Shepherd project

1 Problem

This project is motivated a project proposed by Ifremer to collect autonomously data in the ocean by underwater drifting buoys. To monitor the buoys Ifremer proposed to use 4 saiboat robots.

Sailboat. Each sailboat has a position $\mathbf{a}_i$,$i \in \{1,2,3,4\}$. Each sailboat follows a small triangle with center $\hat{\mathbf{a}}_i$. We have

$$\hat{\mathbf{a}}_i = \hat{\mathbf{a}}_0 + 10^3 \begin{pmatrix} \cos\left(i\frac{\pi}{2}\right) \\ \sin\left(i\frac{\pi}{2}\right) \end{pmatrix},$$

where $\hat{\mathbf{a}}_0 = \hat{\mathbf{b}}_0 + \tilde{\mathbf{a}}_0$. The point $\hat{\mathbf{b}}_0$ is the barycenter of the buoys and $\tilde{\mathbf{a}}_0$ is a vector given by the supervisor to control the position of the group. Define

$$\mathbf{r}_{i,\ell} = \hat{\mathbf{a}}_i + 50 \begin{pmatrix} \cos\left((\ell+1)\frac{2\pi}{3}\right) \\ \sin\left((\ell+1)\frac{2\pi}{3}\right) \end{pmatrix}$$

The robot $\mathcal{R}_i$ follows a line the vertices of which are $\mathbf{r}_{i,\ell}, \mathbf{r}_{i,\ell+1}$ where ℓ is the number of edges that have been followed from the beginning of the mission. When

$$\langle \mathbf{r}_{i,\ell+1} - \mathbf{r}_{i,\ell}, \mathbf{r}_{i,\ell+1} - \mathbf{a}_i \rangle < 0$$

then ℓ is incremented by 1.

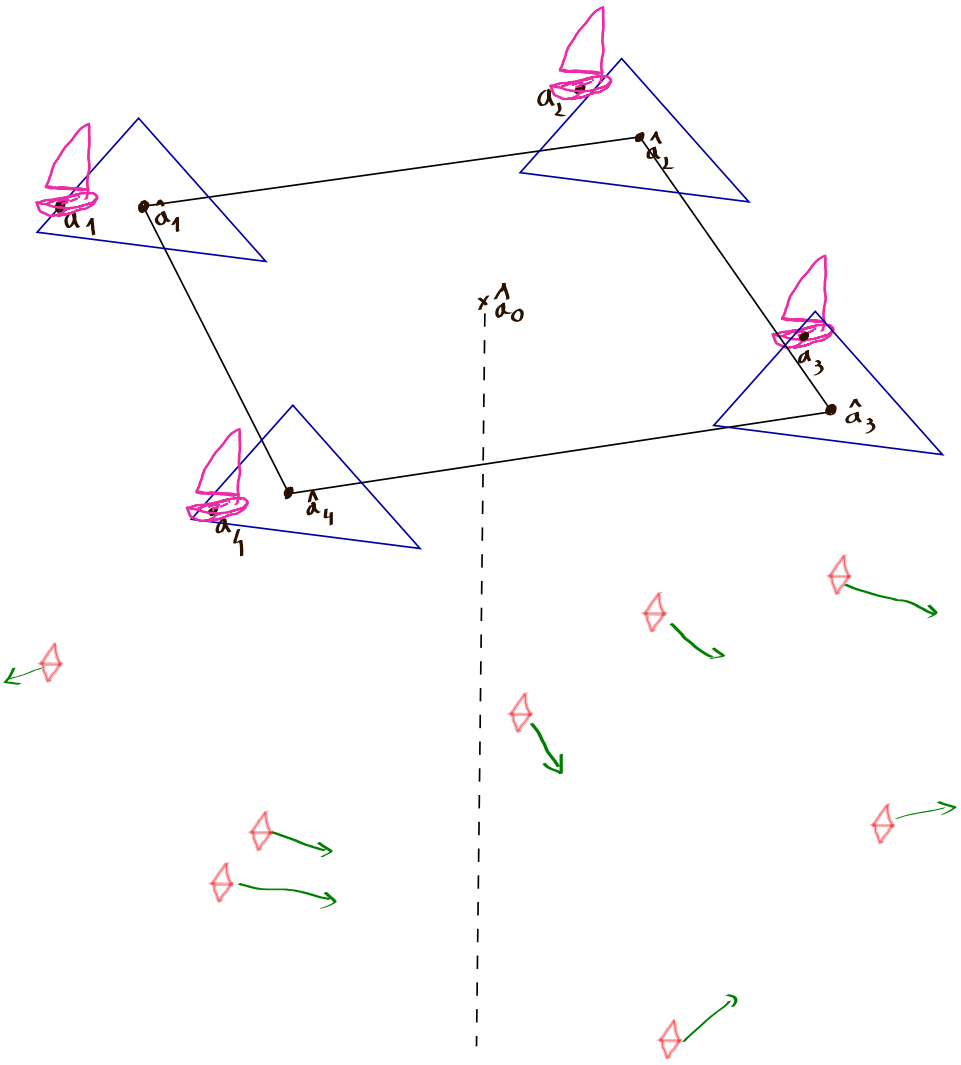
Buoys. Each buoy has a position $\mathbf{b}_j$,$j \in \{1,\ldots,20\}$ and moves up and down with a depth between 0 to 1km. The duration of a cycle of 1 hour. A buoy can stay longer at a depth which fosters a given detection. A buoy is attracted by $\hat{\mathbf{a}}_0$ but is repulsed by nearby buoys. A buoy can move verticaly using its only actuator which is a ballast. Horizontaly, the buoy follows underwater current. We assume that the state equations of a buoy is

$$\dot{\mathbf{x}} = \begin{pmatrix} \sin(10^{-3}(x_2 + 0.9x_3)) \\ -\sin(10^{-3}(x_1 + x_3)) \\ u \end{pmatrix}$$

where $u \in [-1,1]$ is the ballast. The state vector $\mathbf{x} = (x_1, x_2, x_3)$ corresponds to the horizontal coordinates (x_1, x_2) and the depth x_3.

Supervisor. The supervisor control the vector of the point $\tilde{\mathbf{a}}_0$. The supervisor can be a human operator, but a pheromone technique can also be used to avoid staying for too long in a given region of the ocean.

Notation. Hats are used to indicate an estimation. For instance $\hat{\mathbf{a}}_i$ corresponds to an estimation of the position $\mathbf{a}_i$ of the boats. The zero as a subscript corresponds to a abstraction of the group of boat or the group of buoys to a single abstract boat or a single abstract buoy.



Overview of the group of sailboat and buoy robots

2 Formalism

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