Controller and Localization

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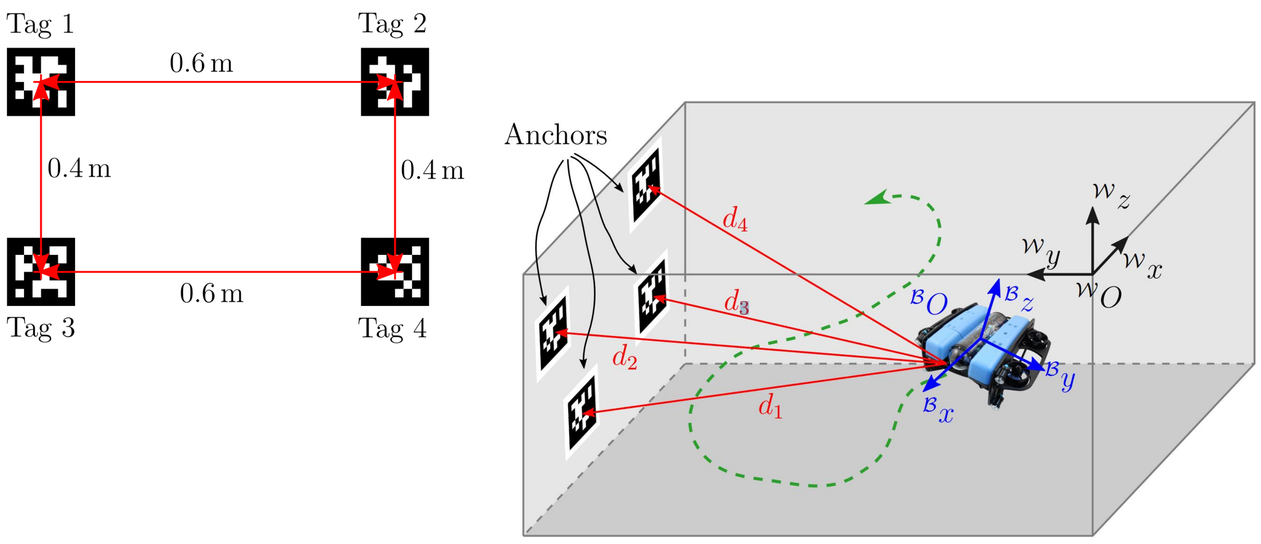
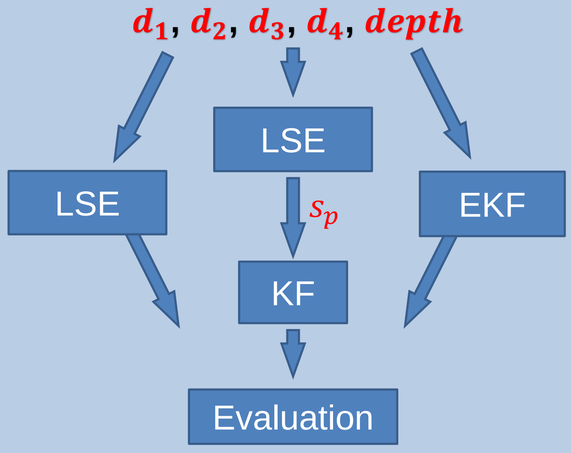
Localization



Tag to ROV distances & with pressure calculated depth

$d_1, d_2, d_3, d_4, depth$



Method → Current Position

Least Square Estimation (LSE)

$$s_p = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

$$\min_{s_p \in T} \sum_{k=1}^{4} ||s_p - r_k| - d_k|^2$$

Kalman Filter (KF)

Prediction

$$s' = Fs + u$$
$$P' = FPF^T + Q$$

Measurement update

$$y = z - Hx'$$
$$S = HP'H^T + Q$$
$$K = P'H^T S^{-1}$$
$$s = s' + Ky$$
$$P = (I - KH)P'$$

Extended Kalman Filter (EKF)

Prediction

$$s' = Fs + \cancel{u} \qquad u = 0$$
$$P' = FPF^T + Q$$

Measurement update

$$y = z - J_{H_1} x'$$
$$S = J_{H_1} P' J_{H_1}^T + Q$$
$$K = P' J_{H_1}^T S^{-1}$$
$$s = s' + Ky$$
$$P = (I - KJ_{H_1})P'$$

Mapping state to range

$$H_1(s) = (|s_p - r_k|)_{k=1}^4$$

Mapping state to depth

$$H_2(s) = (0,0,1,0,0,0) * s$$

Constant velocity model

$$F = \begin{bmatrix} 1 & 0 & 0 & \Delta t & 0 & 0 \\ 0 & 1 & 0 & 0 & \Delta t & 0 \\ 0 & 0 & 1 & 0 & 0 & \Delta t \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

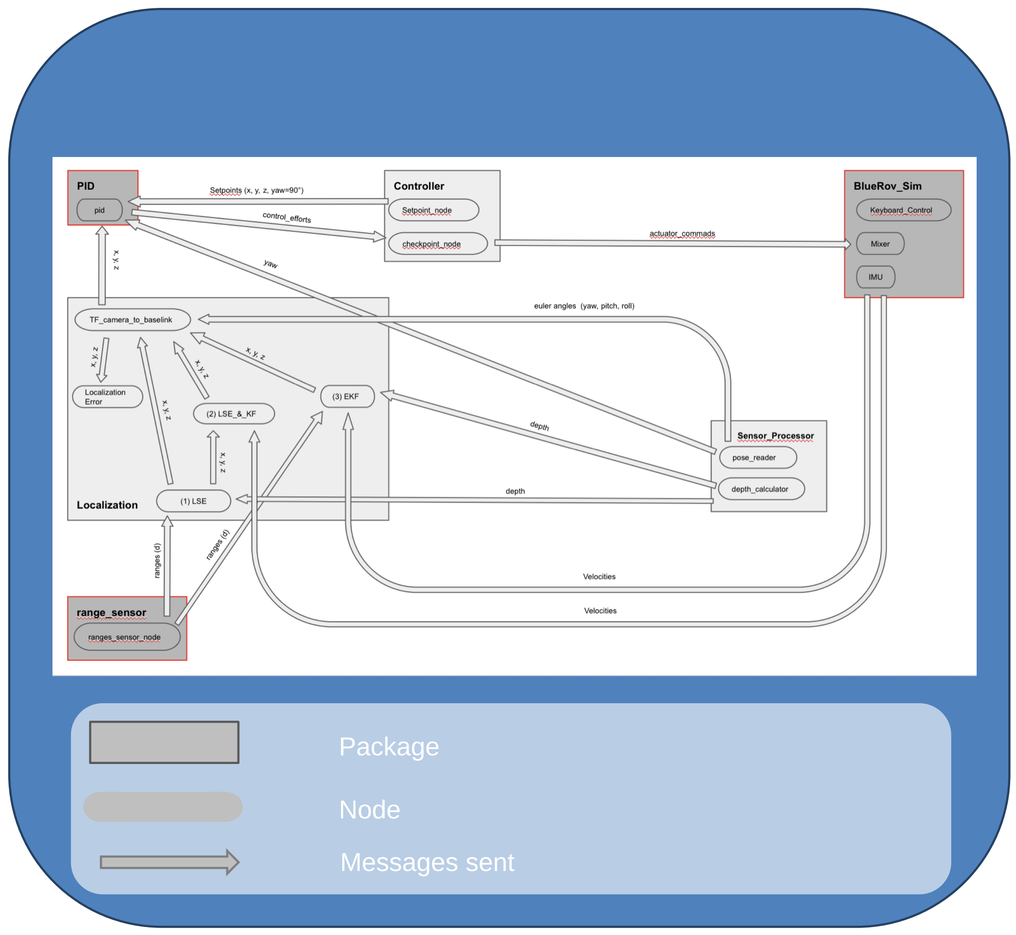
State vector

$$s = \begin{bmatrix} x \\ y \\ z \\ v_x \\ v_y \\ v_z \end{bmatrix}$$

Jacobian of state to range mapping function

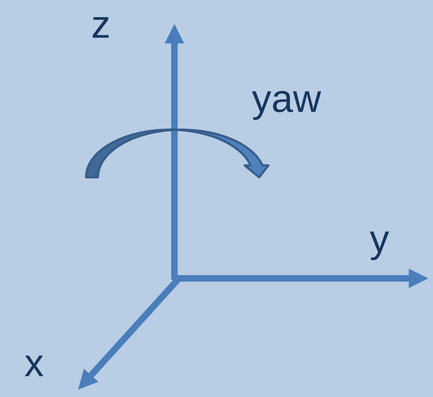
$$J_{H_1}(s) = \begin{bmatrix} \frac{x - r_{1_x}}{|s_p - r_1|} & \frac{y - r_{1_y}}{|s_p - r_1|} & \frac{z - r_{1_z}}{|s_p - r_1|} & 0 & 0 & 0 \\ \frac{x - r_{2_x}}{|s_p - r_2|} & \frac{y - r_{2_y}}{|s_p - r_2|} & \frac{z - r_{2_z}}{|s_p - r_2|} & 0 & 0 & 0 \\ \frac{x - r_{3_x}}{|s_p - r_3|} & \frac{y - r_{3_y}}{|s_p - r_3|} & \frac{z - r_{3_z}}{|s_p - r_3|} & 0 & 0 & 0 \\ \frac{x - r_{4_x}}{|s_p - r_4|} & \frac{y - r_{4_y}}{|s_p - r_4|} & \frac{z - r_{4_z}}{|s_p - r_4|} & 0 & 0 & 0 \end{bmatrix}$$

Node Structure



Controller

- Expectation: LQR/LQG
- Reality: 4 independent PIDs



One PID for each of these states

Pitch and roll?

Mechanically stable on their own!

Final Project?

- Environment mapping
- Obstacle avoidance
- Face recognition to be able saying hello to people near the tank