EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

MATH. - NATURWISS. FAKULTÄT
FACHBEREICH INFORMATIK
KOGNITIVE SYSTEME · PROF. A. ZELL

Lab Course Mobile Robots

Exercise sheet 3, WiSe 2025

Protocols: *Please create a file* `protokoll_xx.pdf` *(*`xx` *number of the exercise) with your answers and experimental results for each exercise sheet with LaTeX and put it into the folder* `Protokolle` *. Please upload the file to* https://bitly.cx/LVepF *as well.*

Preparation: *Please carefully read the provided information about the potential field method, which you can find on* https://bitly.cx/LVepF, *in advance. To visualize the potential field we will use messages of the type* `Marker::ARROW`*. For that, make yourself familiar with quaternions.*

Exercise 1 Collision avoidance

Asimov's famous Three Laws of Robotics are:

1) A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2) A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
3) A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

(a) Implement these laws by writing a node which makes the robot move straight ahead, if no obstacle is in front of the robot, but stops the robot instantly, as soon as something is located "close by". Therefore, check if there are measurement points from the laser scanner, which fall into a rectangular area in front of the robot, oriented according to its driving direction. The side lengths of this rectangle are parameter of your program and need to be determined experimentally. The emergency stop prohibits any further movement. Before the robot starts executing any task, it has to be checked if there is any possible collision.
This principle also applies for **all** future nodes in this practical course!

Hint: Use the provided framework in the packet `obstacle_avoidance`. Get used to using *launch files* and use the provided file in the folder `launch`.

(b) Are the Three Laws of Robotics really met by this node?

Exercise 2 Obstacle avoidance with the potential field method

(a) Start `Stage` with the world file `obstacles.world` and run the node `obstacle_avoidance`. The robot always drives towards the lower right corner, even when put in a different spot using the mouse.

Hint: On using `Stage` with the following command, the laser scanner measurements are published on the topic `/scan` (so you do not need to distinguished between the topics `/scan` and `/base_scan` in your source code): `ros2 launch stage_ros2 stage.launch.py world:=obstacle base_scan:=scan`

(b) Add some obstacles to the simulation by editing the file `obstacles.png`, for example with `Gimp`.
In the following questions, you are going to implement the potential field method for obstacle avoidance in a separate class `PotentialField`. This `PotentialField` class will then be used in your `ObstacleAvoidance`.

(c) `PotentialField` gets as input the goal vector F_{att} and the current laser scan. Visualize the goal vector in `rviz` as a green arrow. Therefore, use messages of type `visualization_msgs::msg::Marker` with `type = visualization_msgs::msg::Marker::ARROW`. Add a plot to your report.

Hint: The class `PotentialField` is completely independent of the odometry. The odometry data is only used to compute the goal vector F_{att}.

(d) Now divide the area scanned by the laser in a few segments. In each segment, determine the nearest obstacle and compute the corresponding vector F_{rep} of the repulsive force. Visualize these vectors as red arrows.

Hint: For multiple arrows you may use messages of the type `visualization_msgs::msg::MarkerArray`.

(e) Compute the resultant force F from goal vector F_{att} and the obstacle vectors F_{rep}. Visualize this force as another arrow. From F, the corresponding steering angle can be determined. Now, the robot should be able to get unscathed from one corner to the other.

Hint: The simple collision avoidance from exercise 1 is to be used again.

(f) What are the advantages and disadvantages of the division of the scan area in a few segments?

(g) For which obstacles the potential field method fails?

(h) Extend the method by considering the orientation of the robot relative to the obstacle. In the provided handout, this is called `rotation potential field`. Describe your approach.

(i) What happens if the target is far away (e.g. at the other end of a soccer field)? What would be a possible countermeasure?

(j) Now, test the method on the real robot by letting the target vector always point into a reasonable direction.