Input Devices: Tracking
An Ultrasonic Tracker is a non-contact position measurement device that uses an ultrasonic signal produced by a stationary transmitter to determine the real-time position/orientation of a moving receiver.
Ultrasonic Trackers

- Use low-frequency ultrasound to measure position
- Sound produced by a fixed triangular source (speakers)
- Number of sources grows with the tracker work envelope
- The receiver is triangular and attached to the tracked object and has three microphones
- Distance is inferred from the sound time of flight
- Sensitive to air temperature and other noise sources
- Requires “direct line of sight”
- Slower than magnetic trackers (max 50 updates/sec)
Ultrasonic tracker (Logitech)
Large-volume ultrasonic tracker (Logitech)
An Optical Tracker is a non-contact position measurement device that uses optical sensing to determine the real-time position/orientation of an object.
Point of View

Outside, looking in

Inside, looking out

CCD camera

LED beacons

LED Ceiling panels
HMD with Sensor
Outside Looking In: LaserBIRD
LaserBIRD

- The two beams are offset
- The three vertices are computed based on known offset, geometry and angular velocity of the beams
- The average of the three vertices is computed and sent to the host at 240 sets/sec
- Range is 2 m latency smaller than that of magnetic trackers
Vicon MX

- Uses 4 Mpixel cameras with own 120 LED array (infrared, or visible red). Accuracy 0.02 of a pixel,
- Camera has real-time onboard image processing (masking and thresholding
- Resolution 2352x1728 @ 160 fps
- 8 cameras are connected to a MX net unit which then communicates with the PC
Vicon MX

- **MX Link** connects several **MX Net** units for more cameras
- To interface with other devices like a force plate, sensing glove or eye tracker – use a MX control unit
Advantages (Inside-out)

- The best accuracy is close to the work envelope
- Very large tracking surface and resistance to visual occlusions (line of sight)
HiBall 3100 Tracker

- High sampling rate (2000 Hz, 1000 Hz for 2 sensors, 500 Hz for 4)
- High accuracy (0.4 mm, 0.02°) and high resolution (0.2 mm, 0.03°)
- Impervious to metallic or ultrasonic interference
- Very large tracking area (up to 40 ft x 40 ft), small weight (6 oz)
HiBall on an HMD
VR Applications

Beacon array modules
(6 strips with 8 LED/strip)
# Hybrid Ultrasonic/Inertial Trackers

- No interference from metallic objects
- No interference from magnetic fields
- Large-volume tracking
- “Source-less” orientation tracking
- Full-room tracking
- A newer technology
Drawbacks

- Accelerometer errors $\Delta a$ lead to decreased accuracy since $\Delta x = \frac{\Delta a t^2}{2}$
- Errors grow geometrically in time!
- Gyroscope errors compound position errors
- Needs independent position estimation to reduce “drift”
IS 900 block diagram
Intersense Hybrid Tracker

- Degrees of freedom: 6
- Resolution: 1.5 mm RMS
- Angular: 0.05 RMS
- Update rate: 180 sets/s max (one station)
- Down to 90 updates/sec for four stations
- Latency 4–10 ms
- Max tracking area: 900 meters$^2$
- (300 strips, 24 hubs)
InterSense Stereo Glasses tracker (courtesy of Intersense Co.)
InterSense Stereo stylus tracker (courtesy of Intersense Co.)
### Table 2.2 Performance comparison of various trackers

<table>
<thead>
<tr>
<th>ACCURACY (mm/°)</th>
<th>RANGE (m)</th>
<th>LATENCY (sec×10^{-8})</th>
<th>UPDATE RATE* (datasets/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5/0.03</td>
<td>30 × 30</td>
<td>0.0002</td>
<td>Best performance</td>
</tr>
<tr>
<td>HiBall</td>
<td>IS-900</td>
<td>Push</td>
<td>2,000</td>
</tr>
<tr>
<td>0.8/0.15</td>
<td>12.2 × 12.2</td>
<td>1</td>
<td>HiBall</td>
</tr>
<tr>
<td>Fastrack</td>
<td>HiBall</td>
<td>HiBall</td>
<td>InterTrax2</td>
</tr>
<tr>
<td>1/0.5</td>
<td>2</td>
<td>4</td>
<td>laserBIRD</td>
</tr>
<tr>
<td>laserBIRD</td>
<td>laserBIRD</td>
<td>InterTrax2</td>
<td>240</td>
</tr>
<tr>
<td>2/0.5</td>
<td>1.52</td>
<td>7</td>
<td>FlockBIRDS</td>
</tr>
<tr>
<td>FlockBIRDS</td>
<td>Logitech</td>
<td>laserBIRD</td>
<td>180</td>
</tr>
<tr>
<td>4/0.2</td>
<td>1.2</td>
<td>7.5</td>
<td>IS-900</td>
</tr>
<tr>
<td>IS-900</td>
<td>FlockBIRDS</td>
<td>flockBIRD</td>
<td>160</td>
</tr>
<tr>
<td>4/NA</td>
<td>0.75</td>
<td>8.5</td>
<td>3-D BIRD</td>
</tr>
<tr>
<td>Push</td>
<td>Fastrack</td>
<td>Fastrack</td>
<td>Push</td>
</tr>
<tr>
<td>NA/4</td>
<td>NA</td>
<td>10</td>
<td>144</td>
</tr>
<tr>
<td>3-D BIRD</td>
<td>3-D BIRD</td>
<td>IS-900</td>
<td>120</td>
</tr>
<tr>
<td>NA/5</td>
<td>NA</td>
<td>15</td>
<td>3-D BIRD</td>
</tr>
<tr>
<td>InterTrax2</td>
<td>InterTrax2</td>
<td>3-D BIRD</td>
<td>70</td>
</tr>
<tr>
<td>30</td>
<td>NA</td>
<td>30</td>
<td>Push</td>
</tr>
<tr>
<td>Logitech</td>
<td>Push</td>
<td>Logitech</td>
<td>Logitech</td>
</tr>
</tbody>
</table>

* For single sensing element

**Worst performance**
IS 120 InertiaCam

- 6 DOF, accuracy 3 mm, 0.1 degree
- Latency 2 ms;
- Requires a minimum of 1 fiducial for every 2 m² at 2 m from camera
- Update rate 120 Hz

InertiaCAM
Fixed-focus lens, on-board DSP
Weight 35 grams
Tracking range 10 m per 10 cm of fiducial diameter