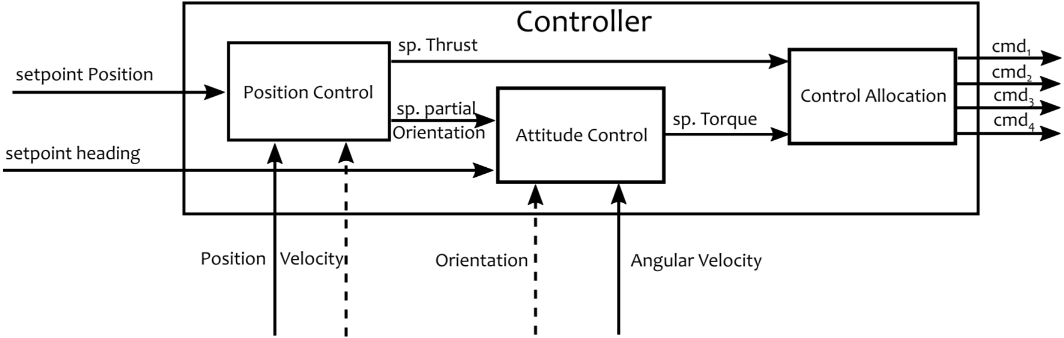
Controller Structure



Position Control

- the purpose of Position Control is to stabilize the quadrotor at the given position set point $\boldsymbol{p}^e = \begin{bmatrix} p_x^e & p_y^e & p_z^e \end{bmatrix}$
- the position is coming from the operator (or from a higher level supervisor control/mission planner)
- the Position Control is slower than the Attitude Control (e.g. 10 Hz)
- We design the vertical position and the horizontal position as separate channels

Horizontal Position Feedback Control

Horizontal movement model and PID controllers:

$$\begin{bmatrix} \dot{p}_x^e \\ \dot{p}_y^e \end{bmatrix} = \overbrace{\begin{bmatrix} v_x^e \\ v_y^e \end{bmatrix}}^{\boldsymbol{u}} = \begin{bmatrix} \mathrm{PID}(\Delta p_x = p_{x,r}^e - p_x^e) \\ \mathrm{PID}(\Delta p_y = p_{y,r}^e - p_y^e) \end{bmatrix} \tag{1a}$$

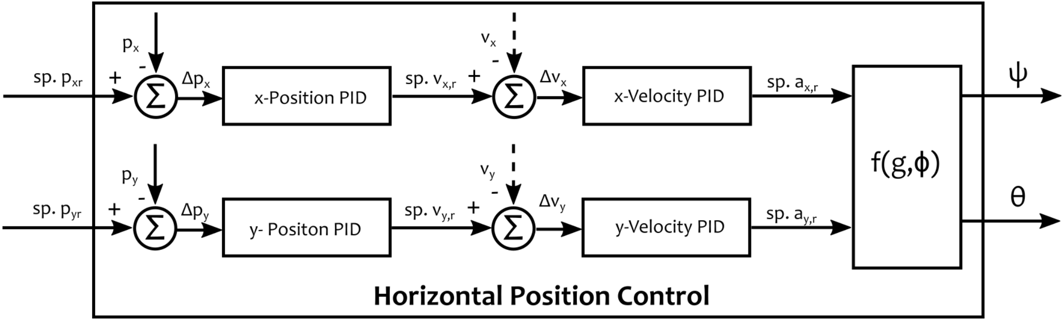
$$\begin{bmatrix} \dot{v}_x^e \\ \dot{v}_y^e \end{bmatrix} = \overbrace{\begin{bmatrix} a_x^e \\ a_y^e \end{bmatrix}}^{\boldsymbol{u}} = \begin{bmatrix} \mathrm{PID}(\Delta v_x = v_{x,r}^e - v_x^e) \\ \mathrm{PID}(\Delta v_y = v_{y,r}^e - v_y^e) \end{bmatrix} \tag{1b}$$

Horizontal Position Model Inversion

The output of the horizontal control should be the platform tilt, so:

$$\begin{bmatrix} a_x^e \\ a_y^e \end{bmatrix} = g \begin{bmatrix} s\phi & c\phi \\ -c\phi & s\phi \end{bmatrix} \begin{bmatrix} \psi \\ \theta \end{bmatrix} \Rightarrow \begin{bmatrix} \psi \\ \theta \end{bmatrix} = \frac{1}{g} \begin{bmatrix} s\phi & -c\phi \\ c\phi & s\phi \end{bmatrix} \begin{bmatrix} a_x^e \\ a_y^e \end{bmatrix} \tag{2}$$

Horizontal Position Control



Vertical Position Feedback Control

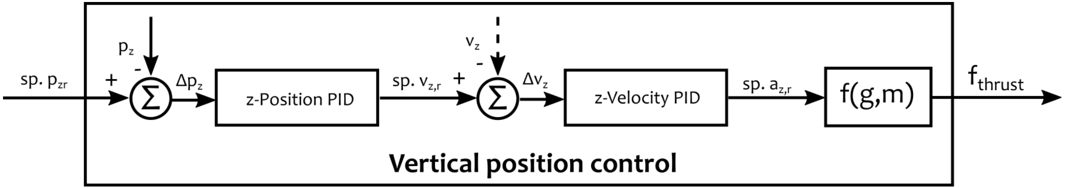
$$\dot{p}_z^e = \underbrace{v_z^e}_{u} = \text{PID}(\Delta p_z = p_{z,r}^e - p_z^e) \tag{3a}$$

$$\dot{v}_z^e = \underbrace{a_z^e}_{u} = \text{PID}(\Delta v_z = v_{z,r}^e - v_z^e) \tag{3b}$$

And we have that:

$$a_z^e = \frac{f_{\text{thrust}}}{m} - g \Rightarrow f_{\text{thrust}} = m(a_z^e + g) \tag{4}$$

Vertical Position Control



Position Control Tunning

Control Simulation usage:

- `main_3_sim_perception_tune_anglectrl.py`