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

Mobile Robots

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Assignment 5

due by: 04.06.2013, presentation: 18.06.2013
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Exercise 1 - Sensor Uncertainty (11 Points)

Naturally, sensors provide their measurement with a particular uncertainty. Here, you will get a first idea on the consequences this might have for the developer of a robot.

(a) In the classical example, a robot with a two wheel differential drive ($l = 0.2\,\text{m}$) is used. To keep things feasible, we will simplify matters a bit. Assume that the distance that each wheel traveled can be measured with an certain accuracy. Compute the radius of the trajectory which can be expected in the worst case scenario for an accuracy of 10%, 5%, and 1%. (2 Points)

(b) If you want the robot to turn 90° to the left on the spot, what distances s_l, s_r will the two wheels have to travel? (1 Point)

(c) For the same accuracies 10%, 5%, and 1%, which turning angles should be expected in worst case for a desired turn of 90°? For simplicity, report only the angles and ignore the fact that the robot could move while turning as well. (1 Point)

(d) In the following, we will assume an accuracy of 5%. The robot should now move along a square: four times in a row, it is commanded to first go straight for $1\,\text{m}$ and than turn to the left by 90° on the spot. You can make the same simplifications as above and reuse your results. Create a scaled drawing of the scene. Include the desired path and the two extreme cases. Shade the area through which the robot could have passed during the experiment. Mark further the area in which the robot could be located in the end. (5 Points)

(e) Report the maximum position and rotation error compared to the desired goal position. (2 Points)

Exercise 2 - Fun with Ultrasonic Sensors (7 Points)

Ultrasonic sensors are highly dependent on environmental parameters as discussed in the lecture. In this exercise, you should get a feeling for the influence of these parameters.

(a) On the internet, several sources provide precise and approximate equations which determine the speed of sound in certain media, e.g. `http://en.wikipedia.org/wiki/Speed_of_sound`. Please list an approximate formula which relates the temperature to the speed of sound for ideal conditions on earth (e.g. assuming no humidity). (1 Point)

(b) Use this formula to compute the speed of sound for -30° C to 40° C in steps of 10° C. (1 Point)

(c) Assume your sensor is strong enough to detect objects in $10\,\text{m}$ distance. In your comfortable lab environment (20° C room temperature), you want to decide on an appropriate frequency to emit ultrasonic beeps such that no interference effects occur. The computation after each detection lasts $0.001\,\text{s}$ until the next beep can be emitted. What is the highest possible frequency that the sensor could achieve? (1 Point)

(d) For the same parameters, what is theoretically the shortest distance that your sensor could detect? Each beep lasts for $0.001\,\text{s}$ and afterwards, the microphone is disabled for another $0.001\,\text{s}$. (1 Point)

(e) Assume that you want to integrate this sensor into the automatic parking assistant of a car and that no temperature reading is available. Which readings do you expect for an object that is in reality $5\,\text{m}$ away from the sensor when the car is tested in cold (-30° C) and warm (40° C) environments? (2 Points)

(f) You now want to sell your sensor due to the magnificent test results. For this purpose (and the purpose of this exercise), you will have to write a data sheet that contains the most important features of your sensor such as suitable environmental conditions, sensing range, update rate, and most importantly the accuracy that you can claim from your tests. Summarize everything nicely in a table. (1 Point)

Exercise 3 - Sensors for different purposes (3 Points)

Clearly, different robots call for different sensors according to their designated purpose. In this exercise, you should be simply creative and familiarize yourself with the requirements of different robots. Short answers are fine.

(a) Your uncle is a member of the local THW group (in case you did not know yet) and they are considering to build a vehicle that is, after an earthquake, suitable to enter a building that might collapse. The vehicle should be portable by a single person and would be mostly used to quickly search the building for injured persons and to investigate the structural damage of the building. What kind of vehicle would you suggest? Which sensor(s) would you mainly rely on? (1 Point)

(b) During a conference, a truck manufacturer asks you for suggestions on how to improve the safety of his vehicles. More specifically, he wants to pick the sensors suitable for an autonomously navigating van. What would be your main choice(s) for which purpose? (1 Point)

(c) As you saw before, sensors can be quite unreliable. Provide a concept you would consider when designing a robot to increase the accuracy of the final system. (1 Point)