Introduction to Animation

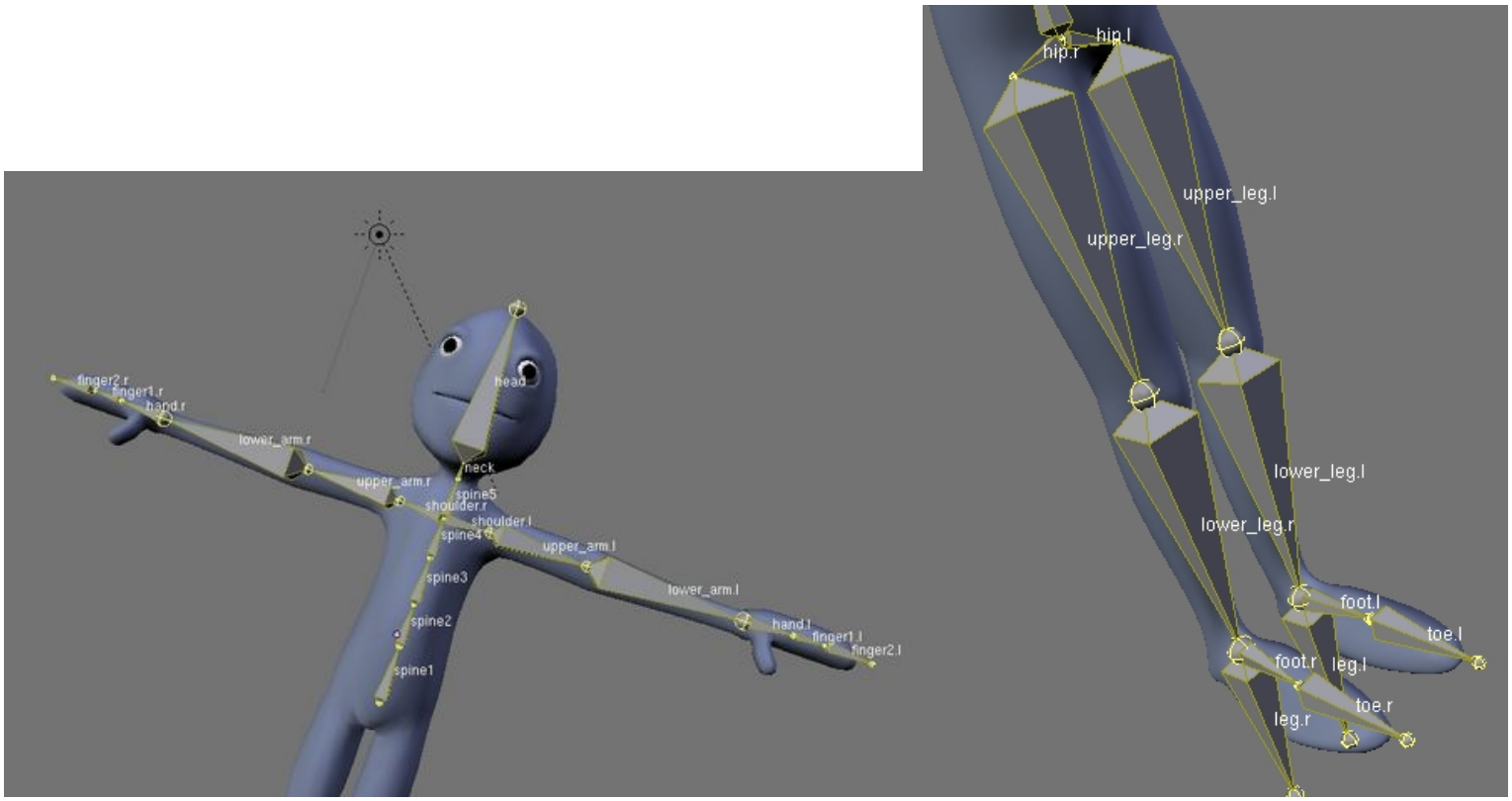
Animating Three Dimensional Models

- Once a 3D model has been built it must be animated.
- There are two problems with animating an mesh object:
  - Moving each vertex in a model to create an individual pose would be time consuming and tedious.
  - Creating multiple poses required to create an animation would also be difficult to achieve.

Skeletal Structures

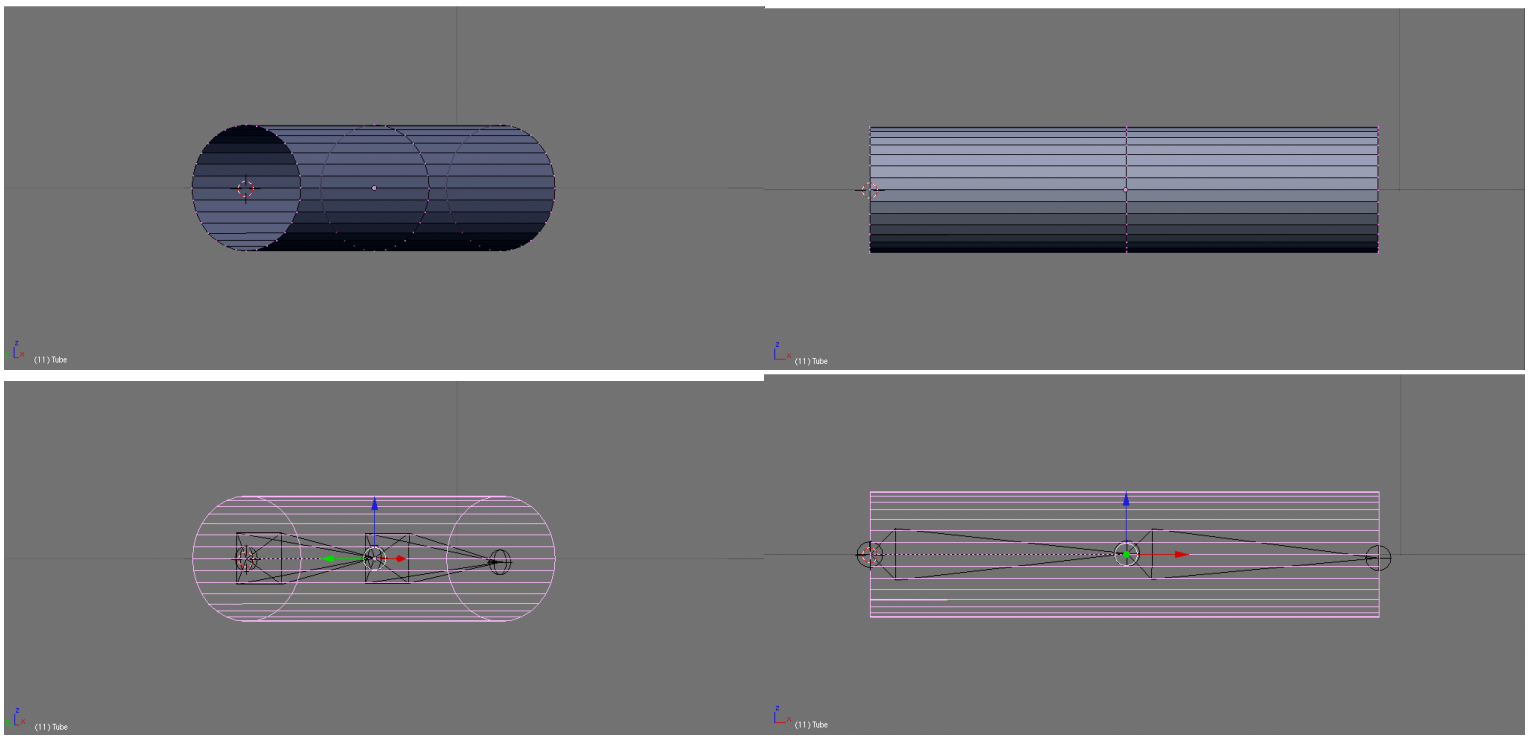
- The solution to moving individual vertices to create a pose is to group the vertices. They can then be moved as a single entity.
- Groupings are often organized so that rigid parts appear in a single entity (like real bones).
- These groups are called **bones** (or armatures). Each bone has a set of vertices associated with it. When the bone is moved it pulls the vertices along with it. This causes the mesh's shape to change to match the bone's motion.
- The points where bones join to each other are where the model should bend. This is often around joints such as elbows and knees.
- A collection of bones in a mesh is called a **rig** or a **skeleton**. Building the skeleton is called rigging.
- Attaching the mesh to the bones is known as **skinning**.

Sample Character Rig



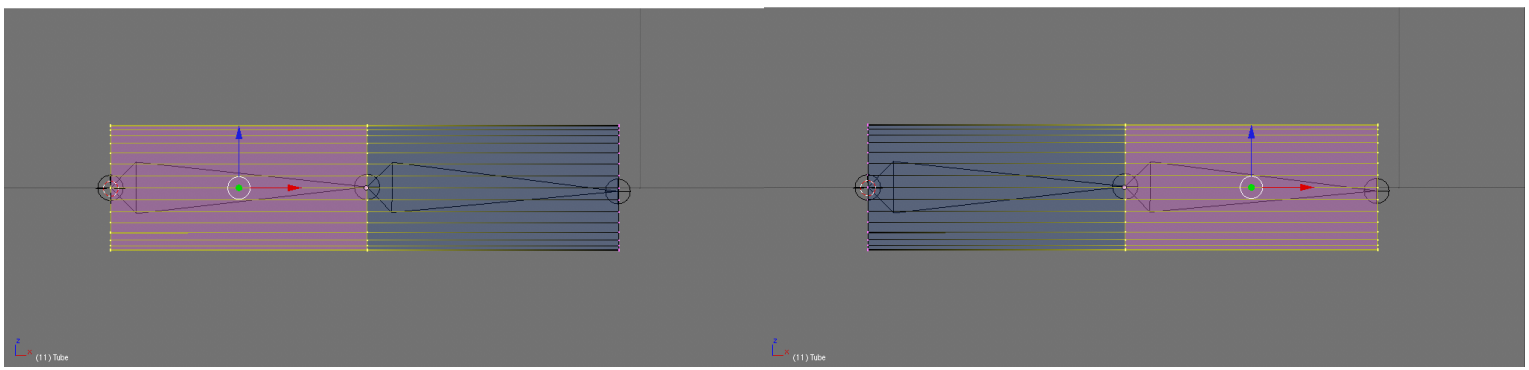
Simple Bones Example

- Adding a pair of bones to a tube.



Influence of Bones

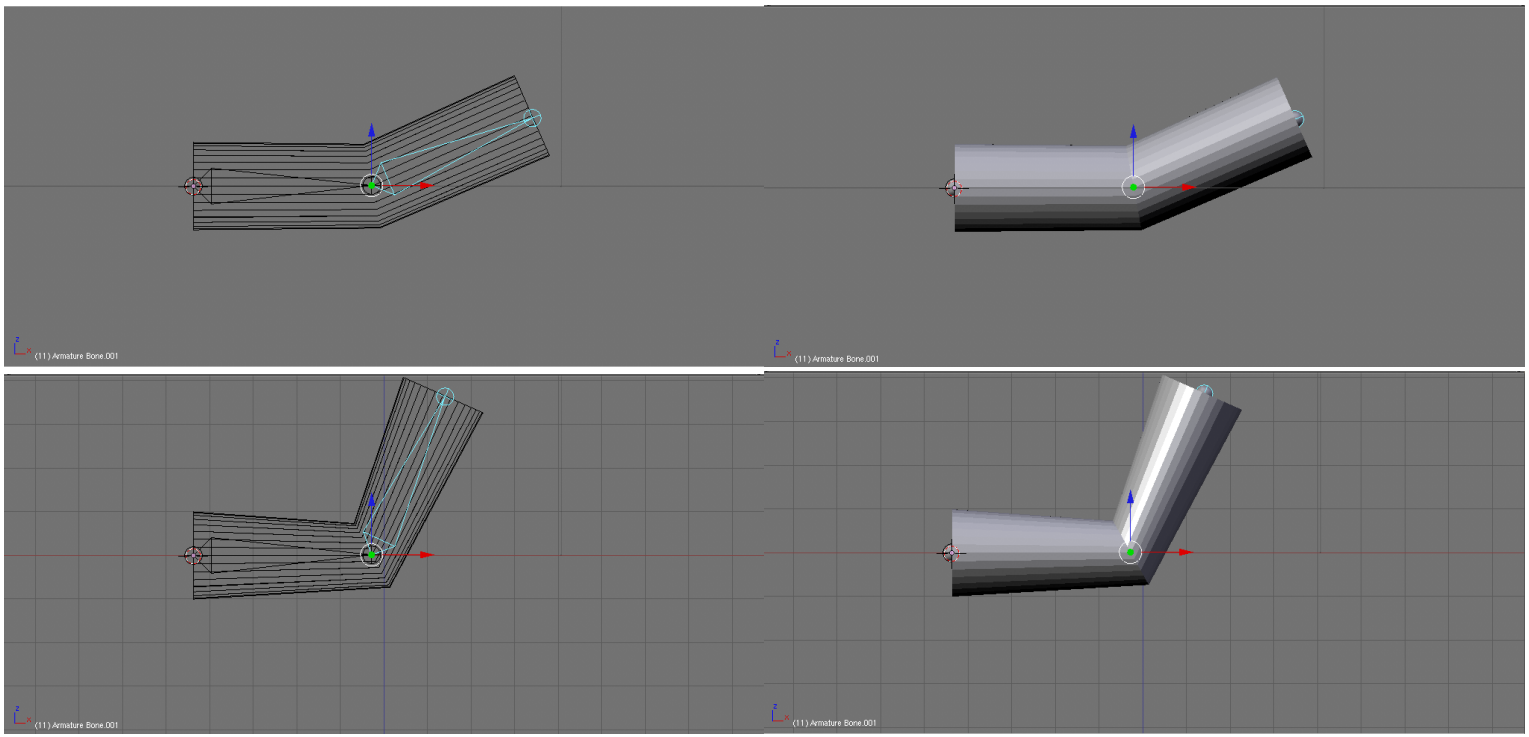
- The tube is made in two halves, with one bone influencing each part.
- The vertices which are associated with each bone move when the bone is moved.



Vertices and associated edges which are influenced by bones are highlighted in yellow.

Adjusting the Rig

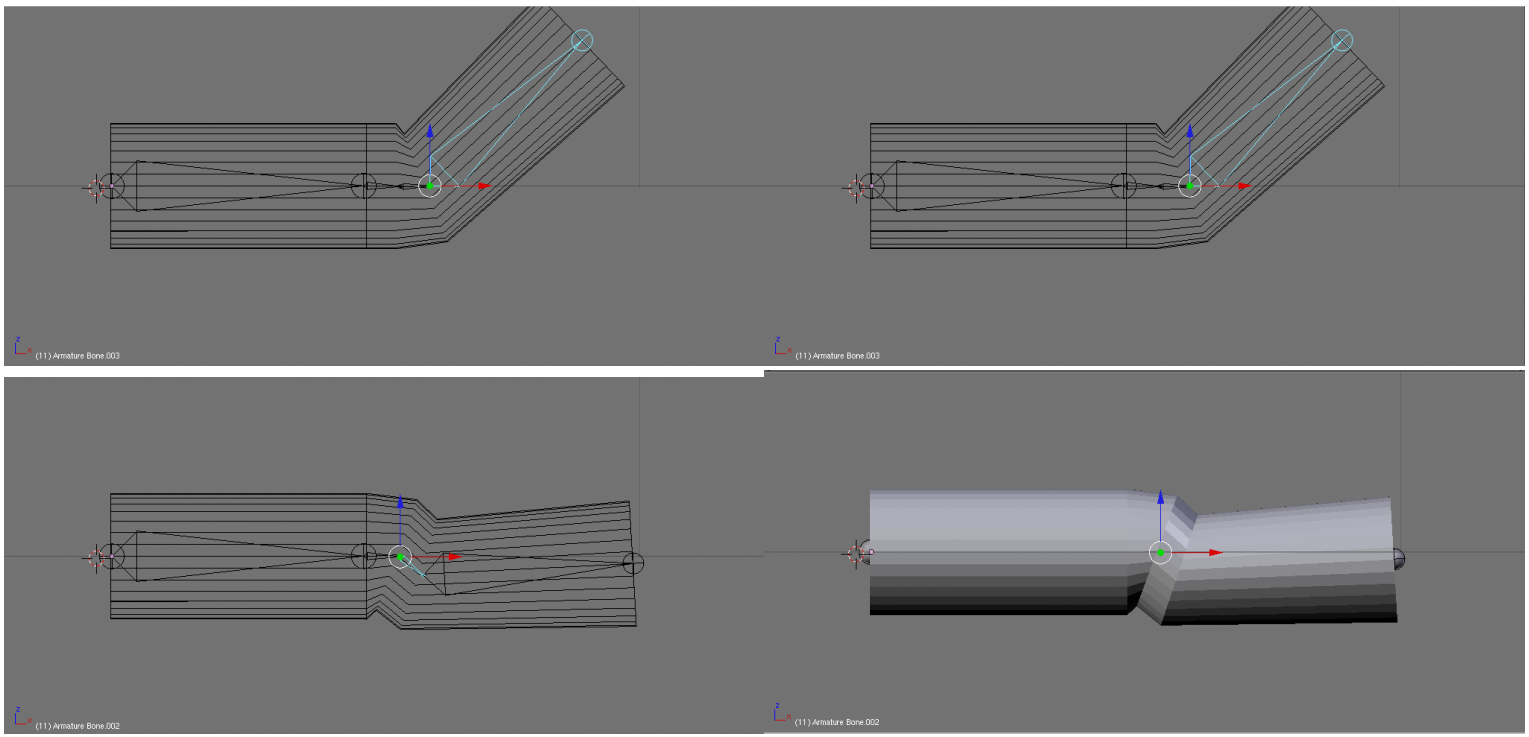
- Once the vertices are attached to a bone, the bone can be moved and it will pull the vertices along with it.



Two different orientations of the bones. Unshaded and shaded images. Notice some distortion around the seam in the lower model.

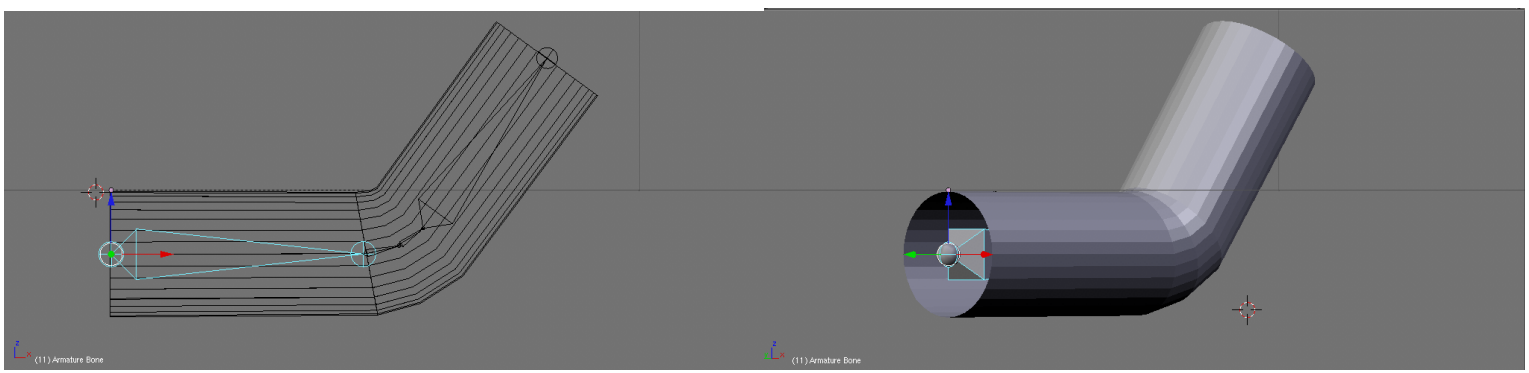
A More Complex Tube

- This model is made in four sections and contains four bones.
- **Pinching** due to the model being distorted around the seams is more prevalent.



A More Complex Tube

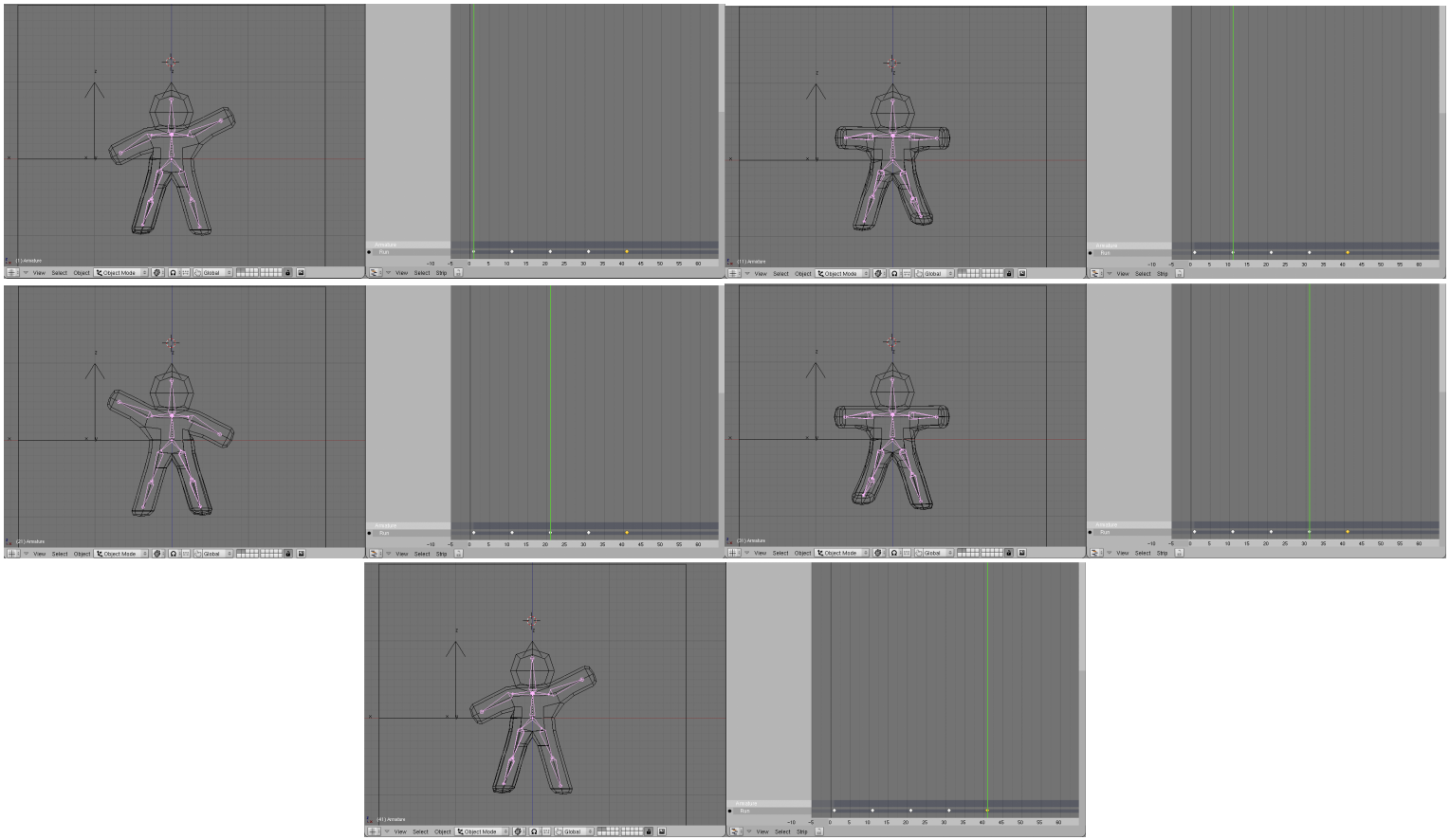
- Distortions in the mesh can be avoided if the model is built and manipulated correctly.



Keyframes

- Skinning provides the ability to easily manipulate a mesh. The second problem was with animation was generating all of the poses necessary to create fluid motion.
- The solution is to pose the mesh only at some points throughout the motion and use software to interpolate the missing posses.
- The poses which are set by an animator are called **keyframes**.
- Interpolation can be either linear which involves straight line motions between vertices in two positions or non-linear which uses curved motions between the points.
- The process of automatically generating frames from keyframes is called **tweening**.
- **Ease-in** and **ease-out** are terms which respectively describe an acceleration and deceleration at the start and end of a motion. They are used so there is not an instantaneous acceleration at the start and end of a motion.
- The number of frames per second (FPS) of animation can be eight or higher.

Sample Keyframes



Five keyframes and their time steps. Notice the first and last are the same.

Kinematics

- Two mathematical techniques for positioning the skeletons are **forward kinematics** (FK) and **inverse kinematics** (IK).
- Forward kinematics treats the bones in a skeleton as a chain. If you rotate one bone in a sequence then those attached to it will follow. Only one joint will move at a given time. To position a skeleton using this method you must move the bones into place individually.
- Inverse kinematics allows the user to position a single bone in a sequence and will find positions for all of the other bones attached to it.
- To position a leg using forward kinematics, each part of the leg would need to be posed separately. To do the same with inverse kinematics, only the foot would need to be placed and the rest of the leg would be positioned automatically.

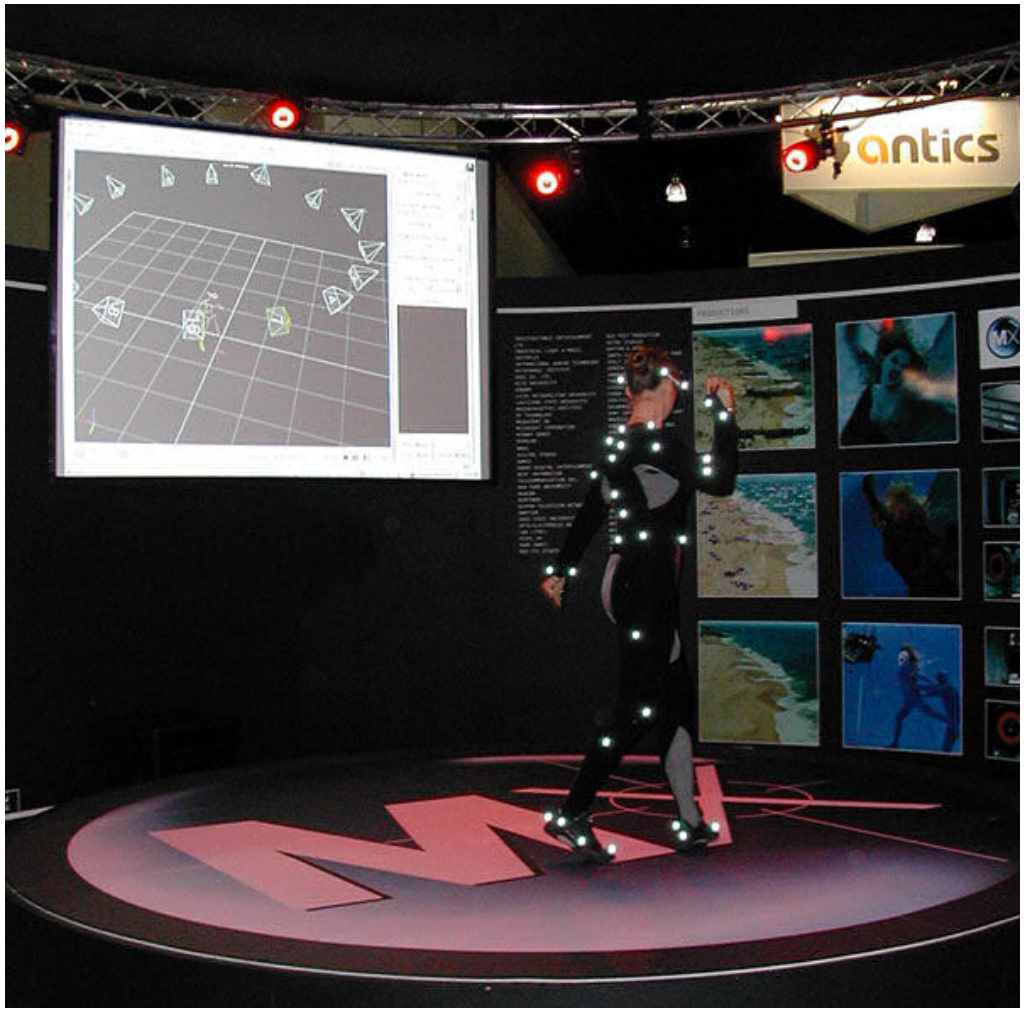
Inverse Kinematics

- Inverse kinematics is often easier to use but is more complex to build.
- Constraints are used to limit the mobility of joints so unnatural poses cannot be generated. These limit the range of motion.
- There can be zero or more solutions to a constrained IK problem. If there are no solutions because there are too many constraints then the problem is called **overconstrained**. If there are too many solutions then the problem is **underconstrained**. An underconstrained problem can generate poses which appear unnatural or ones which are made using extremes in motions or angles.

Motion Capture

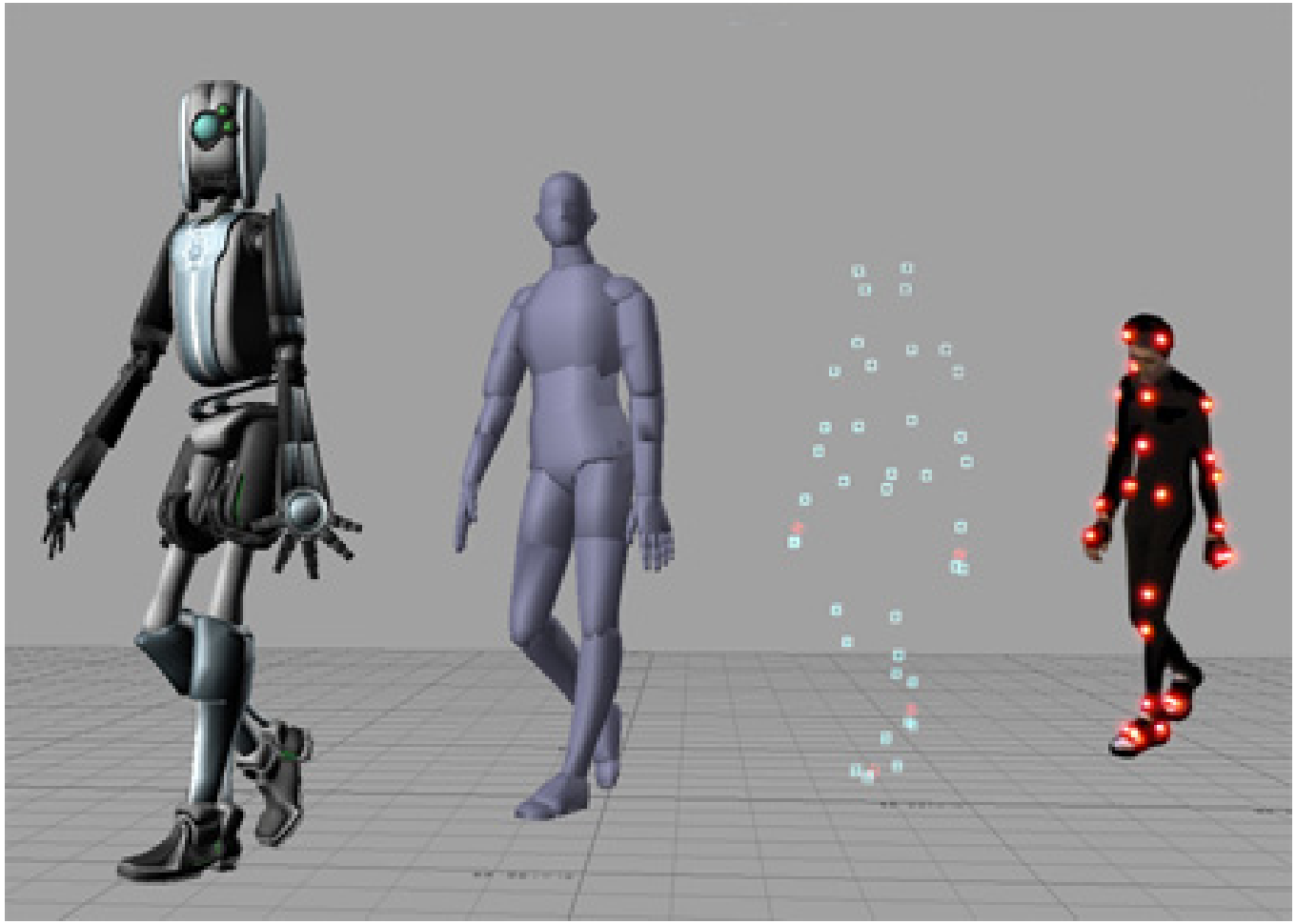
- **Motion capture** (Mocap) or **motion tracking** is an alternative to positioning the skeletons by hand is to use animations that have been recorded from a performer.
- This can be done by placing markers on the performer and recording their position. The position and angle of the performer's limbs is recorded and stored. Mechanical systems also exist which measure the angle of rotation of the limbs.
- The resultant data can be associated with a skeletal model. This involves mapping the motion captured limbs onto the bones of a 3D model. This can be done through the use of naming conventions and predetermined model structures for limbs.
- Motions created this way tend to look very natural. They cannot create anatomically impossible poses.
- The data created can be quite large and can be reduced in size by using extracting keyframes from it and using interpolation.

Motion Capture System



An actor wearing a motion capture system. Note the reflectors around the joints.

Motion Capture System



Mapping the markers from a motion capture onto a three dimensional model.

Animation Cycles and Transitions

- Many motions are cyclical, such as walking. These can be modeled by repeating the motion once it has completed.
- For this to look realistic there should not be any abrupt changes in position or velocity between the start and the end of the motion.
- Transition animations may be used to bridge two animations which have different velocities such as between walking and running.

References

Images and information were taken from:

- Blender3D web site, www.blender3d.org.
- BSoD/Introduction to Character Animation web site, mediawiki.blender.org.
- Parent, Rick, Computer Animation, Algorithms and Techniques, Morgan Kaufmann Publishers, 2002.
- Wikipedia web site, www.wikipedia.org.