22.09.2020

Basics of mobile robotics

Case studie 1

Question 1: Chose robot to help gardener in his maze of Villa presente :

↳ grass !

A) Omnidirectional robot

B) Diff drive robot

"Obvious" answer because it easier to stir in a labyrinth

6 wheels robots are more stable on uneven terrains than 4 wheels robots → chose stability over "drivability" in this case of uneven terrain.

Question 2: You need to build a syst with 1 DoF with a precision of 1 μm and a speed of 1 m/s. For logistics reasons you have to choose a manufacturer among these three, looking for the cheapest solution :

		precision	speed	price
A)	A1	0,5 μm	2m/s	200 CHF
	A2	3μm	2m/s	150 CHF
B)	B1	6μm	3m/s	50 CHF
	B2	0,1 μm	0,5m/s	30 CHF
C)	C1	1μm	1 m/s	180 CHF
	C2	3 μm	1 m/s	120 CHF

Trick drôle à garder en tête

↑

Combine both : for high speed use B1 and when close to target use B2

Question 3: A robot needs to make fast movements between a basic position (where it takes some material) and place which is not far but always ≠. The op is continuous 24h/day. Cycle is :

Taking material : 1s

Moving to target : 2s (high acc)

Discharge material : 0,5s

Back : 2s (high acc)

Which power source ?

Need in priority fast acc

Don't need "fast longer"

A) Fuel cell

B) Lithium battery

C) Capacitor

Looking for a power source with high charge/discharge rate → capacitor slide 9 L1

Question 4: How many actuators do you need (at least) to activate a mobile robot with 3 DoF?

A) 1 → there are robots that can move with 3 DoF with only 1 motor

B) 2

C) 3

B) 4

Question → possible de récupérer la distance d'un objet depuis 1 seule caméra?

→ comment résultant pixel de gaussian smoothing est interprété?

29.09.2020

Basics of mobile robotics

Case studies 2

1) We need to inspect the pipe of a water system (see picture). I want to send in a drone. How should I localize the drone inside the pipe (distance from entrance):

A) Vision looking at surface tube
B) —"— end of tube

No pattern, completely flat
vision based on pattern
=> vision impossible here

C) No vision (laser, rope, ultrasound...)

2) From drone we look at a ground thymio with a black line on it. We want the angle of the robot. How could we do this with the less possible computational power?

Too heavy! → A) Applying a Sobel and a Hough trsf → get peak → get angle
B) For each pixel apply various Sobel with various angles (for instance for 45°)
C) For each pixel we compute Sobel vertical and horizontal, then extract angle, make weighted average

Hough transform = extremely heavy

3) For an indoor mobile robot running on a flat ground, it would be interesting to use vision to identify locations in the environment. How would you position the camera to have the most easy-to-use vision input?

A) Camera looking forward
B) —"— side
C) —"— ground
D) —"— ceiling →

06/10/20

Basics of mobile robotics

Case studies 3

1) There are software using computer vision to recognize gender in picture of people. An analysis of the Microsoft version shows that it works poorly for darker-skinned females, why?

A - Pb in the way the software is coded
B - Darker color levels are harder to distinguish
C - It's not a vision or coding problem
↳ Training set does not include enough dark skinned females
⇒ Problem of learning not coding nor darker color levels

2) You need a robot for dense swarm operations (robots of about $1dm^3$ of volume, 20 robots/m^2, hundreds in the same area) You need to chose a sensor for dense distance measurements of obstacles in front of the robot which one?

Interfer with one another ← Active sensors { A - Time of flight camera
B - Triangulation camera, with projection pattern }
Passive sensor { C - Stereo camera }

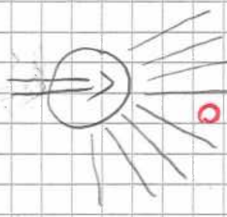
3) Consider a camera system taking static images at several random angles, when rotating around its focal point in a forest. What is the cheapest hardware device (do not consider cost of processing) one can use to retrieve a 3D reconst of the surrounding?

A - Time of flight, camera
B - Triangulation system based on camera
C - Stereo cam
D - Monocular camera
↳ If you train an algo on trees, using a mono camera you can tell the dist ← a forest has a very specific typology

13.10.20

Basics of mobile robotics
Case studies 4

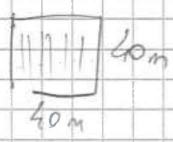
1) You have to design a cheap sensor system (sensor + computation) of a O robot (Ø 1m) that moves indoors. The shape of the robot allows only detection of obstacles from 8 holes in the body. Which sensors do you place there ?



A - Ultrasound → detection cone allows to cover wide range
B - Laser → no detection cone (Ø 1m = miss information)
C - Camera → heavy computation

Relationship between robot and obstacle size would chge the answer
Ex: big walls → laser enough to detect them, small obst → ultrasound

2) You have 10 small cylindrical robots (Ø 50 cm) that need to escape at the same time from a labyrinth. They can perceive the direction of the exit. Which is the simplest, complete and most efficient navigation strategy you can use ?



A - Left wall following
Robots will not meet ← B - ————— + potential field when meeting another rob
Ø 50 cm VS corridors of 4m
C - Potential field (repulsion of walls and robots + attraction exit)
D - Wall following in the direction of exit (when starting)

Potential fields have local minima = no good in a maze

Repeat why wrong?

3) Using a robot equipped with 8 ultrasound sensors for obstacle avoidance and you hesitate between 2 approaches: ANN or PF ?

ANN local min exist ← A - ANN is not subjected to local minima
Ex: thymio with front sensor when one finger in front
B - PF has less parameters to configure → Nope serie 4 = serie 3

C - Both approaches are nearly identical
↳ The weight of the ANN are the same as avoidance vectors as in PF

20.10.20

Basics of mobile robotics

Case studies 5

1) You design a routing sys of a mail delivery robot traveling on footpath in a large city. You have a specific map with all existing footpaths. How do you expect implementing the path planning?

A - Planning once when starting + loc obst avoid

B - —//— several times in one path + loc avoid

C - ——//—————— + map edition + loc avoid

↳ take into account temporary roadwork.

2) In an exposition about planets, you need to implement a navigation of a Thymio robot (simulation a starship) on a large surface (4x4 m^2) through a set of distant planets (circles painted on ground ϕ max = 30cm) toward a planet base (big hot light)

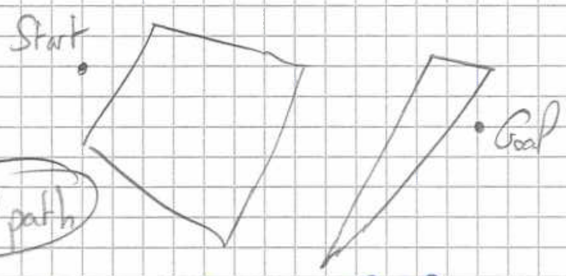
This robot has no way to localize itself ←

A - Visibility graph with expansion of robot size

B - PF (repulsion = planets, attraction = base) → No need to know the pose of the robot for that

C - Ant colony optimisation approach

3) You have an application where your robot needs to navigate through this



which algo?

We shouldn't have a local minima BUT no optimal path

A - PF as there would be no local minima ⊕ resulting traj is optimal

Can work as well but not optimal path

B - Vertical cell decomposition → simple shapes are perfect generally generate a few cells (10), easy to compute ⊕ optimal path

C - This shape of objects, perfect for visibility graphs → easy compute ⊕ optimal path.

27.10.2020

Basics of mobile robots

Case studies 6

1) You want to build a cheap version of a differential wheel robot able to draw polygons (squares, rectangles, etc) on large surfaces.

The robot being for consumer market, you have to chose to ensure the best precision (price not a criteria) :

Encoder better than motor speed sensor

A - Encoder and good wheel design

Compass = best for straight lines ← B - Motor speed sensor, good wheel design, compass

C - Gyro and accelerometer

↳ Removes orientation error → (see slide on pos error getting large with rotation)

⇓

Gives absolute orientation

2) The simplified Bayesian localization process seen last week includes successive steps of motion and sensing. If you add a proprioceptive sensor to the motor (encoder) how this impacts the motor step?

A - Motion model stays the same, no impact of the motion step on loc

B -

C

Error always increases, can only reduces its increasing rate

B - Error is less augmenting

3) In the design of a robot that need to localize itself, you hesitate between putting an encoder on the motor, which is expensive, and the use of an IMU, much cheaper. Which true?

In general, wheel with good contact ground ↳ encoder

A - For simple linear move, encoder > acc because 2x int

B - For rot, encoder < acc, because simple int of gyro

C - IMU better for kidnapping

D - Both acc and gyro integrate errors and drift in the long run

But detail ← Not the error but position drifts

03.11.20

Basics of mobile robotics

Case studies 7

1) Consider a robotic application in a forest, where robot need to move in hard all-terrain conditions. What should be included in the state of the robot in the context of simple displacement?

A - Robot 3D pose
B - Weather conditions
C - Date and hour
D - Start and goal position
E - Battery level

State = all informations that help you to predict the next state

2) You have to deal with a robot where localisation is based on a particle filter. The robot moves by rotations [angle β[deg]] followed by straight movements (distance d[m]). In the software of the particle filter, the sampling of the control action in polar coordinates (r[m], α[deg]) is:

If you move more you get more error

Not incremental / Error indep of angle
encoder ← we do

$$r_{n+1} = r_n + d + d * rand() * 0{,}02 \qquad \alpha_{n+1} = \alpha + \beta + rand \times 0{,}02$$

Which proprioceptive sensors are probably available for this robot?

A - Incremental encoders in the wheel = angle error should depend of how much we turn
B - Motor speed sensor + magnetometer = compass = absolute sensor
C - Accelerometer + gyroscope → integrates once angular speed = angle error should depend of how much we turn

3) You have to implement a localisation algorithm for a hand scanner, that has no other sensor than the scanner and is controlled manually by an operator. When thinking about a Bayes filter for this application, which state = true?

Control model possible movements of hand, speed limit of movements

A - Having no possible control model, one cannot use a Bayes filter

Extremely huge

B - Here a grid-based Baysian filter is applicable and better than a Monte-Carlo localisation → better

C - A Bayes filter can work if the properties of the sensor are adapted to the type of object scanned.

Markov loc = grid based loc → small grid = ok but with large grid too much memory

Monte Carlo = particle based loc → same as Markov in small environment, better than Markov in big env.

10.11.20

Basics of mobots

Case studies 8

1) Consider a robotic application in a forest, where the robot needs to move in difficult all-terrain conditions. When moving in wet conditions, the wheels tend to slip when in pure mud, until they find solid support. To estimate pose of robot we defined the state var as robot pose + humidity. We want an estimation of state. Which filter

A - Kalman filter, compact
B - Particle filter, generic
C - Grid based, more generic

[Impossible to describe slipping disturbance with Gaussian model]
↳ No Kalman

2) For a specific mobile app, we would like to make the estimation of the position of an automatic shuttle for a passenger of a shuttle making link between 2 airport terminals defining a state (position, absolute speed, direction). Use a map that includes the position of several visual landmarks and the many different slopes, the slope sensor of the smartphone and the camera detecting the markers. Which filter?

A - Kalman filter, compact
B - Particle filter, generic
C - Grid based filter, more generic

⚠ Direction is binary so not adapted to the Kalman filter ⚠
↳ remove binary dir from state and Kalman OK

speed sign can indicate pose

3) For the control of the shuttle we evaluate its position and we have to choose the strategy that ensures the best precision. Which is the best approach?

A - Direct measurement (Noisy) of the position by an absolute sensor on the ground
B - Kalman using measured absolute pos
C - Kalman —— // —— + speed of shuttle
↳ 2 info better than only one

Basics of mobots

Case studies 9

1) Need to design a very cheap robot performing SLAM to create maps of empty houses. As you need to create a metric map you equip your robot with a LIDAR with a distance measurement larger than the largest distance you can find on the field.

Essential because at any point you can see nearly all the walls = good reference for the map

Which proprioceptive sensor(s) do you put on the robot to model motion:

A - Wheel encoder
B - Motor speed sensor
C - IMU (acc, gyro, speed)
D - None → LiDAR can be used for localisation as well

2) Why is hard to make SLAM with Thymio?

A - Because odometry is bad (bad sensor ⊕ unprecise wheels) → don't get much with good odometry
B - —"— range of sensors is not large enough
C - —"— sensors are not sufficiently linear → can linearize them
D - —"— not enough computing power → rely on computer

Major issue concerning SLAM → really need good sensors

Good odo / bad or no senso = cannot do anything
No odo / Good sensor = OK

3) You have to design a small robot for semi-autonomous pipe inspection, able to detect (supervision by human) and map the pbs on the network of tubes, to allow intervention from outside. The robot should be autonomous in E and have the smallest possible processor. Pipes have regular bifurcations and you have a plan with some key positions of the network. Which map?

A - Occupancy grid → to heavy
B - Topological map → not enough because misses distance
C - Metric map
D - Mix of them → mix of Topo ⊕ Metric
E - None of them