Examples of Estimation Filters from Recent Aircraft Projects at MIT

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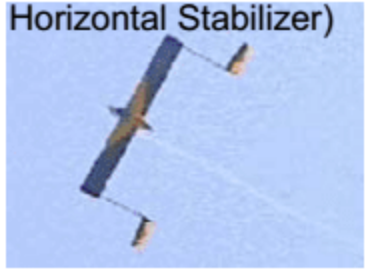
Vehicles & Navigation Sensors

OHS (Outboard Horizontal Stabilizer)



Navigation Sensors (Piccolo from Cloudcap Tech)

- GPS Motorola M12
- Inertial
  - 3 Tokin CG-16D rate gyros
  - 3 ADXL202 accelerometers
- Air Data
  - Dynamic & absolute pressure sensor
  - Air temperature sensor
- MHX 910/2400 radio modem
- MPC555 CPU

- **Crista Inertial Measurement Unit**
  - 3 Analog Devices ADXL accelerometers
  - 3 ADXRS MEMs rate sensors

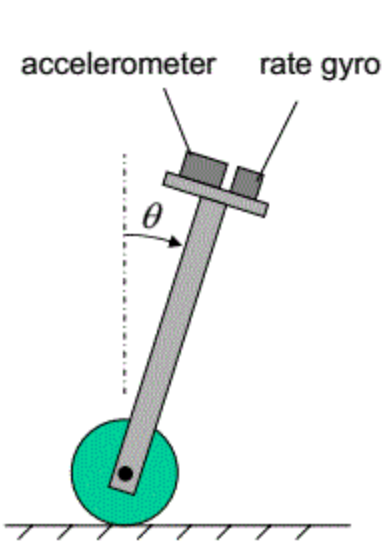
Navigation Sensors

- GPS Receiver (Marconi, Allstar)
- Inertial Sensors
  - Crossbow 3-axis Accelerometer, Tokin Ceramic Gyro (MINI) or Crossbow IMU (OHS)
- Pitot Static Probe: measures airspeed
- Altitude Pressure Sensor

Complementary Filter (CF)

Often, there are cases where you have *two* different measurement sources for estimating *one* variable and the noise properties of the two measurements are such that one source gives good information only in low frequency region while the other is good only in high frequency region.
→ You can use a complementary filter !

Example : Tilt angle estimation using accelerometer and rate gyro

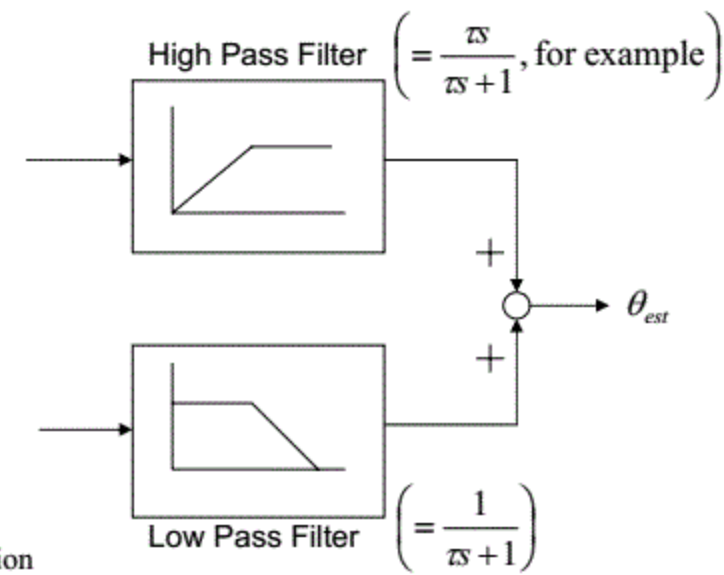


$\theta \approx \int (\text{angular rate})\, dt$

- not good in long term due to integration

$\theta \approx \sin^{-1}\left(\frac{\text{accel. output}}{g}\right)$

- only good in long term
- not proper during fast motion

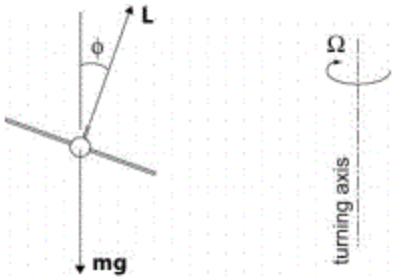


Complementary Filter(CF) Examples

- CF1. Roll Angle Estimation
- CF2. Pitch Angle Estimation
- CF3. Altitude Estimation
- CF4. Altitude Rate Estimation

CF1. Roll Angle Estimation

- High freq. : integrating roll rate (p) gyro output
- Low freq. : using aircraft kinematics
  - Assuming steady state turn dynamics,
    roll angle is related with turning rate, which is close to yaw rate (r)



$$L\sin\phi = mV\Omega$$
$$L \approx mg$$
$$\Omega \approx r$$
$$\sin\phi \approx \phi$$
$$\Rightarrow \quad \phi \approx \frac{V}{g} r$$

CF setup