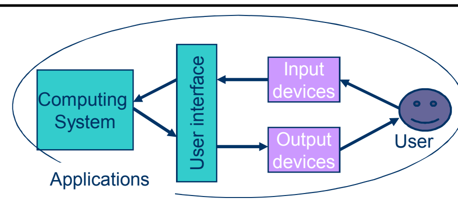
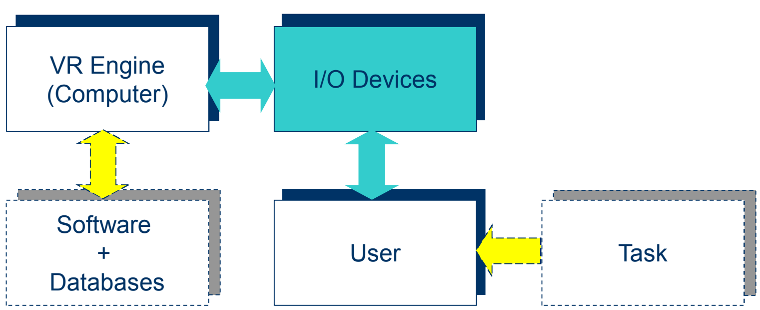
ENSF 545
Introduction to Virtual Reality

Input Devices

A VR System





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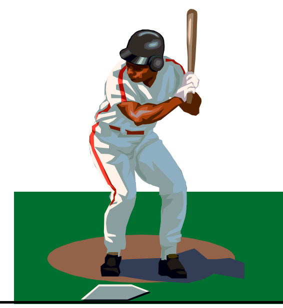
What is *VR*?

- A high-end user interface that involves real-time simulation and interaction through multiple sensorial channels.
  - Vision
  - Sound
  - Touch
  - Smell
  - Taste

Object



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Input Devices for VR

- Trackers
  - mechanical, magnetic, optical, ultrasound, hybrid inertial, vision-based
- Navigation interfaces
  - cubic mouse, trackball, 3D probe
- Gesture interfaces
  - pinch glove, data glove, cyberGlove

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Trackers

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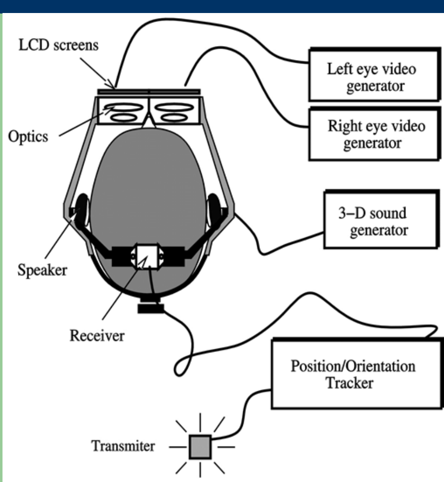
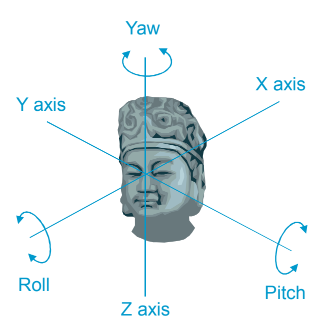
Trackers





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Tracker Characteristics

- Measurement accuracy (errors)
- Sensor noise and drift
- Sensing latency
- Update rate – Readings/sec
- Measurement repeatability
- Tethered or wireless
- Work envelope
- Sensing degradation

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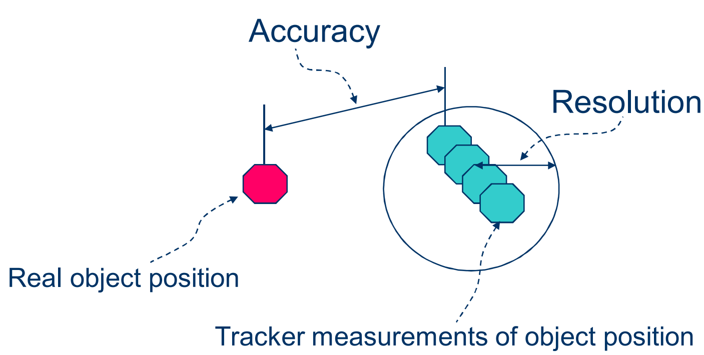
Tracker Accuracy



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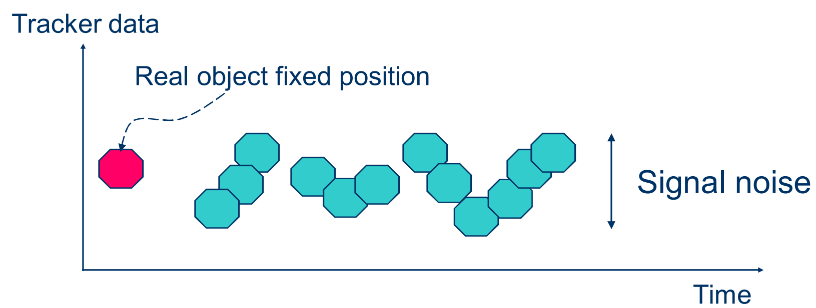
Tracker Noise



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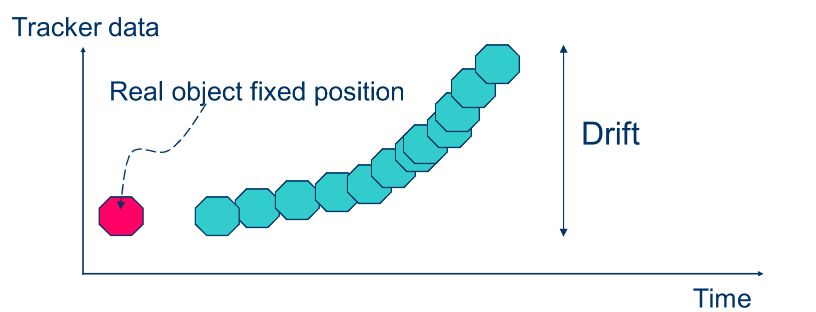
Tracker Drift



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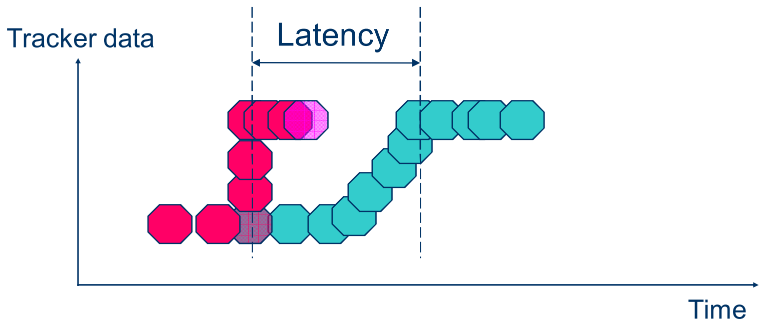
Tracker Latency



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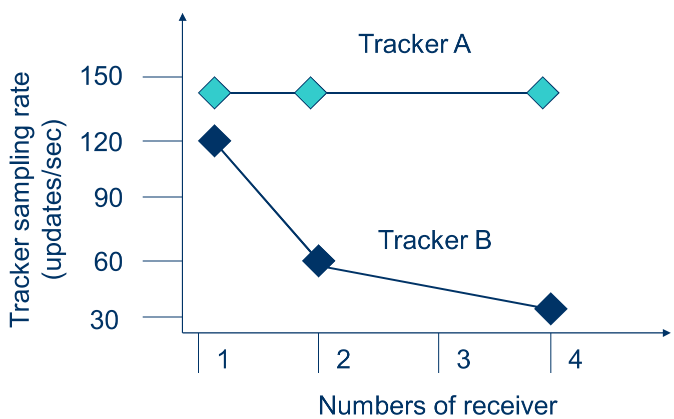
Tracker Update Rate



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Mechanical Trackers

A serial or parallel *kinematic structure* composed of links interconnected using *sensorized* joints.

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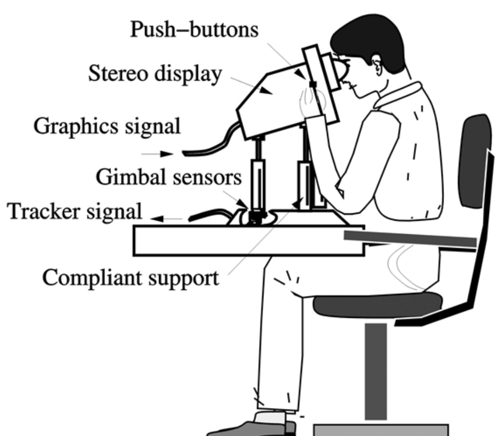
Mechanical Trackers



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Push 1280 (Fakespace Inc)

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Mechanical Trackers - Pros + Cons

- Measure position using imbedded sensors
- Have extremely low latency
- Be immune to interference from magnetic fields

- Constrain the user's freedom of motion
- Can be heavy if worn on the body

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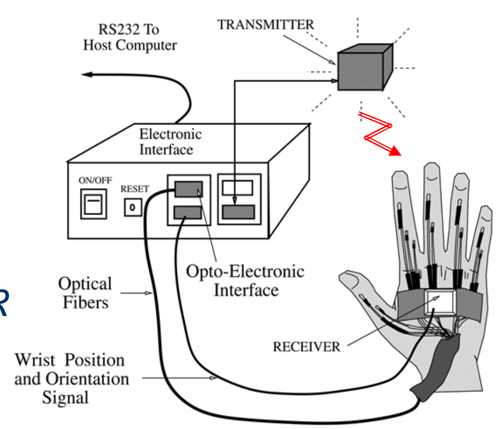
Magnetic Trackers

- A magnetic field produced by a stationary *TRANSMITTER* to determine the real-time position of a moving *RECEIVER* element.
- AC + DC trackers.



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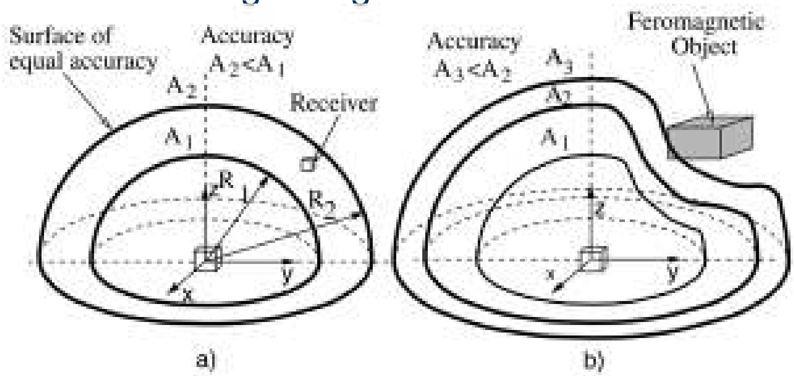
Accuracy Degradation

- Errors in position and orientation
- Size of errors growing from source outwards



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Magnetic Tracker Errors

- Due to ambient noise:

  $e_{ambient} = K_n \, (d_{transmitter\text{-}receiver})^4$

- Due to metal:

$$e_{metal} = \frac{K_r \, (d_{transmitter\text{-}receiver})^4}{(d_{transmitter\text{-}metal})^3 \times (d_{metal\text{-}receiver})^3}$$

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Magnetic Trackers - Pros + Cons

- Measurement in 6 DOF ← low-frequency magnetic fields
- Fields ← a fixed transmitter
- A tracked object ← the receiver

- Larger work envelop → larger transmitter
- Distance → the voltages induced in the receiver (coils) → calibration…

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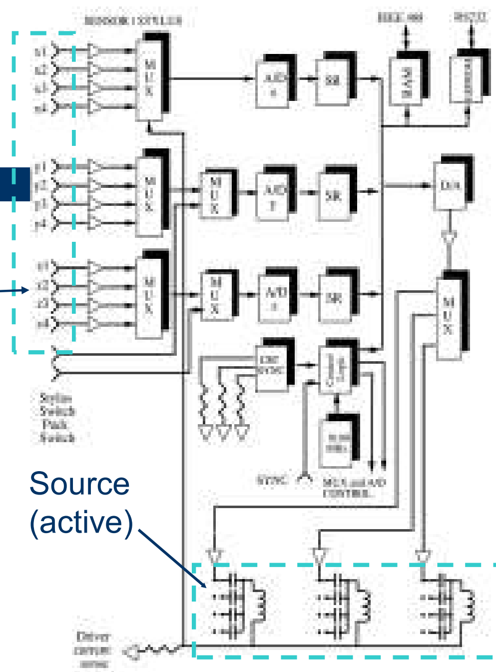
AC Tracker - Fastrack

Sensors (passive)



Source (active)

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AC Tracker - Wireless

Polhemus - PATRIOT

Polhemus - Liberty LATUS

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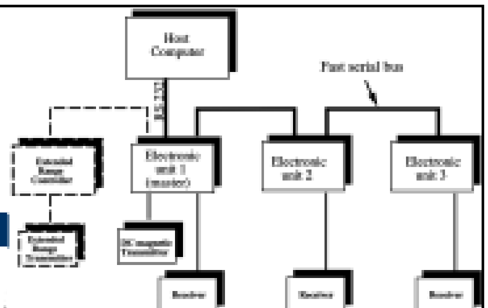
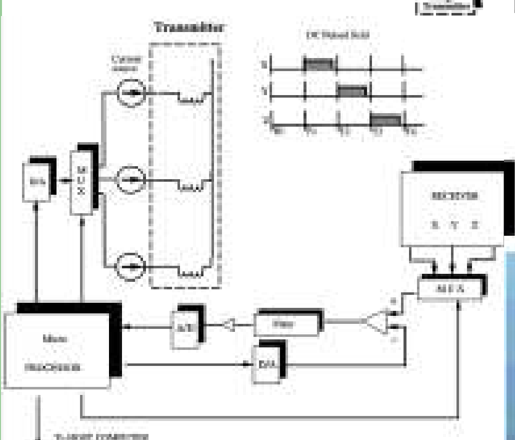
DC Tracker - Flock of Birds





Tracker @ iCentre

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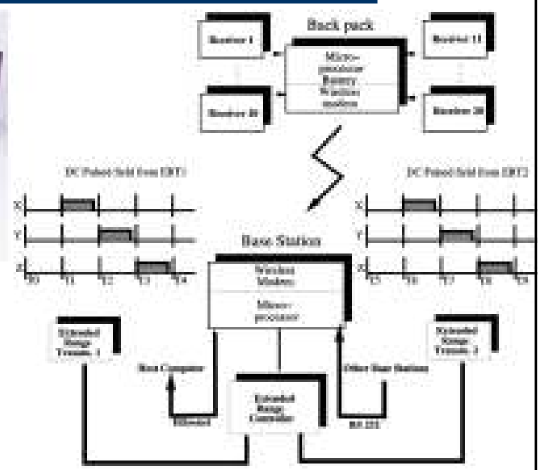
DC Tracker - Wireless

Ascension Technology



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Comparison - Trackers: AC vs. DC

	AC	DC
Non-ferromagnetic metals (aluminum, brass, stainless steel)	affected	immune
Ferromagnetic metals (mild steel, ferrite) and copper	affected	affected
Resolution and accuracy	better	OK
Work envelop	smaller	OK

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Trackers: AC vs. DC

Table 2.1 Performance comparison: Fastrack vs. Flock of Birds

SPECIFICATION	FASTRACK	FLOCK OF BIRDS
Operation radius: normal extended	 0.75 m (30") 2.25 m (90")	 1.2 m (48") 3 m (120")
Angular range	all-attitudes	±180° Azimuth & Roll ±90° Elevation
Transl. accuracy	0.03" RMS	0.1" RMS
Transl. resolution	0.0002"/inch range	0.03" RMS
Angular accuracy	0.15° RMS	0.5° RMS
Angular resolution	0.025° RMS	0.1° RMS at 12"
Update rate (measurements/sec)	120 (one receiver) 60 (two receivers) 30 (four receivers)	144 (up to 30 receivers)
Latency (msec) (single receiver)	8.5 (no filtering)	7.5 (no filtering)
Metal Interference	Ferrite Mild Steel Copper Stainless steel Brass Aluminum	Ferrite Mild Steel Copper
Interface	RS-232 (selec. baud rates to 115,200 or IEEE-488 up to 100 kbaud/sec)	RS-232 (selec. baud rates to 115,200) or RS-422/485 (selec. baud rate to 500,000)
Data format	ASCII of Binary	Binary
Modes	Point or stream	Point or stream

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Optical Trackers

- Optical sensing to determine the position and orientation of a moving object in real time

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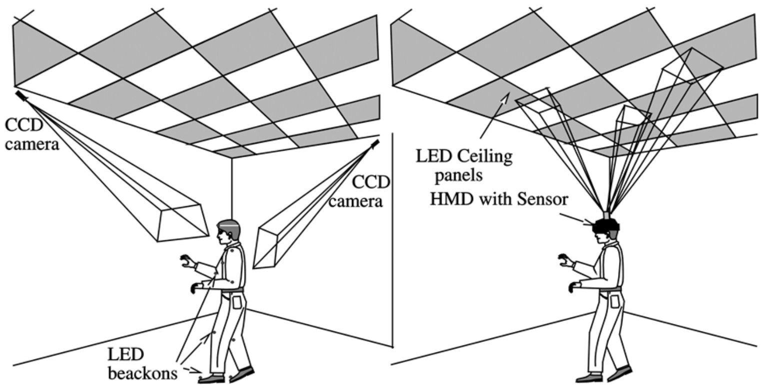
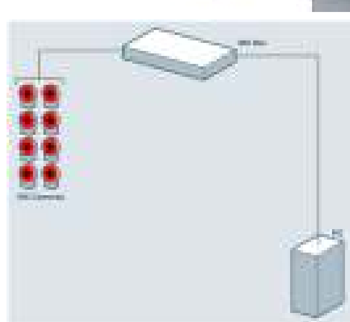
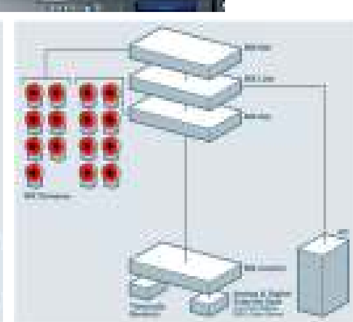
Two Major Configurations

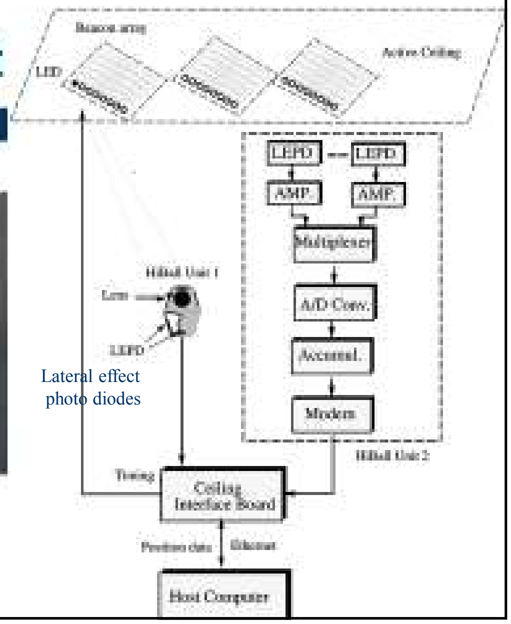


Outside Look-in - Vicon MX





Inside Look-out



HiBall 3000

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Magnetic and Optical Trackers

	Magnetic	Optical
Degrees of freedom	6	3,3(interpret)
Metal effects	yes	no
“Light-in-sight”	no	yes
Sampling rate and accuracy	<150sets/s ~1.0 mm	>500sets/s ~0.5 mm
Work envelop	small	large

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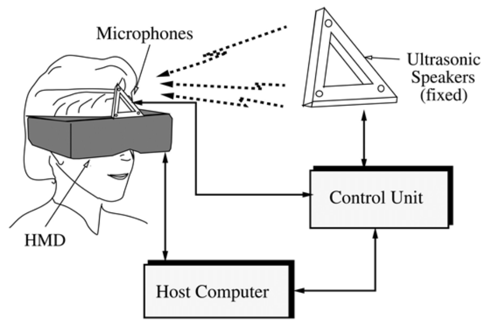
Ultrasonic Trackers

- An ultrasonic signal produced by a stationary transmitter to determine the real-time position/orientation of a moving receiver.



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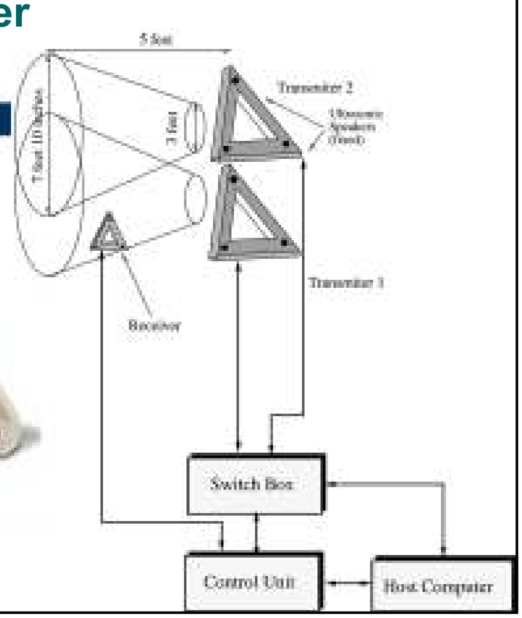
Ultrasonic Tracker - Large Volume



Logitech

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Ultrasonic Trackers (Pros + Cons)

- Position ← low-frequency ultrasound
- Sound ← a fixed triangular source (speakers)
- A tracked object ← a triangular receiver

- Larger work envelope → more sources
- Distance → the sound time of flight
- Accuracy → air temperature and noise sources
- Tracking → “direct line of sight”

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Hybrid Trackers

- Combining 2 or more technologies to track object better than a single technology would allow
- Inertial / ultrasonic
- Inertial / vision

- **Inertial trackers**: self-contained sensors that measure the rate of angular change in an object orientation
  - Gyros

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Hybrid Tracker – IS 900

Sonic Strips

I-cube Accel./gyro

Base Unit

I-cube Accel./gyro

Ultrasonic Emmitter

Intersense Co.

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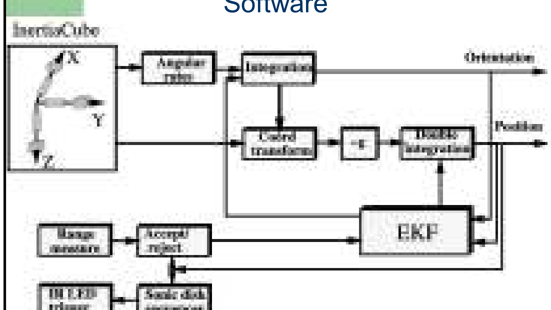
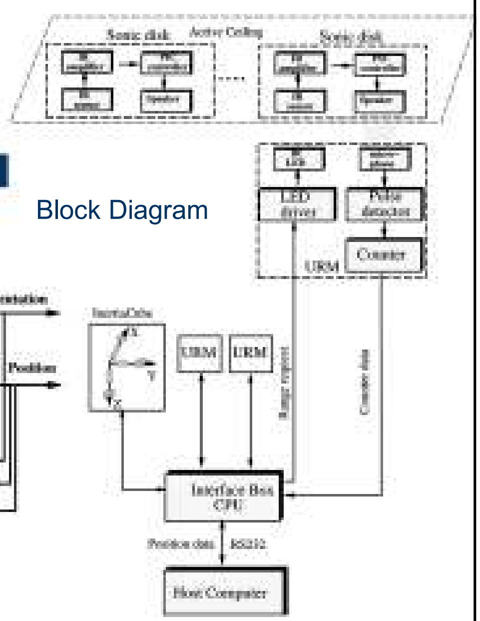
Hybrid Tracker - IS 900

Block Diagram

Software





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Inertial / Ultrasonic Trackers (Pros + Cons)

- Metallic objects + magnetic fields ← no interference
- Tracking ← large-volume + full room
- Orientation tracking ← “source-less”

- Accelerometer errors → decreased accuracy
- Time elapses → errors grow
- Gyroscope errors + position errors → worse, calibration

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Hybrid Tracker – Inertial / Vision

IS 1200

Fiducials

InertiaCAM fixed-focus lens

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Performance Comparison

Table 2.2 Performance comparison of various trackers

ACCURACY (mm/°)	RANGE (m)	LATENCY (sec × 10^-3)	UPDATE RATE* (datasets/sec)
		Best performance	
0.5/0.05 HiBall	30 × 30 IS-900	0.0002 Pinch	2,000 HiBall
0.3/0.15 Fastrack	12.2 × 12.2 HiBall	1 HiBall	278 InterTrax2
1/0.5 laserBIRD	2 laserBIRD	4 InterTrax2	240 laserBIRD
2/0.5 Flock BIRDS	1.52 Logitech	7 laserBIRD	180 IS-900
4/0.2 IS-900	1.2 Flock BIRDS	7.5 Flock BIRD	160 3-D BIRD
4/N/A Pinch	0.75 Fastrack	8.5 Fastrack	144 Flock BIRDS
N/A/4 3-D BIRD	N/A 3-D BIRD	10 IS-900	120 Fastrack
N/A/5 Intertrax2	N/A Intertrax2	15 3-D BIRD	70 Pinch
50 Logitech	N/A Pinch	30 Logitech	50 Logitech
		Worst performance	

* For single receiving element

Navigation Inputs

Navigation Input Devices

- Allow the interactive change of the view to the virtual environment and the exploration through the selection and manipulation of a virtual object of interest.
  - Position/velocity control of virtual objects
  - Either absolute or relatives coordinates
  - Cubic Mouse, Trackball, 3D probe

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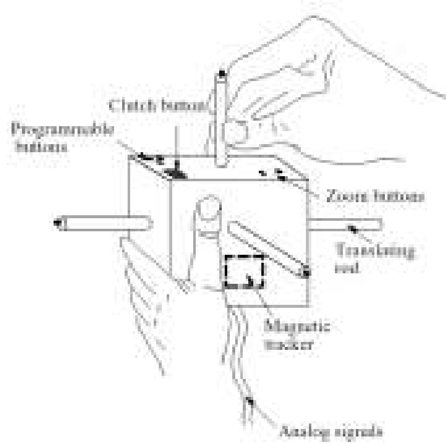
3D Cube

Wand @ iCentre

Magnetic
tracker



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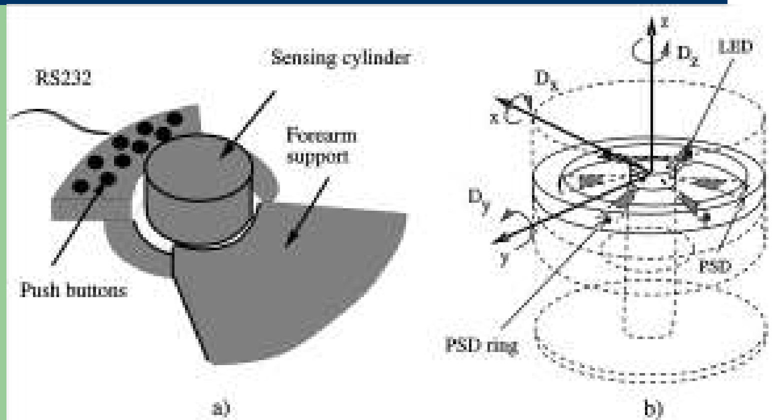
Trackball



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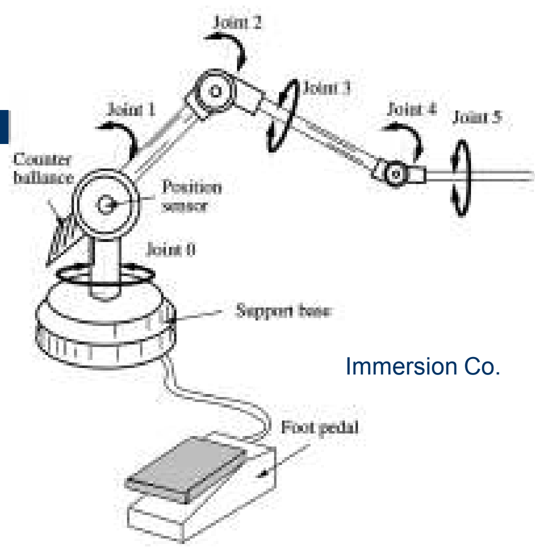
3D Probe

SensAble PHANToM



Immersion Co.

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Gesture Inputs

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Gesture Input Devices

- Allow dextrous control of virtual objects and interaction in real time through gesture recognition
  - Larger work envelope than trackballs, 3D probes
  - Calibration for user's hand needed
  - Sensing gloves: Pinch Glove, 5DT Data Glove, DG5 glove, CyberGlove

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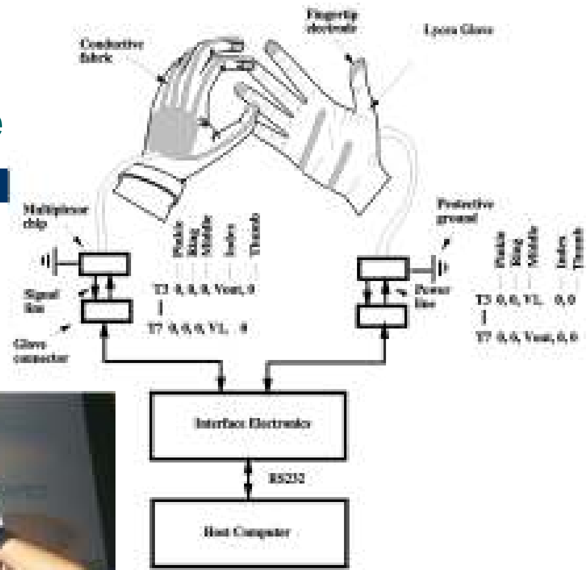
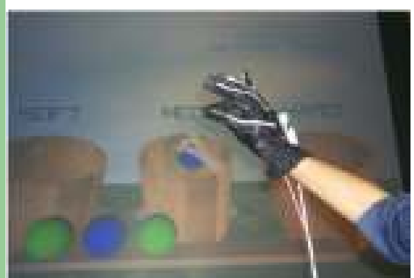
Pinch Glove



Fakespace



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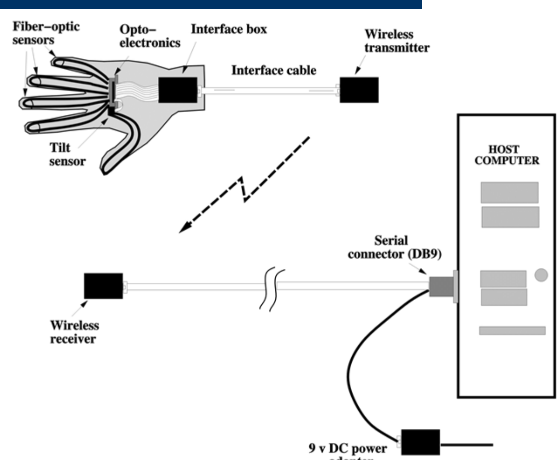
5DT Data Glove

5 sensors

14 sensors



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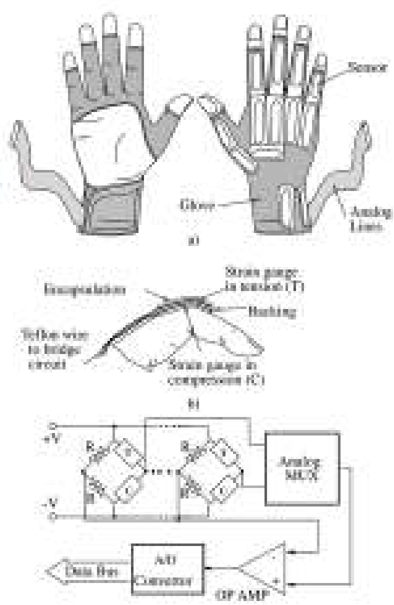
DG5 Glove + DG5 VHand Glove 2.0

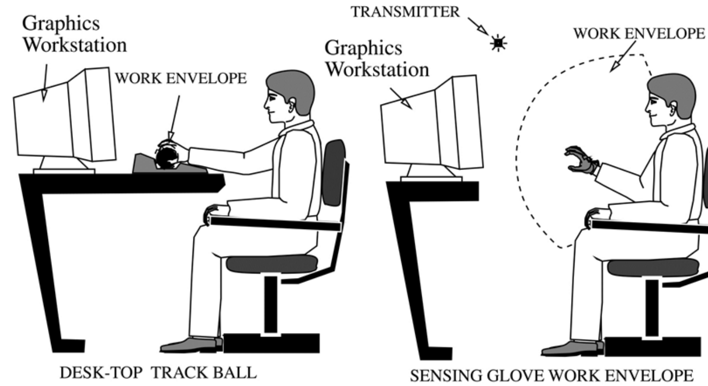
- Angles ← Voltages
- Sensor resolution 10 bit
- Needs calibration
- Less expensive (< $1000)

DG5 Vhand Glove 2.0

Cyber Glove



Comparison of Work Envelop



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Comparison of Gloves

Specification	**Pinch Glove**	**5DT Data Glove**	**DG5 Glove DG5 VHand**	**CyberGlove**
Number of sensors	7 / glove (2 gloves)	5 or 14 / glove (1 glove)	5 / glove (1 glove)	18 or 22 / glove (1 glove)
Sensor type	Electrical	Fiber-optic	Ink film	Strain gauge
Record/sec	N/A	100(5DT 5W), 200(5DT 5)	100 25 (VHand)	150(unfiltered) 112(filtered)
Sensor resolution	1 bit (2 points)	8 bits (256 points)	10 bits (1024 points)	0.5º
Communication rates	Wired (19.2 kb)	Wired(19.2kb), Wireless(9.6kb)	Wired(19.2kb) Wireless (VHand)	Wired (115kb)
Wrist sensors	None	Pitch (5DT 5)	Accelerometers (VHand)	Pitch and yaw

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Conclusion + Recap

- All input devices aim at capturing the user's input in real time and transmitting the input to the host computer running simulation.

- Trackers
- Navigation interfaces
- Gesture interfaces

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