CS 498 VR

Lecture 23 - 4/25/18

go.illinois.edu/VRlect23

Review from last lecture

1. What is vection?

2. What are some symptoms when you experience vestibular-ocular mismatch?

Tracking Systems in VR

What do we want to track? (Think of rigid bodies)

Tracking Systems in VR

What do we want to track? (Think of rigid bodies)

- Head wearing HMD
- Eyes
- Palms of hands
- Fingers
- Entire body
- Interactable objects - controller, coffee cup, desk...
- Other people in the space

Tracking Systems in VR

What do we want to track?

For each body, estimate:

Rotation:

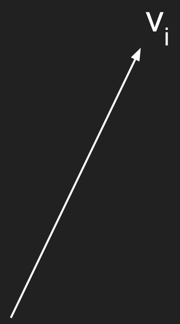
Position:

Equivalently,

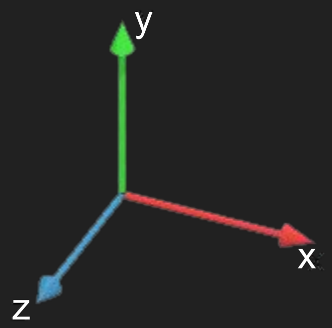
Homogeneous
Transformation
Matrix (H_i)

Tracking Systems in VR: Estimating 3D Orientation

Axis-Angle:



3-axis gyroscope measures:



For every Δt, measure ω_i, and your new rotation is $\theta_i = \omega_i \cdot \Delta t + \theta_{i-1}$

Issue: Drift (or dead reckoning)

Estimating 3D Orientation: Drift Correction

Defining drift error:

Correcting drift error:

- Use another sensor ____
- Gradually apply corrections
    - Fast enough to ____
    - Slow enough to ____

Estimating 3D Orientation

Separate rotational drift into **two components**:

1) Tilt error:
    a) To correct:

2) Yaw error:
    a) To correct

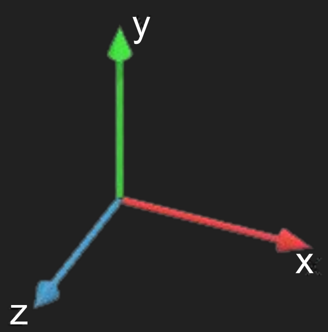
- Complementary Filters on SO(3), Mahoney, 2008

- Head Tracking for the Oculus Rift, ICRA 2014, S. LaValle, A. Yershova, M. Katsev, M. Antonov

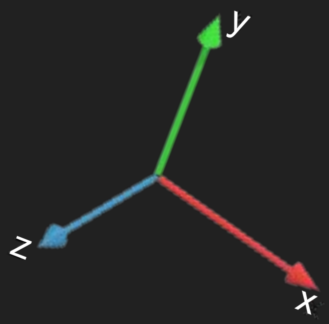
Use “Perfect Up” Sensor to Correct “Tilt Error”

If estimated Y-axis is not aligned with measured up-vector, apply transformation to estimate to correct error.

Global Coordinate Frame

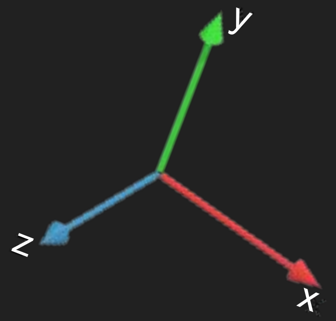


Local Coordinate Frame



Use “Perfect Up” Sensor to Correct “Tilt Error”

Local Coordinate Frame



Find difference between estimated “up” and measured “up”.

Gradually apply transformation. (Also known as complementary filter)

Profit.

Using Accelerometer as “Up” Sensor

What do accelerometers measure?

If device is in free fall?

Using Accelerometer as “Up” Sensor

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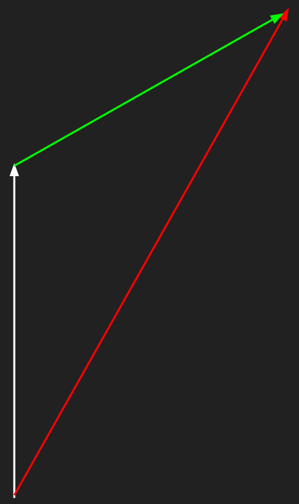
Using Accelerometer as “Up” Sensor

What do accelerometers measure?

If device is in free fall? (hint: or in outer space)

Lying still on a table?

Use Accelerometer to Correct Tilt Error



Problem:

Accelerometer measures vector sum of linear acceleration of the sensor and gravity.

Solution:

Use heuristic to detect when “not moving” and apply correction only then.

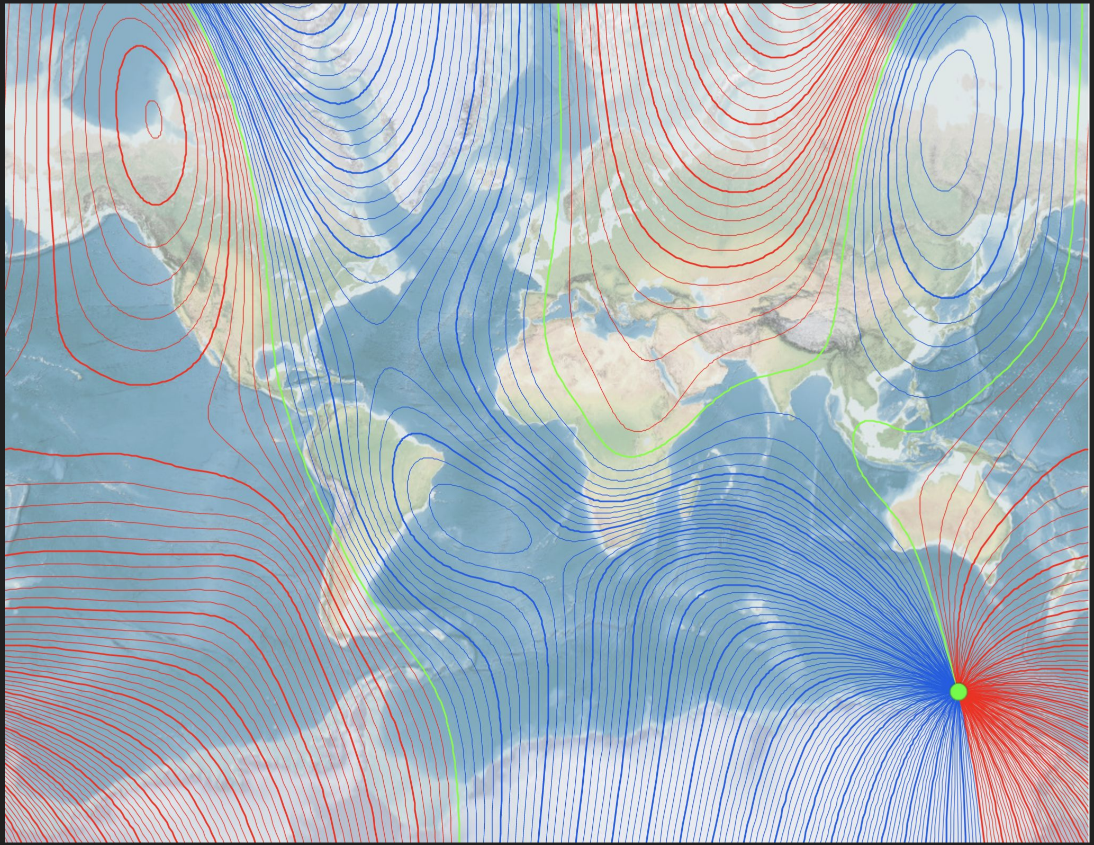
Use Magnetometer to Correct Yaw Error

Similar to tilt correction:

- Calculate reference error
- Gradually apply using complementary filter

Problems:

- Vector sum of



Estimating Position and Orientation

The Problem:

- Allow and track parallax motion (translations)
- IMU (accelerometer + gyroscope + magnetometer) is not enough
  - Drift errors too fast and no good way to detect
- Need: high accuracy and stability

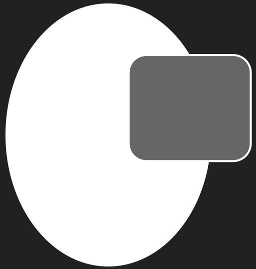
Solutions:

- Generate own EM signal
- Visibility or line-of-sight methods

Position Tracking: Visibility Methods

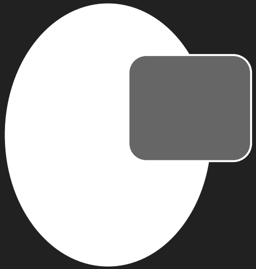
Camera arrangements:

On headset



inside-out

In world



outside-in

Position Tracking: Visibility Methods

Pinhole camera:

Features in an image:

Position Tracking: Visibility Methods

1) Natural
   a) Extract and maintain from natural scenes
   b) Ignore moving objects
   c) Hard computer vision problems
   d) Low reliability

2) Artificial
   a) Use known fixed markers in environment
      i) QR codes, reflective tape, LEDs, lasers
      ii) Can stay in IR spectrum
   b) Trivial computer vision
   c) Requires prior knowledge or setup of environment

Position Tracking: Inside-Out Tracking

Position Tracking: Outside-In Tracking

Position Tracking: Blob Detection

PnP Problem:

Determine rigid body transformation from identified, observed features on a rigidbody.

P1P:

DOF Analysis:

- Start with 6 unknown DOFs (for a rigid body)
- Each feature subtracts 2 DOFs

Position Tracking: Blob Detection

P2P:

DOFs left:

Position Tracking: Blob Detection

P3P:

DOFs left:

Solution:

Review from today

- Detail some strategies for correcting errors in measuring a body’s orientation.

- How many reference points are required to know the position (but not necessarily orientation) of a rigidbody from a single camera’s perspective?
    - What else can you infer from these points?

Announcements

- Check Piazza for final project deadlines, they are coming up soon!

- Reading: Chapter 9 of the book