CSE 165: 3D User Interaction

Lecture #7:
Tracking Technologies

Announcements

- Homework Project 2a
  - Due Friday February 1st at 3pm
  - Solo project
  - Teams not allowed

Overview

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

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

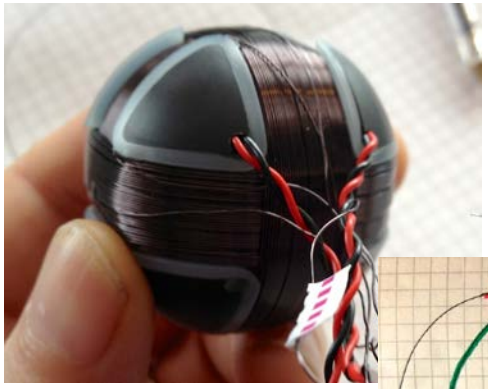
Fakespace Boom

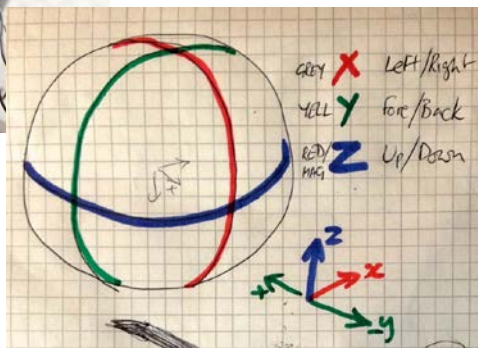
Geomagic Touch

Electro-magnetic Tracking

Example: Razer Hydra

- 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





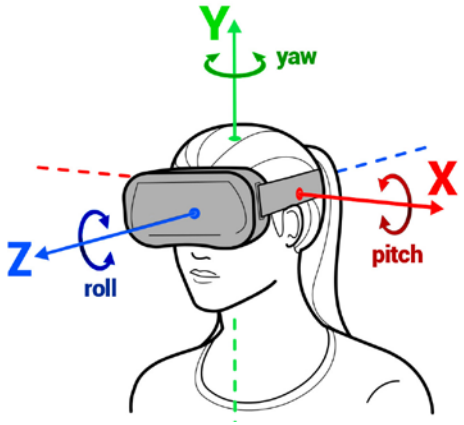
Electromagnetic Tracking

- There are three pulses of about 2ms each.
- The three pulses correspond to each of the three crossed coils in the base – they are pulsed in series.
- The receiver coils in the controller receive each of the pulses with different amplitudes, depending on the relative orientation of the receiving and transmitting coils.
- If their axes are aligned, the corresponding signal is strong.
- If they are not aligned, the signal is weaker, being weakest when the axes are perpendicular.
- Changing the distance of the controller from the base changes the amplitude of all three signals in the same way.
- From this information the DSP in the base can determine the orientation and position of the controller.

Inertial Tracking

- Trackers use miniature **gyroscopes** to measure orientation changes: 3-DOF
- Accelerometers can help calibrate, add position tracking
- Advantages:
  - No external sensors needed
  - Cheap sensors mass manufactured for smart phones
- Disadvantage: drift between actual and reported values, accumulates over time

Gyroscope in Oculus Rift DK1

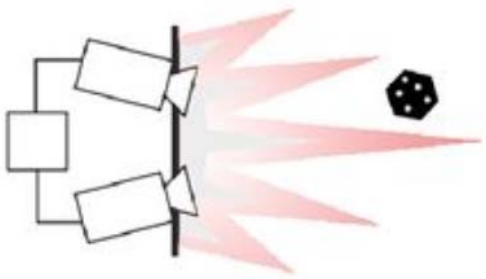


3 Rotational DOF

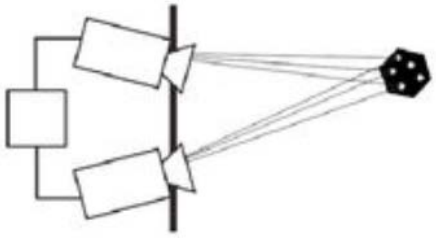
Optical Tracking with Spheres

- (Near-) Infrared light illuminates scene
- Retro-reflective spheres reflect light back to the cameras
- Spheres arranged in fixed, known configurations

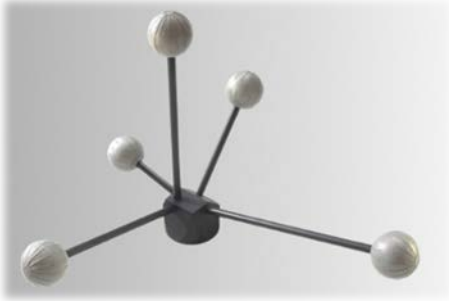
Motion Capture Suit



The object is lit using near IR light



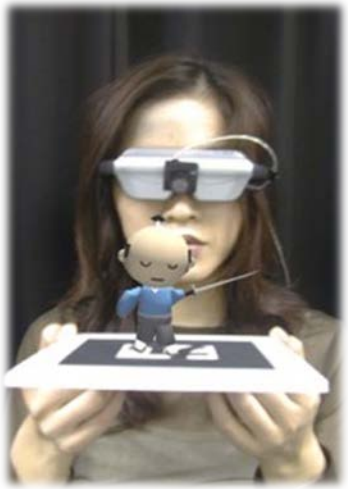
Retro-reflective markers reflect back



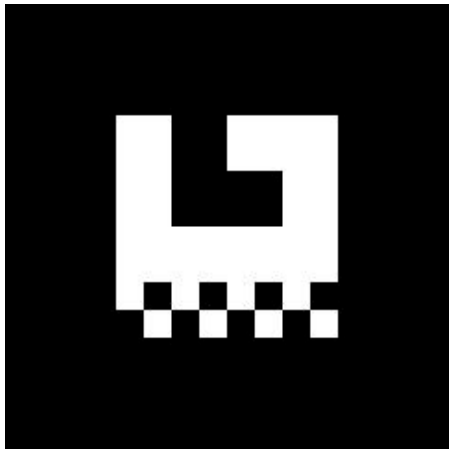
Marker constellation

Optical Tracking with Fiducial Markers

- Printable markers placed in environment or on objects
- Single camera sufficient
- Flexible marker design: similar to QR codes
- Markers cannot be rotationally symmetrical
- 6 DOF tracking possible



ARToolKit

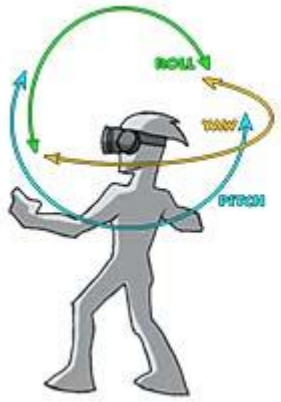


ARToolKit marker

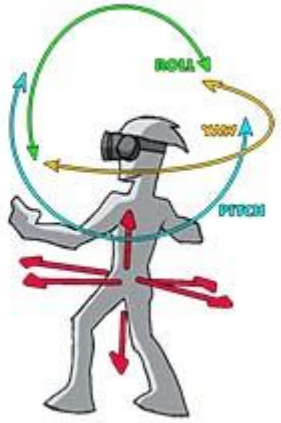
Optical Tracking Allows 6 DOF

- Optical tracking works well for positional tracking
- Can provide full 6 DOF tracking with marker constellations

3 degrees of freedom (3-DoF)



6 degrees of freedom (6-DoF)



Outside-In Tracking

- Cameras or markers are placed around the room
- Pros:
  - Highest tracking accuracy and latency
  - More trackers can be placed to increase accuracy and tracking volume
- Cons:
  - Limited tracking volume
  - More equipment required
  - Set up takes time

Inside-Out Tracking

- Device tracks itself without special preparation of environment
- Typical solutions:
  - SLAM
  - Fiducial markers
- Pro: unrestricted tracking volume
- Cons:
  - Lower accuracy and latency
  - Significant computational requirements for image processing