CSE 190: Virtual Reality Technologies

LECTURE #10: 3D TRACKING TECHNOLOGY

Announcements

Monday: Discussion homework project 2

Project 2 due Sunday May 10th at 11:59pm

Today's VR app presentations:

- Jeremiah Johnson: Hardcode
- Daniel Harnanto: Voxel Fly
- Adam Loop: ARia
- Lucas Hwang: Google Earth VR

Degrees of Freedom (DOF)

Mouse (Relative 2 DOF)

2 independent directions control a cursor

Rate of change proportional to force or velocity of motion

Harder to use with larger screen surfaces (e.g., 4k+ or wide screen monitor)

Gyration presentation controller

Touch or Pen-Based Tablets (Absolute 2 DOF)

Absolute 2D position
- 2 DOF

Microsoft Surface Dial
- Adds 1 DOF

3 DOF: GPS

GPS = Global Positioning Satellite system

24 GPS satellites emit synchronized signals

GPS receiver needs to have line of sight connection with 4+ satellites

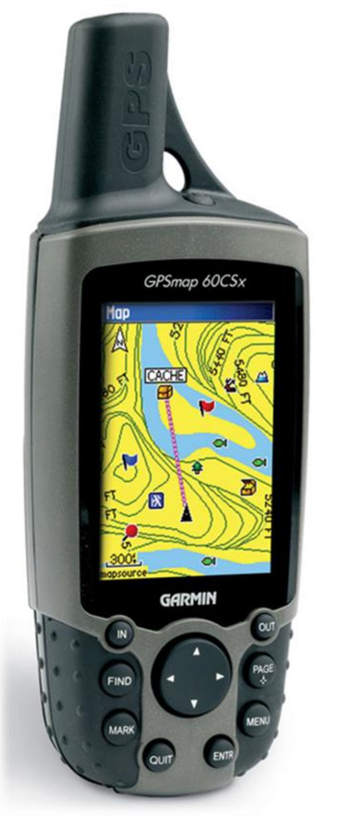
GPS receivers determine exactly how long it takes for the GPS signals to travel from each satellite

Measures:

- Latitude
- Longitude
- Altitude

Does not directly measure:

- Orientation
- Velocity
- Acceleration



6-DOF Relative Devices

Relative position and orientation

Move a cursor around 3D space

Cursor velocity is proportional to directional force

Spaceball

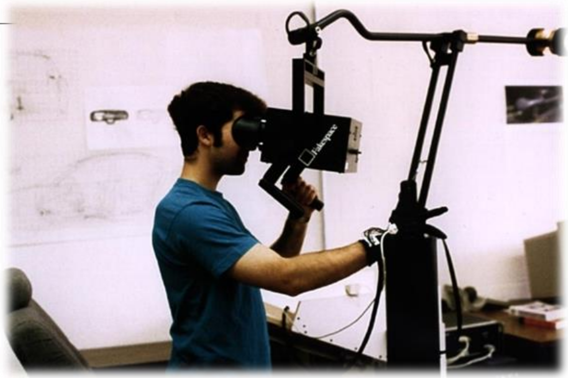
Space Navigator

Mechanical 6-DOF Tracking

Fakespace Boom: doubles as a stereo display. Options:

- Monochrome BOOM 2
- Two primary color (16-bit color) BOOM 2C
- Full color BOOM 3C
- All models are 1280x1024 pixels stereo displays

Geomagic Touch: doubles as a haptic feedback device



Fakespace BOOM

Geomagic Touch

Keyboard, Game Controller

How many DOF?

Tracking Technologies

Electro-magnetic Tracking

Fixed transmitter generates low-level magnetic field from 3 orthogonal coils

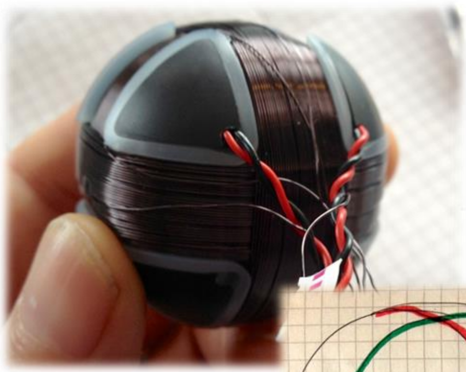
Fields generate current in smaller receiver unit(s) worn by user

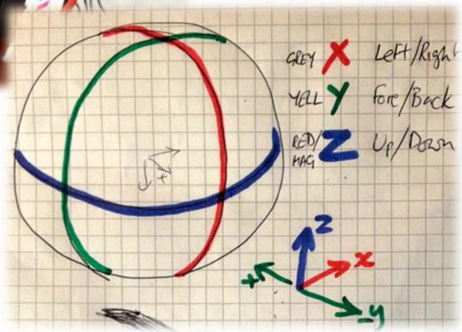
6-DOF tracking achieved by analyzing signal strength in receiving coils

Advantage: no line of sight restrictions

Disadvantage: metal in environment can cause interference

Razer Hydra





Magic Leap

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

Gyroscope in Oculus Rift DK1

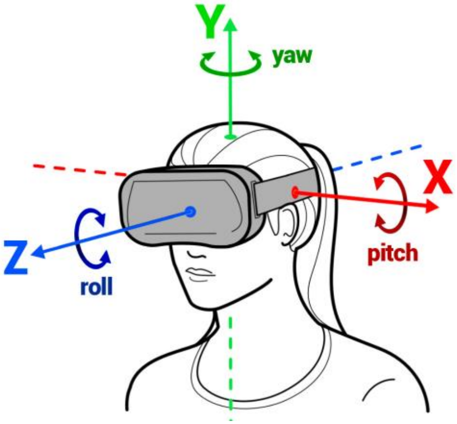
Trackers use miniature **gyroscopes** to measure orientation changes: 3-DOF

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



3 Rotational DOF

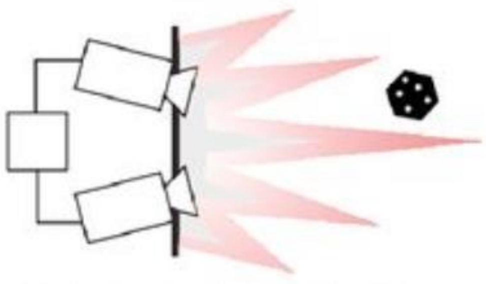
Optical Tracking with Spheres

(Near-) Infrared light illuminates scene

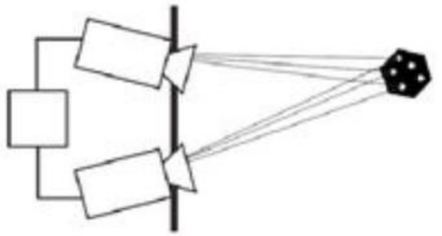
Retro-reflective spheres reflect light back to the cameras

Spheres arranged in fixed, known configurations (constellations) allow for

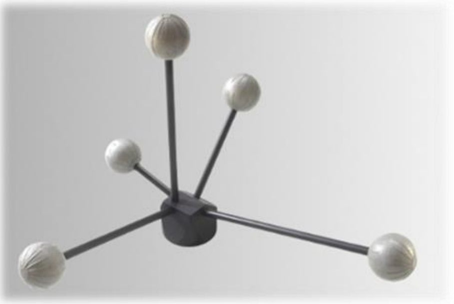
Motion Capture Suit



The object is lit using near IR light



Retro-reflective markers reflect back



Marker constellation

Optical Tracking with Fiducial Markers

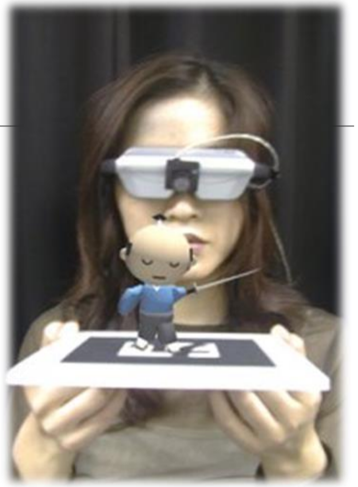
Printable markers placed in environment or on objects

Single camera sufficient

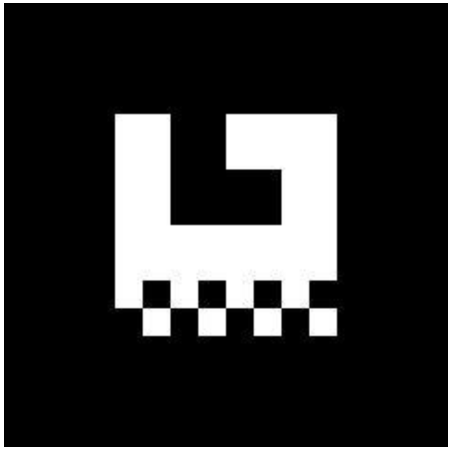
Flexible marker design: similar to QR codes

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

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 solution:

- SLAM

Pro: unrestricted tracking volume

Cons:

- Lower accuracy and latency
- Significant computational requirements for image processing