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Exam in
DD2425 Robotics and Autonomous Systems

Lecturer: Patric Jensfelt

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You are allowed to use a calculator but will not need one I think. Please read the entire exam before preparing the answers to make sure that you have a good view of the questions to be answered. You need at least 40 points to pass. The mapping from exam score to 0-10 which is averaged with your score from the project, is such that 40 points on the exam gives you 0 and max points (100) gives you score 10.

Do not forget to turn the page!

WRITE ONLY ON ONE SIDE OF THE PAPERS. Put your name and the page number on each page and note how many pages are handed in on the cover page!

GOOD LUCK!

Short questions, short answers

1. What does IMU stand for? (2p)

2. If you want to implement a crash detection system (i.e. detect when it has happened) for a robot with a complicated shape moving inside a maze like in this year's project, which sensor would probably be simplest to use; a micro switch, 2-axis accelerometer, IR-sensor, sonar, PrimeSense or a compass? (2p)

3. At what distance are you likely to get the worst measurement of distance from a PrimseSense RGB-D camera as used in the course; 0.2m, 1.2m or 2.2m? (2p)

4. How can you tell how much time it should take to move from the start to the end of a trajectory without knowing what robot will be used (assuming it can follow the trajectory)? (2p)

5. Mention a problem that you might face when you use the inverse kinematics for an arm? (2p)

6. Mention one major challenge for using a robot arm in a domestic environment safely? (2p)

7. Mention a problem when a phase shift laser? (2p)

8. Mention a limitation when using Doppler radar to detect speed? (2p)

9. When using a camera for detecting the position of an object, mention a problem if the focal length in your camera model is wrong? (2p)

10. How can you use the stereo effect with only one camera? (2p)

11. Mention an environment type where GPS is unlikely to be available? (2p)

12. Mention a setting in which a passive sensor is to be preferred and why? (2p)

13. Mention a potential problem with a low resolution encoder for speed control of a motor? (2p)

14. Mention a potential problem with a high resolution encoder? (2p)

15. Mention two advantages with a quadrature encoder compared to a standard one? (4p)

16. Mention a problem when using a visibility graph for path planning? (2p)

17. Mention a challenge when using a feature based representation and an EKF for SLAM? (2p)

Longer questions, longer answers. Make sure to motivate your answers. State any assumptions you make explicitly. ANSWERS MUST BE ON SEPARATE PAGES!!!!!

18. a) What type of components are part of an IMU? (3p)
    b) Describe how it is used to track the pose in 3D (no need for formulas). (7p)
    c) Discuss two limitations / problems. (4p)

19. Describe how topological mapping is done conceptually and how the robot would use the topological map for localization. (5p)

20. You have been tasked with building the vision system using a RGB-D camera (think PrimeSense) on a robot moving in a maze like the one in the course. You need to be able to detect and classify the objects. You can assume that the objects vary in color and shape like the ones used in the course project.
    a) How would you mount your sensor and how would you pre-process the data? (5p)
    b) How would you detect the objects? (5p)
    c) How would you classify the objects? (5p)
    d) Identify and discuss two problems with your solutions above? ("I did not answer b) and c) so I can neither detect nor classify objects" is not an OK answer, although that would clearly be a problem for your system) (5p)

21. Your robot is exploring an environment (can be thought of as 2D) of which only the dimensions are known. You are using an occupancy grid to represent the world. Explain:
    a) How do you initialize (sizes (be explicit what sizes), initial values, etc) the grid? (5p)
    b) How do you update (you do not need exact formulas) the occupancy grid? You do not need to worry about how and where the robot moves as this is taken care of by one of your team mates. All you need to explain is how the occupancy grid gets updated given that the robot moves. (5p)
    c) How do you define unexplored space and good target locations to move to to explore space? (5p)
    d) How do you find a path that the robot can travel from its current position to the target location defined in the previous question (you can call it P if you find that simpler or did not answer c)) when the robot has explored part of the environment? (5p)
    e) Discuss how the way you update the map might influence the exploration behavior and problems that might occur in general (at least one). (5p)