

Gravity compensation of accelerometer measurements

- remove gravity projections to get clear values of acceleration

- Cofunction Identities

$$\sin\left[\frac{\pi}{2} - \theta\right] = \cos[\theta]$$

$$\cos\left[\frac{\pi}{2} - \theta\right] = \sin[\theta]$$

- Square to Linear Identities

$$\sin^2[\theta] = \frac{1 - \cos[2\theta]}{2}$$

$$\cos^2[\theta] = \frac{1 + \cos[2\theta]}{2}$$

$$\tan^2[\theta] = \frac{1 - \cos[2\theta]}{1 + \cos[2\theta]}$$

- Pitch : p angle

$$\text{Pitch} = \text{ArcTan}\left[\frac{\text{acc}_x}{\sqrt{\text{acc}_y^2 + \text{acc}_z^2}}\right]$$

$$\alpha = \pi - \frac{\pi}{2} - p = \frac{\pi}{2} - p$$

$$g_x = g \cos[\alpha] = g \cos\left[\frac{\pi}{2} - p\right] = g \sin[p]$$

$$g_x = g \sin[p]$$

- Roll : r angle

$$\text{Roll} = \text{ArcTan}\left[\frac{-\text{acc}_y}{\text{acc}_z}\right]$$

$$\beta = 180 - 90 - r = 90 - r$$

$$g_y = g \cos[\beta] = g \cos\left[\frac{\pi}{2} - r\right] = g \sin[r]$$

$$g_y = g \sin[r]$$

- Yaw : y angle

$$g_z = g \cos[y]$$

■ Theorem of orths

$$\cos[p]^2 + \cos[r]^2 + \cos[y]^2 = 1$$

$$\cos[y]^2 = 1 - (\cos[p]^2 + \cos[r]^2)$$

■ Calculation

$$\cos[y]^2 = 1 - \left(\frac{(1 + \cos[2p])}{2} + \frac{(1 + \cos[2r])}{2} \right) = - \frac{\cos[2p] + \cos[2r]}{2}$$

$$\cos[y] = \pm \sqrt{- \frac{\cos[2p] + \cos[2r]}{2}} = \pm 0.7071067811865475 * \sqrt{\cos[2p] + \cos[2r]}$$

$$g_z = g * \sqrt{1/2} * \sqrt{\cos[2p] + \cos[2r]}$$

■ Summary

$$acc_x, acc_y, acc_z$$

$$Pitch = \text{ArcTan} \left[\frac{acc_x}{\sqrt{acc_y^2 + acc_z^2}} \right]$$

$$Roll = \text{ArcTan} \left[\frac{-acc_y}{acc_z} \right]$$

$$g_x = \sin[Pitch]$$

$$g_y = \sin[Roll]$$

$$g_z = \sqrt{1/2} * \sqrt{\cos[2 * Pitch] + \cos[2 * Roll]}$$

$$acc_x = acc_x + g_x$$

$$acc_y = acc_y + g_y$$

$$acc_z = \text{If}[\text{Or}[\text{Abs}[Pitch] > \pi, \text{Abs}[Roll] > \pi], acc_z - g_z, acc_z + g_z]$$

Low Pass Filter

$$fValue = Value * \alpha + fValue * (1 - \alpha)$$