

3D Interaction Techniques

* 3D Manipulation: Tasks and Techniques.

=> 3D Manipulation in AR allows users to interact with virtual objects in the world.

Goal of Manipulation is to make interactions more efficient and natural.

=> 3D Manipulation Tasks:

These are the main action users perform to interact with virtual objects.

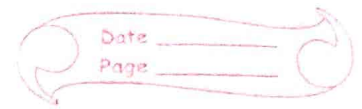
(1) Selection:

User select a virtual object for interaction.

Methods: Touch Selection, RayCasting

(2) Translation:

Also known as Moving Objects.



User shift the object within the AR environment.

Method: Dragging, Mid-air gestures.

(3) Rotation:

Also known as changing Orientation

Task is to adjusting an Object's angle or direction.

Method: Two-Finger Rotation.

(4) Scaling:

Also known as Resizing the object.

User can increase the size of an object.

Method: Pinch-to-zoom

(5) Placement:

Positioning an object within the AR scene while considering real-world surfaces.

Interaction Techniques /

=> 3D Manipulation Techniques:

3D Manipulation in AR involves selecting, moving, rotating and scaling virtual objects.

-> Techniques:

1. Touch-Based Interaction:

Used to select the object in the AR environment.

Used in Smartphone or Tablets AR.

Users can interact with the on-screen gestures.

Ex. Dragging: Moves Object

Pinching: Scales Objects.

2. Gesture-Based Interaction:

Also known as Mid-Air Gestures interaction.

Uses hand and finger tracking for direct manipulation but always required advanced sensors.



Ex. Grabbing: Pick up and moves object.

Hand Orientation

Waving Hand,

3. Device-Based Interaction:

Uses device movement and sensors.

Mainly Used in handheld AR and headsets.

Ex. Tilting Device: Rotates Object
Moving Closer / Farther:
Scales Object.

4 Raycasting:

Raycasting also known as Laser Pointer method.

Projects an invisible ray for selecting distant objects.

Used in AR headsets and controllers.

Ex. Pointing a virtual laser to select, move or resize objects.

5 Virtual Hand Interaction:

Displays a Virtual hand that mimics real movements.

Allows grabbing, pushing and rotating objects naturally.

→ Applications:

- A. AR Interior Design
- B. AR Gaming
- C. Medical AR Training
- D. Industrial AR
- E. Manufacturing and Prototyping

* Manipulation Approaches:

⇒ In AR/VR Manipulation refers to the how user can interact with the virtual objects.

Using Manipulation Task user can move, rotate or resize the object in the environment.



→ Approaches:

1 Direct Manipulation:

Users interact with objects as if touching them in real life.

Methods:

- Virtual Hand Interaction:

A virtual hand mimics real-world movements.

- TouchScreen Interaction:

Multi-touch gestures for moving, scaling and rotating.

2 Indirect Manipulation:

Uses tools or interface instead of direct physical interaction.

Methods:

- Ray Casting: Use Laser Pointer to select or move object.

- UI Controls and widgets:

Uses on-screen button/sliders for adjustments.

3 Gesture-Based Manipulation:

Uses hand or body movements detected by sensors.

Methods:

- Hand Gesture: Grabbing, swiping to move and rotate objects.
- Body Tracking: Moving the head or body for interaction.

4 Device-Based Manipulation:

Uses the motion and orientation of a device to control objects.

Methods:

- Tilting the device: Rotates objects.
- Moving the device closer / Farther: Changes object size.



* Input Devices For 3D Manipulation

=> Input devices help users to interact with virtual objects.

This devices translate physical movements into digital actions.

A. Hand Tracking Devices:

It uses cameras and sensors to track hand movements for direct interaction.

-> Working:

Captures hand and finger movements using infrared or depth sensors.

Detects gestures, position and orientation in real time.

Enables interaction without physical controllers.

-> Advantages:

Highly intuitive and immersive.

Eliminates the need for external controllers.

Provides Natural Interaction with object.

→ Disadvantages:

Requires High processing power

Less precise than controllers for some tasks.

B. 6DOF Controllers:

Provides accurate tracking of movement and rotation for precise 3D manipulation.

→ Working:

Tracks 6 Degrees of Freedom:

- 3 For Position
- 3 For Rotation.

Includes buttons, joysticks and triggers for extra controls.

Uses tracking sensors and cameras for real-time motion detection.

→ Advantages:

High precision and accuracy.

Offers additional controls.

→ Disadvantages:

Requires physical controllers, limiting natural movement.

Can feel less immersive than direct hand tracking.

* Hybrid Techniques in 3D manipulation.

⇒ Hybrid Techniques combine multiple interaction methods to create a more intuitive, efficient and adaptable user experience.

This Technique supports different user preferences and skill levels.

Switches between interaction modes based on task needs,

A. Touch + Hand Gestures:

Touch Gestures used to Move and resize the objects.

Hand Gestures used to adjust and rotation for objects.

Used in AR apps, 3D Modeling and Design Software.

B. 6DoF Controllers + Hand Tracking:

6DoF Controllers: Handle precise tasks in VR.

Hand Tracking: Enables grabbing, pointing and natural interaction.

Used in VR gaming, medical simulations and CAD modeling.

C. Ray Casting + Direct Manipulation:

Ray Casting: Selects distant objects quickly

Direct Manipulation: Adjusts position, rotation and size with accuracy.

Used in Virtual environments, object selection and interior design.

D. 2D Inputs + 3D Inputs:

2D Inputs: Mouse and Keyboard: UI Navigation, rough positioning and menu selection.

3D Inputs: VR Controller: Precise depth-aware drawing or manipulation.

Used in Medical imaging, 3D Modeling and engineering applications.

* 3D Computer Graphics and Rendering Process:

=> 3D Computer Graphics involve creating three-dimensional images that can be display on a 2D-Screen.

This Technology Used in,

Entertainment: Movies, Video games and animation.

Architecture and Design: Realistic Building

Medical Imaging: 3D models of organs for surgery.

Engineering and Simulation: Designing and testing mechanical parts.

=> Rendering Process in 3D Graphics:

Rendering is the process of converting a 3D scene into a 2D Image.

1 Modeling:

Creating 3D objects using software like Blender, Maya or 3ds Max.

Defines the shape, size and geometry of the objects.

Methods: Polygonal Modeling, NURBS modeling

2 Shading and Texturing:

Texturing: Applying surfaces material like wood, metal or glass.

Shading: Simulating how lights interacts with objects.

Methods: Flat shading,
Phong Shading.

3 Lighting:

Adds light sources like spotlights, point lights and directional lights.

Determine shadows, reflections and brightness.

Method: Global Illumination.

4 Rendering Techniques:

This steps converts the 3D scene into a Final image.

Methods:

1) Ray Tracing: Simulates real light behavior for realistic shadows and reflections.

2) Rasterization: Converts objects into pixel for fast rendering.

5 Post Processing:

Enhances image quality with effects like,

- Anti-aliasing: Smooths jagged edges.
- Motion Blur: Adds realism to fast moving objects.
- Color Grading and Bloom: Adjusts brightness and contrast.
- Depth of Field: Simulates camera focus.