COMP220: Graphics & Simulation

7: Rigging and animation

Learning outcomes

- **Explain** the role of rigging in 3D animation
- **Describe** how a rigged model is transformed to produce animation
- **Use** skeletal animation in your own programs

Scene graphs

Coordinate spaces

Model space

↓ Model matrix

World space

↓ View matrix

Camera space

↓ Projection matrix

Screen space

Rule of thumb

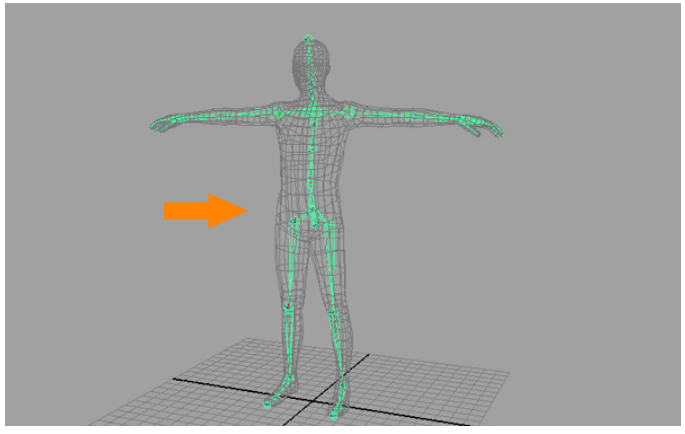
- When performing calculations, **do not mix** vectors from **different coordinate spaces**
- E.g. when performing lighting calculations, ensure your fragment position, normal, light direction, eye direction are all in the **same** space

Scene graph

- It is often useful to organise objects into a **hierarchy**
- Each node in the hierarchy has its own model matrix
- Transformations stack: object is affected by its own transformation, and that of its parent, and that of its grandparent, and so on
- The model matrix is the **product** of model matrices for the node and its ancestors

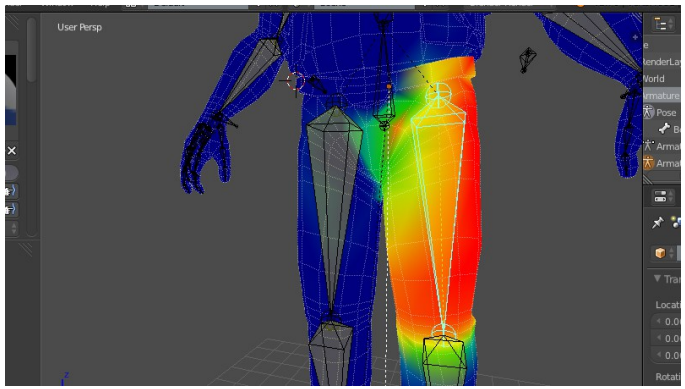
Skeletal animation

Rigging



- A **skeleton** is composed of **bones**
- Arranged in a **hierarchy**
- Each bone is essentially just a **transformation**
  - Usually just rotation around a pivot point
  - 3D modelling software often represents bones as lines from parent bone to child bone

Bone weights



- Each vertex in the model has a list of **bone weights**
- Usually “painted” onto the model by the 3D artist
- Weights specify how much each vertex is affected by each bone’s transformation

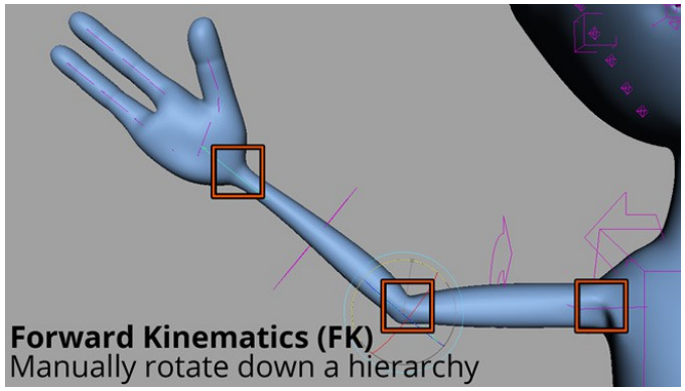
Skinning

- The character is animated by changing the bone transformations
- **Skinning** is the process of applying these transformations to the vertices of the model according to the bone weights
- Generally handled by a **vertex shader**

Keyframe animation

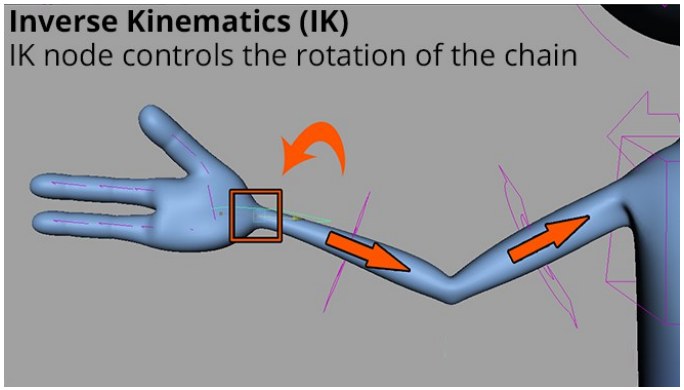
- Most basic form of skeletal animation: specify bone transformations for each frame of animation
- ... or just for **keyframes** and interpolate between them
- Keyframes set up by an animator, through motion capture, or a combination of the two
- More advanced: can **blend** animations
  - E.g. blend between walking and running
  - E.g. bottom half plays "walk" animation, top half plays "fire weapon" animation

Forward kinematics (FK)



- Bone transformations are set **explicitly**
- Children are affected by parent transformations, e.g. if upper arm rotates, lower arm rotates with it

Inverse kinematics (IK)



- Bone transformations are calculated to reach a **target**
- E.g. we want character's hand to touch an object; IK calculates rotations of upper and lower arm to achieve this subject to constraints

The most common use for IK

Ragdolls

- Attach a **rigid body** to each bone and run a **physics simulation**
- Often used for death animations

Procedural animation

- Many games mix some or all of keyframe animation, IK, and physics simulation
- `https://www.youtube.com/watch?v=JEzxDbIK2Yk`
- `https://www.youtube.com/watch?v=UQdkkmP7amI`

Advanced animation

Animating with Math

http://www.gdcvault.com.ezproxy.falmouth.ac.uk/play/1023249/Animating-With