CS 498 VR

Lecture 21 - 4/18/18

go.illinois.edu/VRlect21

Review from last lecture

- What are five solutions to increase frame rate?
- What is tearing? And how to solve it?
- Which one has less inertia? Head or finger?
- What are flaws of post-rendering image warp?

Challenges for Rendering in VR: Latency

Motion-to-photon latency: the amount of time that it takes to update the display in response to head motion (change in current position and orientation)

Latency: key obstacle of past generations of VR

Current methods for latency reduction:

- Lower complexity of virtual world
- Improve rendering pipeline performance
- Remove delays along the path from rendered image to switching pixels

Problem: all of these need to work for higher resolution & faster fps screens!

Reducing “effective” latency:

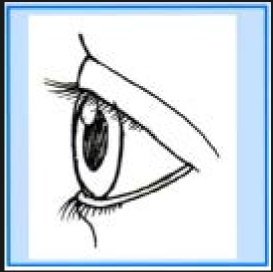
- Use prediction to estimate future viewpoints and world states
- Shift or distort image to compensate for last-minute viewpoint errors

Mathematical modeling of motion

- The physics of both real and virtual worlds impact VR experiences.
- Physics engines may model the motions of dynamic bodies in the virtual world, but not the motion of the virtual world itself.
- Tracking methods rely on accelerations and velocities.
- Human vestibular organs rely on accelerations and velocities.

How to display the world right?

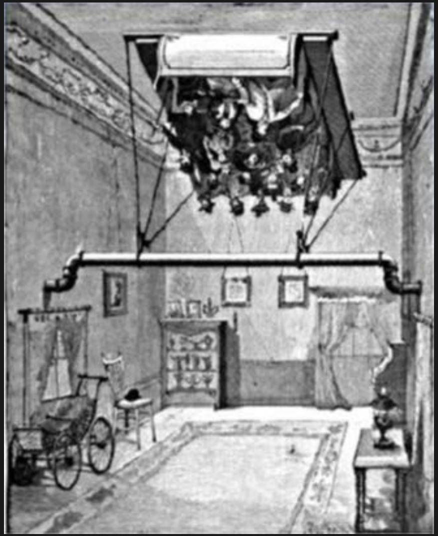
- Only have one display
- But you have *more* than two senses that detect motion (eye, ear, proprioception)

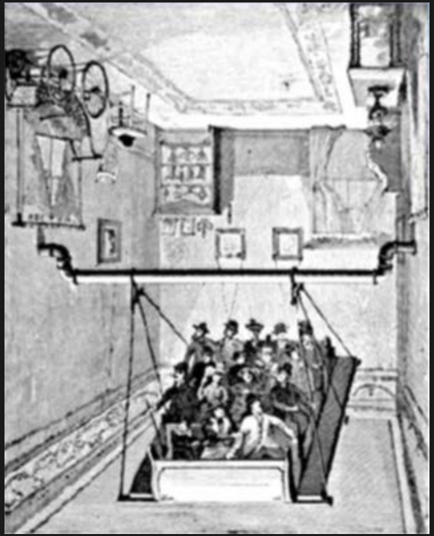


Vestibular and visual perception of motion mismatch

Vestibular system	Vision	Example
Yes	No	
No	Yes	
Yes	Delayed Mismatched	

Motion Detection Circuitry





Motion Detection Circuitry

HitchcockZoom_Micael_Reynaud.gif

“Hitchcock effect”

Example of vection

Is it comfortable?

1D Motion

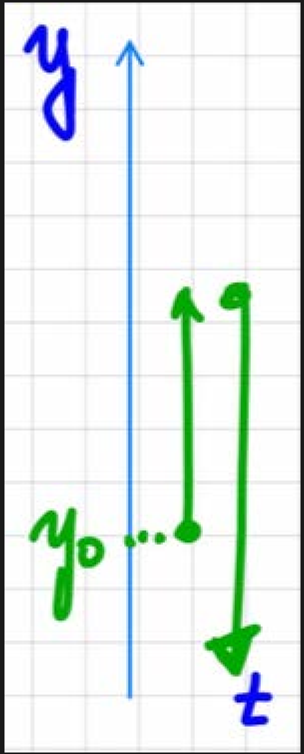
- How do I find out y(t) ?

GPS-like sensor for y(t) would be great but may be expensive / inaccurate / inpractical.
We have velocity sensor for v(t)

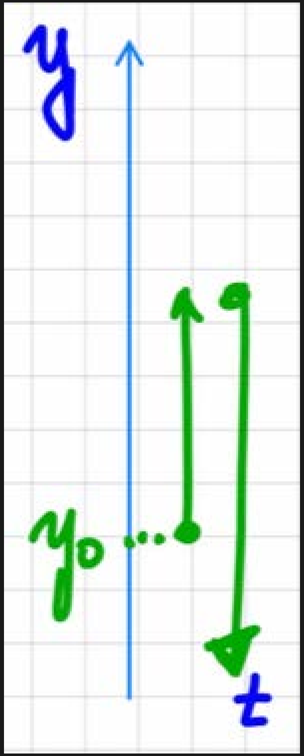
$$v\left(t\right)=\frac{dy\left(t\right)}{dt} \qquad y(t)=y(0)+\int_0^t v(t)d(t)$$

For constant v(t), y(t) = ?

For varying v(t), y(t) = ?



1D Motion using odometer (e.g. 200Hz to 1KHz)



Discrete numerical solution

$$y(t) = y(0) + \int_0^t v(t)d(t)$$

$$y(t) \approx y(0) + \sum_{i=0}^{N} vi \cdot dt$$

Example:

1 KHz Measurement frequency so Δt = 0.001 s

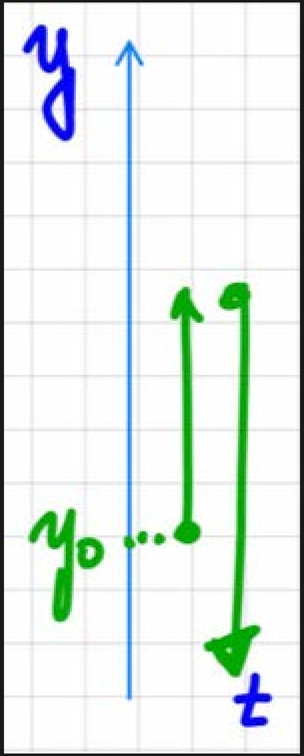
Numerical measurement error is Δv_i =0.0001 m s^{-1}

Tracking error > 1 m, when N > ?

… when T>

(Linear)Drift !!!

1D Motion



Sensor for a(t) -> accelerometer

$$v\left(t\right) = \frac{dy\left(t\right)}{dt}$$

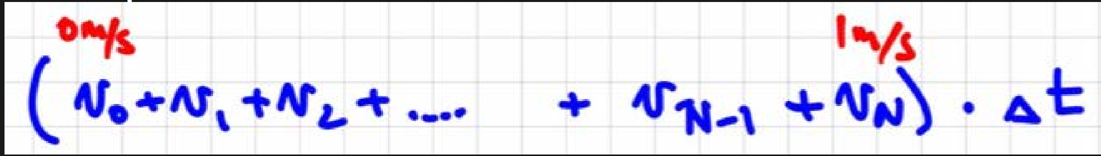
$$a(t) = \frac{dv(t)}{dt}$$

Numerical solution

$$y(t) \approx y(0) + \sum_{i=0}^{N} vi \cdot dt$$

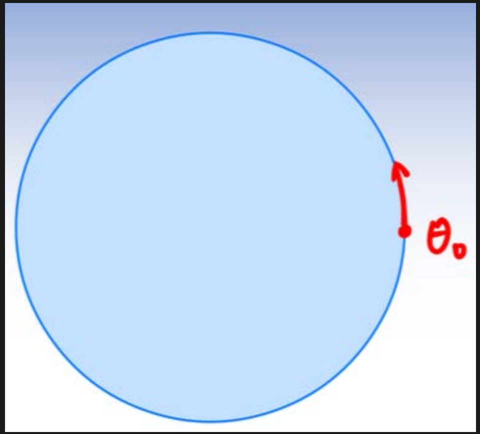
$$v(t) = v(0) + \sum_{i=0}^{N} a_i \cdot dt$$

Example:



Quadratic drift !!!

Tracking System in VR: Estimating 2D Orientation



How do I find out θ(t) ?

Sensor for θ(t) (GPS) would be nice

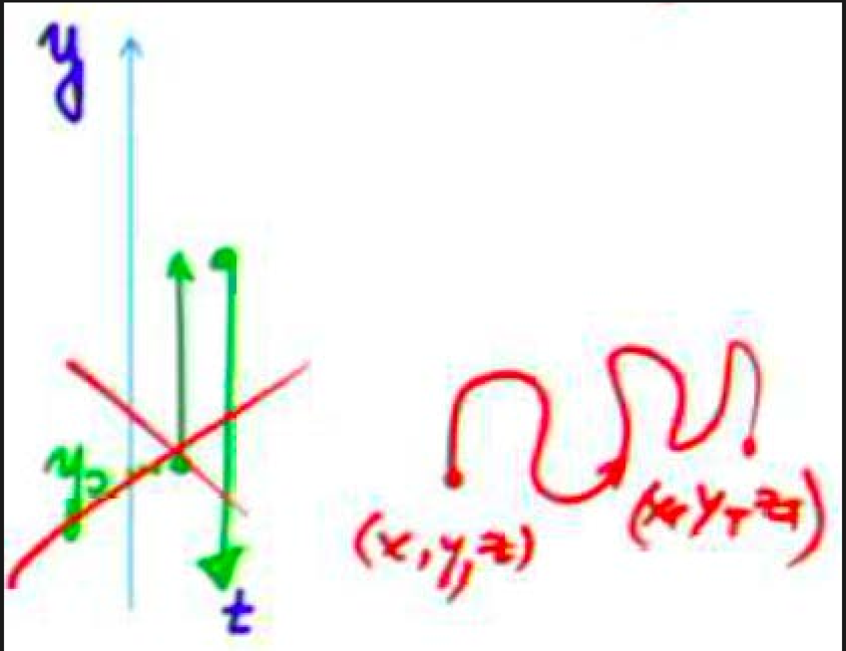
Otherwise: sensor for ω(t) : gyroscope

$$\omega(t) = \frac{d\theta(t)}{dt} \qquad \theta(T) = \theta_0 + \int_0^T \omega(t) \cdot dt$$

Numerical Solution:

$$\theta(T) = \theta_0 + \sum_{i=0}^{T} \omega_i \cdot \Delta_t$$

3D Motion?



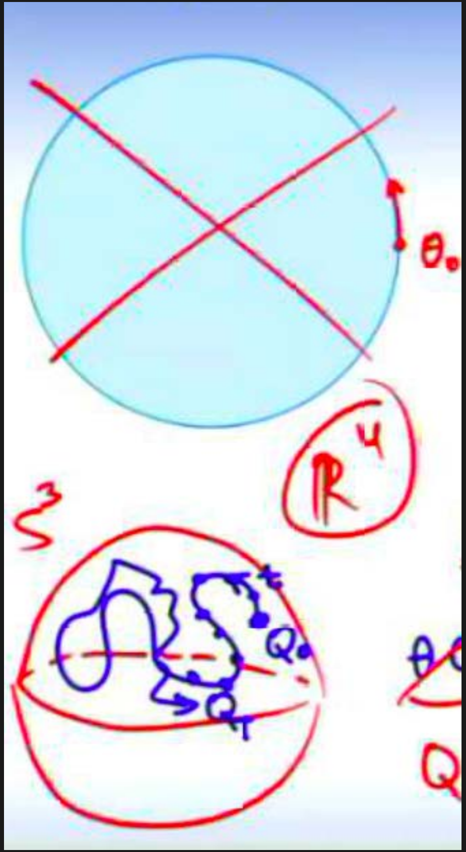
Sensor for [x(t); y(t); z(t)]

$$\begin{pmatrix} x_T \\ y_T \\ z_T \end{pmatrix} = \begin{pmatrix} x_0 \\ y_0 \\ z_0 \end{pmatrix} + \int_0^T \begin{pmatrix} v_x \\ v_y \\ v_z \end{pmatrix} \cdot dt$$

Numerical solution

$$\begin{pmatrix} x_T \\ y_T \\ z_T \end{pmatrix} = \begin{pmatrix} x_0 \\ y_0 \\ z_0 \end{pmatrix} + \sum_{i=0}^{N} \begin{pmatrix} v_{xi} \\ v_{yi} \\ v_{zi} \end{pmatrix} \cdot \Delta t$$

Tracking System in VR: Estimating 3D Orientation



How do I find out Q(t) ?

Sensor for Q(t) (GPS) would be nice

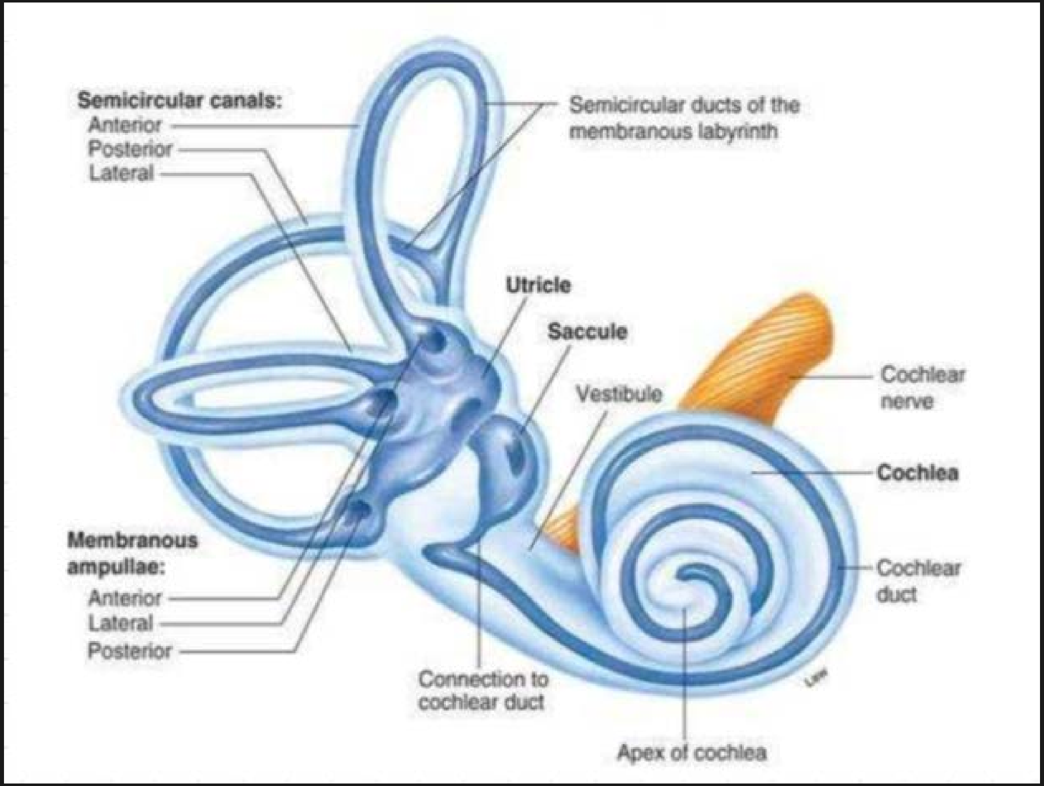
Otherwise: sensor for [ω_x(t); ω_y(t); ω_z(t)] : gyroscope

$$\omega(t) = (\frac{d\alpha}{dt}, \frac{d\beta}{dt}, \frac{d\gamma}{dt}) \quad Q_t = Q_0 \circ \int_0^T \omega(t) \cdot dt$$

Numerical Solution:

$$Q_t = Q_0 \circ \bigcap_{i=0}^{N} \Delta Q_i, \Delta Q_i = (axis, angle)$$

Human Vestibular System



Review from today

- What happens if there’s vestibular system and vision mismatch?
- What’s the reason for drift?
- What’s difference between estimating 2D orientation and 3D orientation?

Announcements

- See you next week and keep your final project on track!
- Read Chapter 12