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# CMP 494-10 INTELLIGENT AUTONOMOUS ROBOTICS

## HOMEWORK #3

**Due date/time: Thursday, 28 March 2024, at 11 pm**

**Instructions**: Submit via the assignment box on *iLearn,* before the deadline, a single *Zip/Rar* archive that contains your *answers* in a *Word doc* and your *Webots project folders.* Make sure to include the *name and AUS ID* of each teammate at the start of all your files. Include them in the archive name as well, as per this format: "CMP494-HW2-MPasquier74321-ARAlAli64213-SDhou83524.zip". Follow the instructions below and any other on *iLearn.* Note that late submissions will be penalized as per the course policy.

Note that you are to complete this assignment *as a team of students.* Furthermore, each team must *work independently* and hand in their own original answers. You are *not* allowed to discuss or *share* any solution or to *copy* from others or from any sourced material. Plagiarism and cheating will be severely penalized, starting with a zero grade for the assignment. Recall you are bound by the AUS Academic Integrity Code, which you signed when joining AUS.

This assignment requires that you downloaded and installed the Webots robot simulator from Cyberbotics.com, and studied beforehand a couple Webots tutorials, as emphasized in class and on iLearn. Note that some questions hereafter can be answered theoretically, without any simulation, while some other problems must be solved by implementing a controller program and running a simulation.

**Question 1**: **(a)** Explain briefly what *passive* and *active sensors* are in robotics, using an example of each to illustrate your answer, and indicate clearly *why* the distinction matters. Define what *active sensing* is, and give a working example. (4 marks)

**(b)** Which robotics sensor is a *car odometer* related to and why? How *accurate* is such a sensor, and *why* exactly? Explain clearly what *forward kinematics* is and how it relates to *odometry.* Give a simple example to illustrate. (4 marks)

**Question 2:** **(a)** *Logical sensors* are a powerful abstraction for AI robotics. For instance, a logical `front_distance_sensor` might return a single value that is the distance to an obstacle ahead of robot, averaged from 4 ultrasonic sensors. Explain briefly the purpose of logical sensors, and elaborate their pros and cons. (3 marks)

**(b)** Could logical sensors comprise a *mix* of different sensors? Justify you answer clearly i.e., give the purpose and point out the pros and cons of such a design. What combination could we use for the distance sensor in part (a)? (4 marks)

**(c)** Define what *sensor fusion* is then highlight the pros and cons of this approach. Explain briefly but clearly the difference/s between a hybrid logical sensor as discussed in part (b) and sensor fusion. (3 marks)

**Question 3:** The following exercise is a simplified version of the "Pick Up the Trash" example from class. The description is as follows:

"A small, circular, wheeled robot is used to find all the cans in a room, log their position, then return to its base station. The robot is equipped with a simple color camera for finding objects and a bumper sensor for detecting contact with an object; it has no gripper or other sensor. The robot implements reactive behaviors only, namely: *Wander* should move the robot randomly in the environment, while *Forward* should move the robot toward a target object until it comes in contact with it. The robot has memory, to remember which cans have been found, or not."

The expected scenario is thus as follows: The robot should start wandering, looking for a can. Once a can is located, the robot should move toward the can until touching it. The robot will then record the position of the can (assume this part is done automatically). It will repeat this behavior until all three cans have been found, after which it will start wandering again, looking for its base station this time. The robot will stop upon reaching the base station.

**(a)** Define the robot behavior as a *Finite State Automaton* (FSA). Draw a diagram, showing all states and transitions, and provide a matching table as well (cf. class examples). Recall there is always a Start state; in this case you should also have a Final state, which is to be at the base station. (6 marks)

**(b)** Implement your FSA in Webots. Make a copy of the *Camera* device demo in your own projects folder and add a *Bumper* sensor to the robot (or the other way). Modify the environment so it looks like the one depicted in Figure 1, which is a square room with dark grey walls and a light parquet floor, a red can, a green can, and a yellow can, as well as a base station in the corner.

Program your FSA in the robot controller, defining appropriate functions for the sensors (incl. for detecting each can) and the behaviors (Wander and Forward). Remember to structure your code properly. Test your program to make sure it works as per the above description / scenario, regardless of the position of the cans and the robot's starting location. (6 marks)

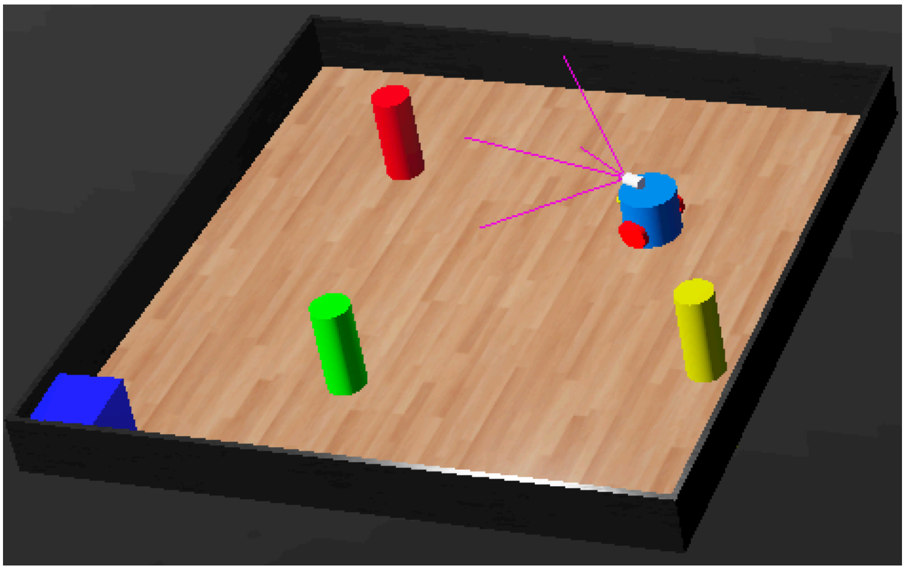

Figure 1: Test environment with three cans, a robot, and its base station.

Notes: Obstacle avoidance is not necessary in this simple exercise. Webots' *Bumper* device demo shows for instance how to use the bumper to move around and explore the environment. The *Camera* device demo shows how to extract and use color information from the images. Adapt to your own use.