Performance metrics - Localization

- Accuracy metric: Error between true and estimated positions

$$e_{loc} = \sum_{i=1}^{N} ||(x^i_{\text{true}} - x^i_{\text{estimated}})||$$

  Implement supervisor code to provide you with ground truth for accuracy.

- You should explain in your report
  - What accuracy you obtained with various methods
  - How you implemented Kalman filter – what were your process and measurement models.
  - If / why / why not Kalman filter improves accuracy

Performance metrics - Flocking

For each timestep we have the flocking metric

$$M_{fl}[t] = o[t] * dfl[t] * v[t]$$

Note: the higher the metric, the better the performance!

The overall metric is the average over all $M_{fl}[t]$.

- **Orientation between robots**

$$o[t] = 1 - \frac{1}{N_{pairs}} \sum_{j=1}^{N_{pairs}} abs(H_{diff,j}[t])/\pi$$

With $N_{pairs} = \frac{N(N-1)}{2}$ the number of inter-robot pairs for N robots and $H_{diff,j}[t]$ the difference of heading between the pair j.

- **Distance between robots**

$$d_{fl}[t] = \left(1 + \frac{1}{N} \sum_{k=1}^{N} \left|\left|x_k[t] - \bar{x}[t]\right|\right|\right)^{-1} * \left(\frac{1}{N_{pairs}} \sum_{j=1}^{N_{pairs}} \min\left(\frac{\Delta xj}{D_{fl}}, \frac{1}{(1 - Dfl + \Delta xj)2}\right)\right)$$

With x_k the position of robot k and $\bar{x}$ the center of the flock, Δxj the inter-robot distance of pair j and D_{fl} the targeted flocking distance.

- **Velocity of the team towards the goal direction**

$$v[t] = \frac{||\bar{x}[t] - \bar{x}[t-1]||}{D_{max}}$$

With D_{max} the maximal distance possible per timestep given the robots maximal speed $v_{max.}$

Performance metrics – Formation control

For each timestep we have the formation control metric

$$M_{fo}[t] = d_{fo}[t] * v[t]$$

Note: the higher the metric, the better the performance!

The overall metric is the average over all $M_{fo}[t]$.

- **Distance between robots and their target positions**

$$d_{fo}[t] = \left(1 + \frac{1}{N}\sum_{k=1}^{N} ||x_k - gk||\right)^{-1}$$

With N the number of robots, x_k the position of robot k, and g_k the target position of robot k.
Hint: make sure that both x_k and g_k are in the same coordinate frame!

- **Velocity of the team towards the goal direction**

$$v[t] = \frac{||\bar{x}[t] - \bar{x}[t-1]||}{D_{max}}$$

With D_{max} the maximal distance possible per timestep given the robots maximal speed $v_{max.}$