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

- Surge: Moving forward/backward
- Heave: Moving up/down
- Sway: Moving left/right

Rotational Movement about Three Perpendicular Axes

- Roll: Tilting side to side
- Pitch: Tilting forward and backward
- Yaw: Turning left and right

Six Degrees of Freedom

Heave
Roll
Sway
Pitch
Yaw
Surge
Roll
Pitch
Sway
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
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
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

2011 Razer Hydra

2018 Magic Leap One
Magic Leap

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.
Ultrasonic Tracking
Ultrasonic Tracking

Systems measure duration of an ultrasound signal to reach microphones.

InterSense system uses combination of ultrasound and gyroscope.

Problems with echoes from walls, people, objects in tracking space.
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
Xsens Motion Tracking

Long range motion tracking

Version
Lyra suit

Trackers
17 Wired

Motion data
Lab quality

Setup time
10 minutes

Latency
20 ms

Battery management
One battery

On-body recording

Wireless data link
One Access Point for Multiple persons

Wireless range Indoor/outdoor
50/150 m (150/450 ft) Extendable

On-body buffering
10 m

Internal update rate
1000 Hz

Output rate
240 Hz

Accessibility
Lyra suit, 5 sizes

Battery life
9.5 h

Portability
Suitcase

Validated

Validator