
 - ▶ What can be sacrificed without compromising the end result (too much)?
- ▶ Optimisations are possible at each stage of the graphics pipeline
- ▶ Different applications require different balances of trade-offs; in games, speed is paramount (but detail is desirable!)

Next steps

Now you have a general idea of what graphics and simulation is about, and the factors to bear in mind whilst implementing the techniques,

- ▶ **Review** content from COMP270 on the graphics pipeline.
- ▶ **Research** the main topics within graphics and simulation to decide which areas you'd like to focus on for your artefact.