Extended Reality in Industry 4.0

Lecture 13: Rigging and animation

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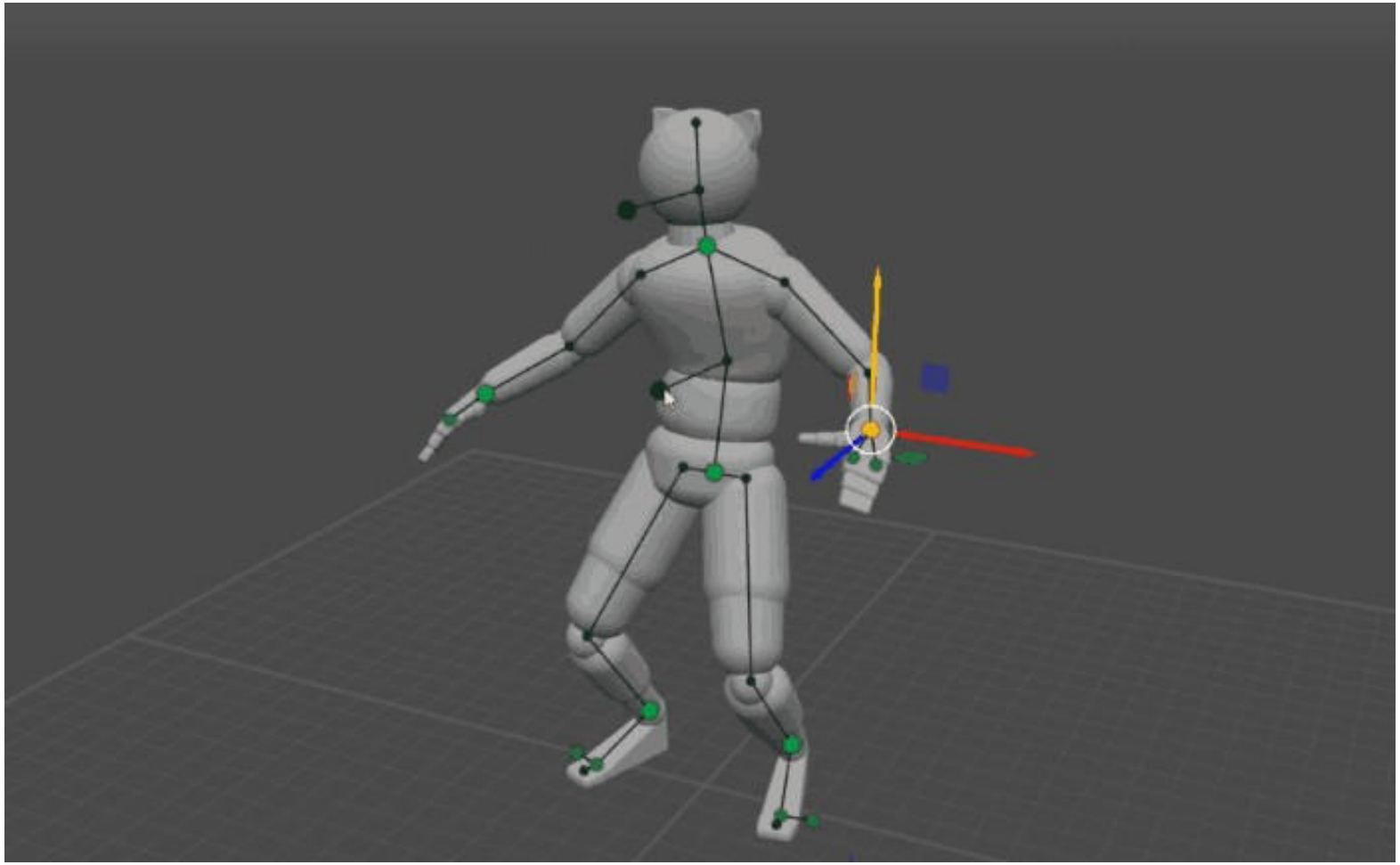
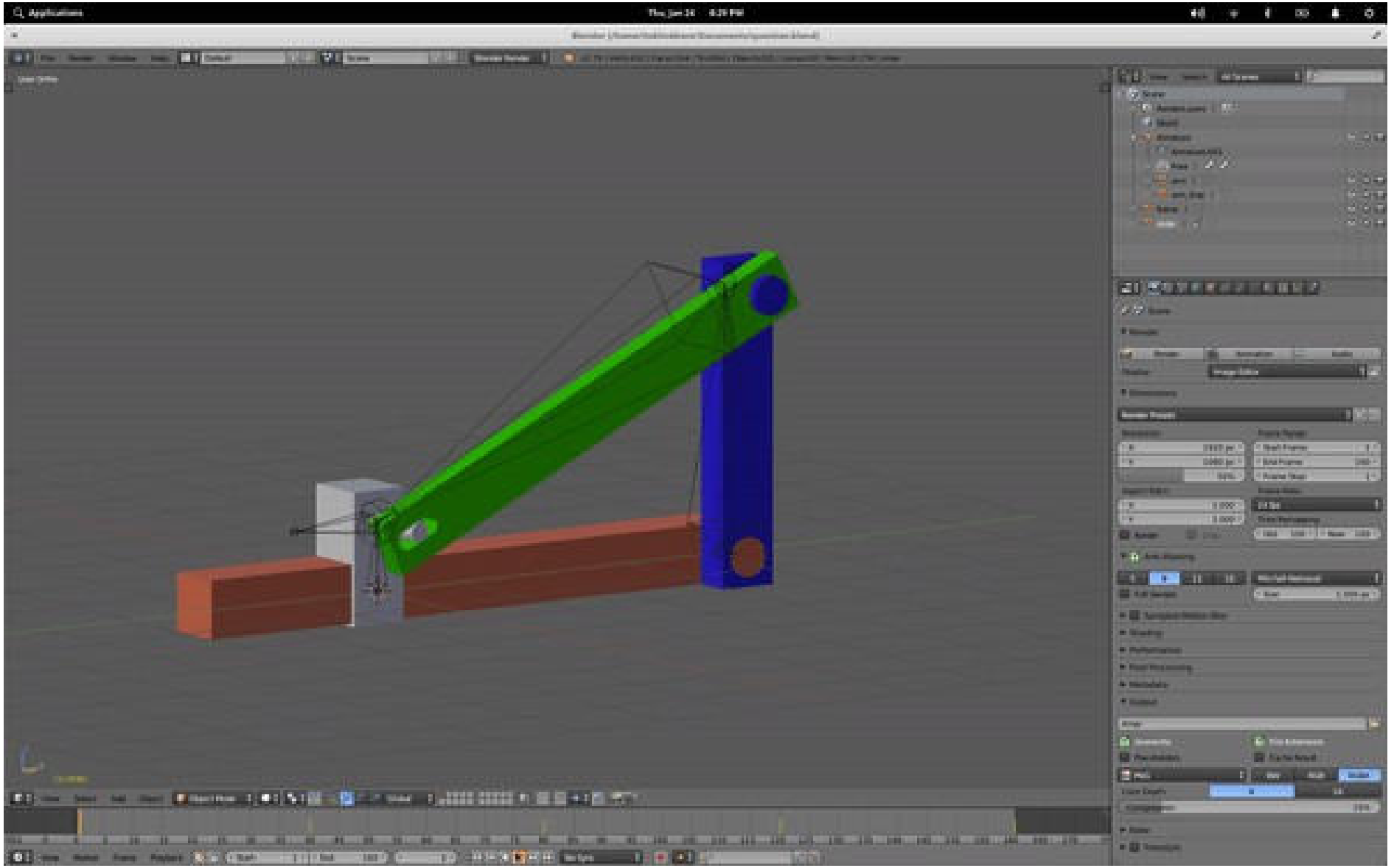
Rigging in 3D

- Rigging refers to the process of creating bone structure of a 3D model so that it can be moved in any direction and orientation.
- It is used to animate 3D objects.
- Rig is a chain of object relationships.
- It is an essential step in the 3D animation process, as it allows animators to manipulate the 3D model and make it move in whatever way you want it to.

Rigging in 3D

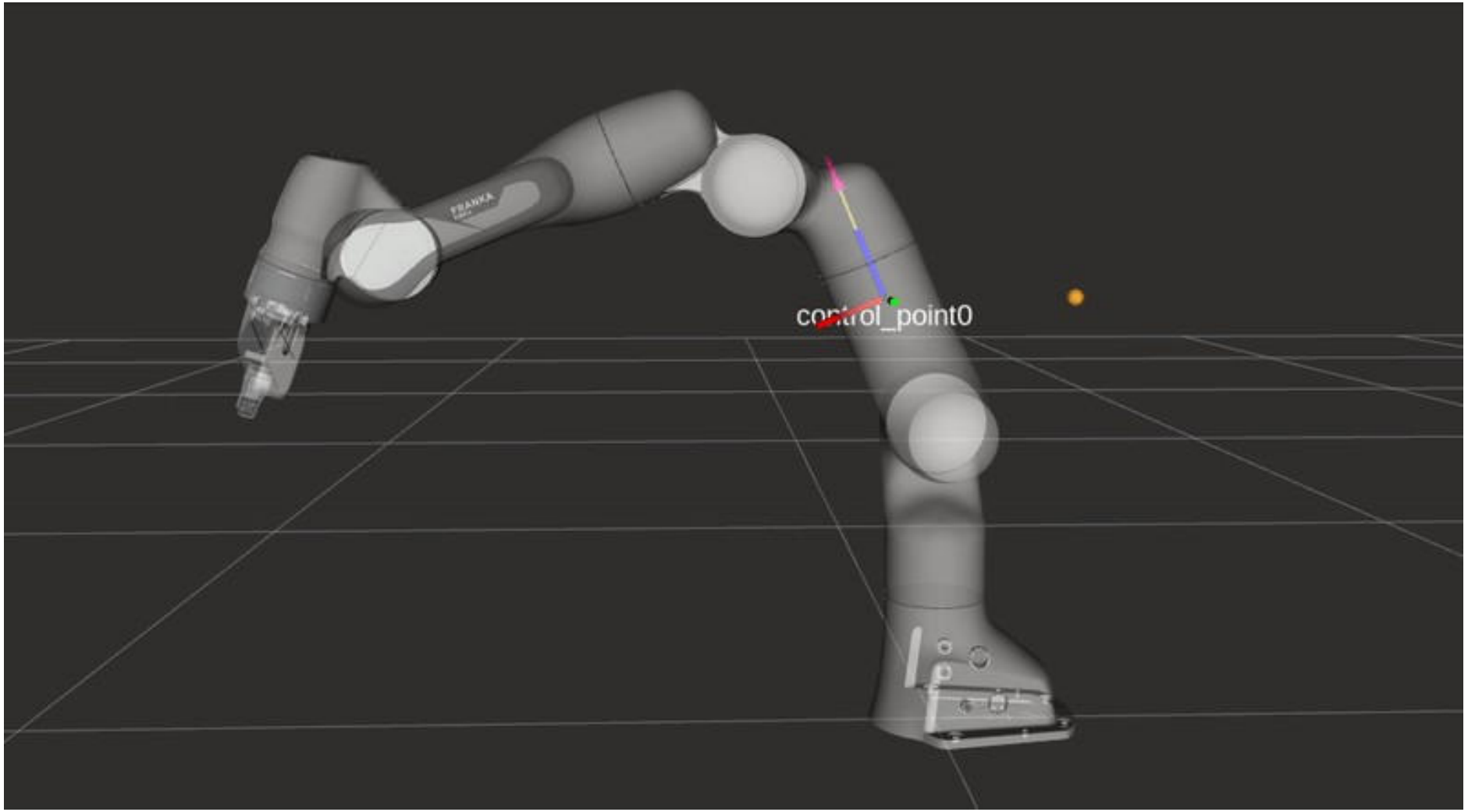


Examples



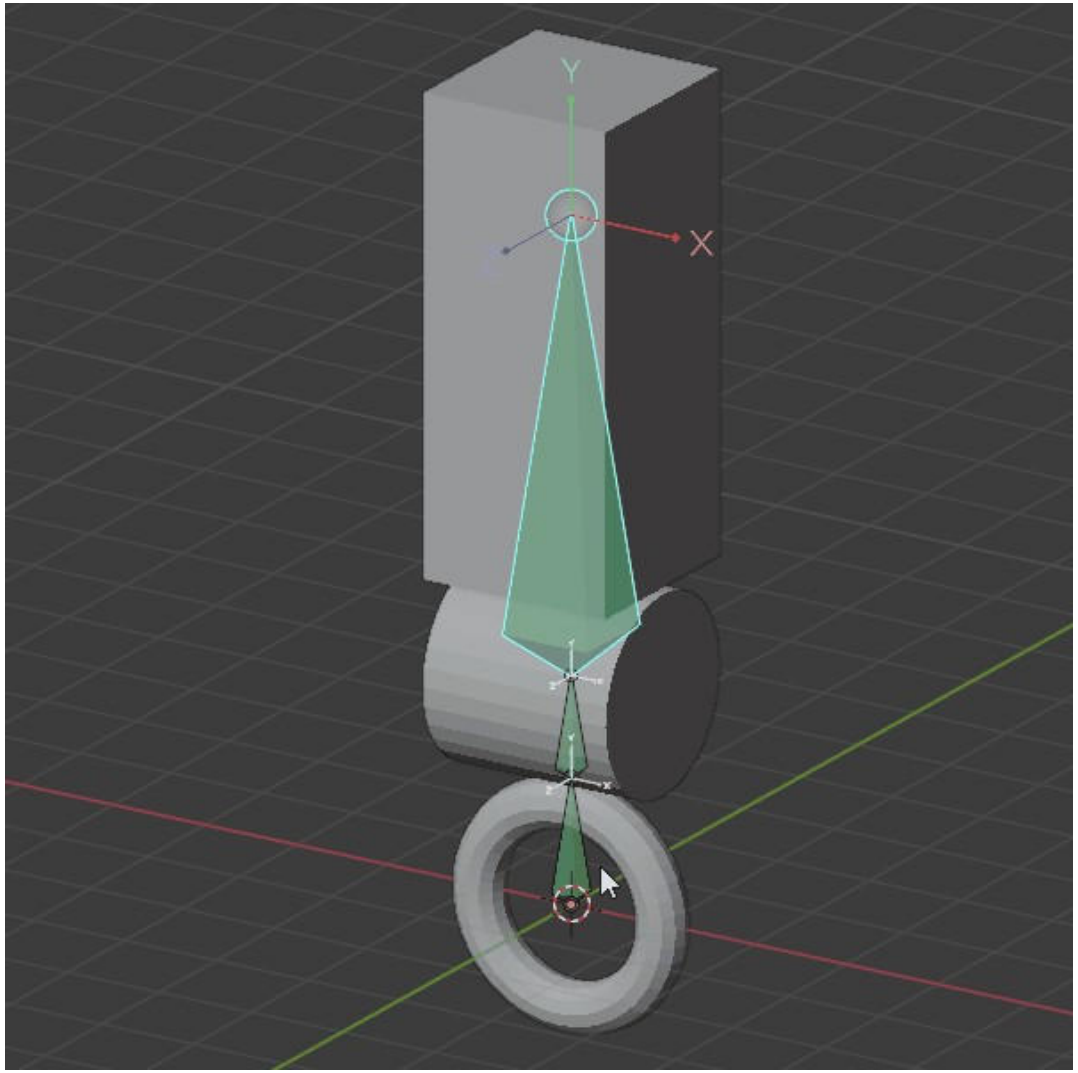
Slider crank mechanism

Examples



Robotic arm with 3 degree of freedom

Examples



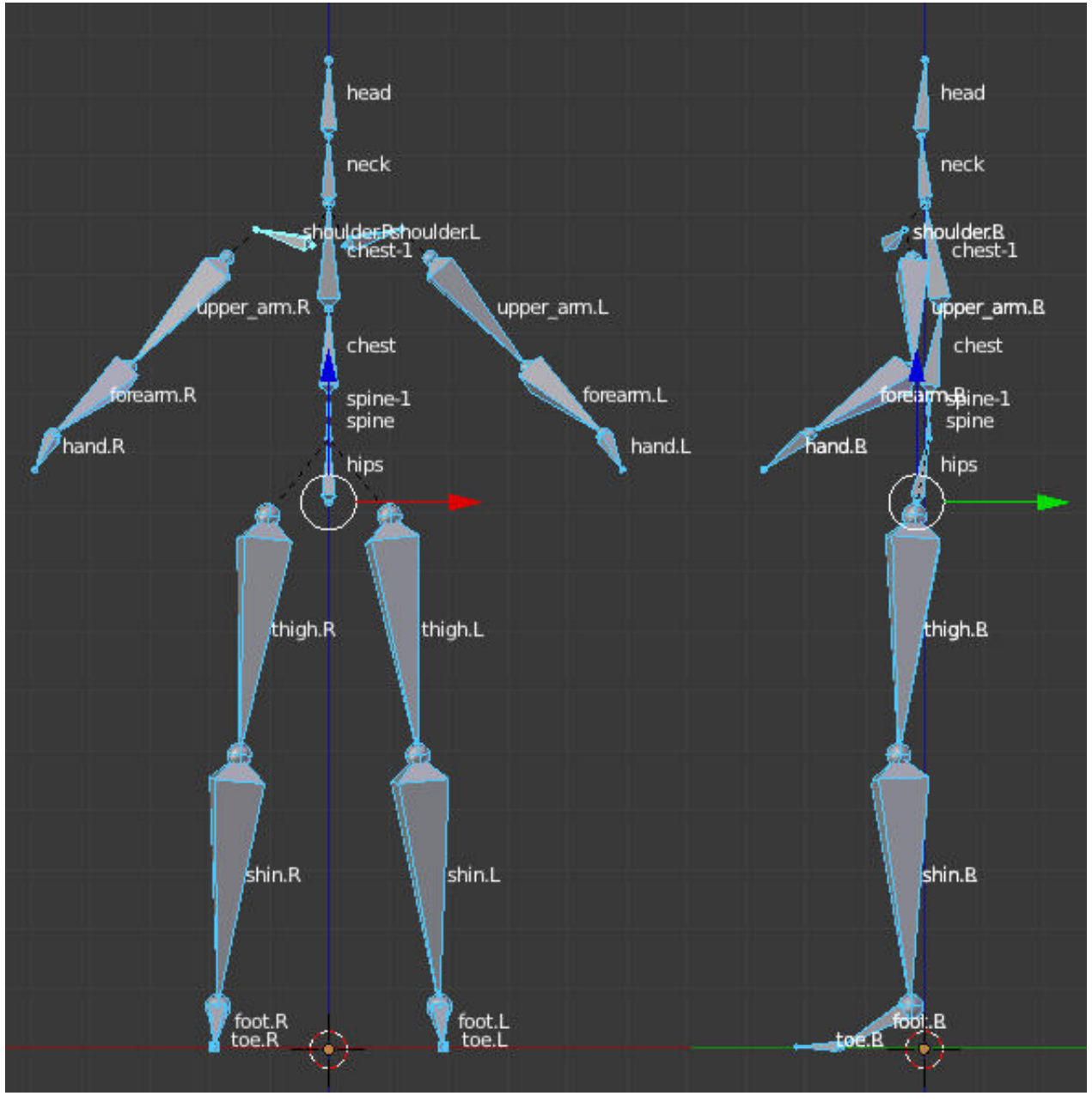
Process of rigging

- Armature
- Bone
- Joints
- Parenting
- Forward and Inverse kinematics

Armature

- An “armature” is a type of object used for rigging.
- It can be thought of as similar to a real skeleton, and just like a real skeleton an armature can consist of many bones.
- These bones can be moved around and anything that they are attached to or associated with will move and deform in a similar way.

Armature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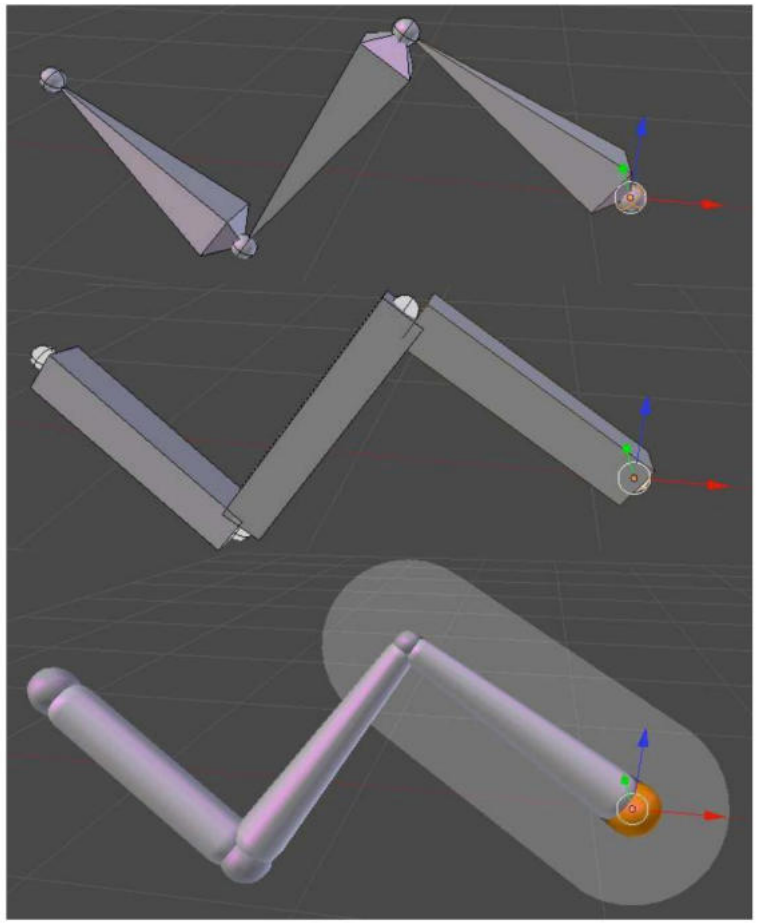
neck
shoulder.R
shoulder.L
chest-1
upper_arm.R
upper_arm.L
chest
forearm.R
forearm.L
spine-1
spine
hand.R
hand.L
hips
thigh.R
thigh.L
shin.R
shin.L
foot.R
toe.R
foot.L
toe.L
head
neck
shoulder.B
chest-1
upper_arm.B
chest
spine-1
spine
hand.B
hips
thigh.B
shin.B
toe.B

Bone

- Element of the skeleton



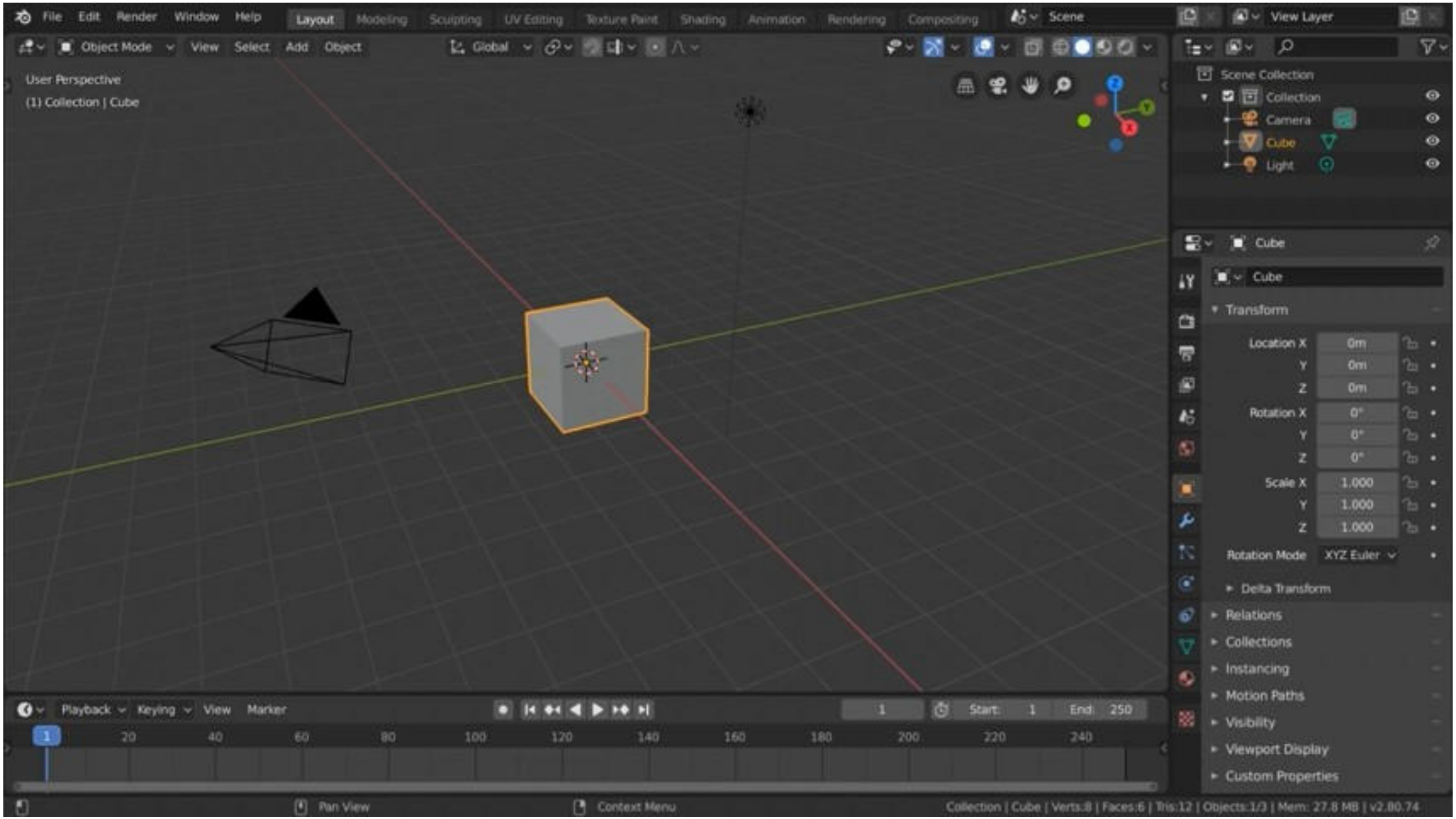
Joints

- One purpose of joints is to define the freedom that the character has in its movement.
- The rotation of the joints affect the movement and deformation of the character's geometry.
- Joints are usually arranged in a hierarchy from the time they are created.

Parenting

- When joints are created, each parent joint points towards its child with one of its rotation axes
- In a hierarchy of objects, an object directly above another object is called a *parent* of that other object, while an object directly below another object is called a *child* of that object

Parenting


File Edit Render Window Help
Layout Modeling Sculpting UV Editing Texture Paint Shading Animation Rendering Compositing
Scene
View Layer
Object Mode View Select Add Object
Global
User Perspective
(1) Collection | Cube
Scene Collection
Collection
Camera
Cube
Light
Cube
Transform
Location X 0m
Y 0m
Z 0m
Rotation X 0°
Y 0°
Z 0°
Scale X 1.000
Y 1.000
Z 1.000
Rotation Mode XYZ Euler
Delta Transform
Relations
Collections
Instancing
Motion Paths
Visibility
Viewport Display
Custom Properties
Playback Keying View Marker
Start: 1 End: 250
Pan View
Context Menu
Collection | Cube | Verts:8 | Faces:6 | Tris:12 | Objects:1/3 | Mem: 27.8 MB | v2.80.74

Kinematics

- Kinematics in animation involves the study of motion without considering the forces that cause it. It is about defining the possible movements of a character or object.
- **Kinematics in Animation** is crucial for setting the stage for how characters will move and interact within their virtual environments.
- There are two primary forms of kinematics used in **3D Character Rigging**: **Forward Kinematics (FK)** and **Inverse Kinematics (IK)**.

Forward Kinematics

- **Forward Kinematics (FK)** is a foundational technique used to animate characters and objects. It is a method where each joint in the character's body is moved individually, starting from the root (usually located at the hips or pelvis) and moving outwards through the limb.
- **Forward Kinematics** operates on a hierarchical system.
- For example, a character's arm, which consists of the shoulder, elbow, and wrist joints. In FK, moving the shoulder will affect the position of the elbow and wrist, but moving the wrist won't affect the shoulder or elbow.
- This hierarchy is crucial, as it dictates the flow of motion from the parent joint down to the child joints.

Inverse Kinematics

- **Inverse Kinematics** simplifies the animation process by allowing animators to specify where a limb's end point should be, and the IK system calculates how the rest of the limb's joints should be angled to achieve that position
- For instance, if an animator wants a character's hand to touch an object, they position the hand, and the IK system automatically adjusts the shoulder and elbow accordingly.
- This automation makes it easier to create more natural and realistic movements, especially when characters interact with objects or environments.

Forward and Inverse Kinematics

Links for practice

- Basic character rigging

https://www.youtube.com/watch?v=4z7G4TyKE9g

- Robot dog animation
  - Modeling

    https://www.youtube.com/watch?v=xy8yFclpC9E
  - Rigging

    https://www.youtube.com/watch?v=lF6ryktrht0
  - Animation

    https://www.youtube.com/watch?v=W4TkA5P5Qes&t=6s

Exporting rigged animations to Unity

https://www.youtube.com/watch?v=ysl0qYq5p9w

Final Project guidelines

- Education
- Training
- Assembly
- Maintenance
- Instructional guidance of a process
- Gaming
- Medical training
- E-commerce & advertisement
- Exhibition expo
- High-fidelity prototyping
- Technical exhibition
- Virtual showrooms
- AI in XR
- Visio-haptic XR

Grading criteria

- Creativity and novelty of the idea
- Presentation
- Level of difficulty involved
- Incorporation of UI elements
- Intuitiveness
- Fidelity
- Bonus Points (If anything additional from the class lectures is added in the project / publishable project work in journals or conferences)

Visuo-haptic XR-based manual metal arc welding training system

Presented by

Department of Mechanical Engineering
National Taiwain University
Kalpana Shankhwar and Shana Smith