

We model the acceleration observed by a 3-axis accelerometer mounted in a car (Fig. 8). The direction of travel is aligned with accelerometer axis x and the accelerometer is offset from the car center of mass (COM) by some distance x_c .

We assume the car is on a flat 2D plane and that the car is traveling without skidding or sliding. The only car degrees of freedom are in x and in yaw/rotation around z . We hold $y = z = 0$ and pitch = roll = 0. As the car turns with an angular velocity $-\omega_r$ around the z axis, the accelerometer rotates both around the car's COM and around the radius of the turn r_t , such that

$$\vec{r} = x_c \hat{i} + r_t \hat{j} \quad (5)$$

where \hat{i}, \hat{j} are the unit vectors corresponding to x and y , respectively

The force that the accelerometer will observe is a combination of any force from the car engine, the Euler force, the Coriolis force, and the centrifugal force:

$$\vec{F}_{obs} = \vec{F}_{engine} - m \frac{d\vec{\omega}}{dt} \times \vec{r} - 2m\vec{\omega} \times \vec{v} - m\vec{\omega} \times (\vec{\omega} \times \vec{r}) \quad (6)$$

Taking (6) and dropping the mass term, we get the acceleration observed by the accelerometer

$$\vec{a}_{obs} = \vec{a}_{engine} - \frac{d\vec{\omega}}{dt} \times \vec{r} - 2\vec{\omega} \times \vec{v} - \vec{\omega} \times (\vec{\omega} \times \vec{r}) \quad (7)$$

Splitting the acceleration terms into their respective axes and setting $v_x = 0$, we have

$$\begin{aligned} \vec{a}_{obs} &= a_{engine} \hat{i} \\ -\frac{d\omega}{dt} \hat{k} \times (x_c \hat{i} + r_t \hat{j}) &+ 2\omega \hat{k} \times (v_x \hat{i} + 0 \hat{j}) \\ -\omega \hat{k} \times \omega \hat{k} \times (x_c \hat{i} + r_t \hat{j}) \end{aligned} \quad (8)$$

such that

$$\begin{aligned} \vec{a}_{obs} &= a_{engine} \hat{i} \\ -\frac{d\omega}{dt} (-r_t \hat{i} + x_c \hat{j}) &- 2\omega v_x \hat{j} \\ -\omega^2 (-x_c \hat{i} - r_t \hat{j}) \end{aligned} \quad (9)$$

such that

$$a_{x,obs} = a_{engine} + \frac{d\omega}{dt} r_t + 0 + \omega^2 x_c \quad (10)$$

and

$$a_{y,obs} = -\frac{d\omega}{dt} x_c - 2\omega v_y + \omega^2 r_t \quad (11)$$

Please note that according to the sign convention, ω is negative, so

$$a_{x,obs} = a_{engine} - \frac{d|\omega_r|}{dt} r_t + \omega_r^2 x_c \quad (12)$$

and

$$a_{y,obs} = \frac{d|\omega_r|}{dt} x_c + 2|\omega_r| v_y + \omega_r^2 r_t \quad (13)$$

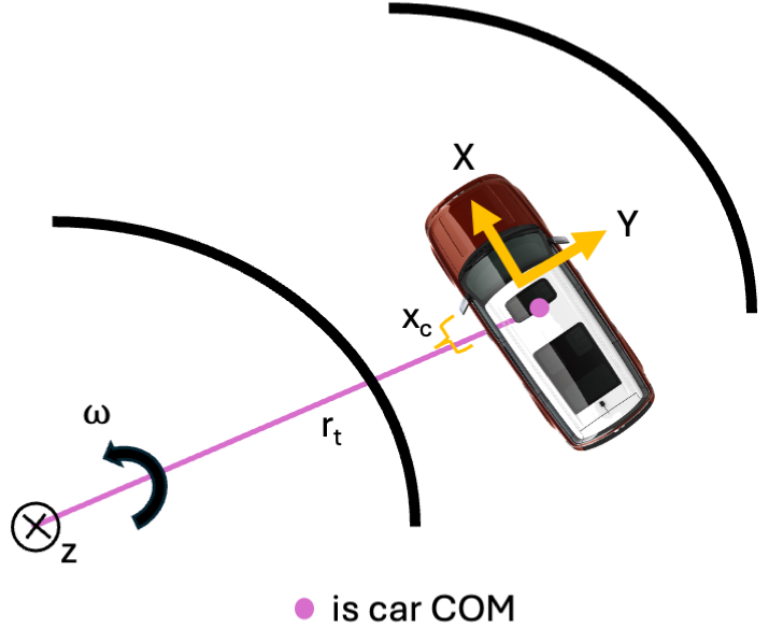


Fig. 8: The motion model for the car and accelerometer