CSE 190: Virtual Reality Technologies

LECTURE #9: 3D TRACKING TECHNOLOGIES

Upcoming Deadlines

Sunday, May 2: Project 2 due

Monday, May 3: Discussion Project 3

Sunday, May 9: Project 2 late deadline

Monday, May 10: Discussion Project 3

Sunday, May 16: Project 3 due

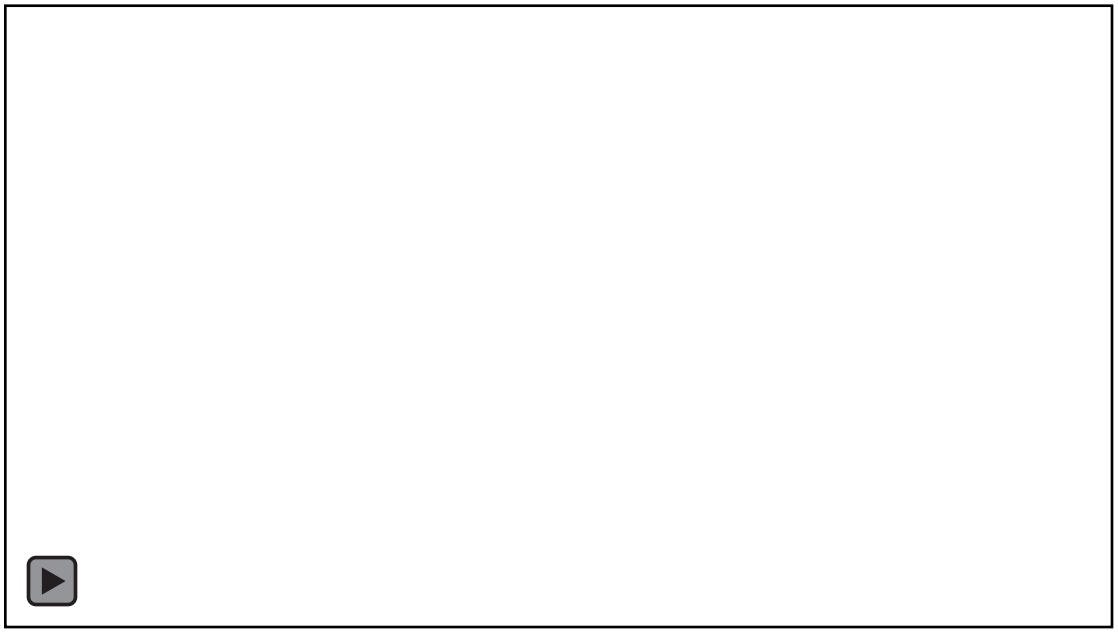
App Presentations

Nick Mak

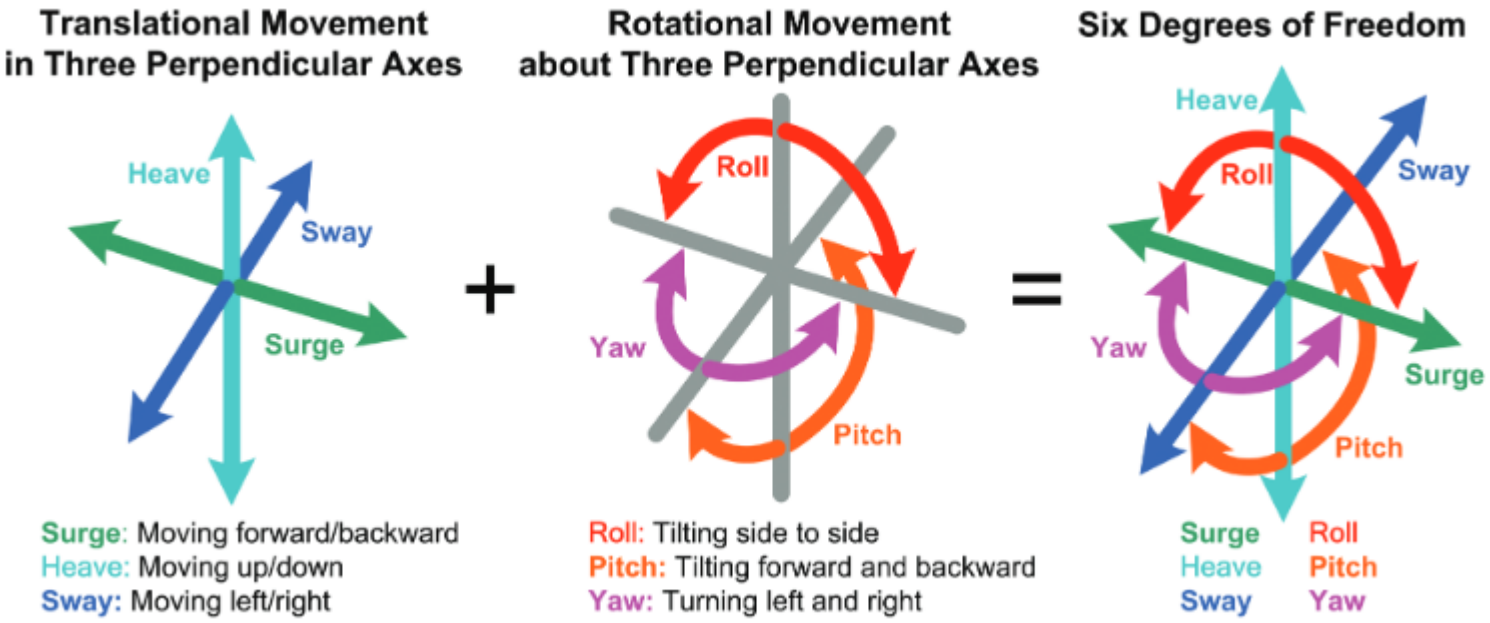
- Immersed VR

Degrees of Freedom (DOF)

Degrees of Freedom



Overview


Translational Movement
in Three Perpendicular Axes
Heave
Sway
Surge
Surge: Moving forward/backward
Heave: Moving up/down
Sway: Moving left/right
+
Rotational Movement
about Three Perpendicular Axes
Roll
Yaw
Pitch
Roll: Tilting side to side
Pitch: Tilting forward and backward
Yaw: Turning left and right
=
Six Degrees of Freedom
Heave
Roll
Sway
Yaw
Surge
Pitch
Surge
Heave
Sway
Roll
Pitch
Yaw

Mouse (Relative 2 DOF Position)

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 Position)

Absolute 2D position
- 2 DOF

Microsoft Surface Dial
- Adds 1 DOF

Absolute 3 DOF Position: 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

Relative 3 DOF Rotation

Low end HMDs

3 rotational directions:

- Roll
- Pitch
- Yaw

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?

Overview

Position/Orientation Tracking
- Mechanical Tracking
- Electromagnetic Tracking
- Ultrasonic Tracking
- Inertial Tracking
- Optical Tracking
- Tracking with Radar

Outside-in/Inside-out Tracking

Hand/Finger Tracking

Eye Tracking

Application-specific Input Devices

Mechanical Tracking

Mechanical Tracking

Dependent on a physical link between a fixed reference point and the target

Example: BOOM display

- A HMD is attached on the rear of a mechanical arm with multiple points of articulation
- Detection of orientation and position is done through the arm

High tracking update rate

Limited range of motion for the user

Electromagnetic Tracking

Electromagnetic Tracking

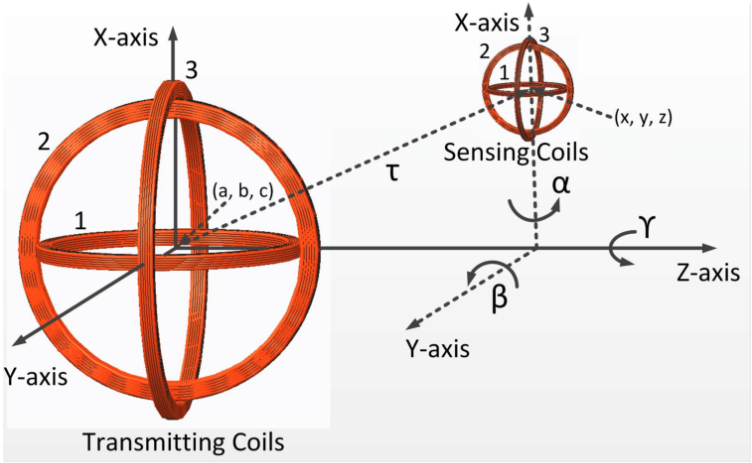
First used by military and in medical and animation industries

Concept:

- 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 tracked device 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 computer can determine orientation and position of the tracked device.

One of the Earliest VR Tracking Technologies

1990 Ascention Flock of Birds

Flock of Birds

2011 Razer Hydra

2018 Magic Leap One

Magic Leap One

Razer Hydra

Magic Leap

Magic Leap One

Uses electromagnetic tracking to track controller's position and orientation.

Electromagnetic signal emitter is in controller.

Receiver in on right side of headset. Tracking will probably be worse for left-handed use.

Copper shielding sprayed into the coil housings protects from RF interference, while letting the magnetic field through.

Interference could explain the tracker's placement outside of frame.

Receiver

Emitter

Ultrasonic Tracking

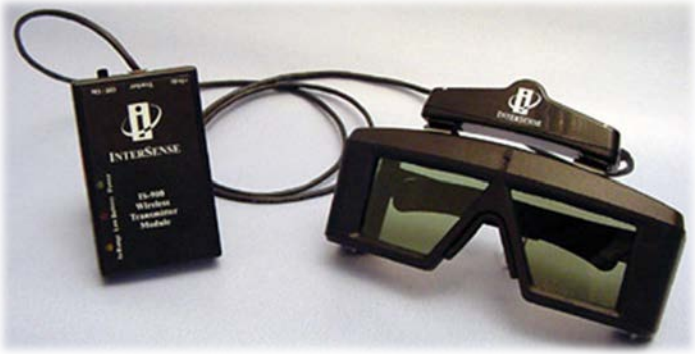
Ultrasonic Tracking

Systems measure duration of an ultrasound signal to reach microphones.

InterSense system uses combination of ultrasound and gyroscope.

Problems with echos from walls, people, objects in tracking space.

Logitech 3D Mouse



InterSense IS-900 tracker

InterSense IS-900 Wand

Inertial Tracking

Inertial Tracking

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

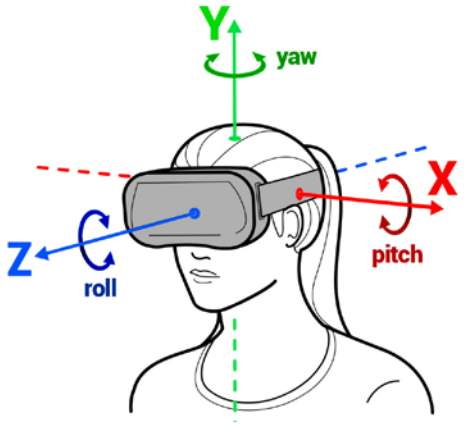
Accelerometers can help calibrate, add position tracking

Advantages:

- No external sensors needed
- Works outdoors
- No limitations on tracking space
- Cheap sensors mass manufactured for smartphones

Disadvantage: drift between actual and reported values, accumulates over time

Gyroscope in Oculus Rift DK1



3 Rotational DOF

Xsens Motion Tracking

Long range motion tracking