Inertial navigation **3/15/2017**
Proposals Due

What is inertial navigation?

Starting from a known location and orientation, estimate your position by estimating your change in position and heading

How do we do this?

Gyroscope to measure orientation

Accelerometer to measure acceleration

(diagram)

How do we know current location / orientation

GPS
Position / height of stars (for latitude),
or time of sunrise / sunset, if we know time (for longitude)
Compass

Why would we want to do this?

- long range navigation prior to advent of GPS
- navigation without dependence on some external source (GPS), as in nuclear war
- be more accurate / frequent than GPS
- need orientation, which GPS doesn't give

(Show slides)

Ok, so what does an accelerometer do?

- measure instantaneous force (acceleration) being applied to some system

How do they work?

- Simplest: spring-mass system -- diagram
- Show MEMS diagram

(Need one per axis)

Ok, so what does a gyroscope do?

- Measure instantaneous change in angle

How does it work?

- Show Gyro
- Show MEMS diagram

<u>Ok, so what is the theory of operation for an IMU?</u>

Gimbaled:

Have a platform on a gimbal
Measure the change in rotation of the platform using gyros
Use servos to rotate the platform to be in the same orientation
Accelerometers now always measuring acceleration with respect to the initial orientation.

Strap down:

Gyros & accelerometers are fixed to the body of the vehicle (or phone, etc.)
(show 2D example)

<u>Why is the reading so complicated?</u>

3 dimensions

gravity

Coriolis forces

Suppose I am shooting a missile at some far away target -- if i point at it and fly in a straight line, and there is no error in my sensors, will I hit it? No, because the earth will rotate underneath it.

https://www.youtube.com/watch?v=dt_XJp77-mk

Slide: <u>https://www.youtube.com/watch?v=_36MiCUS1ro</u> + Wikipedia diagram.

Point is that the ball / cannon has the same velocity as the point where it was launched, but the other points change their velocity as they spin.

On the earth, points further north / south are moving at different rates!

(see http://courses.physics.northwestern.edu/Phyx125/Coriolis.pdf)

<u>How much of a problem is this in practice?</u>
A sniper shooting at a target 1000m away will encounter 7cm of drift (flight times will be 1-2 seconds)

For an ICBM or a plane that might travel for many minutes or hours, this drift will be much more significant.

One way to think about this:

You are a point at the north pole. You have no velocity in any direction.

You shoot a target 1000 meters away and the bullet takes 1 second to get there. In that second the earth will have rotated 7e-5 radians which means the target moves 7e-5*1000 meters or 7 cm. Your bullet had no initial velocity in the direction of rotation.

This same math works no matter where you are on the earth, if you are firing perpendicular to the direction of rotation.

Frame of reference also complicates -- if I am observing from space, vs from the surface of the earth, calculations are different (see diagram)

Review block diagram

iOS App and Demo

Demonstrate high noise levels, review sources of noise