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MCQ **MOCK EXAM**

Basics of Mobile Robotics
2019-2020

Duration : 1h45 hours.
No documents allowed. The use of electronic calculators is forbidden.
Questions using the sign ♣ may have zero, one or several correct answers. Other questions have a single correct answer.
Justification is required for all options to explain why or why not that option was selected. Negative points will be attributed to questions to which no justification or a bad justification is provided.

Question 1 You need to design a robot for dense swarm operations (about 20 robots / m^2, with hundreds of robots in the same area). You need to choose a sensor for dense distance measurements of obstacles in front of the robot. What do you choose?

Active

☐ Triangulation camera based on a pattern projection
Why was / wasn't this option selected?
Overlap with patterns of different robots → not a good idea (Interference)
(Could be possible if pattern projected every 1/20 ms for each robot)

3D view

Passive

☑ Stereo camera
Why was / wasn't this option selected?
Passive sensor better to avoid interferences

Active

☐ Time-of-flight camera
Why was / wasn't this option selected?
Interferences

Question 2 ♣ Compare the trajectories in the images below. Which statements are correct?

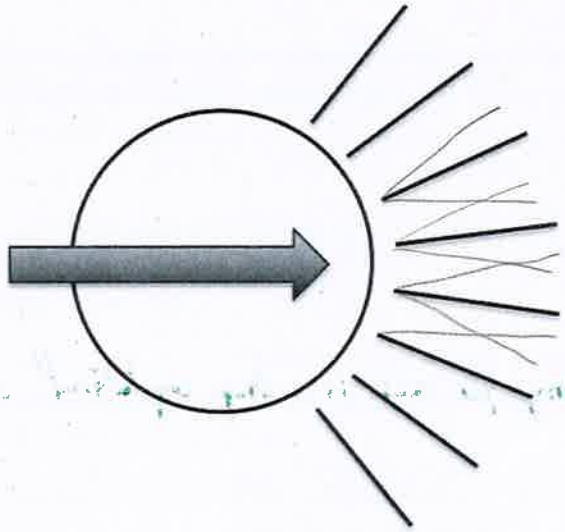
☐ It's impossible to create map with the behaviour of robot c
Why was / wasn't this option selected?
Wrong it is possible with SLAM

☐ Robots a. and c. do not localise themselves, robot b. is able to localise
Why was / wasn't this option selected?
c does not localize but a does, looking at its regular pattern

☑ Robot b. could be implementing active SLAM
Why was / wasn't this option selected?

☐ *None of these answers are correct.*

Question 3 You have to design a cheap sensor system (sensor + computation) of a circular robot (1m in diameter) that moves indoors. The shape of the robot allows only detection of obstacles from 8 holes in the body. Which sensors do you place there?



☐ TOF Laser
Why was / wasn't this option selected?
Nope, cone detection about in their case.

☐ Cameras
Why was / wasn't this option selected?

✓

☑ Ultrasound
Why was / wasn't this option selected?
Yes they have a detection cone + cheap

Question 4 For an inspection robot, we would like to automatically detect the inclination of the robot using the vertical stripes that are present in the environment. How would you extract the angle of the lines from the image with the less possible computational power?

☑ For each pixel compute the vertical and horizonal Sobel filter (output images s_1 and s_2), then extracting the angle using the following equations :

$$|G| \cong \sqrt{s_1^2 + s_2^2} \tag{1}$$

$$\theta \cong \arctan \frac{s_1^2}{s_2^2} \tag{2}$$

Why was / wasn't this option selected?
Everything you need in a cheap computational solution

☐ For each pixel apply the Sobel filter with various orientations. For example, the filter for an angle of 45 degrees would be :

0	1	1	0
1	2	0	-1
1	0	-2	-1
0	-1	0	0

Why was / wasn't this option selected?
Don't know how many sobels you need to apply → not a good idea

☐ Applying a Sobel filter then the Hough transform to get the angle
Why was / wasn't this option selected?
Not computationally cheap enough

Question 5 You need to compute path planning on a robot similar to the e-puck, having a small memory (consider 1MByte) and targeting an optimal path with a precision of 1cm around the target position in an area of 10x10 m2, with sparse objects, which algorithm do you choose among those?

↙ Novais aussi

☑ A* on larger cells (40x40cm2), then smaller cells around start and target.
Why was / wasn't this option selected?
Too much memory

☐ A* on a regular grid with cells of size 1cm2.
Why was / wasn't this option selected?
Too much memory

✓

☑ A* on adaptive cell decomposition, with different cell sizes.
Why was / wasn't this option selected?
Optimal case since big cells in empty space and smaller around obstacles and s & g

☐ A* on a moving subgrid of smaller size (5x5m2), always with cells of size 1cm2.
Why was / wasn't this option selected?
~~Eats up too much memory~~ Does not make sense to do global with local grid size

Question 6
You need to design a robotic system to work in a park, and the sensors need to capture the visual texture and 3D structure of the environment. You don't have any limit with the budget, but you want to use as little computation possible to keep a long autonomy. What sensor do you choose among these?

☐ Single camera
Why was / wasn't this option selected?
Single camera can't 3D

X ☑ Kinect 3D camera
Why was / wasn't this option selected?
~~Can't because don't have to process whole image only discrete points~~
Kinect 3D camera not working outdoor

☐ Lidar (radar)
Why was / wasn't this option selected?
Heavy computation

☑ Stereo camera
Why was / wasn't this option selected?
Heavier than kinect

Question 7 We want to detect when a driver gets too close to the border of a straight road. We apply a Sobel and a Hough transform to the image of a front camera looking forward to the street. What condition should we set for the alarms to turn on?

☐ $r >$ threshold, $|angle| < 20°$
Why was / wasn't this option selected?
.....

☒ $|r| <$ threshold
Why was / wasn't this option selected?
.....

☐ $r >$ threshold, $|angle| > 20°$
Why was / wasn't this option selected?
.....

☐ $r >$ threshold
Why was / wasn't this option selected?
.....

Question 8 It is possible to combine SLAM and Bayes filters?

☑ Yes, just put the map in the state
Why was / wasn't this option selected?
→ Discussed in case studies

☐ No, the map can change but needs to be updated by another mechanism
Why was / wasn't this option selected?
.....

☐ No, for Bayes filters assume a static world and a fix map
Why was / wasn't this option selected?
.....

Question 9 Active beacons for indoor consumer (home) use are...

☐ ... interesting because simplifying the detection and therefore reducing the price of the whole system.
Why was / wasn't this option selected?
They are more expensive

☑ ... interesting when you need to be as independent as possible from the environment.
Why was / wasn't this option selected?
Indeed just need something projected on the ceiling to localize (NorthStar)

☐ ... not often used because requiring a complex receiver and signal processing system.
Why was / wasn't this option selected?
Actually simple

☐ ... a bad idea because active systems in indoor situations can cause perturbations also for a single robot.
Why was / wasn't this option selected?

Question 10
A toy company ask you to design a robot that learns from a child: when the robot makes something wrong the child can say "bad" and when the robots behaves well he can say "nice". The robot learns from this feedback to adapt its behaviour. They want to have a slogan "ANN inside". What type of learning you propose them?

☐ Unsupervised learning
Why was / wasn't this option selected?

☐ Supervised learning
Why was / wasn't this option selected?

☑ Reinforcement learning
Why was / wasn't this option selected?
This is the definition of reinforcement learning → reward good behavior and punish bad ones.

Question 11 Consider a robot with four omnidirectional wheels that actuated independently, each by one motor. What is this impact of this configuration on the control?

☐ As number of actuators = DOM = DOF the control is very simple
Why was / wasn't this option selected?
False. DoM > DoF

X ☑ As number of actuators = DOM > DOF there are various possibilities to combine the actuators to achieve the same end result
DoM cannot be superior to DoF !
Why was / wasn't this option selected?
4 motor = 4 DoM, drive robot = 3 DoF DoM > DoF

☑ As DOF = DOM < number of actuators the control need to avoid conflicting commands
Why was / wasn't this option selected?
~~False. DoM > DoF~~ with omnidirectional wheels
↳ 4 DoF = DoM
↳ 4 omni wheels > DoF = DoM = 3

Question 12 The one dimensional grid based Bayesian localisation process seen in the course includes successive steps of motion and sensing. If you add a proprioceptive sensor to the motor (encoder, for instance) how does this impact the motion step between t and $t+1$?

☐ This helps the motion step reduce the global localisation uncertainty
Why was / wasn't this option selected?
The global uncertainty never reduces, it only increases less at best.

☐ The motion model stays the same, no impact of the motion step on the localisation uncertainty
Why was / wasn't this option selected?
Localisation uncertainty less increases

☐ The motion step become precise, there is no uncertainty anymore
Why was / wasn't this option selected?
Impossible.

☑ This helps the motion step in less augmenting the global localisation uncertainty
Why was / wasn't this option selected?
An additional measurement even helps the ↓ to increase less.

Question 13 For the control of an automatic shuttle making the link between two airport terminals, we estimate its position. We have to choose the strategy that ensures the best precision. Which is the best approach?

☐ Direct measurement of the position by an absolute sensor on the ground
Why was / wasn't this option selected?
Direct measurements are noisy

☑ Kalman filter using the measured absolute position and the measured speed of the shuttle
Why was / wasn't this option selected?
"Choose a lot of information"

☐ Kalman filter using the measured absolute position
Why was / wasn't this option selected?
Better with velocity added

Question 14 Developing the position estimation filter in a robot for indoor use, we can combine the odometry with an information about the colour of the ground, made of tiles. What type of tile pattern do you choose?

☑ Random color
Why was / wasn't this option selected?
Not useful if we want to define a threshold for the sensor
Better to have a random pattern of random color (c'est bizarre ça)

☐ Black and white chessboard pattern
Why was / wasn't this option selected?
Better than random colors but impossible to tell the direction

☑ Regular lines of tiles of same colour, on x and y direction, one different colour per direction
Why was / wasn't this option selected?
Best choice for direction

→ Meh

Question 15
You need to implement a path following behaviour for a robot serving drinks in a restaurant. The requirement is to have a smooth trajectory. You have a set of positions and orientations in the path, set at a distance of one meter. Which among the following approaches you would choose?

☐ Two PID regulators in distance and orientation with targets to the next point
Why was / wasn't this option selected?
.....

☑ Regular speed and P regulator on the orientation with target toward the next point
Why was / wasn't this option selected?
.....
If regulator on speed → acceleration intempestive = drop drinks

☐ Two P regulators in distance and orientation with targets to the next point
Why was / wasn't this option selected?
.....

Question 16 A robot needs to make fast movements between a home position where it can gather some material and a nearby position that changes often. The operation is continuos 24h/day. The cycle is :

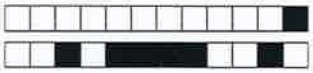
- Taking material : 1s
- Moving to target : 2s (high acceleration)
- Discharge material: 0.5s
- Back: 2s (high acceleration)

What power source would you choose to ensure a maximal ratio between operation time / time blocked for recharging?

☑ Lithium battery
Why was / wasn't this option selected?
.....

☑ Capacitors
Why was / wasn't this option selected?
Seen in case studies
.....

☐ Fuel cells
Why was / wasn't this option selected?
Acceleration needed not guaranteed
.....



+1/11/50+

Question 17 ♣ You have to design a small robot for semi-autonomous pipe inspection, able to detect (supervision of a human expert by remote camera, image preprocessed on the robot) and map the problems on a network of tubes, to allow intervention from outside. The robot should be autonomous in energy and have the smallest possible processor. The pipes have regular bifurcations and you have a technical map of the network. Which map do you choose for your robot.

☑ A mix of the topological and the metric maps
Why was / wasn't this option selected?
Perfect, node at bif ⊕ know distance traveled

☐ Occupancy-grid map
Why was / wasn't this option selected?
Not useful with pipes

☐ Topological map
Why was / wasn't this option selected?
Perfect for pipes, just put a node at bifurcations but need distance info to travel

☐ Metric map
Why was / wasn't this option selected?
Don't know the bifurcation with this

☐ *None of these answers are correct.*

Question 18 You design and produce a low-cost robot moving in all-terrain conditions. To measure the inclination of the robot you use an accelerometer. During production you observe that the soldering of the accelerometer introduces offsets in the inclination. Here is a set of soldering situation among the same production. What do you do?

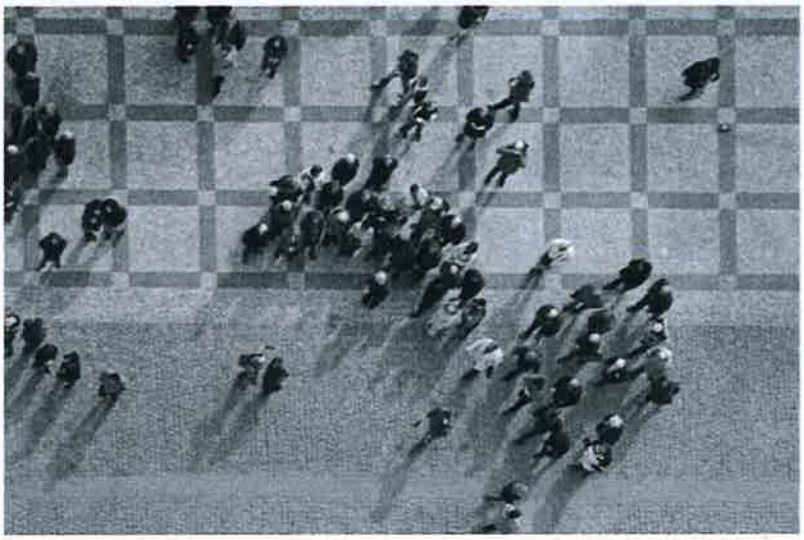
☑ choose another better manufacturer costing 2 CHF more per robot
Why was / wasn't this option selected?
.....

☑ introduce a calibration the robot improving precision, adding 1 CHF / robot to the production costs
Why was / wasn't this option selected?
By improving precision we reduce random spread. Afterwards, we just need to apply an offset to bring the measured value to the true one.

☐ introduce a calibration the robot improving accuracy, adding 3 CHF / robot to the production costs
Why was / wasn't this option selected?
.....

Question 19 ♣ With your mobile robot you need to pass in regular way trough a crowd of tourists in a place, where global navigation is not feasible. You have the positioning of the robot and the global goal. What local approach would you apply to go through in the fastest way and without disturbing too much the tourists?

Assume tourists immobile



☑ Wall following
Why was / wasn't this option selected?
~~not fast~~ Follow the boarder of tourists groups
→ What if robot moves at the same speed as the group? → Trap

☒ Potential field
Why was / wasn't this option selected?
Optimal path → Shape of tourists here will trap the potential field

☐ ANN
Why was / wasn't this option selected?
~~Disturb too much tourists~~ Trap as well

☐ *None of these answers are correct.*

Question 20 ♣ Consider a robotic application in a forest, where a robot need to move in hard all-terrain conditions. What should be included in the state of the robot, to be complete in the context of simple displacement? (several answers possible)

☑ Weather conditions
Why was / wasn't this option selected?
So that the robots knows if the terrain will be slippery or not due to rain for ex

☐ Start and goal position
Why was / wasn't this option selected?
Don't need that in the state

☑ Robot 3D pose
Why was / wasn't this option selected?
Of course need position

☑ Battery level
Why was / wasn't this option selected?
So that it knows if it has to return to the base to recharge or not

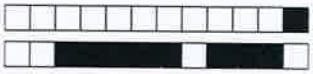
☐ *None of these answers are correct.*

Question 21 We need the distance measurement of a laser-based sensor for a measurement range from 1m to 2 m at 1000 Hz. We found a sensor whose characteristics are the same over the whole measurement range. In the following table, you find a set of raw measurements when measuring a distance of 1.5m. Can you improve the precision of the sensor?

time [ms]	0	1	2	3	4	5	6	7	8	9
measured value [m]	1.5073	1.5069	1.5072	1.5070	1.5071	1.5068	1.5069	1.5070	1.5071	1.5067

☑ Yes
Why was / wasn't this option selected?
Substract the mean of the offsets

☒ No
Why was / wasn't this option selected?
Not the right frequency



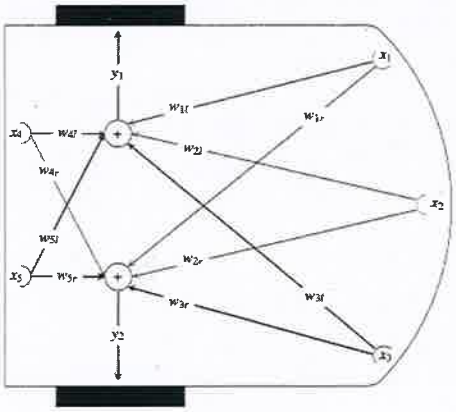
Question 22 For the estimation of the orientation (3 angles) of a small robotic drone we take measurements from an IMU (acc + gyro + magnetometer) and apply a filter. Which filter seems well suited for this type of application?

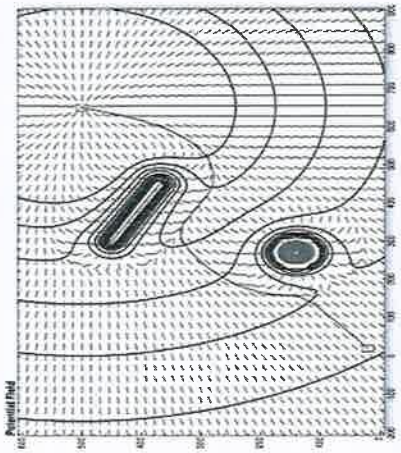
☑ Kalman filtert
Why was / wasn't this option selected?
Typical use of kalman

☐ Grid-based filter
Why was / wasn't this option selected?

☐ Particle filter
Why was / wasn't this option selected?

Question 23 Using a robot equipped with a set of 8 ultrasound sensors for obstacle detection, you need to choose a smooth behaviour for obstacle avoidance and you are hesitating between two approaches, Artificial Neural Networks (one layer ANN) and potential field (PF). Which one is easier to implement and smoother?



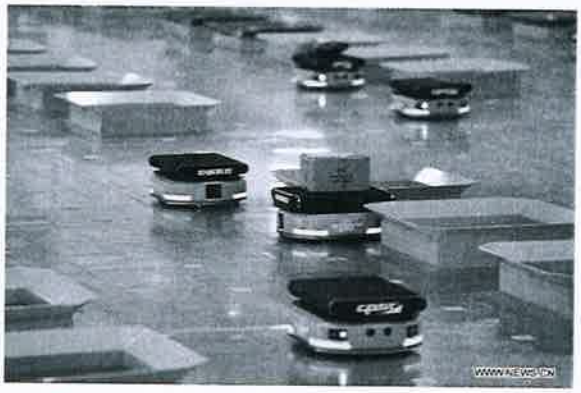


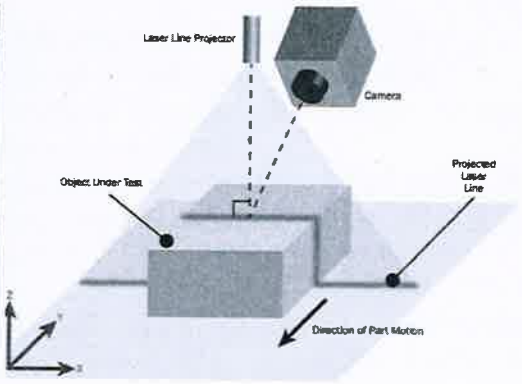
☐ PF has less parameters to configure
Why was / wasn't this option selected?
.....

☑ Both approaches are nearly identical
Why was / wasn't this option selected?
.....

☐ ANN, is not subject to local minima
Why was / wasn't this option selected?
..... No but it can be blocked depending on how it is implemented .....

Question 24 For a robotics solution with multiple robots in a logistic center, you need to implement a safety system to detect obstacles in front of the robot. A colleague suggests to have a red laser plan projected in front of the robot (1-2 m away) with a camera. He suggests to extract the distance through triangulation from the picture of the projected area. What is your reaction?





Courtesy of Coherent Inc.

☑ Not adapted, let's use stereo vision
Why was / wasn't this option selected?
..... Passive better in crowds to avoid interference

☐ Good idea, this can get any obstacles
Why was / wasn't this option selected?
.....

☐ The red laser is not a solution, let's use infrared
Why was / wasn't this option selected?
.....