

Distributed Control System Project

Autonomous Marine cleaning fleet

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Project overview

A very current problem is the presence of shoals of litter in the seas. An hybrid fleet composed by drones and vessels is involved in the detection and collection of that garbage to make our planet a better place for the marine fauna and not only. Some drones are observing the environment and when some garbage agglomerates are detected they send a cleaning request to the human operator within the position. Then the human evaluates the entity cleaning intervention and send one or more vessels based on the amount of garbage, to clean that area.

Environment

The working place is a small portion of a see, which can be discretized in a grid; each cell may contain some garbage which a certain surface coverage, from 0 to N (0 if no garbage is present, N if the cell is completely covered). Figure 1 shows a rough representation of it. Some assumptions have been made:

- no marine currents are present;
- garbage is fixed;
- sea depth negligible.

The environment is not known in advance, and the location of the waste is detected by the drone fleet after it enters the system.

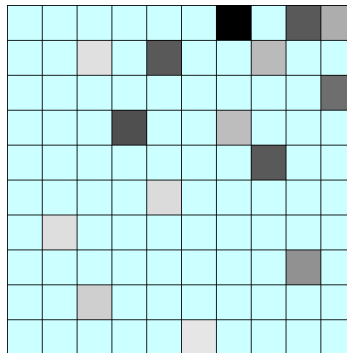


Figure 1: Discretized sea environment with garbage.

Step 0: Initialization

In close proximity to the grid there is the "Mother-boat". This boat is the place from where the human makes decisions and from which drones and boats leave on expeditions and return to (Figure 2).

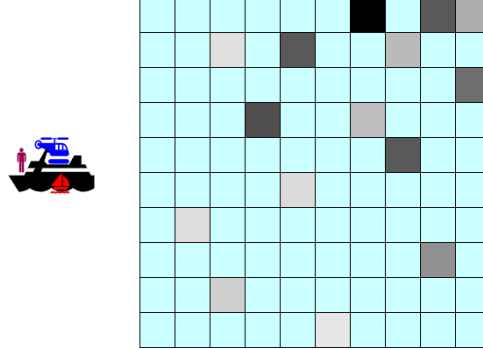


Figure 2: Initial situation with mother-boat, drones & vessels fleets and human.

Step 1: Drone fleet

At this point the environment must be observed in order to detect the garbage. For this reason the fleet of drones takes off, going to explore the grid following a certain path and moving in a coordinated way, keeping a geometric formation (Figure 3). The goal is to detect the garbage and verify the quantity of it. In order to have a more reliable measurement, the average among the detected quantity of litter by each drone, for every single cell, is computed, sending the information to the human. Now the fleet comes back to the mother-boat.

In case of raining or too windy conditions, drones don't take off or immediately come back if are in recognition.

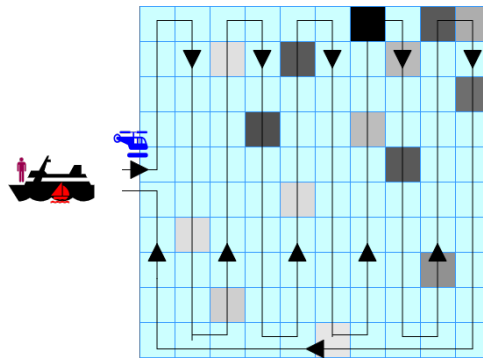


Figure 3: Drone recognition (the path is not necessarily this one).

Step 2: Mother-boat

Now that the environment is known, the mother-boat enters the environment and places itself in the position given by the weighted average of the position of the garbage, to get as close as possible to the most concentrated area and so that the fuel consumption of each vessel is minimized. If the cell given by the weighted average is partially or completely covered by garbage, then the mother-boat is placed in a nearby empty cell. On the way to go into the

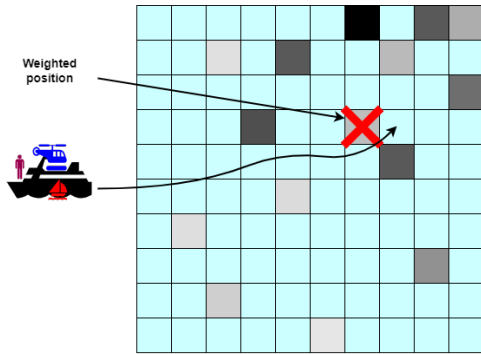


Figure 4: Mother-boat moves in the assigned cell, avoiding garbage.

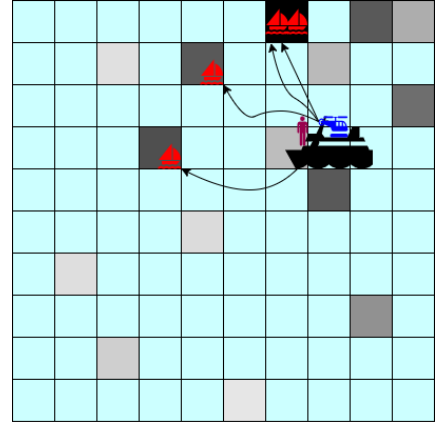


Figure 5: Garbage collection by means of vessels.

assigned cell, garbage must be avoided (Figure 4). Thereafter the boat will remain in this position.

Steps 3-4: Human control & Garbage collection boats

Then, in according to human choice, a fleet of ships (or a single ship) is dispatched to collect the defined garbage target, following a paired formation (Figure: 5). In particular the human looks at the information provided by drones and decides how many boats must be sent in a certain area, depending on distance and quantity of garbage criterion. Since the GPS position is subject to uncertainty, the ships must follow a cleaning pattern for guarantee a sufficient result. At the end of the mission, all ships must return to the base to unload their contents.

All expeditions are carried out in a good weather conditions, i.e. no wind and sunny day (no rain). In case of adverse conditions and human's discretion the boats may be call back. The sensors are mounted on the mother ship and it is assumed that they are sufficient to detect changes in the weather.

It is possible that other (external) boats may appear in the area and the cleaning boats, equipped with a sonar, will have to keep a safe distance from them and find an alternative route for complete their task.