Task Sheet 0

Recap: Introduction to Autonomous Robotics

Deadline 10:00 16.04.2024
Review 16/17.04.2024

Lecture: *Advanced Autonomous Robotics*, Summer Term 2024

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Attention: This task sheet is a recap of the Introduction to Autonomous Robotics lecture and does not contribute to obtaining the exam admission! You do not have to upload anything to ILIAS. If you have not attended the Introduction to Autonomous Robotics course, try to familiarize yourself with the topics present in this sheet.

Task 0.1 Simple robot behaviors - Drunkard's Walk

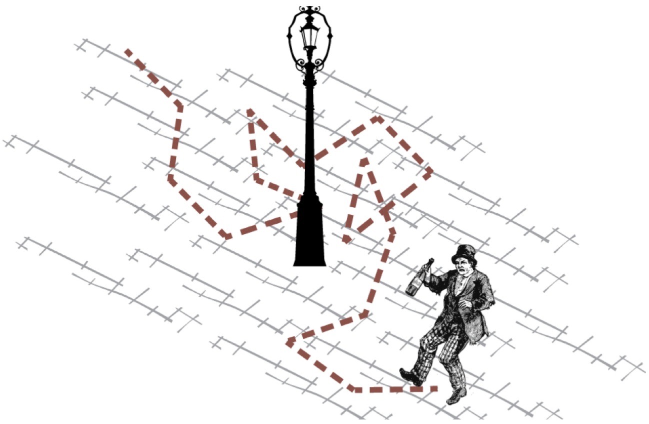


Figure 1: The Drunkard's Walk.

Based on the *Drunkard's Walk* (see Figure. 1) we want to develop a robot behavior. Initially the robot should not move. When the light sensor (L) is triggered the robot should do one step of the Drunkard's Walk. The Drunkard's walk consists of n steps in which the robot first moves straight for a certain amount of time ($t = 15$ s) and second turns left for some time (3 s $\leq t \leq$ 21 s). After moving the step the robot should wait until the light sensor gets triggered again to execute the next step. You are allowed to use one timer T which can be set to an arbitrary value and counts down.

a) Formally describe the behavior as a finite state machine, i.e., define the sets S, Σ, and $\delta = S \times \Sigma$. Further denote the initial state q_0.

b) Draw the finite state machine of the described behavior with fewest states possible.

c) Construct the state table of the described behavior with fewest states possible.

Task 0.2 Complex robot behaviors - Ants trail

Please consider the following behavior:

The robot implements an ant-like behavior, that is, the robot follows a line (cf. ant trail). In the case of an obstacle blocking the way, the robot leaves the path to avoid it. After avoiding the obstacle the robot explores the environment to find the path again. See Figure 2 for illustration of the described robot behavior.

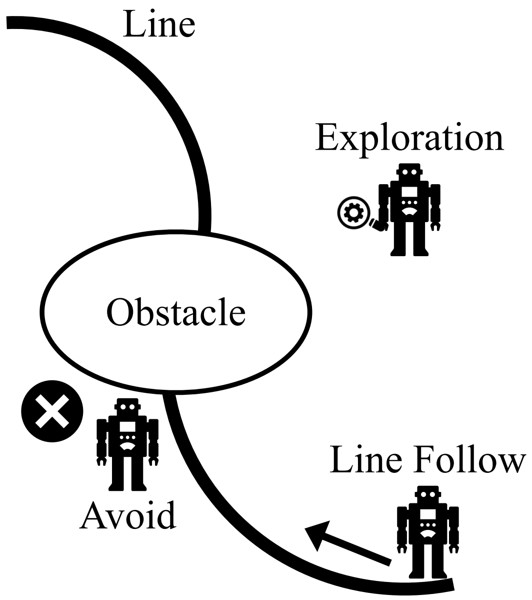
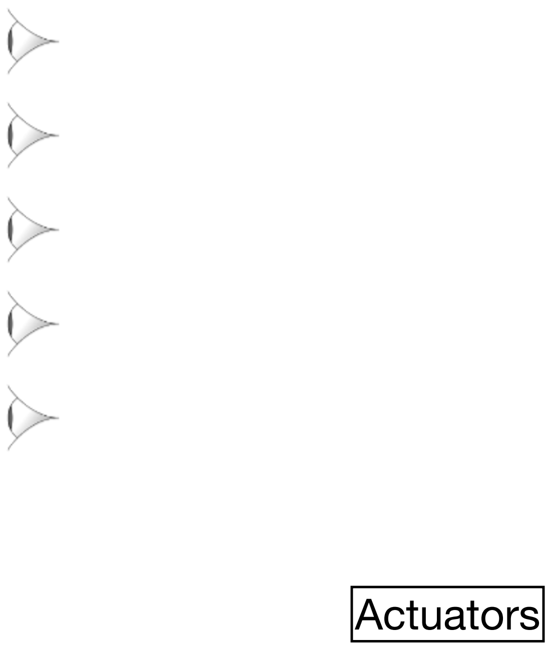


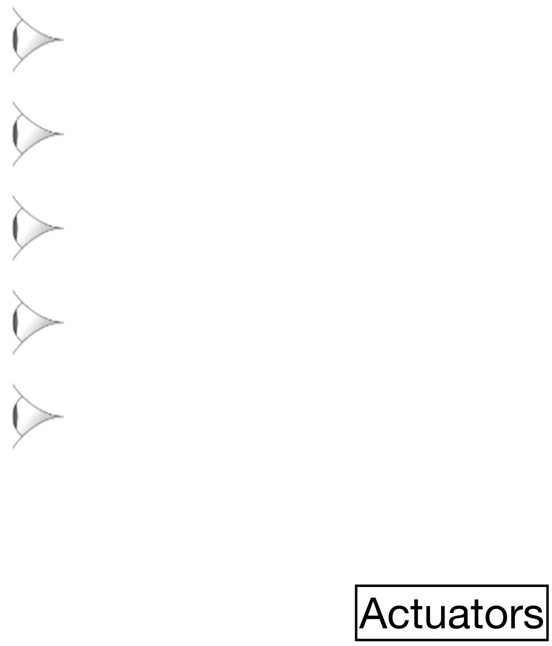
Figure 2: Illustration of the robot behavior.

a) Shortly describe the robot architecture (a sketch may be useful!). Mark all actuators and sensors, which are required.

b) Use the following arbiter template to implement the desired behavior.



c) Implement the behavior using the subsumption architecture.



Task 0.3 Planning

a) Find a valid path, from the starting position of the robot to the goal, using Meadow Maps in the map shown in Figure 3.

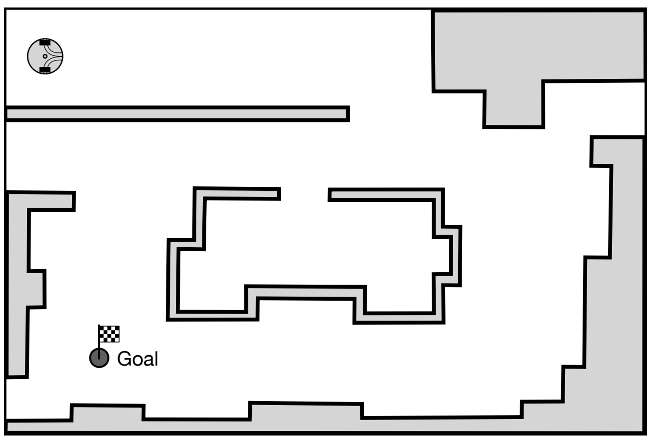


Figure 3: Meadow maps map.

b) Find the shortest path, from start to goal, using the visibility graph in Figure 4.

c) Generate the Generalized Voronoi Graph for the map in Figure 5.

d) Find the shortest path, from start to goal, using the wavefront algorithm Grassfire in the map shown in Figure 6.

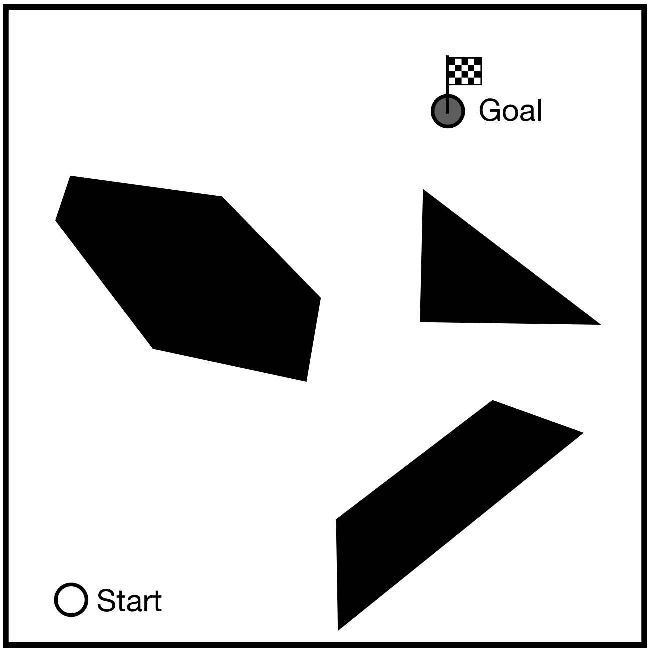


Figure 4: Visibility graph map.

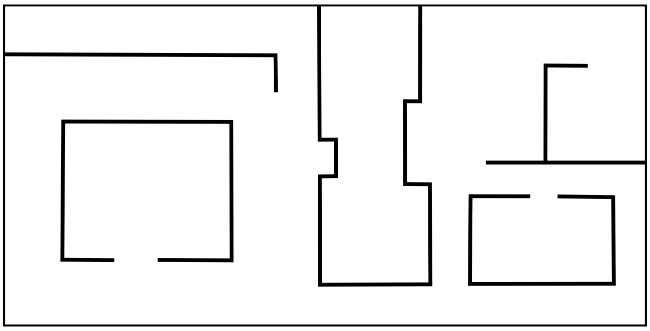


Figure 5: Generalized Voronoi graph map.

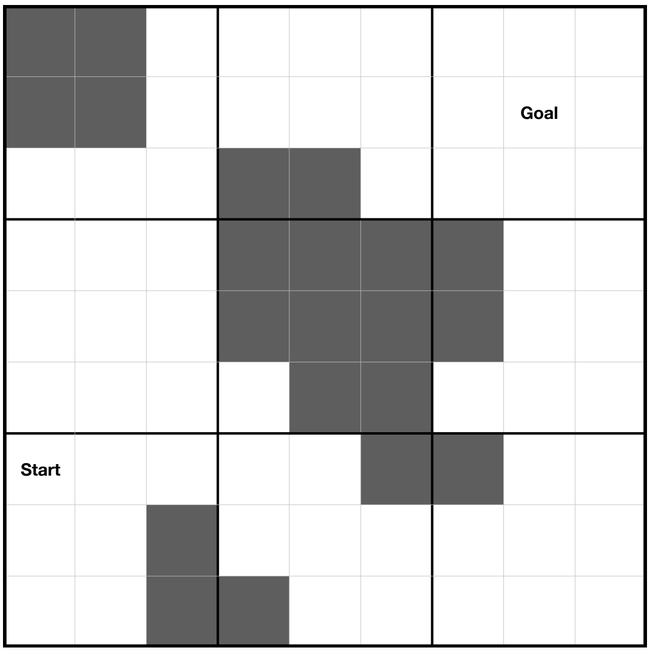


Figure 6: Wavefront map.

Task 0.4 Designing a robot system

Your task is to build a cost-efficient robot for the transport of goods in a warehouse. A combination of various basic behaviors will lead to the overall robot behavior.

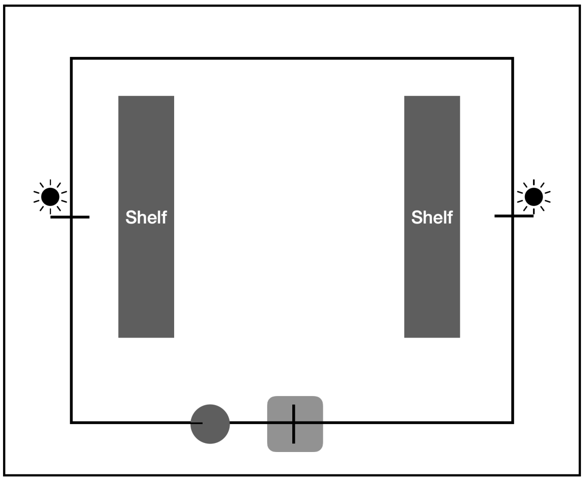


Figure 7: Example of the robot in the warehouse. The dark gray circle represents the robot, the light gray square is the starting area. The black lines are floor markings. The sun symbols represent lamps.

Figure 7 illustrates our scenario. A robot is positioned in a warehouse with several shelves. The robot has to move through the warehouse along the markings on the floor. In doing so, it must be able to react to moving obstacles, e.g. people. At the starting point there is an IR beacon that can be seen throughout the warehouse by an IR receiver (i.e., there are no IR shadows).

The behavior of the robot is specified as follows: Initially, the robot is on the starting point. The robot travels through the warehouse along the lines on the floor. If the robot perceives one of the crosswise markings along the line and detects a light value above 200, the robot will wait until the light value is lower than 200 again. In the event of a collision with an obstacle, the robot should reverse briefly, wait and then continue to follow the line. If the robot loses the line, it should return to the starting point with the help of the IR beacon and follow the line again from there.

a) Select four types of sensors to be integrated in your robot and indicate the required number of sensors for each type. Justify your choice of sensors and describe how they are attached to the robot. Illustrate it with a sketch.

b) State which primitive behaviors are needed to implement the robot's behavior. Briefly explain each behavior (When is it activated? What does the robot do?). Indicate the priority of each behavior.

c) Complete the following behavior diagram for the overall behavior using arbitration.