Tracking Technology

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- The problem: where is “stuff” in the real world?
- Some things are fixed and can be modeled
  - Buildings, Roads, props used for your experience
- What about everything else?
  - User: Head, hands, body
  - Mobile objects like chairs and tables
  - Other people
- Most important for AR: user’s head (really, display and eye) *relative* to the physical world being augmented
  - To overlay graphics on world, we need to know the relationships between everything we care about

- *Tracking* refers to keeping track of moving things over time

The Basic Idea

- A device that monitors the location of something

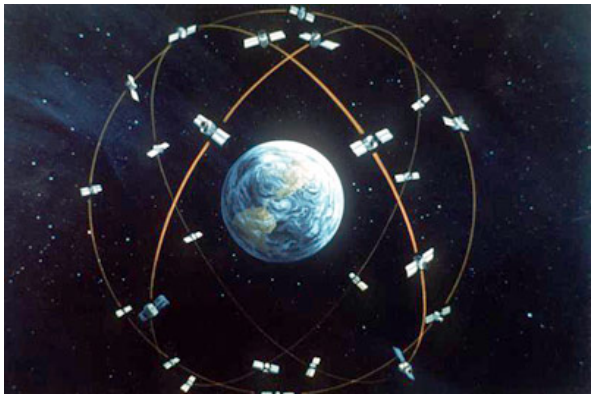
- Absolute location requires a measurement frame
  - Compass, inclinometers (the earth)
  - Computer vision (the center of projection of the camera)
  - GPS (the satellites circling the earth)
  - Magnetic (a controlled electromagnet and a sensor)
  - Ultrasonic (speakers and microphones)
- Relative location typically infers location
  - Accelerometers (sense acceleration, integrate to get motion)
  - Pedometers (count steps, infer distance)

- All subject to error!

Trackers that use Fixed Sources

- Examples
  - UNC/3rdTech HiBall (shown)
  - Intersense IS-600, IS-900
  - Polhemus and Ascension Magnetic Trackers
  - GPS, Magnetic compass
- One component is fixed in known location
  - E.g., LEDs or microphones on ceiling
- Second component location unknown
  - E.g., Hiball camera, speaker
- Typically sense multiple 1 or 2d relationships and triangulate
  - Multiple speakers hear sound, multiple LEDs are seen, multiple satellites are heard

Example: GPS
(www.howstuffworks.com/gps.html)

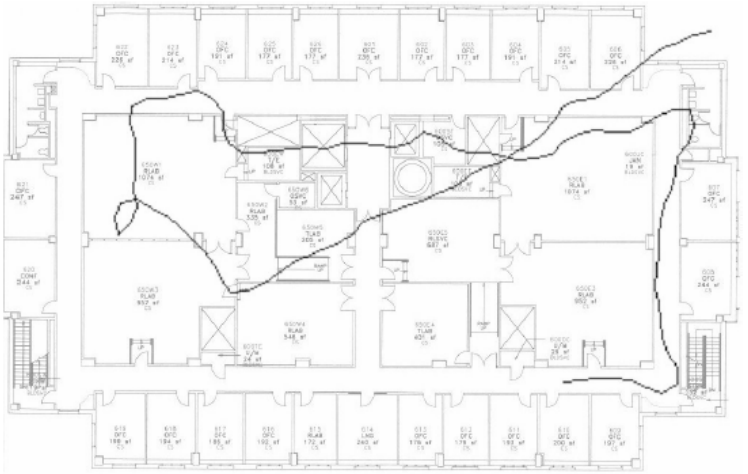


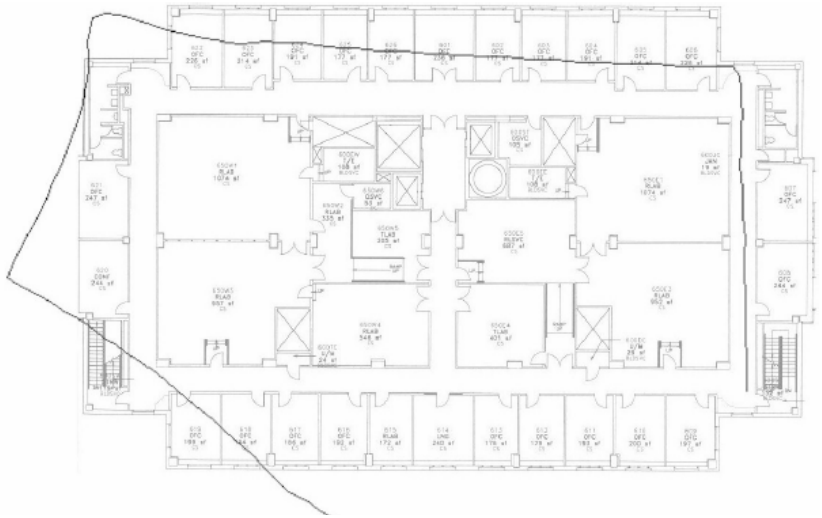
- Receive signal from satellites
  - Estimate distance to each
    - Time of flight (crude)
    - Code decryption (much better)
  - Triangulate multiple signals
- Errors
  - Selective Availability (no longer)
  - Upper atmosphere
  - Clouds, trees, …
  - Multipath effects from signal bounce

- Differential GPS
  - Compute the error is at a know location
  - Apply correction to other receivers (sort of…)

Relative Sensors Accumulate Error

- Even the best sensors become inaccurate over time as errors accumulate
- Can be usefully combined with other information
- E.g., pedometer data from Columbia University





Registration Error: Misalignment of Virtual and Physical World

- A primary source of *static* registration error is tracking error
  - Also Calibration Error of multiple trackers, HMD,…
- Dynamic error is more significant: latency is a killer
  - Internal tracker computation time
  - Communication to computer
  - Updating of graphics state, rendering on screen

- Much more serious in optical- than video-see-through
  - Can delay video to match other latency if needed!
    - Jacobs, M., Livingston, M. A., and State, A. (1997) "Managing Latency in Complex Augmented Reality Systems." In Proceedings of 1997 Symposium on Interactive 3D Graphics, Providence, RI, April 27-30, 1997, pp. 49–54.

Tracking tech you might use

- GPS (Differential WAAS)
  - 1-2m best case, 2-4m typical case, 10m+ often
- Orientation
  - Fused phone sensors (accel, mag, gyro)
  - Better commercial ones: Intersense Inertiacube/Motionnode
    - High accuracy orientation sensor
- Planar Image or b&w marker tracking
  - Relative to camera, multiple at a time
  - Build more complex objects in fixed relationships, sometimes

- Other devices in AEL (might be available)
  - Intersense trackers (Inertiacube, IS-600, Vistracker)
  - More accurate GPS (40-90cm)