

Exam questions

ANSWERS

Correct

Wrong

Explanations

Q1: Sustainability

We want to reduce the impact on the environment of the Thymio robot production and use (full life cycle). Which statements are correct among the three listed above? (several possible answers)



A: By cutting half of the power consumption, we can reduce by 20% the impact on CO₂ of the full life cycle.

B: We can improve the quality of the components, doubling the life duration of the product and therefore reducing the life cycle impact of at least 30%.

C: We can produce it in Switzerland for the Swiss customers, reducing transportation and therefore reducing 20% of the impact.

Q1: Sustainability

A: By cutting half of the power consumption, we can reduce by 20% the impact on CO2 of the full life cycle.

Wrong: The power consumption has very little impact in the life cycle of Thymio, as the robot is consuming very little power and is not used very often in educational settings where >95% of the robot are sold.

B: We can improve the quality of the components, doubling the life duration of the product and therefore reducing the life cycle impact of at least 30%.

Correct, by increasing the life duration, on cut on the production impact, which is the main impact of the robot.

C: We can produce it in Switzerland for the Swiss customers, reducing transportation and therefore reducing 20% of the impact.

Wrong: the transportation has few impact in the life cycle (<10%) and in any case we would have to transport the components, made mainly in Asia, to Switzerland.

Q2: Kalman filtering

Which of the following state variables should not be filtered using a Kalman filter (basic or extended)? For instance because they do not respect some of the basic assumptions of the filter...

Several answers are possible.

- A. The number of containers a robotics-ship is transporting.
- B. The direction of a train shuttle in an airport (terminal A to B, or B to A).
- C. The orientation (angle in respect to the north) of a 3DOF robot.
- D. The cartesian coordinates of a mobile robot on a plane.

Q2: Kalman filtering

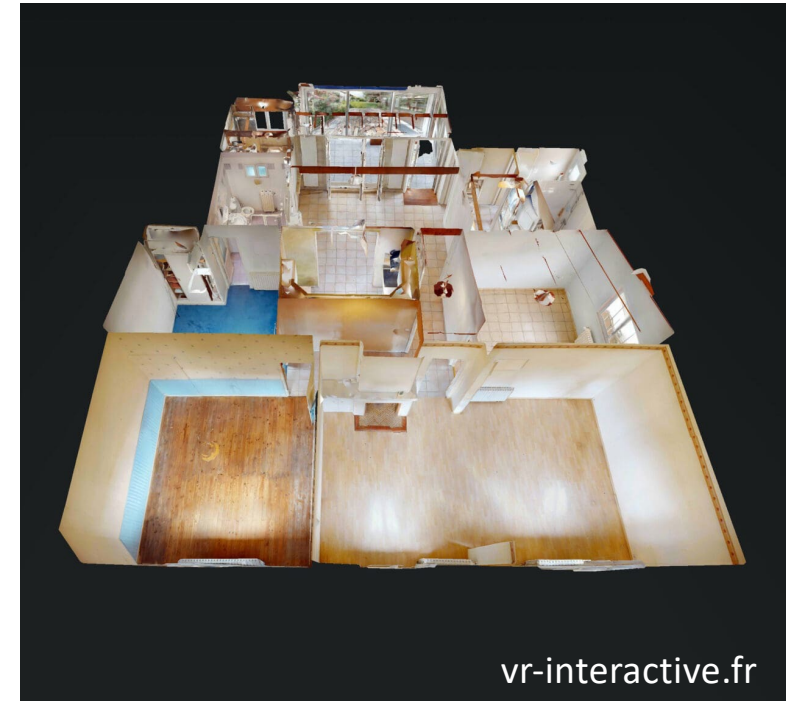
- A. The number of containers a robotics-ship is transporting.
 - A. this is an integer variable and has not a gaussian noise as modeled by a kalman filter.
- B. The direction of a train shuttle in an airport (terminal A to B, or B to A).
 - A. this is a boolean variable and has not a gaussian noise as modeled by a KF.
- C. The orientation (angle in respect to the north) of a 3DOF robot
 - A. this variable has all characteristics one would need in a KF.
- D. The cartesian coordinates of a mobile robot on a plane.
 - A. his variable has all characteristics one would need in a KF.

Q3a Problem of sensor

We target the application of creating the 3D visualisation of apartments. We want to use a robot that explores the whole apartment, extracts the 3D structure, and maps on this structure the visual texture to create a 3D navigable online environment. There are no budget or computational limitations for the robot and the goal is to have the higher resolution possible. We can only install one device on the robot.

Which single device is the best (in term of resolution) to perform this task?

- A. Radar
- B. Laser scanner
- C. Stereo camera
- D. Single camera



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Q3a Problem of sensor

- A. **Radar**
Wrong, the radar has a large cone than the laser and has less resolution
- B. **Laser scanner**
Wrong, the laser scanner can get the 3D structure but not the texture.
- C. **Stereo camera**
Correct, this is the only sensor that can acquire both 3D structure and texture
- D. **Single camera**
Wrong, a single camera can get the texture and in some cases the 3D structure, but cannot have a 3D structure resolution as the stereo camera.

Q4: Kalman filtering 2

In the project of this course, done with the Thymio robot, we use a camera for tracking and a Kalman filter for pose estimation.

A colleague tells you that by using the camera as sensor in the prediction phase of the filter, there is no need to apply the correction part of the filter, as the camera gives already a very precise positioning.

Which is the best reaction to this approach:

- A. This can work well, as the camera gives an absolute position and has no drift
- B. This cannot work, this is not the right way to use this sensors and the variance of the position estimation will only increase
- C. This can work well if we consider a very small variance of the camera.

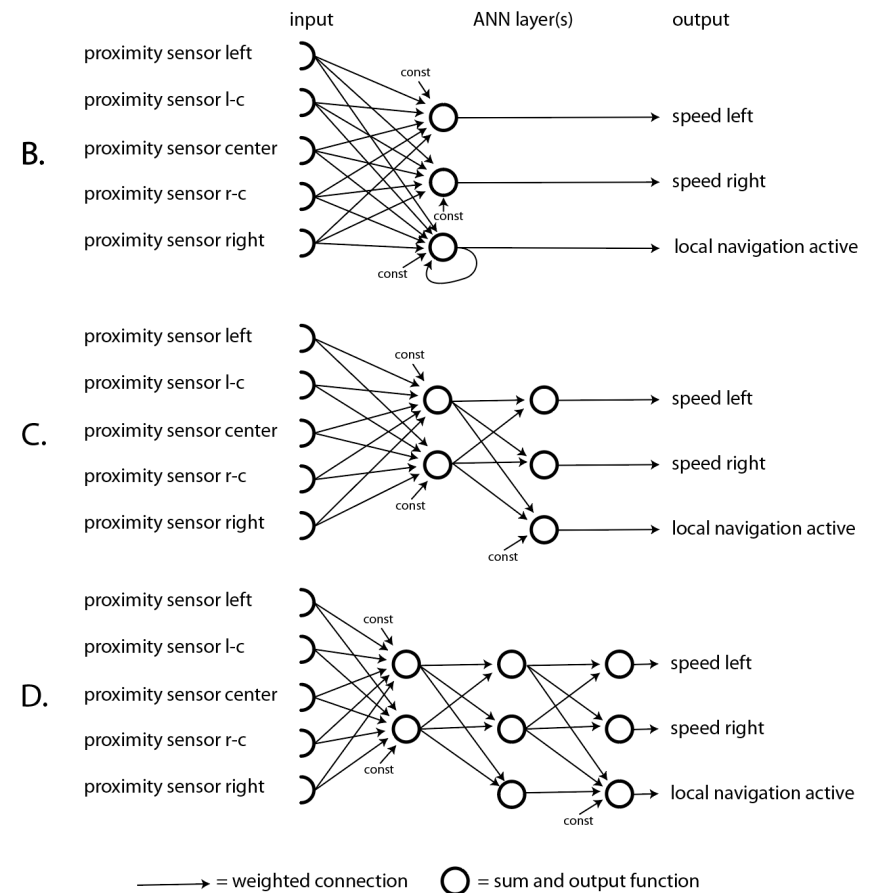
Q4: Kalman filtering 2

- A. This can work well, as the camera gives an absolute position and has no drift
In the prediction phase the variance is not reduced, the camera cannot be used.
- B. This cannot work, this is not the right way to use this sensors and the variance of the position estimation will only increase
Correct
- C. This can work well if we consider a very small variance of the camera.
In the prediction phase the variance is not reduced (even if small), the camera cannot be used.

Q5: ANN for obstacle avoidance?

In the project for this course, using Thymio, you decide to use artificial neural networks (ANN) to implement the local navigation: when an obstacle is detected, you want to activate local navigation, and when the obstacle is not detected anymore you want to continue to move during several iterations of the ANN before going back to global navigation. You decide to have an ANN with three outputs, two for wheel speed and one giving the indication of when the local navigation is active (when this output is above a threshold the robot runs in local navigation, when below in global navigation). Which of the following ANN could perform this task? **Network B**

A. None of the networks can ensure this functionality



Q5: ANN for obstacle avoidance?

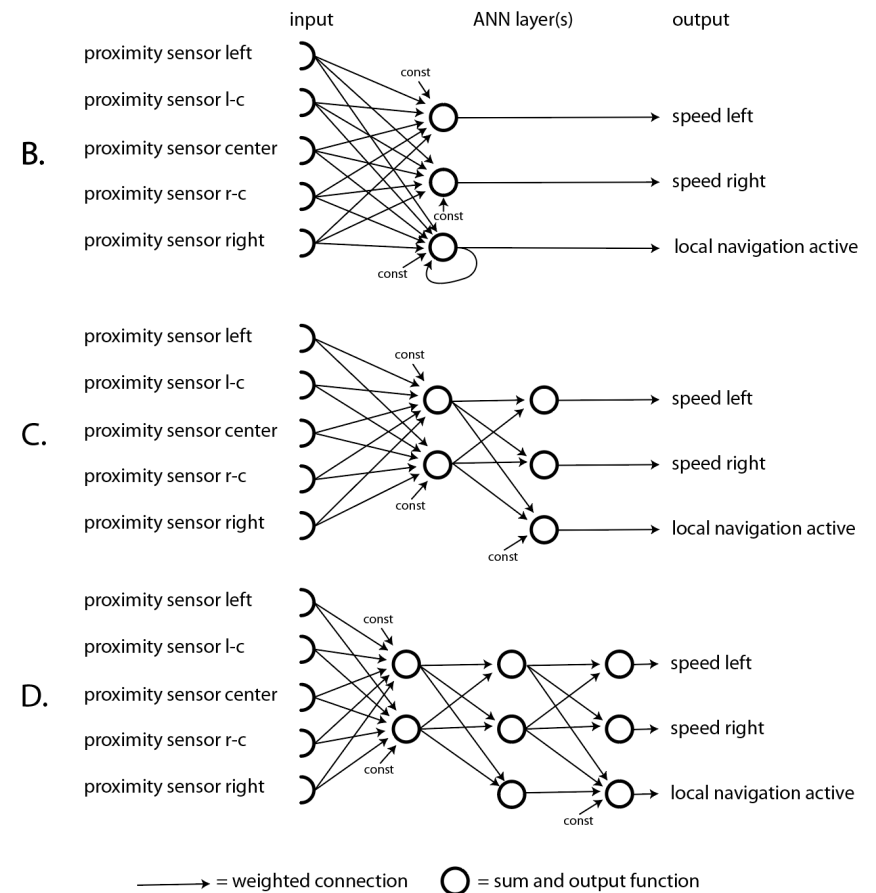
A: Wrong, the network with the recurrent connection can perform this functionality (answer B)

B: Correct, even with one single layer but with a recurrent connection (memory) this is possible.

C: Wrong, having an output delayed requires memory and therefore a recurrent connection that is only in network B.

D: Wrong, having an output delayed requires memory and therefore a recurrent connection that is only in network B.

A. None of the networks can ensure this functionality



Q6: Accuracy VS precision

For an application where a robot should transport food inside a kitchen, you hesitate between three types of sensors for measuring its distance to obstacles:

- **A laser sensor:** fast (50 Hz), accurate, but not very precise in an environment full of reflections (glass, stainless steel) where its gaussian noise has a large variance.
- **An ultrasonic sensors:** slow (5Hz), generally a bit less accurate than the laser because of manufacturing variations, but twice as precise as the laser in this specific environment.
- **A radar sensor:** measuring at 10 Hz, more accurate than ultrasound but less than laser, and measuring with a precision equivalent to the ultrasound sensor.

Which sensor can provide you the best precision for an accuracy at least equivalent to the one of the ultrasonic sensor and for a distance measurement that need to be done at 5Hz? Do not consider the cone of measure (larger for ultrasound and radar, and thin for laser)



Q6: Accuracy VS precision

- **A laser sensor:** Correct, as the variance can be reduced making an average between several measurements and here one can make the average between 10 measurements.
- **An ultrasonic sensors:** Wrong, as the laser, despite its variance, can be improved making an average between several measurements and here one can make the average between 10 measurements, being just two times less precise.
- **A radar sensor:** Wrong, as the laser, despite its variance, can be improved making an average between several measurements and here one can make the average between 10 measurements (the radar only two), being just two times less precise.

Q7: Energy

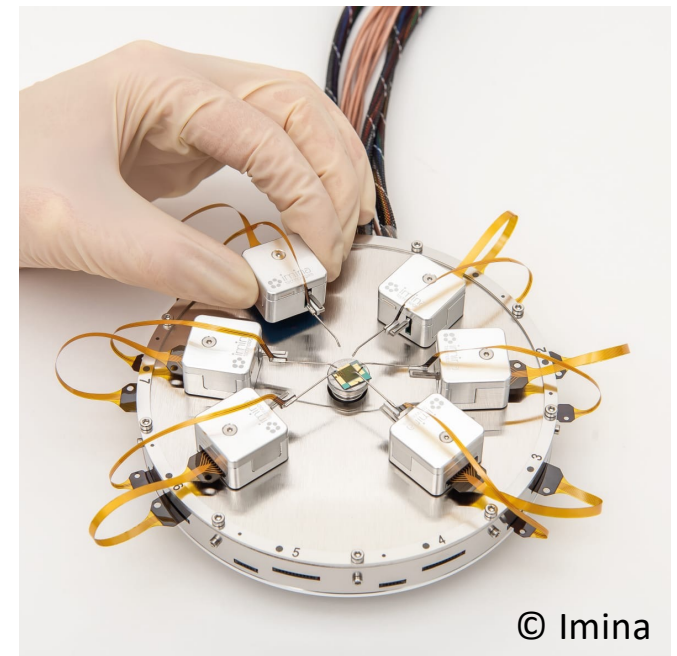
A company has developed a nanoprobng mobile robot (sliding on a plate using ultrasound actuators) operating under vacuum.

Now they want to remove the powering cables that disturb the robot's movements and integrate an energy storage system inside their robots.

The devices do not consume much and need to be fully operational the maximum amount of time. They can go to a loading station, but the loading operation should be as short as possible so the ratio working-loading is maximized.

Which energy storage would you suggest, being simple to implement and well adapted to this situation?

- A. Li-po accumulators
- B. Capacitors
- C. Ni-Cd accumularots
- D. Fuel cells



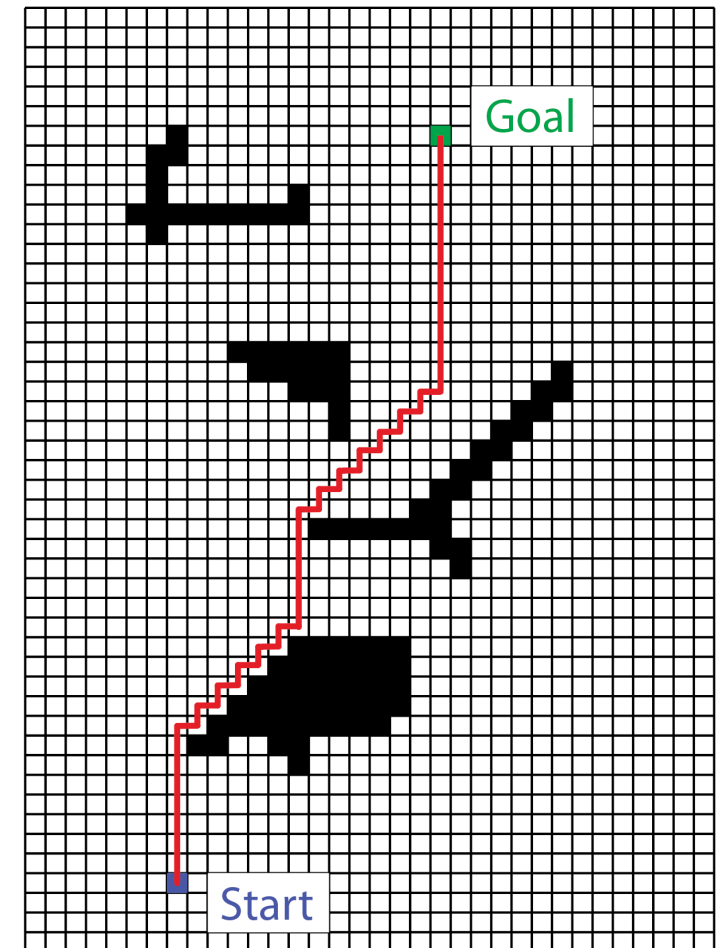
Q7: Energy

- A. **Li-po accumulators:** Wrong: these accumulators are slower to charge than capacitors.
- A. **Capacitors:** Correct: fast charging and ok for low consumption. And simple implementation.
- B. **Ni-Cd accumularots:** Wrong: these accumulators are slower to charge than capacitors.
- c. **Fuel cells:** Wrong: in vacuum is hard to use these cells and their recharge (fuel) is more complicated than accumulators.

Q8: Mapping - planning

A robot is used to sample noise in new buildings to check phonic insulation. The robot measures the sound at 1.8m from the ground, from a base of 50cm of diameter. To navigate in the room (often still with ongoing construction work in it) the robot has been equipped with a simple navigation system based on a grid-map (cells of 10x10cm). The robot maps the obstacles by navigating in the environment. The localization is done by using both the odometry and a ceiling projection system. The path is found using the A* algorithm. The image on the side shows a path computed by the system, the black cells representing cells that have part of them occupied by an object. Which of the following statements apply to this system and are correct? (several answers possible)

- A. The path, using this map and this planner, cannot be optimal.
- B. The path, even simplified, cannot be followed by the robot.
- C. A visibility graph with object expansion by 35 cm would generate trajectories that are nearly optimal.
- D. The approach chosen cannot be trapped in local minima.



Q8: Mapping - planning

- A. The path, using this map and this planner, cannot be optimal.
Correct, here we have only vertical and horizontal moves.
- B. The path, even simplified, cannot be followed by the robot.
Correct, here there are no margins with the obstacles.
- C. A visibility graph with object expansion by 35 cm would generate trajectories that are nearly optimal.
Correct, because a visibility graph generates optimal paths, if the margin to the obstacles are respected (here with some margin for path following)
- D. The approach chosen cannot be trapped in local minima.
Correct, the approach is looking for paths over the whole environment.

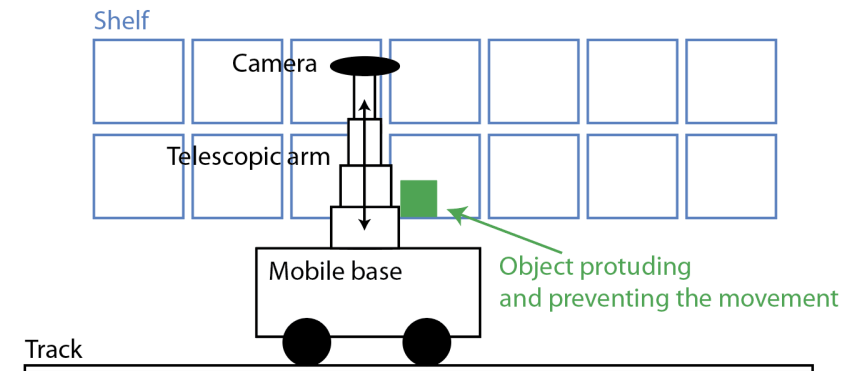
Q9: DOF - DOM

A mobile platform moving on a track (linear movement) is equipped with a camera to identify objects on a shelf. As the track is close to the shelf and some objects protrude from the shelves, preventing the robot from reaching the upper levels, the telescopic arm of design A was replaced by a serial arm with 5 actuators (design B, red crosses indicating the axis of the actuators that are perpendicular to the plane of the drawing). The camera must be kept horizontal.

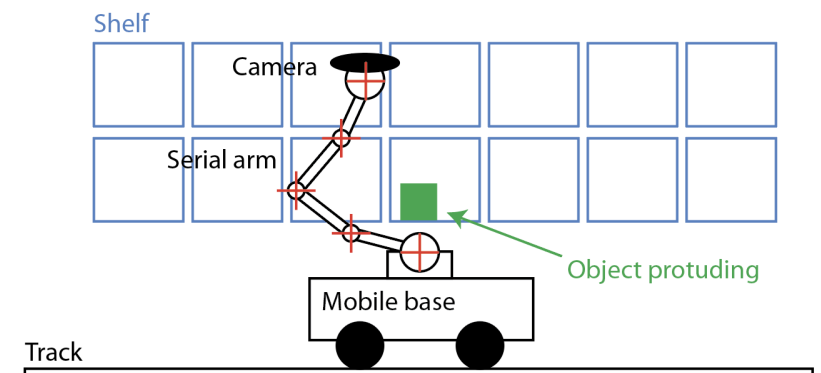
Based on the definitions we gave in the course, how do you describe this design?

- A. The design B allows to solve the issue of A by adding one degree of freedom to the robotic system
- B. The design B allows to solve the issue of A by adding four degrees of freedom to the robotic system
- C. The design B allows to solve the issue of A with the same degrees of mobility as before
- D. None of the 3 other descriptions is correct

Design A



Design B



Q9: DOF - DOM

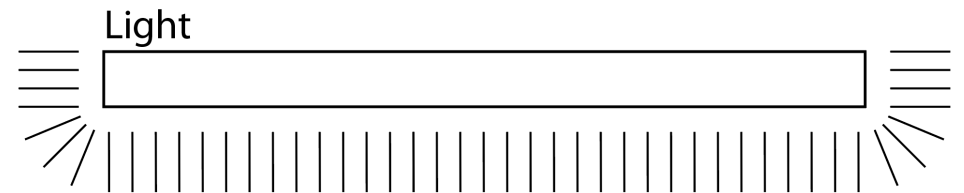
- A. The design B allows to solve the issue of A by adding one degree of freedom to the robotic system
Wrong, the number of DOF stay unchanged.
- B. The design B allows to solve the issue of A by adding four degrees of freedom to the robotic system
Wrong, the number of DOF stay unchanged.
- C. The design B allows to solve the issue of A with the same degrees of mobility as before
Correct, the degrees of mobility are in both situations maximal (2).
- D. None of the 3 other descriptions is correct
Wrong, design B allows to solve the issue of A with the same degrees of mobility as before, as the degrees of mobility are in both situations maximal (2).

Q10: Local navigation and local minima

To test local navigation algorithms, we place the Thymio robot on a paper surface where a local obstacle has been printed (see image on the right). Thymio can detect it with the ground sensors, can drive on its borders to do obstacle following, for instance, but should not pass this obstacle. A light with a strong IR component is placed as a goal and Thymio has to reach it. Thymio can detect the light with the two ground sensors (the only sensors on Thymio that have an ambient light detector) and can therefore orient toward the light.

Which local avoidance strategy will allow to pass the obstacle?

- A. Potential field
- B. Pledge algorithm
- C. Moving toward the goal when no obstacle, turn left when obstacle



Obstacle printed on ground



Thymio robot

Q10: Local navigation and local minima

A. **Potential field**

Wrong, as this will trap the robot in the obstacle.

B. **Pledge algorithm**

Correct, as this algorithm makes wall following but by remembering the angle and going to the goal only when back to the original angle.

C. **Moving toward the goal when no obstacle, turn left when obstacle**

Wrong, as this will trap the robot in the obstacle because of its shape, making infinite loops.