Metrics for multi-robot system nabvigation

Simplified metrics for multi-robot system nabvigation, using the following notation:

- x_k, ψ_k represent the position and heading of robot k
- $\bar{x}$ represents the position of the center of mass of the swarm
- $proj_b a$ represents the scalar projection of a onto b ($a.b/|b|$)
- Φ is a vector representing the migratory urge ($\cos\phi, \sin\phi$)
- v_{max} is the e-puck maximum speed, 0.1287 m/s (make sure that the Webots maxSpeed for your robots is set to 6.28 rad/s)

1 Orientation

Measures the alignment between the robots.

$$o[t] = \frac{1}{N}\left|\sum_{k=1}^{N} e^{i\psi_k[t]}\right| \tag{1}$$

2 Cohesion

Measures the dispersion of robots, i.e. the average distance to the formation centre of mass.

$$c[t] = \left(1 + \frac{1}{N}\sum_{k=1}^{N} dist(x_k[t], \bar{x}[t])\right)^{-1} \tag{2}$$

3 Velocity

Measures the average displacement velocity of the centre of mass along the direction of the migratory urge.

$$v[t] = \frac{1}{v_{max}} max(proj_{\Phi}(\bar{x}[t] - \bar{x}[t-1]), 0) \tag{3}$$

4 Performance (instant)

As all performance measures are in $[0, 1]$, we can multiply to obtain the global performance at each step. Note that your performance will be 0 at each step when the centre of mass does not move forward.

$$p[t] = o[t]\ c[t]\ v[t] \tag{4}$$

5 Performance (overall)

And for the overall performance, we just average over time (steps). Note that your overall fitness should be quite low, as the center of mass will not normally move at a speed close to the e-puck top speed.

$$\bar{p}[t] = \frac{1}{t} \sum_{k=1}^{t} p[k] \tag{5}$$