# Aggregation

## The problem

Aggregation is a group behavior in which the individuals approach each other and form clusters. In nature, for example, bees aggregate in the hive and fish remain together in schools. In swarm robotics, aggregation behaviors are widely studied as they determine the ability of the robots to remain together as a group. Robots can aggregate either because they perceive a region of interest to aggregate in the environment, like bees aggregate in the hive, or because they sense other robots that are already forming a cluster, like schools of fish.

## Experiment layout

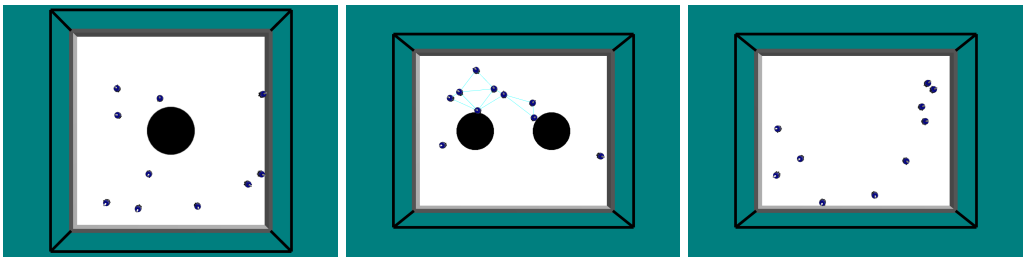

Figure 1: The one-spot aggregation experiment (left), two-spot aggregation experiment (middle), and the no-spot aggregation experiment (right).

In all experiments, ten footbots are distributed randomly in the experimental arena that is bounded by walls. The arena for one-spot aggregation experiment contains a single black spot in the center. The arena for the two-spot aggregation experiment contains two identical black spots.

## Robot layout

In this experiment, the robot has access to the following sensors and actuators:

| Available sensors | Available actuators |
|---|---|
| `robot.id` | `robot.wheels` |
| `robot.random` | `robot.leds` |
| `robot.range_and_bearing` | `robot.range_and_bearing` |
| `robot.proximity` | |

## Objective

This exercise consists of three parts. Please use your control software of the previous exercise (random walk and obstacle avoidance) as base for the control software of this exercise.

### Part 1: One-spot aggregation

In the experiment corresponding to `aggregation_1.argos` the swarm is tasked with aggregating on the black spot. The simple solution is just to move the robots around in the arena and to stop when the ground sensor detects the black floor. But maybe you can find a more efficient strategy?

### Part 2: Two-spot aggregation

In the experiment corresponding to `aggregation_2.argos` the swarm is tasked with aggregating on one of the two spots. As a starting point, run the control software you wrote for the first part. What do you observe? Do the robots aggregate on the same spot or are they spreading out across both spots? If the robots spread out over both locations, try to adapt your control software, so that the swarm aggregates on only one spot.

### Part 3: No-spot aggregation

In the experiment corresponding to `aggregation_0.argos` the swarm is tasked with aggregating anywhere in the arena. The difficulty here is that by default no place is more suitable to aggregate than any other. Program the robots in such a way that the swarm aggregates in a single group somewhere in the arena.

## General remarks

The control software of the robots is executed in the form of time steps–that is, the script is executed in the simulator once for each time step. In this experiment, the time step has a length of 100ms. In other words, each of the actions defined in the Lua script will be executed 10 times per second.
Many basic robotic behaviors follow the *Sense-Think-Act* scheme.
Remember that the individual actions of each robot are the ones that lead to the robot swarm achieving the desired behavior.