Fast AHRS Filter for Accelerometer, Magnetometer, and Gyroscope Combination with Separated Sensor Corrections

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$$v = \omega \, \Delta t$$

$$\tilde{q}_x = \sin\frac{v_x}{2}, \tilde{q}_y = \sin\frac{v_y}{2}, \tilde{q}_z = \sin\frac{v_z}{2}, \tilde{q}_s = \sqrt{1 - \left(\tilde{q}_x^2 + \tilde{q}_y^2 + \tilde{q}_z^2\right)}$$

$$FSCF\colon \tilde{q} \cong \left(1, \frac{v_x}{2}, \frac{v_y}{2}, \frac{v_z}{2}\right)$$

$$q_{pre} = q \otimes \tilde{q}$$

$$a_{ref} = (0, 0, 1) \rightarrow a_{pre} = q \otimes a_{ref} \otimes q^* = M_q \cdot a_{ref}$$

$$e_a = \left|a_{msr} \times a_{pre}\right|, \alpha_a = \cos^{-1}(a_{msr} \cdot a_{pre})$$

$$m_z = a_{pre,x} m_{msr,x} + a_{pre,y} m_{msr,y} + a_{pre,z} m_{msr,z}, \, m_y = \sqrt{1 - m_z^2}$$

$$m_{ref} = (0, m_y, m_z) \rightarrow m_{pre} = q \otimes m_{ref} \otimes q^* = M_q \cdot m_{ref}$$

$$e_m = \left|m_{mse} \times m_{pre}\right|, \alpha_m = \cos^{-1}(m_{msr} \cdot m_{pre})$$

$$e = f_{\lambda_a}(\alpha_a) \, e_a + f_{\lambda_m}(\alpha_m) \, e_m \; with \; f_\lambda(\alpha) = min(\alpha\lambda_1, \lambda_2)$$

$$q_{corr} = \left(s = \sqrt{1 - \|\gamma e\|}, v = \gamma e\right), \gamma = \frac{sin\|e\|}{\|e\|}$$

$$FSCF\colon q_{corr} \cong (s = 1, v = e)$$

$$q = q_{pre} \otimes q_{corr}$$