CSE 165: 3D User Interaction

Lecture #7: Input Devices

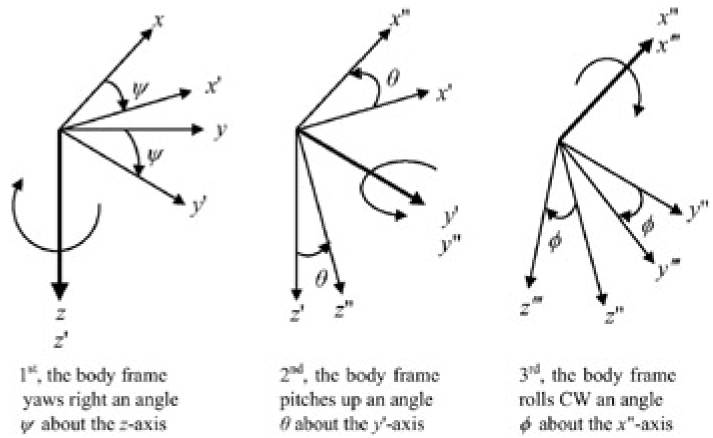
Announcements

- Homework project 2 is on line
  - Due Friday Feb 10th

Quaternions

Rotation Calculations

- Intuitive approach: Euler Angles:
  - Simplest way to calculate rotations
  - Defines rotation by 3 sequential rotations about coordinate axes
  - Example Z-Y-X:



http://www.globalspec.com/reference/49379/203279/3-3-euler-angles

Problems With Euler Angles

- Problems with Euler angles:
  - No standard for order of rotations
  - Gimbal Lock, occurs in certain object orientations
    - Video
      - https://www.youtube.com/watch?v=rrUCBOlJdt4
- Better: rotation about arbitrary axis (no Gimbal lock)
  - Can be done with 4x4 matrix
  - But: smoothly interpolating between two orientations is difficult

➔ Quaternions

Quaternion Definition

- Given angle and axis of rotation:
  - a: rotation angle
  - {nx,ny,nz}: normalized rotation axis
- Calculation of quaternion coefficients w, x, y, z:
  - w = cos(a/2)
  - x = sin(a/2) * nx
  - y = sin(a/2) * ny
  - z = sin(a/2) * nz

Useful Quaternions

w	x	y	z	Description
1	0	0	0	Identity quaternion, no rotation
0	1	0	0	180° turn around X axis
0	0	1	0	180° turn around Y axis
0	0	0	1	180° turn around Z axis
sqrt(0.5)	sqrt(0.5)	0	0	90° rotation around X axis
sqrt(0.5)	0	sqrt(0.5)	0	90° rotation around Y axis
sqrt(0.5)	0	0	sqrt(0.5)	90° rotation around Z axis
sqrt(0.5)	-sqrt(0.5)	0	0	-90° rotation around X axis
sqrt(0.5)	0	-sqrt(0.5)	0	-90° rotation around Y axis
sqrt(0.5)	0	0	-sqrt(0.5)	-90° rotation around Z axis

Quaternions: Further Reading

- Rotating Objects Using Quaternions
  - http://www.gamasutra.com/view/feature/131686/rotating_objects_using_quaternions.php
- Quaternions in Unity 3D:
  - https://docs.unity3d.com/ScriptReference/Quaternion.html
- Quaternions in OpenSceneGraph:
  - http://www.openscenegraph.org/projects/osg/wiki/Support/Maths/QuaternionMaths

Input Devices

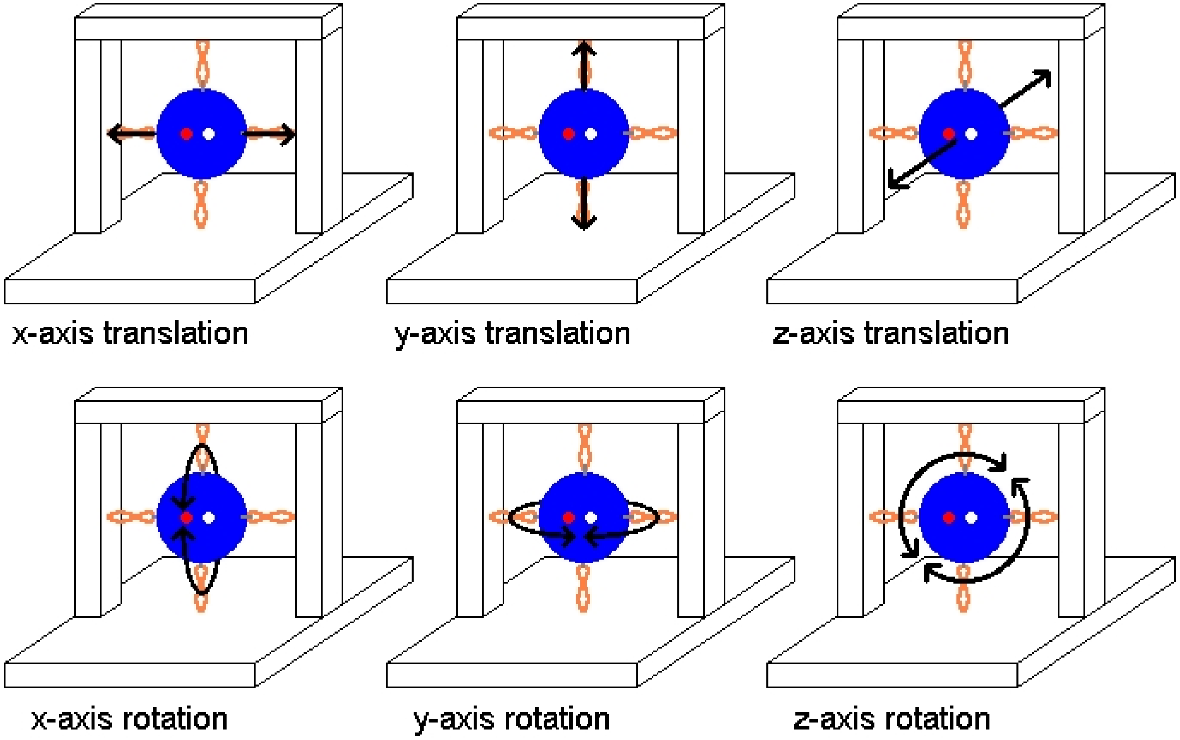
Overview

- Degrees of freedom
- 2-DOF devices
- Relative 6-DOF devices
- Absolute 6-DOF devices
  - mechanical
  - electromagnetic
  - inertial
  - optical
  - ultrasound
  - hybrid
  - special purpose

Degrees of Freedom (DOF)

- DOF: Set of independent displacements that specify completely the displaced or deformed position of a body or system.
- 3 DOF for position:
  - Moving up and down (heaving)
  - Moving left and right (swaying)
  - Moving forward and backward (surging)
- 3 DOF for orientation:
  - Tilting up and down (pitching)
  - Turning left and right (yawing)
  - Tilting side to side (rolling)
  - See also: Euler angles

6 Degrees of Freedom



Keyboard (binary n-DOF) and Mouse (2-DOF)

- Some VR applications are designed for keyboard, mouse or game pads
- Can work well for walk/fly-through applications
- Doesn't work well for 3D selection and manipulation

3 DOF: GPS

- GPS = Global Positioning Satellite system
- GPS receivers determine exactly how long it takes for the signals to travel from each satellite
- Result:
  - Latitude
  - Longitude
  - Altitude

Touch or Pen-based Tablets

- Absolute 2D position
  - 2 DOF
- Microsoft Surface Dial
  - Adds 1 DOF

6-DOF Relative Devices

- Relative position and orientation
- 3dconnexion/Logitech

Spaceball

Space Navigator

Mechanical 6-DOF Tracking

- Fakespace Boom: doubles as a stereo display
- Geomagic Touch: doubles as a haptic feedback device

Fakespace Boom

Geomagic Touch

Electro-magnetic Tracking

- Fixed transmitter generates low-level magnetic field from 3 orthogonal coils
- Fields generate current in smaller receiver unit(s) worn by user
- 6-DOF tracking achieved by analyzing signal strength in receiving coils
- Advantage: no line of sight restrictions
- Disadvantage: metal in environment can cause interference

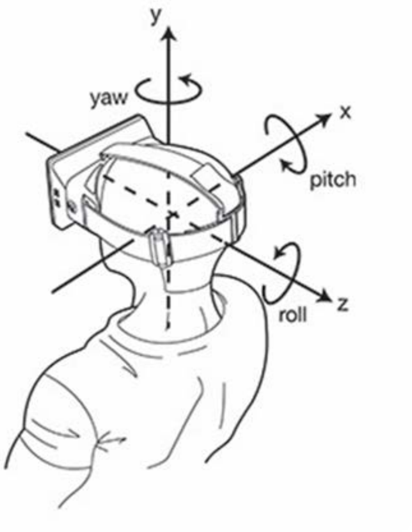
Razer Hydra

Sixense STEM

Inertial Tracking

- Trackers use miniature gyroscopes to measure orientation changes: 3-DOF
- Accelerometers can help calibrate, add position tracking
- Disadvantage: drift between actual and reported values, accumulates over time

Gyro in Oculus Rift DK1

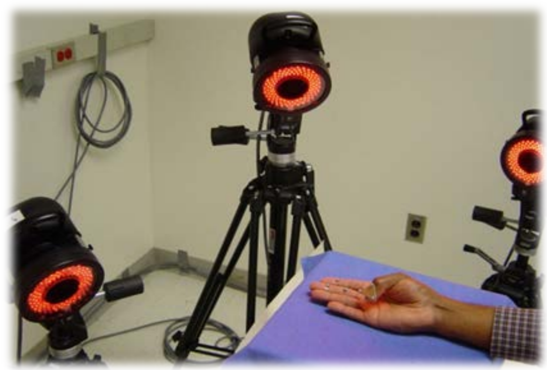


3 Rotational DOF

Optical Tracking: Mocap Devices

- Infrared (IR) cameras illuminate scene for easier detection of markers
- Multiple markers (highly reflective spheres) arranged in fixed, known configurations allow for 6 DOF tracking

ART Tracking System



Vicon Tracking System