

Written exam Oct 25, 2016 (robot16) DD2425 Robotics and Autonomous Systems

NOTE:

- **Fill in name and personnummer and nothing else!**
- **Copy “Exam id” to all other pages**

* Name:.....

* Personnummer:.....

Exam id:

Summary of results Used by examiner only!!!!

Scoring: 1 for correct answer, 0 for wrong answer and blank for no answer.

Section A: Must have at least 7 correct to pass.

	1	2	3	4	5	6	7	8	9	10	Sum	P/F
A												

Result Section A:..... (either P or F)

Section B: Must have at least 3 correct in a subsection to pass. Must pass all subsections.

	1	2	3	4	Sum	P/F
B.1						
B.2						
B.3						
B.4						
B.5						

Result Section B:(either P or F)

Result overall exam:(either P or F)

Date:.....

Signature of examiner:.....

Exam id: (copy the exam id from the cover page)

Written exam Oct 25, 2016 (robot16) DD2425 Robotics and Autonomous Systems

Lecturer: Patric Jensfelt

You are NOT allowed to use any books or calculators.

Hand in the exam no later than 15:45. Take your belongings and leave the room, **BUT return at 16:00 for an immediate feedback section.** Every student should give feedback on one other (anonymous) student's exam. The examiner will check the feedback, make modifications if needed and do the actual grading.

Requirements: To pass the exam you need to pass sections A and B. Passing section B requires passing all subsections in that part. You need at least 70% on each subsection to pass (7/10 on section A and 3/4 in subsections B.x).

Make sure to:

- ONLY write your name on the cover page! (to stay anonymous)
- Copy the "Exam id" from the cover page to all other pages
- DO NOT write in the square boxes next to the questions (these are for grading).
- Keep your answers short. It is not an essay!
- Write only on the pages provided to you. Use backside if needed but make it clear that you used it.
- **Return at 16:00 for the feedback session!!!!**

The written exam is assessing your fulfillment of

ILO 1: recall basic concepts in robotics

The gist of this ILO is that the student is able to interact in a working environment where robotics is the domain. This means that basic nomenclature and concepts needs to be known. It is possible to learn the details about things while working but unless you know the basics you cannot even discuss about robotics.

ILO1 consists of two parts,

- A. Knows the basic nomenclature used in robotics
- B. Can recall basic concepts in the areas
 1. Locomotion and kinematics
 2. Manipulators
 3. Sensors and perception
 4. Navigation
 5. Mapping and localization

GOOD LUCK!

Exam id: (copy the exam id from the cover page)

Section A

A.1: What do you call the wheel configuration where you have two independently powered wheels, one on each side of the robot and typically a caster wheel to keep the balance?

Correct answer: Differential drive

A.2: What do you call the wheel type with many small, freely moving, rollers along the periphery of the wheel that allow the wheel to slide in one direction?

Correct answer: Swedish wheel, Omni-directional wheel, Mecanum wheel, Ilon wheel (after the inventor Bengt Erland Ilon)

A.3: We typically talk about two types of UAVs. Name one of them?

Correct answer: Fixed wing and Multirotor, Multicopter

Accepted answers: Special cases such as quadcopter, quadrotor, or descriptions of the two types

A.4: Which of the following sensors are proprioceptive (can be more than one)?
Sonar, gyro, camera, radar, encoder

Correct answer: Gyro AND encoder (must give both!)

A.5: What does pose mean (as in “the pose of the robot” or “the pose of the object”)?

Correct answer: Position and orientation

Not OK answers: (x,y,θ) as it does not make it clear that it is in general position in 3D and orientation in 3D. This is a special case for a robot moving in 2D.

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A.6: What does the acronym UWB stand for (e.g. used in radio based positioning)?

Correct answer: Ultrawide band

Accepted answers: Descriptions that make it clear that the person knows what we are talking about here, i.e., not something generic like radio (which we already gave in the question)

A.7: What does the C in C-Space stand for in the context of motion planning?

Correct answer: Configuration

A.8: What do you call the function that maps the Cartesian position to joint angles for a manipulator?

Correct answer: Inverse kinematics

Accepted answers: Inverse <something sensible>

A.9: What does RRT stand for in the context of motion planning?

Correct answer: Rapidly exploring Random Tree

Accepted answers: Rapidly Random Tree or similar

A.10: What does SLAM stand for?

Correct answer: Simultaneous Localization and Mapping

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Section B.1 Locomotion and kinematics

B1.1: Consider a robot with kinematics described by
 $dx/dt = v \cdot \cos(\theta)$
 $dy/dt = v \cdot \sin(\theta)$
 $d\theta/dt = \omega$

where you control v and ω . What geometric shape does the robot describe for a fixed input with none of the signal being 0 (keep it brief!!!!!!)?

Correct answer: Circular arcs
Accepted answers: Circles

B1.2: Give 1 advantage and 1 disadvantage with having a holonomic car (keep it brief!!!!!!)?

Correct answer:

Advantages: Can move in any direction, easy to park, great turn radius,...

Disadvantages: Mechanically complicated, control more complicated, ...

Accepted answers: Many other answers possible for a car that can move in any direction

Not OK answers: Mixing it with non-holonomic, i.e. cannot move in all directions.

B1.3: Give 1 advantage and 1 disadvantage with skid steering (keep it brief!!!!!!)?

Correct answer:

Advantages: Easy to implement, mechanically robust,...

Disadvantages: Horribly inaccurate odometry, driving surface heavily worn,...

B1.4: Give 1 advantage and 1 disadvantage of a legged robot over a wheeled robot (keep it brief!!!!!!)?

Correct answer:

Advantages: Only need support at the location of the feet, can step over obstacles,...

Disadvantages: Mechanically complex, power hungry, complex to control,...

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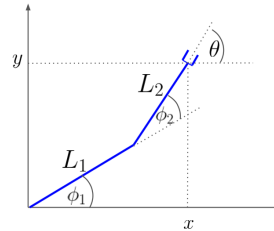
Section B.2 Manipulators

B2.1: What is a prismatic joint (keep it brief!!!!)?

Correct answer: Linear joint, slider, linear motion

Accepted answers: Any other answer that makes it clear that the person knows that a prismatic joint gives motion along an axis and not around an axis.

B2.2: Give the forward kinematics for the arm in the image to the right. Focus on the center of the end effector, (x,y,θ) , marked in the image.



Correct answer:

$$x = L_1 \cos(\theta_1) + L_2 \cos(\theta_1 + \theta_2)$$

$$y = L_1 \sin(\theta_1) + L_2 \sin(\theta_1 + \theta_2)$$

$$\theta = \theta_1 + \theta_2$$

B2.3: Mentioned a challenge with motion planning for a manipulator (keep it brief!!!!)?

Correct answer: Need to avoid obstacles, hard to detect obstacles, computationally intense for complex scenarios, sensing obstacles is hard, high dimensional search spaces; redundancy -> need to plan on c-space; shapes of obstacles in C-space complex

B2.4: Give 1 advantage and 1 disadvantage of using a suction cup instead of a dexterous hand for manipulating objects (keep it brief!!!!)?

Correct answer:

Advantages: You do not need to grasp the object, mechanically simple, ...

Disadvantages: Cannot pick up all objects

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Section B.3 Sensors and perception

B3.1: Motivate why sensor redundancy is considered important for many applications (keep it brief!!!!!!)?

Correct answer: No sensor handle all situations, robustness, detect all obstacles, ...

B3.2: Mention 1 advantage of using sound instead of laser light for measuring distances (keep it brief!!!!!!)?

Correct answer: Sound travels slower which means that measuring time is not as hard, cheaper/simpler electronics, ...

B3.3: What does the matrix typically decomposed as $A[R\ T]$ where A, R and T are matrices describe in the context of a camera (keep it brief!!!!!!)?

Correct answer: Maps world position (X,Y,Z) to image position (u,v)
Accepted answers: Something close in meaning to the above

B3.4: Give 1 advantage and 1 disadvantage with fish eye lenses for cameras (keep it brief!!!!!!)?

Correct answer:
Advantages: Large field of view, ...
Disadvantages: Large distortion, a given piece of the world represented with fewer pixels, ...

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Section B.4 Navigation

B4.1: When you do path planning in an occupancy grid you typically start by expanding the obstacles by the size of the robot. Why? (keep it brief!!!!)

Correct answer: So that we can treat the robot as a point in the search

Accepted answers: Simplify path planning, avoid obstacles, ...

B4.2: Outline how you could do path smoothing for a path generated from a grid map (keep it brief!!!!)

Correct answer: Remove nodes such that the lines between remaining nodes are collision free, non linear optimization of path, ...

B4.3: Give a **brief** description of the how RRTs work (keep it brief!!!!)?

Correct answer: Sample C-space, connect new sample to nearest sample if path is collision free, build search tree, search for connected path from start to goal.

Answer must contain: check samples (and their connections) for validity and that the algorithm builds a search tree.

B4.4: Why do most robot systems have both global and local planners in the navigation system (keep it brief!!!!)?

Correct answer: Global path can cover large scale planning problems because they use less details / lower resolution and local planners are needed to avoid obstacles and handle the dynamic world

Accepted answers: Gives reasonable reason for both global and local planners

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Section B.5 Localization and mapping

B5.1: Assuming that you have a partial map of the environment why might SLAM not be needed (keep it brief!!!!)?

Correct answer: You can get the position using the map and then only need to do mapping.

Accepted answers: No need to do mapping as you already have a map

B5.2: Give 1 advantage and 1 disadvantage with using particle filters for localization (keep it brief!!!!)?

Correct answer:

Advantages: Can represent any distribution, handled multi-modal distributions, handles both global localization and tracking, general solution, ...

Disadvantages: Curse of dimensionality, does not scale well with number of degrees of freedom, can be computationally heavy, results in a distribution not an “answer” to where is the robot, ...

B5.3: Loop closures are important when doing SLAM. Why? (keep it brief!!!!)

Correct answer: Reduce error, propagate information from areas with high certainty to areas with high uncertainty, be able handle larger areas, re-observe previous landmarks,

Accepted answers: Answers that makes it clear that the person knows what it is about

B5.4: Grid maps are frequently used as a representation in robotics. Give 2 advantages with the representation (keep it brief!!!!)

Correct answer: Simple to use, simple to implement, represents free space explicitly, can adjust resolution easily, can be easily used also in 3D, a representation that supports path planning, localization, mapping and more or less everything directly, ...

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Grading sheet for students

NOTE: This is ONLY to be used the other student when correcting your exam. Do not write on this page during the first part (when you answer questions)!!!

Name of grader:.....

By signing this, I certify that I am NOT correcting my own exam, that I am NOT making any changes to the answers given by the other student and that I doing my best to make the corrections in a fair way.

Signature of grader:.....

Summary of results

Scoring: 1 for correct answer, 0 for wrong answer and blank for no answer.

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Result overall exam:(P/F)