# Complementary Filter

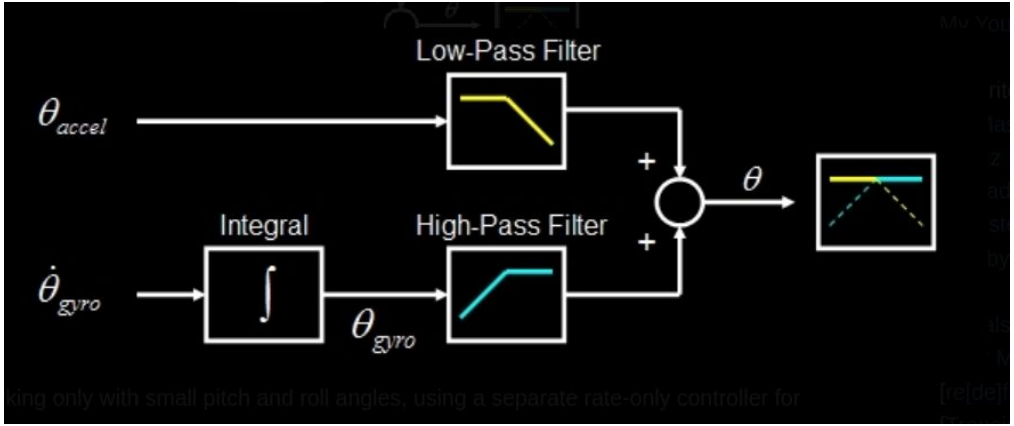
-Sensor fusion algorithm .

(This slides demonstrates fusion of 6dof IMU)

# Complementary Filter:

- A complementary filter is a simple and effective technique used to fuse the data from different sensors to provide a more accurate and stable output.

- Combine many sensors that complement each other's weaknesses (hence complementary) with their strengths.



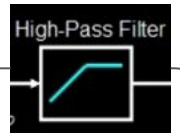
- This is achieved by blending the complementary characteristics of the sensors using a
    - HIGH PASS FILTER on one sensor's output and a
    - LOW PASS FILTER on another sensor's output.

- High Pass Filter:
    - Allows or let pass through only the High frequency signals (Quick changes)
    - Attenuates or reduces the amplitude of the Low frequency signals (Drifts)
- Low Pass Filter:
    - Allows or let pass through only the Low frequency signals (stable readings)
    - Attenuates or reduces the amplitude of the High frequency signals .

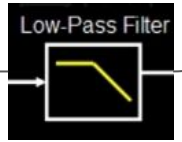
Complementary data ,
===> Accelerometer_data * (low pass filter) + Gyroscope_data * (High pass filter)

(Fast and noiseless reading)

GYROSCOPE DATA

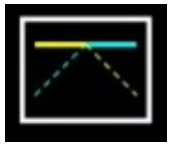



ACCELEROMETER DATA




(Reliable and noisy reading)

CALIBRATED DATA



(Filtered , Reliable , Noiseless reading)

# Mathematical Equation of complementary filter

$$\Theta_n = \alpha \cdot (\Theta_{n-1} + g \cdot \Delta t) + (1 - \alpha) \cdot a$$

ACCELEROMETER PART

$$Filtered\_angle = \{\alpha \times (previous\_filtered\_angle + gyro\_rate \times \Delta t)\} + \{(1-\alpha) \times accel\_angle\}$$

GYRO PART

- $\alpha$ is the filter coefficient ($0 < \alpha < 1$), typically close to 1. $(1-\alpha)$ is complement of $\alpha$

## Applying High Pass Filter

- For gyroscope data, this helps in removing the slow drift and focusing on the rapid changes.
- The high-pass filter is typically applied by integrating the gyroscope rate of change over time and combining it with the previous filtered angle.

Gyro:

$$(previous\_filtered\_angle + gyro\_rate \times \Delta t) \quad \text{----- 1}$$

## Applying Low pass Filter

- For accelerometer data, this helps in smoothing out the noisy data and focusing on the stable, long-term orientation.
- The low-pass filter is applied by using the accelerometer data to directly calculate the angle.

Accel: (accelerometer_angle) -------- 2

Complementary Filter = [Low Pass (Accele)] + [High Pass (Gyro)] = 1 + 2

$$\Rightarrow \quad [(1-\alpha) \times accel\_angle] + \alpha \times (previous\_filtered\_angle + gyro\_rate \times \Delta t)$$