증강현실

(2023. 10. 11.)

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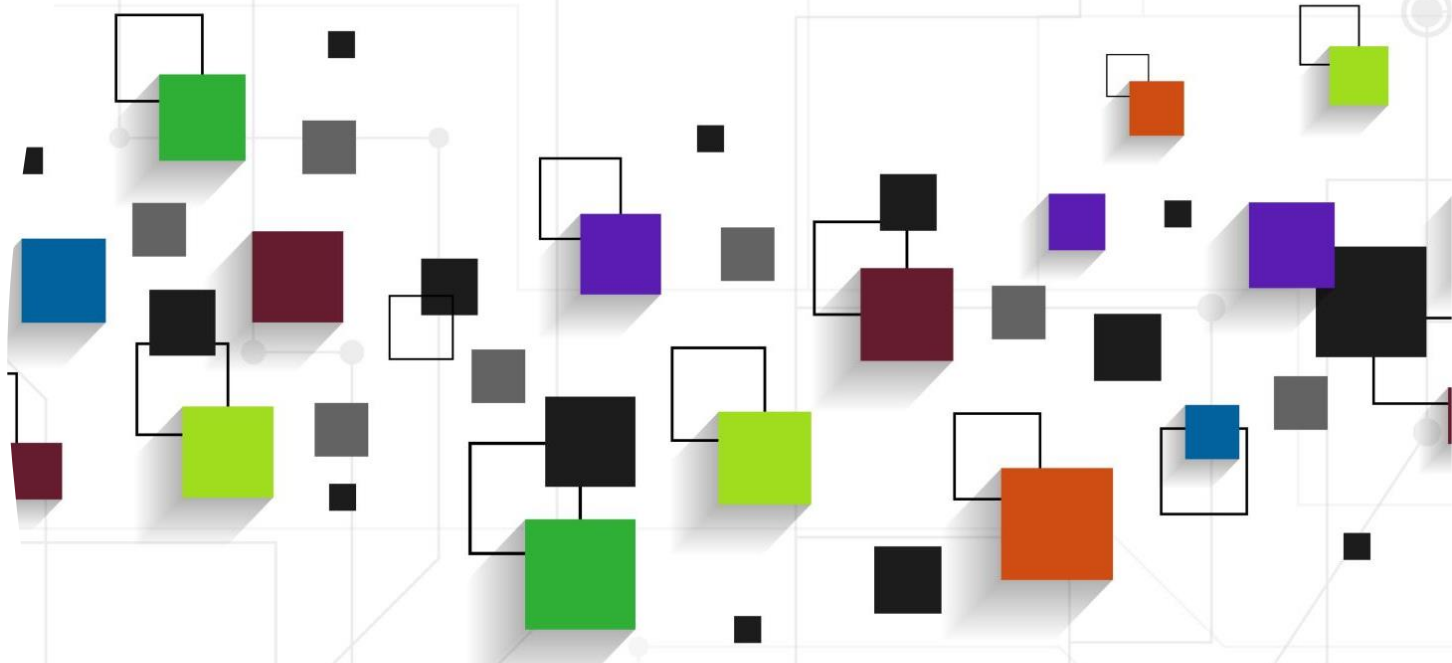
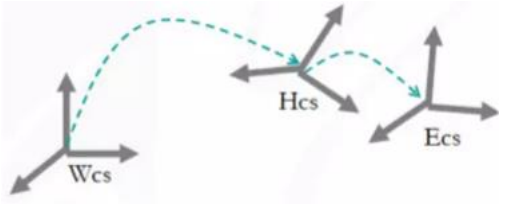


AR Tracking

AR Requires Tracking and Registration

✓Registration

- Positioning virtual object wrt real world
- Fixing virtual object on real object when view is fixed



✓Calibration

- Offline measurements
- Measure camera relative to HMD

✓Tracking

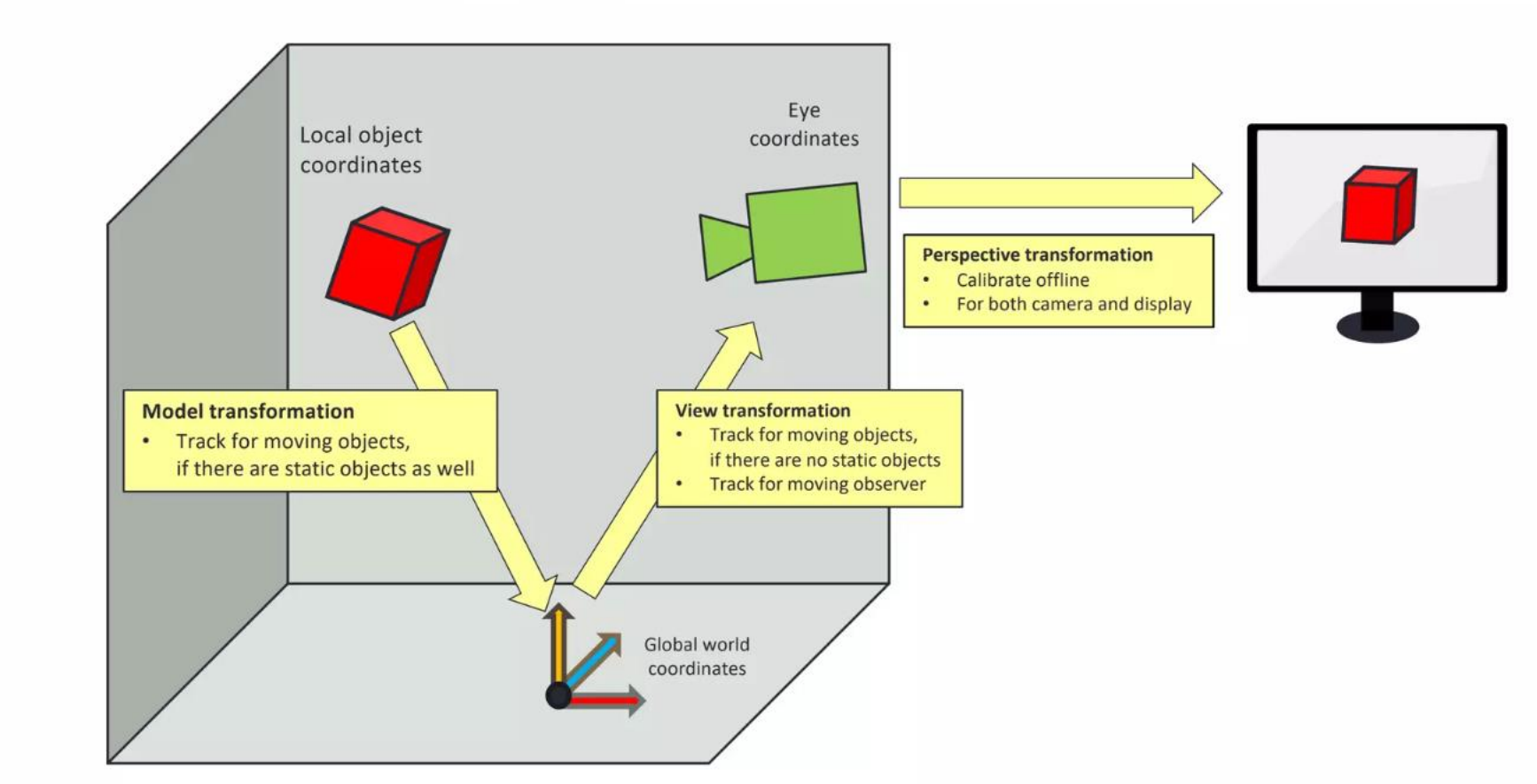
- Continually locating the user's viewpoint when view moving
- Position (x, y, z), Orientation(r, p, y)

Tracking Requirements

✓Augmented reality information display

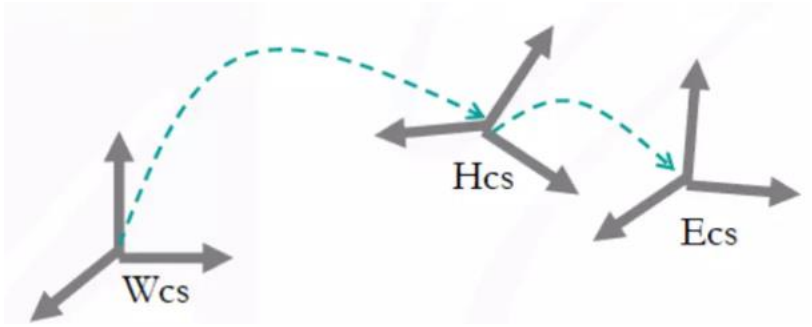
- World stabilized
- Body stabilized
- Head stabilized

Coordinate Systems



Spatial Registration

- ✓Define relative position of each elements of a scene
- ✓Elements: User, user's eye, environment (e.g., table, room, building), objects, etc.
- ✓Initially: calibration
- ✓3D/6D tracking



Wcs: World coordinate system
Hcs: Head coordinate system
Ecs: Eye coordinate system

Registration Problem

✓Virtual and real content must stay properly aligned

✓If not aligned properly

- Break the illusion that the two coexist
- Prevent acceptance of many serious applications

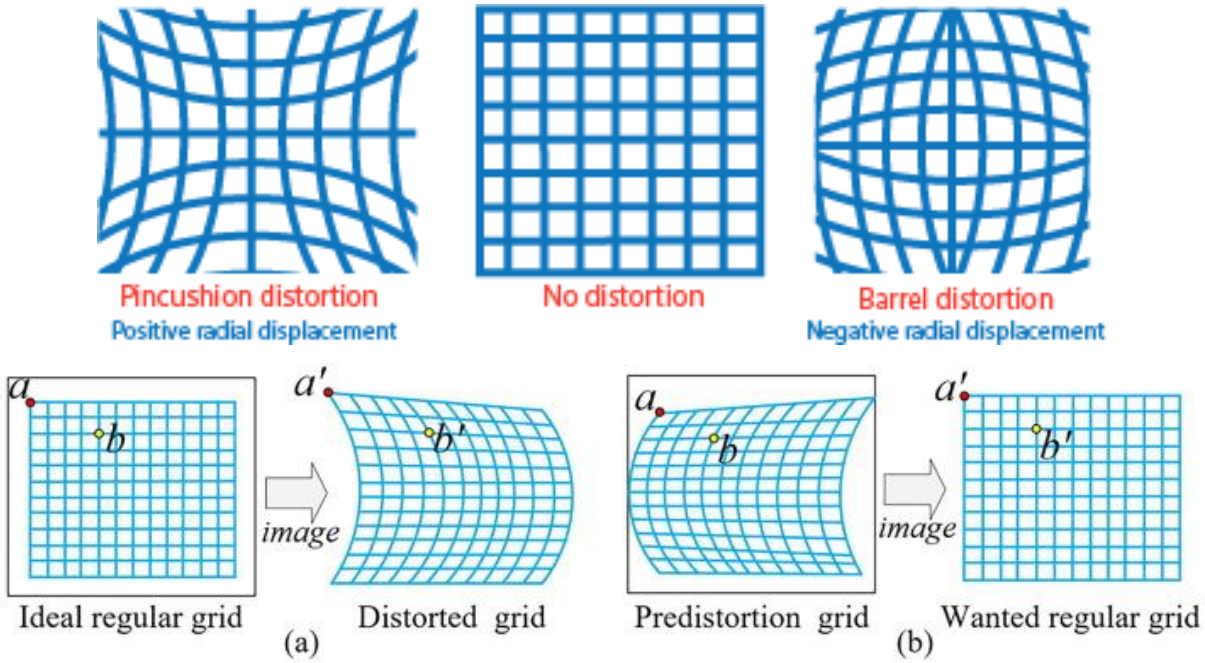
t = 0 seconds t = 0.5 second

Source of Registration Errors

- ✓Static errors
- ✓Dynamic errors

Static Errors

- ✓Optical distortions (in HMD)
- ✓Mechanical misalignments
- ✓Tracker errors
- ✓Incorrect viewing parameters
  - Field of View
  - Center of projection
  - Interpupillary distance
  - …



Reducing Static Errors

✓Distortion compensation

- For lens or display distortions

✓Manual adjustments

- Have user manually align AR and VR content

✓View-based or direct measurements

- Have user measure eye position

✓Camera calibration (video AR)

- Measuring camera properties

View Based Calibration (Azuma 94)

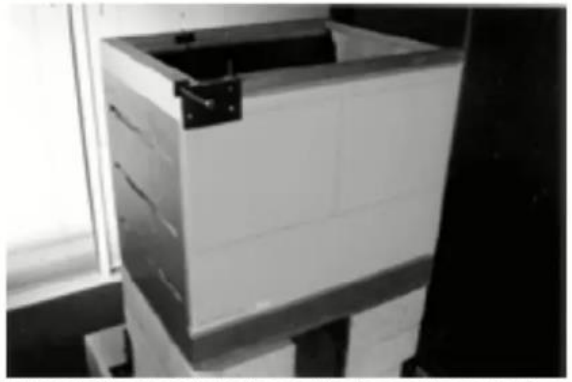


Figure 1: Wooden frame for calibration and registration

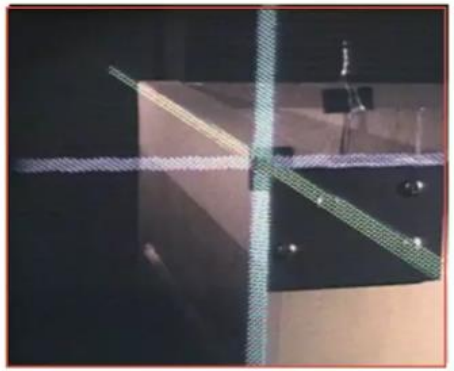


Figure 2: View seen in HMD, virtual axes on real frame

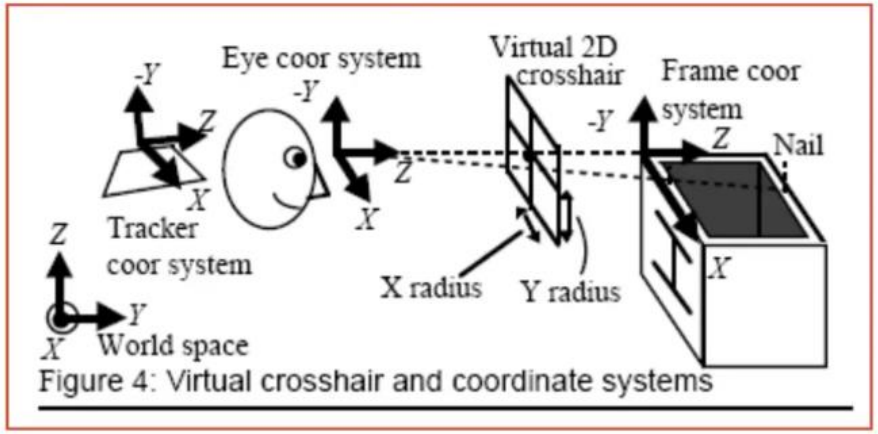


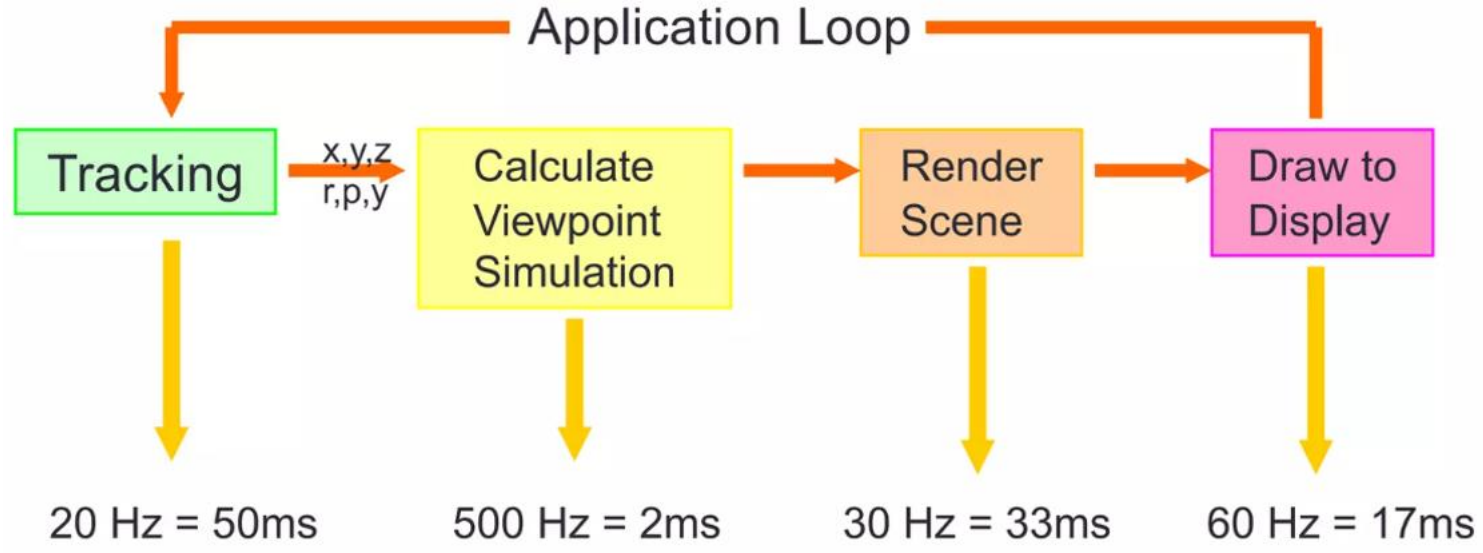
Figure 4: Virtual crosshair and coordinate systems

Dynamic Errors

✓System delays (largest source of error)

- The time difference between the measurement and generating images
- The delays exist because each component in the AR system requires some time to do its job
- End-to-end system delays cause registration errors only when motion occurs

Dynamic Errors



✓Total delay = 50 + 2 + 33 + 17 = 102ms

- 1ms delay = 1/3mm = 33mm registration error

Reducing Dynamic Errors (1)

✓Reduce system lag

- Faster components/system modules

✓Reduce apparent lag

- Image deflection
- Image warping

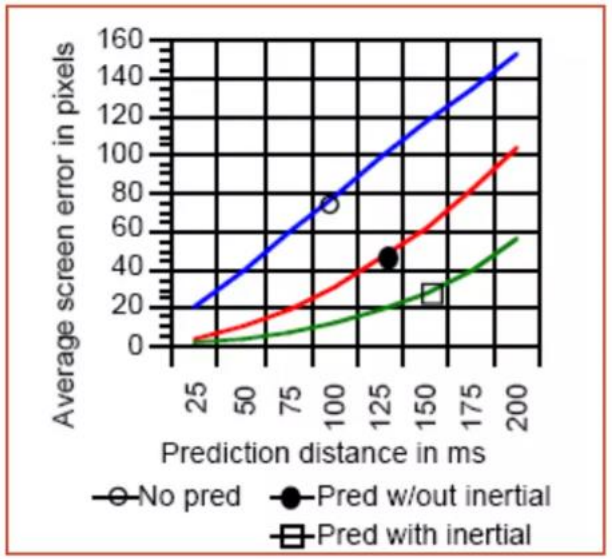
Reducing Dynamic Errors (2)

✓Match video + graphics input streams (video AR)

- Delay video of real world to match system lag
- User doesn't notice

✓Predictive tracking

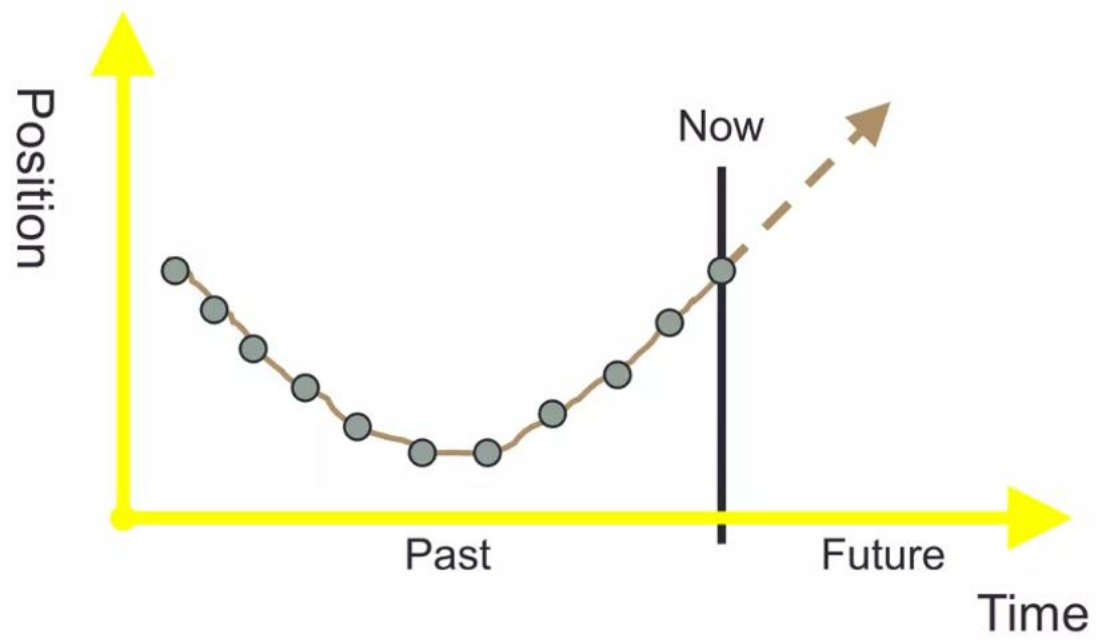
- Inertial sensors helpful



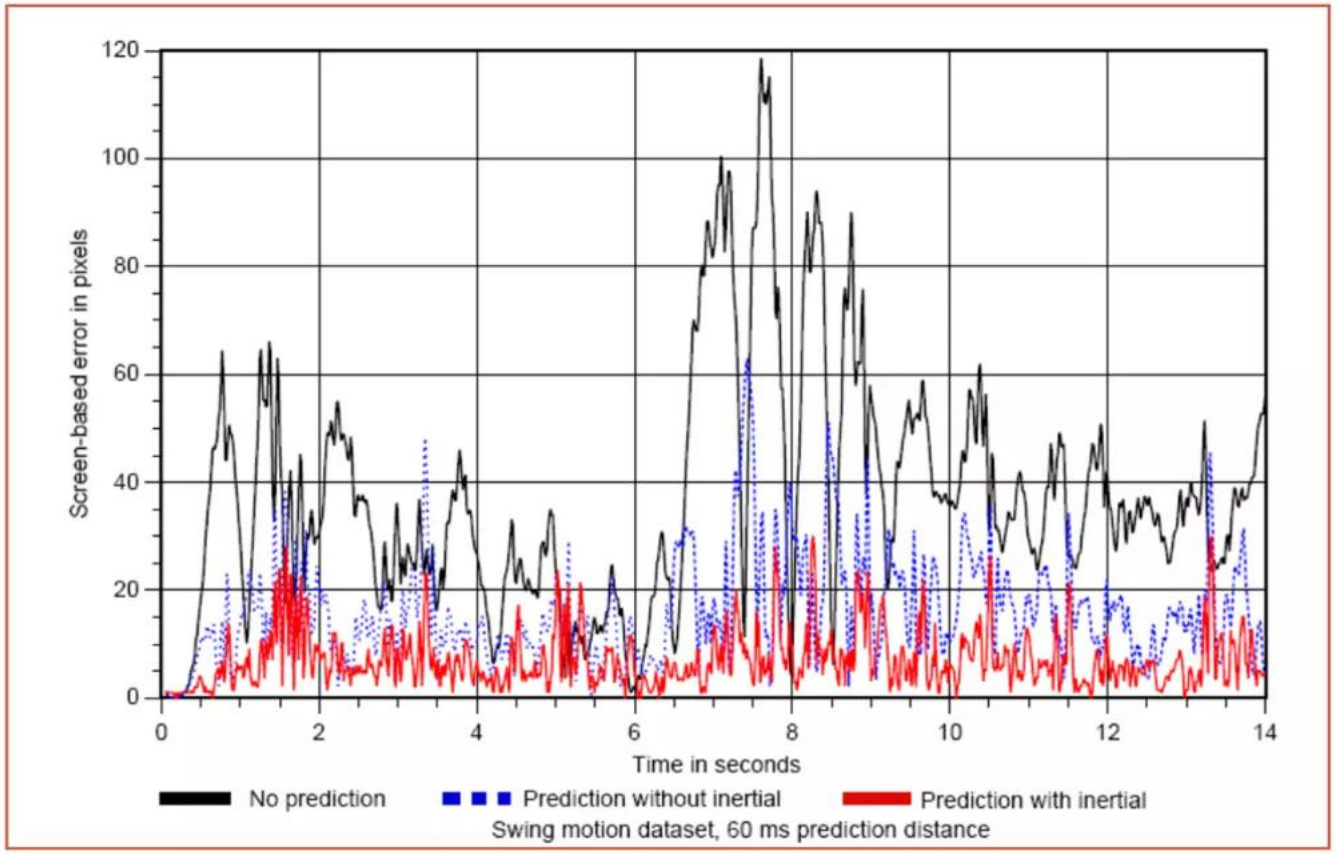
Azuma/Bishop 1994

Predictive Tracking

✓Can predict up to 80ms in future (Holloway)



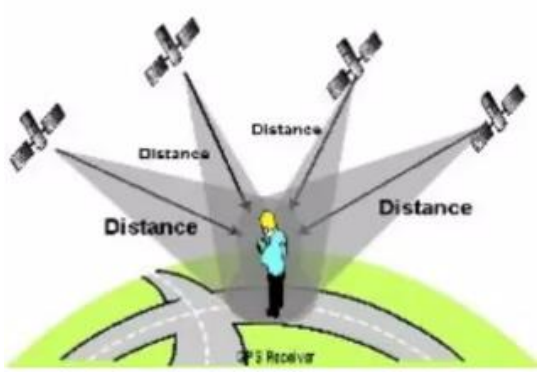
Predictive Tracking (Azuma 94)

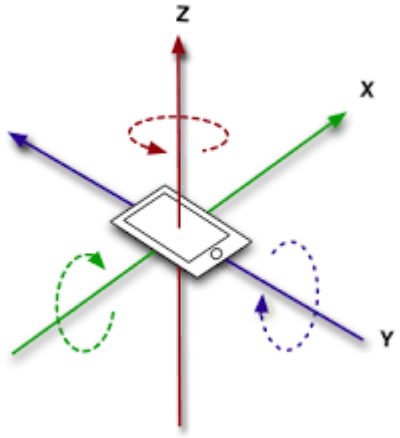


Tracking Technologies

✓Active

- Mechanical, magnetic, ultrasonic
- GPS, Wi-Fi, cell location





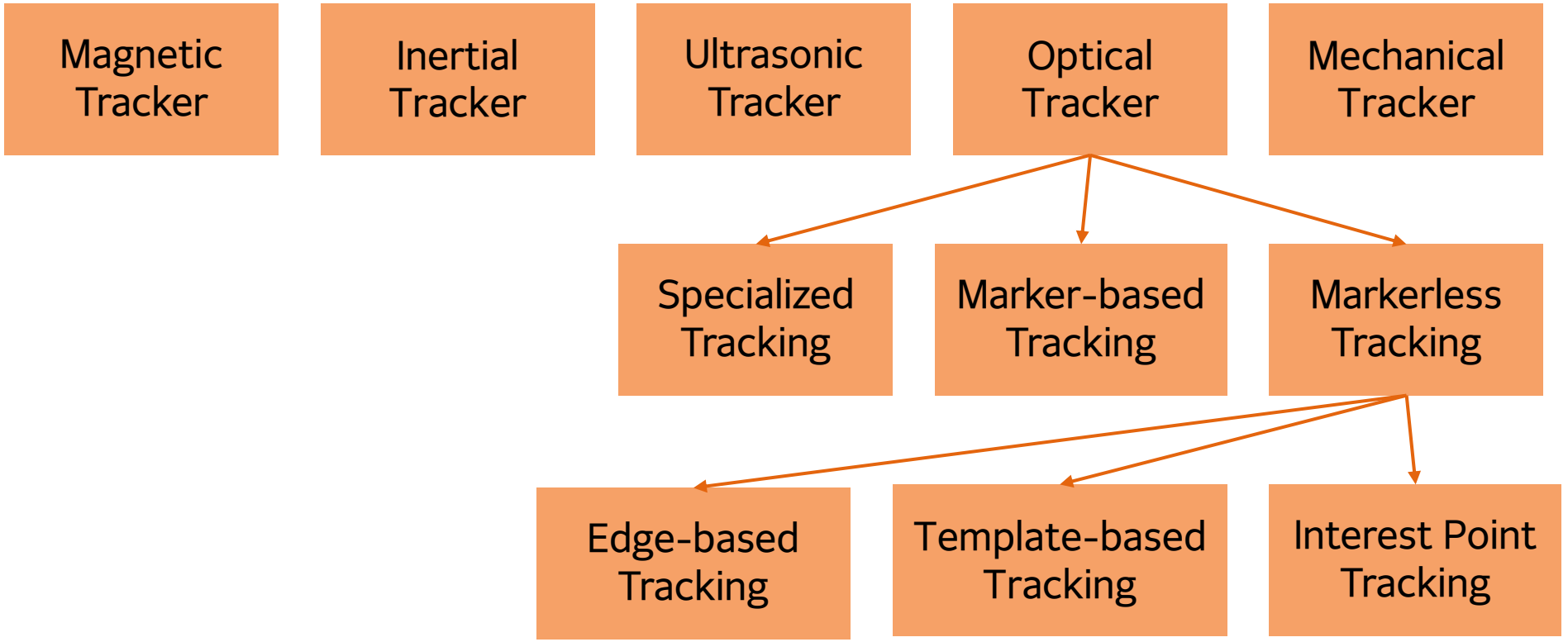
✓Passive

- Inertial sensors (compass, accelerometer, gyro)
- Computer vision: marker based, natural feature tracking

✓Hybrid tracking

- Combined sensors (e.g., vision + inertial)

Tracking Types



Mechanical Tracker

✓Idea: mechanical arms with joint sensors

✓++: high accuracy, haptic feedback

✓--: cumbersome, expensive

Microscribe

Magnetic Tracker

✓Idea: Coil generates current when moved in magnetic field.
Measuring current gives position and orientation relative to magnetic source


Flock of Birds (Ascension)

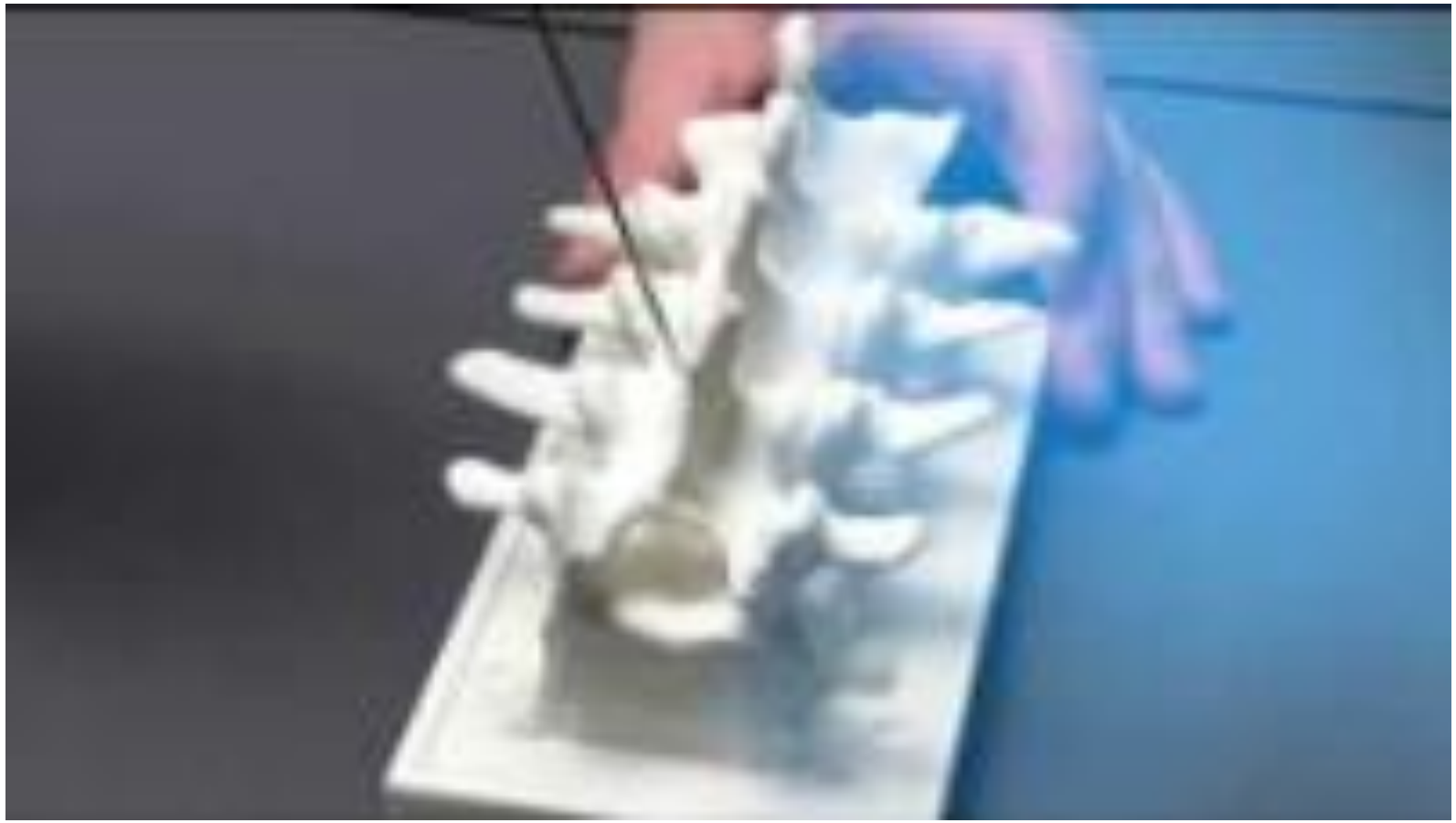
✓++: 6DOF, robust

✓--: Wired, sensible to metal, noisy, expensive

Electromagnetic Tracking

https://youtu.be/kVz_kzb-6n8?si=wLtIdFggNRXLeQPo (2018, 0:20 ~)

Electromagnetic Tracking

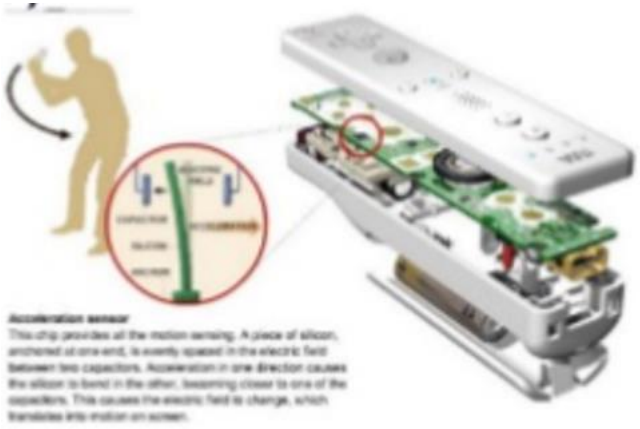


https://youtu.be/rN5-NDzZduE?si=7b4KsWcFobnJakyi (2020, 0:43)

Inertial Tracker

- ✓Idea: Measuring linear and angular orientation rates (accelerometer/gyroscope)
- ✓++: No transmitter, cheap, small, high frequency, wireless
- ✓--: Drifts over time, hysteresis effect, only 3DOF

IS300 (Intersense)



Wii Remote

3D Motion Capture with Inertial Sensors

https://youtu.be/KqKa2Gc7lh8?si=xj6V15JvdLxlghJI (2018, 13:50)

What is IMU?

https://youtu.be/fG-JQlzQxWQ?si=RMcfpf1qr1yhsXOZ (2021, 8:08)

Ultrasonic Tracker

✓Idea: Time of Flight or phase-Coherence Sound Waves

✓++: Small, cheap

✓--: 3DOF, line of sight, low resolution, affected by environmental conditions (pressure, temperature)

Global Positioning System (GPS)

✓Created by US in 1978: Currently 29 satellites

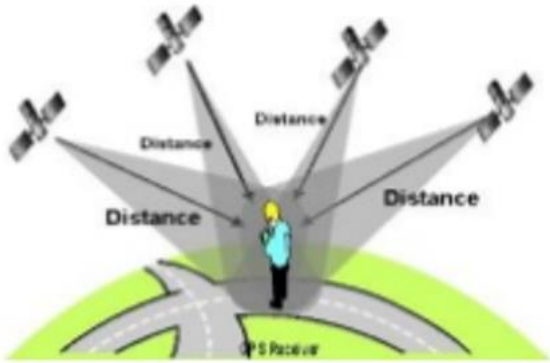
✓Satellites send position + time

✓GPS receiver positioning

- 4 satellites need to be visible
- Differential time of arrival
- Triangulation

✓Accuracy

- 5-30m+, blocked by weather, buildings etc.



Mobile Sensors

- ✓Inertial compass
  - Earth's magnetic field
  - Measures absolute orientation
- ✓Accelerometers
  - Measures acceleration about axis
  - Used for tilt, relative rotation
  - Can drift over time

Q/A