Virtual Reality Technology and Programming

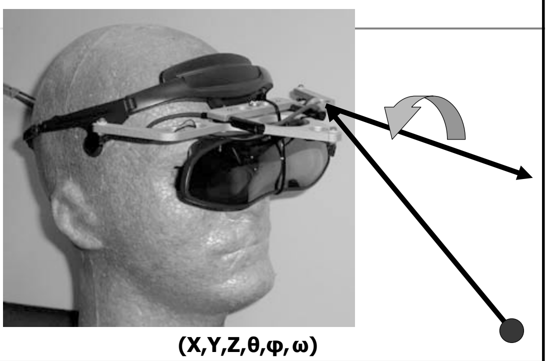
TNM053:

Lecture 5: Tracking and I/O devices

Tracking devices

- Referred to ‘head-tracking’ many times
  - Needed to get good stereo effect with parallax
  - Essential for HMD’s as well.
  - And for Augmented reality
- Devices to locate a point in 3D
  - Immediately – sample rate (latency)
  - Continuously – refresh rate
- Also want to Orientate:
  - In 3D space
  - In other degrees of freedom

6 Degrees of freedom



(X,Y,Z,θ,φ,ω)

Important features

- Accuracy
- Latency
  - Immediacy of the data
- Update Rate
  - Frequent samples
- Range
  - Affects the suitability for uses

Types

- Mechanical
- Ultrasonic
- Inertial Navigation Systems
- Electromagnetic
- ‘Vision’-based
- GPS?

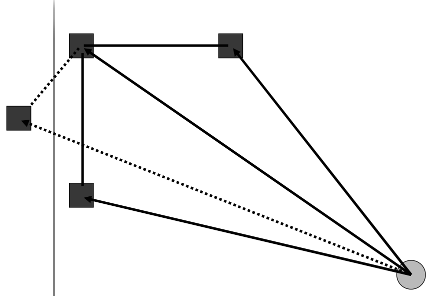
Mechanical devices

- Consists of an armature
- Electro-mechanical devices measure angles
  - Optical devices
  - Electrical potentiometers
- Compute position (and orientation) using known lengths and angles
- Not very good for head tracking

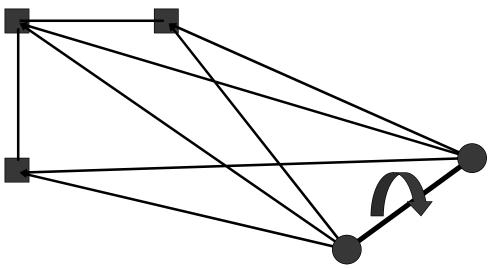
Ultrasonic trackers

- Lots of types
- Use mobile ultrasound emitters
  - Can be battery powered
- Multiple Pick-ups:
  - Minimum of 3
  - More helps to avoid occlusion

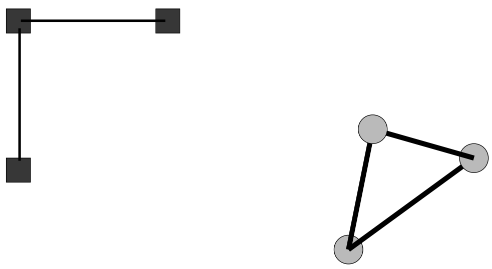
Ultrasonic tracking (3dof)



Ultrasonic tracking (5dof)



Ultrasonic tracking (6dof)



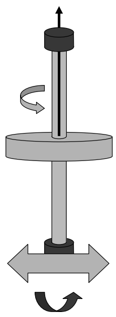
Ultrasonic trackers: Summary

- Relatively cheap
- Light
- Quite accurate in 3 dof
- Often not so good in 5 (or 6) dof
  - Need wide separation of emitters
  - Reduced sample rate

Inertial Navigation

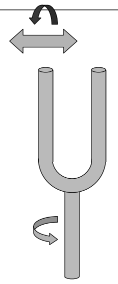
- Measures acceleration
- Measures rate of rotation
- Requires initialization
  - Typically based on assumption
  - Possibly fixed point
- Drifts over time
  - Small errors, if not random, accumulate

Gyroscopic tracking

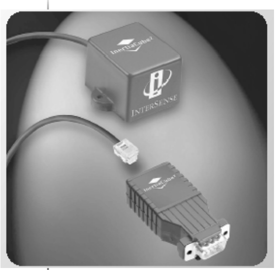


Modern 'Gyroscopic' tracking

- Smaller
- Quieter
- No moving parts
  - No wear



Inertial tracking: InterSense InertiaCube2



Box contains:
  - 3 orthogonal gyros
  - 3 linear accelerometers
- Support hardware does the integration
- Also magnetic sensors
  - avoid error build-up

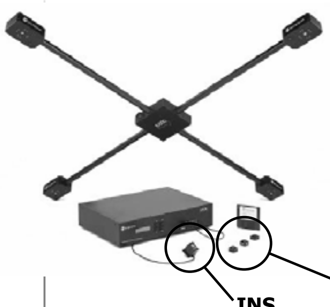
Inertial tracking

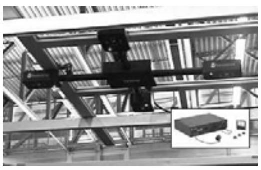
- Fairly fast results (latency)
- Fast sampling (180Hz to 90Hz)
- No interference
- No occlusion
- Not accurate enough
  - Accumulates error
  - 0.1° per second error
  - Similar error in distance movement
- Hence hybrid devices

Hybrid tracking

- Ultrasound/Inertial
  - Ultrasound provides updates and error correction
  - Doesn't rely entirely on either
- May rely on magnetic fields as well
  - Passive sensors pick up earth field
- E.g. InterSense devices in lab

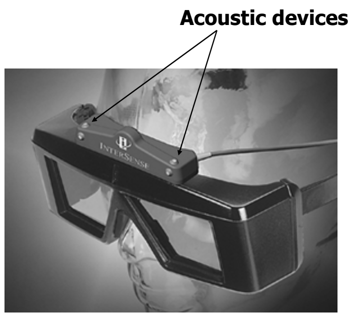
Hybrid tracking: InterSense IS600 mk2





Hybrid tracking: InterSense IS900IT

Hybrid head trackers: InterSense 900 MiniTrax



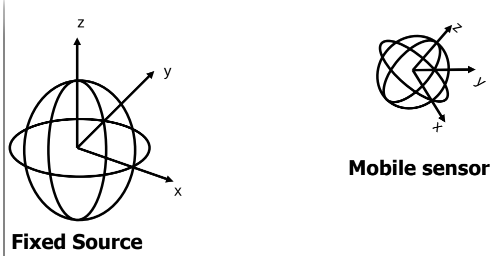
Hybrid head trackers

- Latency
- Sample rate ~180Hz
  - Divided by number of 'stations'
  - Station = three emitter set
- Accuracy:
  - ±4mm, ± 0.5° (RMS error)
- Coverage ~25 square metres

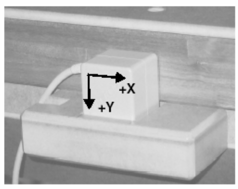
Electromagnetic

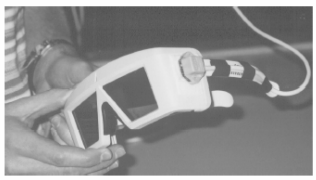
- Use a source and small detectors
- Multiple detectors per system
  - Typically 4-16
- Signal produced in three planes
- Detected in three planes
- Typically medium range (<10 metres)
- Suffers from interference

Electromagnetic trackers



Polhemus FastTrack





Polhemus trackers

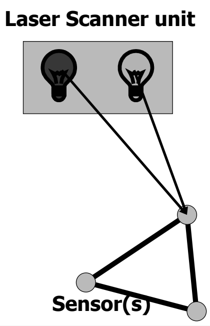
- Latency ~4mS
- Sample rate: ~120Hz
  - Each receiver unit functions independently
  - Same sample rate regardless of number of detectors (if the hardware supports it)
  - usually use 2-4
- Accurate!
  - ±0.07mm, ± 0.15° (RMS error)
- No Accumulation of errors

Laser tracking

- Fixed laser sources
- Mobile detectors receive signal
- Compute position at three points
  - Like ultrasound, fast processing required
- Compute 6DOF from three points

Laser Tracking: Ascension laserBIRD

- Two source ‘scanner’
- Three point sensor
  - Fitted to headset
- Uses stereo ‘vision’
  - Gives 3D position of sensors



Laser tracking: Ascension laserBIRD

- 6 DOF
- 240 Hz sampling rate
- Quite accurate:
  - ±1mm, ±1° (RMS error)
- No interference
- Suffers from occlusion

Laser tracking: Ascension laserBIRD

Optical tracking

- New in the last couple of years.
- ‘Vision’ systems used to track moving objects automatically
- Like motion-capture for film industry
- Works in the infra-red

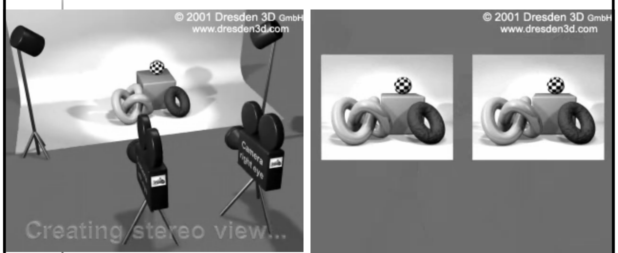
‘Optical’ tracking: markers

Optical Tracking: Cameras

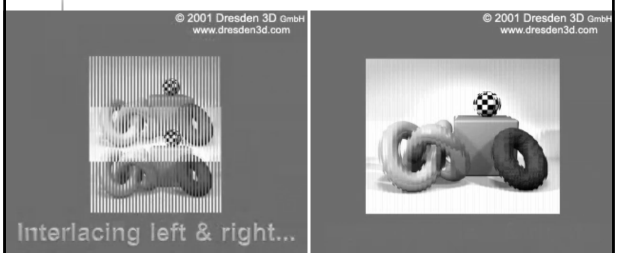
Image based

- Uses limited face-recognition to track head
  - Actually tracks eyes
- Determines position of head
- Adjusts display accordingly
- Not common
  - Primarily used in display technology
  - E.g. i2i D4D display

i2i - D4D display: Taking the image



i2i - D4D display: Processing the image



i2i - D4D display: Displaying the image

Eye surgery at the University of Münster

Head Tracking: Summary

- Mechanical – not used much
- Ultrasonic
- Inertial
  - hybrid
- Electromagnetic
- Optical – Getting popular
- Laser – not common yet
- Vision – very specialized

(Inertial, Electromagnetic) — No occlusion

What to use and why:

- Electromagnetic
  - Most accurate
  - Expensive
  - Can't use everywhere
    - Interference issues – Maybe with iron?
    - Hospitals
- Hybrid inertial/acoustic
  - Quite accurate
  - cheaper

Common Problems with tracking hardware

- Tracking
  - Linearity
  - Latency
  - Noisy signals
    - Frequently need filtering
- Cables!
  - Becoming less of a problem through wireless technologies

Virtual Reality Technology and Programming

TNM053:

Lecture 5.5: I/O devices

I/O Devices

- Important aspects:
  - Degrees of Freedom (DOF)
  - Precision
  - Latency
  - Long Term usage effects
- Mouse – 2 to 6 DOF
- Wand – 5 DOF
- Joysticks – 6 DOF
- Glove – Hand 'gestures'
- Suit – Body 'gestures'

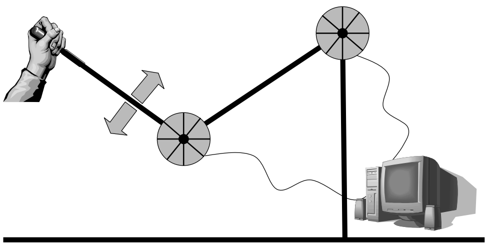
Tracking

- All the same methods apply
  - Attach sensor(s) to object
  - it's an interactor
- Mechanical tracking is more common

Mechanical tracking

- Consists of an armature
- Electro-mechanical devices measure angles
  - Optical devices
  - Electrical potentiometers
- Compute position (and orientation) using known lengths and angles
- Commonly used in adapting tools

Optical detectors



Optical detectors

- System always knows position
- Can be extremely accurate
- Little 'wear and tear'
- System has to be initialized
  - Bring to a fixed point and start system
  - If it loses position it's useless
- Requires expensive parts

Potentiometers

- Similar but with different properties
- No Initialization required
  - Voltage gives immediate position
- Can be much cheaper to build
- Parts more prone to wear out
- Can't easily rotate through zero
  - Problem with the shoulder?

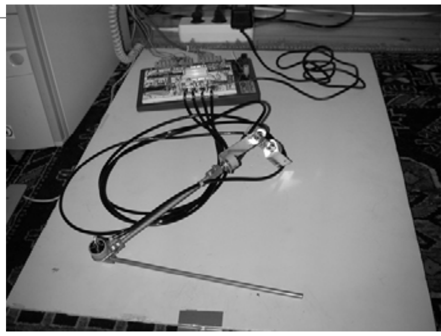
Mechanical devices

- Relatively cheap
- Can be extremely accurate
- Gives better quality signal
  - Little or no noise
  - Avoids need for filtering

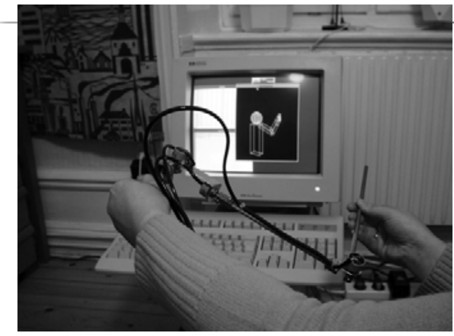
Stefan's 'Monkey'

- Home-built 3D position device
  - Designed with motion capture in mind
  - Represents a humanoid arm
- Three stage armature (with 'shoulder')
- Four potentiometers
  - Three in the 'shoulder'
  - One in the 'elbow'

Stefan's 'monkey' (2)



Stefan's 'monkey' (3)



Stefan's 'monkey' (4)

- Presented at SIGGRAPH 2002
  - "Motion Capture Done Dirt Cheap"
- Total cost ~$300
  - Provides for up to 16 potentiometers
  - Add $10 for each extra potentiometer
- http://www.itn.liu.se/~stegu/monkey/
  - Parts list
  - Circuit diagrams

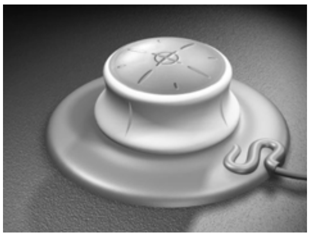
Mouse interaction

- Extension of the 2D mouse
  - Tries to provide 6DOF
- Some attempts to use for interaction
  - Selection of objects
  - Selection of menu options etc.
- Doesn't really work
- Principally useful for navigation

3D Mouse

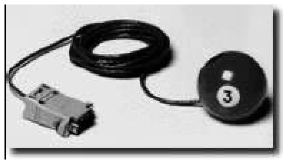
- LogiCAD Magellan SpaceMouse

More Mice



More useful mouse: Polhemus 3Ball

- Provides 3(-6)DOF in a usable package

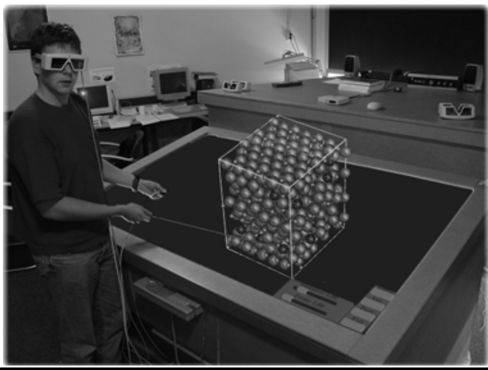


- Actually nothing like a mouse at all

3D Mouse = 'Wand'

- Provides 5DOF (maybe 6)
- Typically used as a pointing device
- Provides buttons for selection
- The 3D equivalent of the mouse

Wand:



Wand: InterSense devices

Geological data analysis at Schlumberger

Wand = Joystick

- 6DOF makes it a joystick
  – Tracking systems used can provide 6
- Allows complex navigation
- Allows wand-like selection

Joystick devices

Virtual Presence 'SpaceStick'

- Polhemus device
- Made from game joystick
  - Quite literally!

Gloves

- Hand position tracking
- Also track finger positions
  - Allows for 'gestures'
  - Allows for picking up objects

Gloves: Hand tracking

IS900 MiniTrax Hand tracker

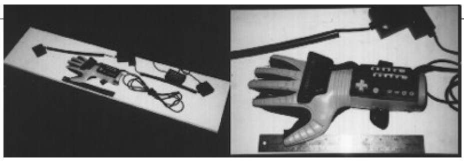
Gloves: Finger tracking

Optical fibres measure bend of the finger

Gloves

- Of limited availability due to cost
- Tracking devices already available
  - Not the source of the cost
- Optical fibres and sensors
  - Very expensive technology
  - Not much demand
  - Very expensive devices

Gloves: Done cheap



- MATTEL (NES) PowerGlove
- Produced in 1989-1991
- Cost $99 originally
- Now cost ~$40 (on ebay)

Gloves for the user

- Can use as a wand or joystick
- Can use 'hand gestures' – flex fingers
  - To select objects
  - To call up menus
- Can interact with virtual objects in the scene
  - Can't feel them of course

Suits

- Extension of the data glove
- Use trackers and flexion detectors
  - Monitor whole body position
- Mostly used for motion capture
  - Can be used interactively
  - Can use 'body gestures' to interact

Suits - Mechanical: Metamotion Gypsy

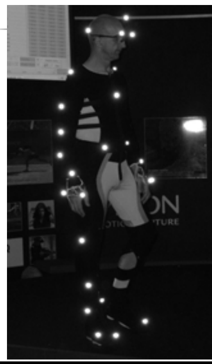
Gypsy Jr – Upper body

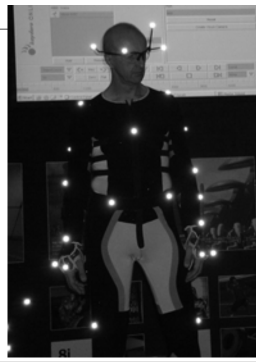
Gypsy 3 – Whole body

Suits – e/m tracking: Ascension MotionStar

Real Time e/m tracking

Optical tracking: Full Body





Summary

- A dazzling array of toys to play with
- Any tool you want can be made virtual
  - Adding tracking can be quite cheap…
    - …as long as you already have it
  - Adding optical or e/m sensors is easy
  - Building kit is not hard or expensive
- Working out how to interact is hard