Robotics Questions bank 24

بسم الله الرحمن الرحيم

>> في الفايل ده هدفنا نبني بنك أسئلة ونتشارك كدفعة في حله للاستفادة العامة

لضيق الوقت ياريت اللي يقدر يضيف امتحان من الامتحانات القديمة يضيفها على الفايل

الملف عبارة عن جزئين : **دليل الفينال - ثم الأسئلة**

قواعد منظمة للملف اقرأها أولا

0- **يفضل نحل الأسئلة بألوان مختلفة عن الأسود لتسهيل تمييزها عند قراءة الشيت**

1- لو لقيت سؤال مفيد (امتحان {فاينال - ميد - كويز}) ضيفه تحت عنوان المحاضرة التابع له (يفضل ايضا تقول مصدره مثلا فاينال سنة كذا او ميدترم سنة كذا أو هكذا) .

2- برده لو في سؤال على Algorithm في المحاضرة مش موجود في الشيت ضيفه عادي بس يكون من منهجنا و قابل للحل.

3- لو سؤال يشمل كذا محاضرة ضيفه تحت عنوان **More than 1 lec** في الآخر.

4- لو عارف إجابة سؤال تقدر تضيف حلك سواء text أو تصوره وتضيفه كصورة تحت السؤال.

5- لو مش متأكد من حلك اكتب **Unverified** .

6- لو في تعديل على حل اكتب عليه كومنت أو أعد حله تحته بكتابة **Solution #2** مثلا .

مع بعض نقدر نكون ملف كبير مفيد إن شاء الله - وربنا يوفقنا يا شباب

شوية نوتس:

Monte Carlo VS EKF:

	MCL	EKF
Measurements	Raw Measurements	Landmarks
Measurement Noise	Any	Gaussian
Posterior	Particles	Gaussian
Efficiency(memory)	✔	✔✔
Efficiency(time)	✔	✔✔
Ease of Implementation	✔✔	✔
Resolution	✔	✔✔
Robustness	✔✔	x
Memory & Resolution Control	Yes	No
Global Localization	Yes	No
State Space	Multimodel Discrete	Unimodal Continuous

CR MCQ Final 23

Some Notes:

- For some of the questions (especially those involving equations), our colleagues were not able to reconstruct the given choices.
- Problem questions were possibly spread out across more than one MCQ
- The slides reference often contains something that closely matches the solution, not always the solution itself.
- Questions in pink marked with [] are degrees ambiguous, you may pretend the given solution by the authors is only a suggestion. Some of these were recolored to teal as a result of the degree of ambiguity being too small.
- For some of these questions, the Underthinking Hypothesis will be applied. It assumes that the professor made the questions from the slides without pondering much about the other choices he has put and without realizing that some of them might be valid under overthinking scenarios

I. Introduction to Cognitive Robotics

Q1. Probabilistic robotics………………………

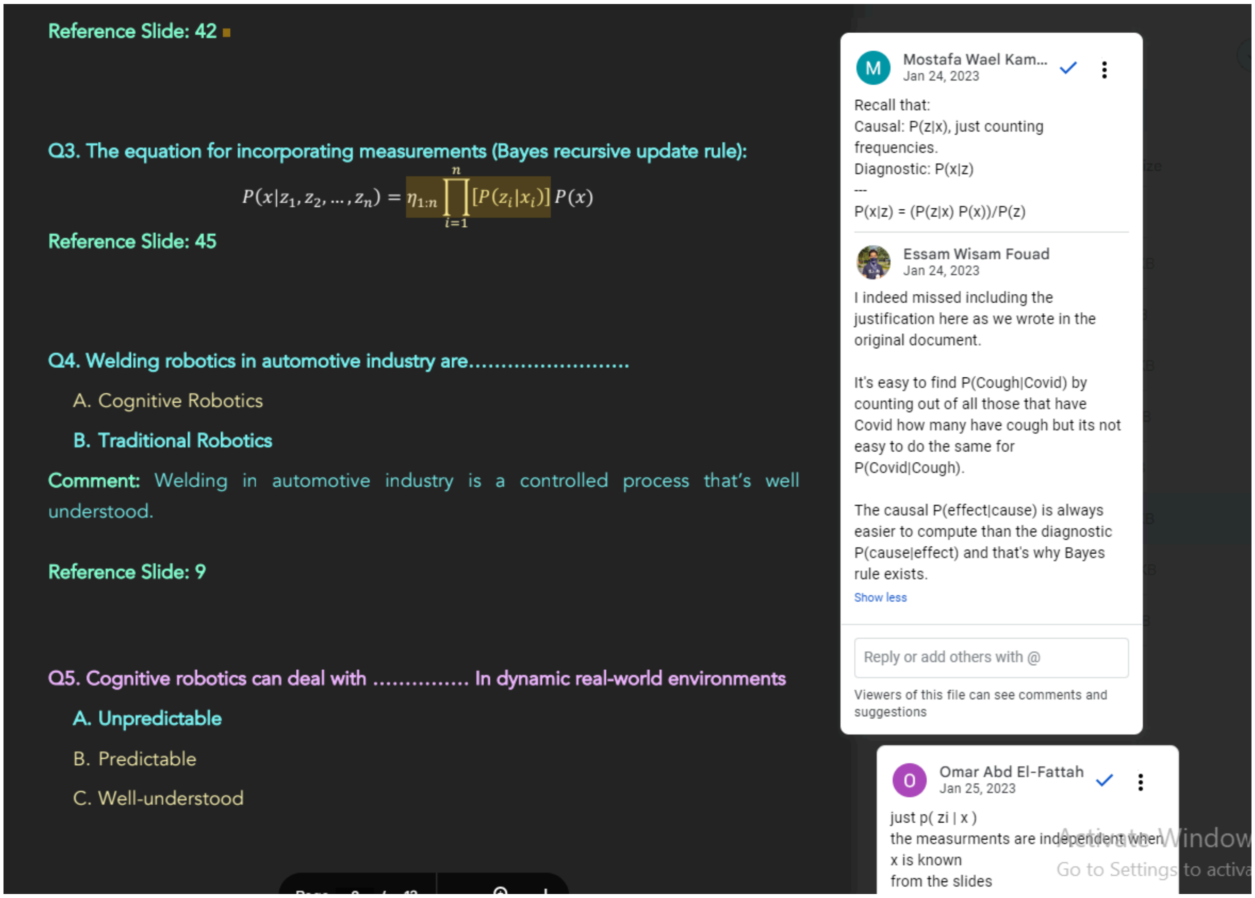
A. perception by state estimation
B. action by utility optimization
C. models uncertainty in actions and measurements using calculus probability theory
D. All
E. None

Reference Slide: 27

Q2. Causal reasoning is …………………

A. Easier to calculate than diagnostic
B. Estimates target Probability
C. Calculates probability of effect given the cause.
D. All of the above
E. None of the above

Reference Slide: 42



Reference Slide: 42

Q3. The equation for incorporating measurements (Bayes recursive update rule):

$$P(x|z_1, z_2, \dots, z_n) = \eta_{1:n} \prod_{i=1}^{n} [P(z_i|x_i)]\, P(x)$$

Reference Slide: 45

Q4. Welding robotics in automotive industry are……………………

A. Cognitive Robotics

B. Traditional Robotics

Comment: Welding in automotive industry is a controlled process that's well understood.

Reference Slide: 9

Q5. Cognitive robotics can deal with …………… In dynamic real-world environments

A. Unpredictable

B. Predictable

C. Well-understood

Mostafa Wael Kam...
Jan 24, 2023

Recall that:
Causal: P(z|x), just counting frequencies.
Diagnostic: P(x|z)

P(x|z) = (P(z|x) P(x))/P(z)

Essam Wisam Fouad
Jan 24, 2023

I indeed missed including the justification here as we wrote in the original document.

It's easy to find P(Cough|Covid) by counting out of all those that have Covid how many have cough but its not easy to do the same for P(Covid|Cough).

The causal P(effect|cause) is always easier to compute than the diagnostic P(cause|effect) and that's why Bayes rule exists.

Show less

Reply or add others with @

Viewers of this file can see comments and suggestions

Omar Abd El-Fattah
Jan 25, 2023

just p(zi | x)
the measurments are independent when x is known
from the slides

<u>I think 4 will be B , as in slides , it is written that traditional robotics are used in well understood processes , here they wrote welding is well-understood , so …</u>

Q5. Cognitive robotics can deal with .... In dynamic real-world environments

A. Unpredictable

B. Predictable

C. Well-understood

D. All of the above

E. None of the above

Comment: Unpredictable follows by the underthinking hypothesis. The overthinking hypothesis suggests that D should be true since by logic if A holds then so should B and C.

Reference Slide: 11

هنا المفروض A ولا ايه؟ 🥺

I think it is D , as it should deal with them all

Q6.

A robot is equipped with an unreliable door detector that outputs either "Door" or "NoDoor".

If there is a door in front of the robot, it indicates "Door" with a probability of 0.9. However, if there is no door in front of the robot, the detector also indicates "Door" with a probability of 0.2

Before observing the detector, the prior belief of the robot about a door being in front of it is 0.6.

What is the posterior probability of a door being in front of the robot when the detector outputs "NoDoor"?

Comment:

Given is $P(Z = D|X = D) = 0.9$ and $P(Z = D|X = \bar{D}) = 0.2$ and $P(X = D) = 0.6$

Wanted is $P(X = D|Z = \bar{D})$

Apply Bayes Rule (Expanded)

$$P(X = D|Z = \bar{D}) = \frac{P(Z = \bar{D}|X = D)P(X = D)}{\sum_x P(Z = \bar{D}|X = x)P(X = x)}$$

$$= \frac{P(Z = \bar{D}|X = D)P(X = D)}{P(Z = \bar{D}|X = D)P(X = D) + P(Z = \bar{D}|X = \bar{D})P(X = \bar{D})}$$

$$= \frac{(1 - 0.9)(0.6)}{(1 - 0.9)(0.6) + (1 - 0.2)(0.4)} = \frac{3}{19}$$

Reference Slide: 43

Q7.

1. A special-purpose robot is equipped with a vacuum unit to clean the floor. The robot has a binary sensor to detect whether a floor tile is clean or dirty.

- However, neither the cleaning unit nor the sensor are perfect.

2. From previous experience, you know that the robot succeeds in cleaning a dirty floor tile with a probability of $P(x_{t+1} = clean \,|x_t = dirty) = 0.6$, where x_t is the state of the floor tile at time t and x_{t+1} is the resulting state after the action has been applied.

3. Activating the cleaning unit when the tile is clean will never make it dirty.

4. Assume the robot always cleans at every time t (i.e., the transition probabilities model the fact that the robot is cleaning the floor tile).

5. The probability that the sensor indicates that the floor tile is clean although it is dirty is $P(z_t = clean \,|x_t = dirty) = 0.2$ and the probability that the sensor correctly detects a clean tile is $P(z_t = clean \,|\, x_t = clean) = 0.6$

6. Assume a prior distribution at time t as $P(x_t = clean) = c$, where $0 < c < 1$.

Unfortunately, you have no knowledge about the current state of the floor tile. However, after cleaning the tile, the robot's sensor indicates that it is clean. Compute $P(x_{t+1} = clean \,|z_{t+1} = clean)$ i.e., the probability that at time t + 1, the floor tile is now clean given that the sensor indicates it is clean.

Use Bayes Rule:

$$P(x_{t+1} = C\,|z_{t+1} = C) = \frac{P(z_{t+1} = C|x_{t+1} = C)P(x_{t+1} = C)}{\sum_{x_{t+1}} P(z_{t+1} = C|x_{t+1})P(x_{t+1})}$$

$$= \frac{P(z_{t+1} = C|x_{t+1} = C)P(x_{t+1} = C)}{P(z_{t+1} = C|x_{t+1} = C)P(x_{t+1} = C) + P(z_{t+1} = C|x_{t+1} = D)P(x_{t+1} = D)}$$

- From 5, $P(z_{t+1} = C|x_{t+1} = C) = 0.6$ and $P(z_{t+1} = C|x_{t+1} = D) = 0.2$ (these are properties of the sensor regardless to any timestep)
- Now we only need $P(x_{t+1} = C)$. Which the probability of the floor being clean in $t + 1$ given that the robot attempted to clean in t, as defined in 2.
- Since $P(x_{t+1} = C\,|x_t = D) = 0.6$ is given in 2, $P(x_{t+1} = C|x_t = C) = 1.0$ is given in 3 and the prior probability before cleaning $P(x_t = clean) = c$ as given in 6, we can find $P(x_{t+1} = C)$ by using total probability as follows:

$$P(x_{t+1} = C) = P(x_{t+1} = C|x_t = C)P(x_t = C) + P(x_{t+1} = C|x_t = D)P(x_t = D)$$
$$= c + 0.6(1 - c) = 0.6 + 0.4c$$

Thus,

$$P(x_{t+1} = C\,|z_{t+1} = C) = \frac{0.6(0.6 + 0.4c)}{0.6(0.6 + 0.4c) + 0.2(1 - (0.6 + 0.4c))} = \frac{1.5c + 2.25}{c + 2.75}$$

Essam Wisam Fou...
Jan 24, 2023

This is the trick, x_t+1 implicitly implies an action.

Show more

II. Bayes & Kalman Filter

Q1. Kalman gain ....

A. Measure how much we trust the sensor

B. if σ_{obs} = 0, then $K = 1$

C. if σ_{obs}= ∞, then $K = 0$

D. All

E. None

Comment:

$$k_t = \frac{\bar{\Sigma}_t C_t^T}{C_t \bar{\Sigma}_t C_t^T + Q_t}$$

Indeed, as Q $(i.e., \sigma_{obs}^2)$ approaches 0 or 1, K_t approaches 1 or 0 respectively (assuming $C = 1$). The higher is the Kalman gain the more we trust our sensor because this implies it has less uncertainty.

Reference Slide: 38

Q2. In the Kalman filter, ...

A. Motion model is applied first
B. Sensor model is applied first
C. Order is not important.

Comment: In Bayes filter in general, there is no specific order that has to be followed. In real life, prediction and correction calls are arbitrarily interleaved depending on how often sensors or actions are "published" on the relevant topic.
Reference Slide: 18

Q3. Kalman Filter ....

A. Assumes gaussian world
B. Can handle nonlinear systems
C. Assume arbitrary distributions
D. All
E. None

Comment: Without extensions, it cannot be applied to nonlinear systems and it can't work with arbitrary distributions (generally).

Reference Slide: 24

In Q2) why shouldn't it be motion first ?? from slides :
→ slide 18

Algorithm **Kalman_filter**($\mu_{t-1}, \Sigma_{t-1}, u_t, z_t$):

Prediction:

$\bar{\mu}_t = A_t \mu_{t-1} + B_t u_t$ // apply motion model

$\bar{\Sigma}_t = A_t \Sigma_{t-1} A_t^T + R_t$

Correction:

$K_t = \bar{\Sigma}_t C_t^T (C_t \bar{\Sigma}_t C_t^T + Q_t)^{-1}$ // compute Kalman gain

$\mu_t = \bar{\mu}_t + K_t (z_t - C_t \bar{\mu}_t)$ // compare expected with observed measurement

$\Sigma_t = (I - K_t C_t) \bar{\Sigma}_t$

Return μ_t, Σ_t

Q4. According to Markov assumption .... //Mainstream version

A. Current measurement depends only on the previous state

B. Current state depends only on the previous state

C. Current measurement depends only on the current action

D. All

E. None

Comment: The Markov assumption says that if we know the current state, then the past and future are independent. This leads to:

$P(z_t | x_{0:t}, z_{1:t-1}, u_{1:t}) = P(z_t | x_t)$ // current measurement depends only on current state

Here we know x_t so z_t (future) is independent of $x_{0:t-1}, z_{1:t-1}, u_{1:t}$ (the past of x_t)

$P(x_t | x_{0:t-1}, z_{1:t-1}, u_{1:t}) = P(x_t | x_{t-1}, u_t)$ // current state depends only on previous state & action

Here we know x_{t-1} so x_t (future) is independent of $x_{0:t-2}, z_{1:t-1}, u_{1:t-1}$ (the past of x_{t-1}).

Reference Slide: 15

Q4. According to Markov assumption .... //Credit version

A. Measurement likelihood depends on state and current map

Comment: The choices were different compared to mainstream but they were not remembered except for the one above which was suggested as the correct choice.

Indeed, $P(z_t | x_{0:t}, z_{1:t-1}, u_{1:t}, m) = P(z_t | x_t, m)$

عياث عجم
Jan 24, 2023
Slideset 7, slide 23

Q5. In Kalman prediction correction cycle ....

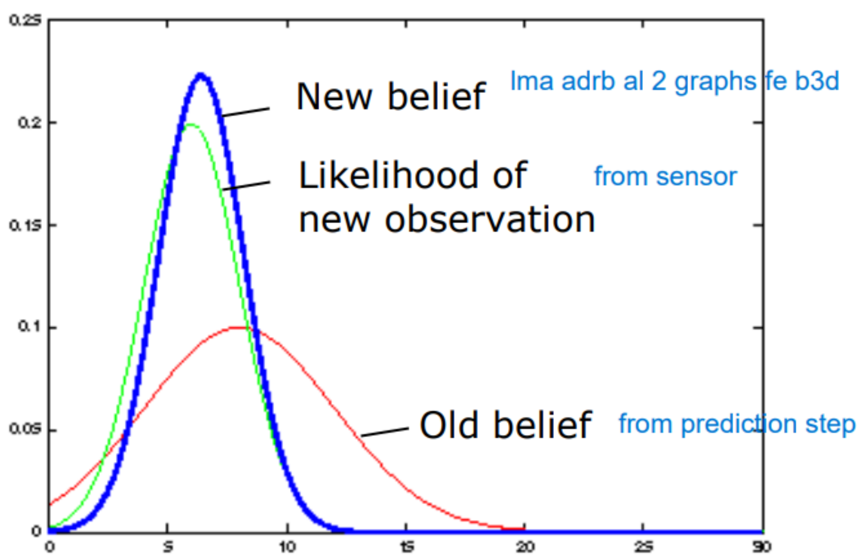
A. The new belief is between the old belief and the belief plus the measurement
B. The predicted uncertainty is smaller than the old uncertainty since we incorporate new actions
C. The correction step moves the mean using the action
D. All
E. None

Reference Slides: -

Comment: Whether we think that A is referring to the value of the belief or the mean, the statement does not hold. The opposite of B is obviously true and in C the correction step does not use the action and can be done without an action.

[Can skip this] To show that A doesn't hold if the value is the belief, observe that if the old belief is p then the new belief is expected to be $p - c_1$ and and the belief after correction is expected to be $p + c_2$ but $p < p - c_1 < p + c_2$ does not hold. To show that it doesn't hold if the value is the mean observe that $\mu_{t-1} < \mu_{t-1} + c < \mu_{t-1} + c \pm \epsilon$ is also not guaranteed to hold as the ϵ introduced by correction can move the mean after or before its predicted state depending on which better explains the measurement.

I think A is wrong because of this:



Q6. Suppose a stationary robot has a noisy distance sensor which reports distances to a wall with standard deviation $\sigma_{sensor} = 3m$ (Gaussian noise).

Suppose the Gaussian robot belief about its distance to the wall is 10m with $\sigma_{belief} = 1m$ before making a measurement.

What should the belief of the robot about the wall distance be after incorporating a measurement of 11 m distance?

Comment:

Given is $Q = 3^2$ and $\bar{\mu} = 10$ and $\bar{\Sigma} = 1^2$ and $z = 11$ and $C_t = 1$ (since what's being measured and the state are the same type of quantity)

A. Compute Kalman gain:

$$k_t = \frac{\bar{\Sigma}_t C_t^T}{C_t \bar{\Sigma}_t C_t^T + Q_t} = \frac{1}{1+9} = 0.1$$

B. Compute the Corrected Mean:

$$\mu_t = \bar{\mu}_t + k_t(z_t - C_t \bar{\mu}_t) = 10 + 0.1(11 - 10) = 10.1$$

C. Compute the Standard Deviation:

$$\Sigma_t = (I - K_t C_t)\, \bar{\Sigma}_t = (1 - 0.1) * 1 = 0.9$$

$$\sigma_t = \sqrt{0.9}$$

Reference Slide: 38

III. Kalman Filter Extensions

Q1. EKF is ……………………..

A. Approximate to two Taylors terms

B. Slower than UKF by constant factor because it needs sampling

C. Can work with nonlinear processes as long as they can be linearized

D. All

E. None

Reference Slide: 41

Comment: EKF is approximate to one Taylor term only and is faster than UKF by a constant factor. It extends the Kalman filter to work with nonlinear motion and sensor models.

IV. Motion Models

Q1. ………….. is an inherited uncertainty.

A. Robot motion

B. Sensor measurements

C. EKF

D. None

E. All

Reference Slide: -

Comment: Uncertainty in motion propagates (gets inherited) through time due to its accumulative nature. Since the choice EKF exists we can rule out sensor measurements, but anyway the covariance gets directly updated on through R, Q only sets the Kalman gain.

Passant Abdelgalil
Jan 24, 2023
7

Q2. Odometry model motion has …………. elementary motions

A. Two

B. Three

C. Four

D. Five

Comment: They are Rotation, Translation and Rotation. In this we have used the Underthinking Hypothesis to avoid choosing Two.

Reference Slide: 14

Q3. possible source of motion uncertainty in wheeled robot……………….

A. Bump

B. Uncalibrated joints

C. Uncalibrated manipulators

D. All

E. None

Reference Slide: 14

Comment: Has no explicit answer in the slides but wheeled robots seem to involve joints and motion uncertainty would be increases if they are uncalibrated. When the professor mentioned wheel encoders in the lecture, he said "this doesn't just apply to wheels".

Q3. possible source of motion uncertainty in wheeled robot ………………

A. Bad light Conditions
B. Uncalibrated joints
C. Uncalibrated manipulators
D. All
E. None

Reference Slide: 12

Comment: Motor encoders rely on counting light interruptions by disk falling on photo sensors.

V. Probabilistic Sensor Models

Q1. Physical interpretation of a max range measurement ....

A. **Beam wasn't reflected back**
B. Bean hit an unknown obstacle.

C. All
D. None

Reference Slide: 15

Comment: Max range measurements happen when no object within the range was reached or when the beam fails to reflect to the right sensor (or when it fails*).

Q2. Sensor not affected by rain or fog:

A. Lidar
B. Sonar
C. Camera
D. All of the above
E. **None of the above**

Reference Slide: -

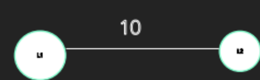
Comment: Rain affects LIDAR due to reflection and refraction, and causes noise for Sonar and Camera is obviously affected by rain and fog. It's more obvious for Sonar that depends on sound waves and cameras which need clear vision.

Q3. If a robot observes a landmark L1 at a distance of 6m and with a degree 90 counterclockwise of his heading, then he observes a landmark L2 at a distance of 8 m and the angle to the landmark is unknown. The distance between the two landmarks is 10m. The robot can be in .... locations

A. 1
B. 2
C. 3
D. 4
E. None

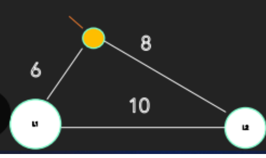
Comment: Consider any two points 10m apart from each other. Draw a circle of radius 8m from one of them and a circle of radius 6m from the other, you are guaranteed to find two intersections (two possible robot locations).

Alternatively, consider two landmarks separated by 10m in any two locations



If the robot is 6m away from the first and 10m away from the second then the three must for a right-angled triangle. This is one of them and the other would reflect the robot about the 10m long line.

Mostafa Elgendy
Jan 24, 2023
8m



Page 9 / 13

Q4. Ultrasonic sensor is affected by ....

A. Beam reflected by obstacles
B. Max range measurement
C. Crosstalk
D. All of the above
E. None

Reference Slide: 14

Comment: The first choice is a little bit ambiguous but B and C definitely hold.

VI. Non-Parametric Filters

Q1. To solve the kidnapped robot problem…………………

A. Insert a fixed number of random samples periodically.
B. Apply scan matching
C. Insert a number of random samples proportional to the number of particles.
D. All
E. None

Reference Slide: 56

Comment: We didn't cover anything that relates scan matching to the kidnapped robot problem, its purpose is to improve odometry. A is explicit in the slides and C should be okay because the professor mentioned it while explaining A (a number of random samples proportional to J is a fixed number of samples.

I can not understand the comment here , but i think C is not correct because: The second choice for solving kidnapped robot is inserting random samples proportional to the average likelihood of the particles not proportional to the number of particles

Approaches

- At each time step, randomly insert a fixed number of samples
- Alternatively, insert random samples proportional to the average likelihood of the particles

VII. Mapping with Known Poses

Q1. Occupancy maps

A. represents the material
B. Each cell represents the reflectance and the map represents material such as glass
C. Each cell states the occupancy probability and can converge to 0 or 1
D. All
E. None

Reference Slide: 13

Comment: As was shown later in the same slideset (65), the probability converges eventually for occupied objects regardless to the degree of reflectance (doesn't represent glass).

Q2. Mapping is used for ....

A. Navigation

B. Motion calibration

C. Industrial factories

D. All

E. None

Reference Slide: 3

Comment: Mapping has nothing to do with calibration and A is mentioned in the slides (path planning)

Q3. pose correction is vital to mapping

A. True

B. False

Reference Slide: 8 (Next Slideset)

Comment: Mapping assumes known poses and correction is vital to make that assumption hold.

VIII. Simultaneous Localization and Mapping (SLAM)

Q1. In SLAM ....

A. Mapping is done first

B. Mapping and localization accuracy depend on each other.

C. Localization and mapping are sequential

D. All

E. None

Reference Slide: 27

Comment: They are "simultaneously" done (in the interleaving sense) and their errors are correlated.

IX. FastSLAM

Q1. landmark based fast SLAM Rao Blackwellization equation

$$P(x_{0:t}, m_{1:M} | z_{1:t}, u_{1:t}) = P(x_{0:t} | z_{1:t}, u_{1:t}) P(m_{1:M} | x_{0:t}, z_{1:t})$$

I think lsa fe more simplification for the eq , it has to be the last eq here:

Rao-Blackwellization for SLAM

Factorization of the SLAM posterior

$$p(x_{0:t}, m_{1:M} \mid z_{1:t}, u_{1:t}) =$$
$$p(x_{0:t} \mid z_{1:t}, u_{1:t}) \; \underline{p(m_{1:M} \mid x_{0:t}, z_{1:t})}$$

Landmarks are conditionally independent given the poses

Montemerlo et al., 2002]

Rao-Blackwellization for SLAM

Factorization of the SLAM posterior

$$p(x_{0:t}, m_{1:M} \mid z_{1:t}, u_{1:t}) =$$
$$= p(x_{0:t} \mid z_{1:t}, u_{1:t}) \; p(m_{1:M} \mid x_{0:t}, z_{1:t})$$
$$= p(x_{0:t} \mid z_{1:t}, u_{1:t}) \; \prod_{i=1}^{M} p(m_i \mid x_{0:t}, z_{1:t})$$

Q2. Data association is ……………………

A. Tracking different hypothesis to associate landmarks to them in EKF SLAM

B. Linking observations to landmarks

C. Not an issue for single mode

D. None

Reference Slide: 28

Comment: Data association is defined by B and is an issue for single mode (such as EKF) as wrong data association can cause divergence.

Mostafa Wael Kam...
Jan 25, 2023

May hold if this was particle filter i.e Fast SLAM.

Q3. Scan matching is used to ………………

A. Correct the odometry before using it in FastSLAM prediction step.
B. Maximize likelihood of the current pose relative to the previous pose and map.
C. Apply local consistent pose corrections.
D. All.
E. None

Reference Slide: 17 (C), 10 (B), 53 [Next Slideset] (A)

غياث عجم
Jan 24, 2023
A: Slideset 9, slide 53
B: Slideset 8, slide 10
C: Slideste 8, slide 17

X. Grid-Based FastSLAM

X. Grid-Based FastSLAM

Q1. Particle depletion …………………

A. Can cause important samples to be lost by chance
B. Results in redundant samples
C. Can be solved by selective resampling
D. All
E. None

Reference Slide: 27 (C)

Comment: Suppose we had samples A, B, C with probabilities 1/3, 1/3, 1/3 then when resampling gives us A, A, A we have introduced redundancy and possibly have lost important samples (B, C)

XI. Path Planning and Collision Avoidance

Q1. A velocity is admissible if ………………..

A. **The robot is able to stop before colliding with an obstacle**

B. Are reachable by acceleration within time period t

Reference Slide: 7

Comment: Follows by the definition

Mostafa Wael Kam...
Jan 25, 2023

The answer would be B, if the question asked for reachablity instead of admissiblity.

Q2. A* disadvantages …………………

A. Don't respect robot kinematics

B. Overestimates distances to obstacles

C. Doesn't consider the goal

D. Its randomness makes the path not optimal

E. **None**

Reference Slide: 37

Comment: None of A, B, C or D hold. Refer to the slideset for A.

Reference Slide: 37

Comment: None of A, B, C or D hold. Refer to the slideset for A.

Mostafa Wael Kam...
Jan 25, 2023

A; refer to the slides.
B: it underestimates it, that's why we used Convolution.
C: It considers the goal to make the path.
D: It's optimal regardless its randomness(I think he meant its use of heuristics).
Feel free to correct me if I missed sth.

Show less

Reply or add others with @

Viewers of this file can see comments and suggestions

Q3. What is the step that does not exist in the 5D path planning algorithm?

A. Use A* to find a path in the $<x, y>$-space using the updated grid map

B. **A* search in the full 5D $<x, y, \theta, v, \omega>$-configuration space**

C. Use heuristic navigation function to drive fast in the right direction

D. Find a trajectory by planning in this restricted $<x, y, \theta, v, \omega>$-space using 2D value iteration as heuristic

E. None

Yahia Zakaria
Jan 25, 2023

The answer is C as B is mentioned in slide 36

Reference Slide: 40

Comment: B is definitely false since we don't search in the full 5D space. C was mentioned for DWA only in the slides (no specific heuristic for 5D A* was set) but its more valid than B.

I think it is B (not C as in the comment) , because the A* search in full 5D yes, but it does not exactly searching in it , it uses the 2D at first to generate the restricted 5D channel

Main Steps of 5D Path Planning

1. Update the grid map based on sensory input

2. Use A* to find a path in the <x,y>-space using the updated grid map

3. Determine a restricted 5D configuration space based on step 2

4. Find a trajectory by planning in this restricted <x,y,θ,v,ω>-space

40

But here it says the full search space before restriction improvement, and in the question, it doesn't specify if it is restricted or not ?! (refer to the pic below)

5D Planning – An Alternative to the Two-Layered Architecture

- **A* search in the full 5D $<x,y,\theta,v,\omega>$-configuration space**
- Considers the robot's kinematic constraints directly
- Generates a sequence of steering commands to reach the goal location
- Considers driving time and distance to obstacles in the cost function

Q4. Collision avoidance depends mainly on ....

A. Map
B. Sensor data
C. Motion commands
D. All
E. None

Reference Slide: 4
Comment: Sensor data is what helps it spot dynamic obstacles.

Mostafa Wael Kam...
Jan 24, 2023
A question was missed while writing the document, sorry for that.
Show more

XII. ROS

Q1. ROS is open-source meta-OS used for hardware abstraction and makes robot software easier development

A. True
B. False

Comment: As defined on ROS wiki here

Q2. ROS bags are used to replay experiments

A. True

B. False

Comment: As defined on ROS wiki here

Final 2022: (This final is the same as above)

35 MCQ .. each one with 2 mark

WITH PENALTY " -2 " ON EACH WRONG AND BLANK ANSWERS

The below questions are from memory. **DO NOT** Memorize it blindly as it can vary or change a little bit in your exam.

1.Sensor not affected by rain or fog:

- Lidar
- Sonar
- Camera
- All of the above
- None of the above

2.A velocity is admissible if :

- the robot is able to stop before colliding with an obstacle
- are reachable by acceleration within the time period t:

3. The 5D Path Planning considers the robot's kinematic constraints:

- True
- False

4.(Copied from Exam Test (Masters) https://drive.google.com/drive/folders/1BaAORYZM1-TZbudiNDS8hpQmpfDdnyuK)

A robot is equipped with an unreliable door detector that outputs either "Door" or "NoDoor". If there is a door in front of the robot, it indicates "Door" with probability 0.9. However, if there is no door in front of the robot, the detector also indicates "Door" with probability 0.2 Before observing the detector, the prior belief of the robot about a door being in front of it is 0.6. What is the posterior probability of a door being in front of the robot when the detector outputs "No Door"?

ANS:

$$p(\text{"}Door\text{"}|door) = 0.9 \qquad p(\text{"}Door\text{"}|!\,door) = 0.2 \qquad p(door) = 0.6$$

$$P(\text{"}No\ Door\text{"}|door) = 0.1 \qquad p(\text{"}No\ Door\text{"}\,|\,!\,door) = 0.8 \qquad p(!\,door) = 0.4$$

$$P(door\,|\,\text{"}No\ Door\text{"}) = \frac{P(\text{"No Door"}|door)P(door)}{P(\text{"No Door"})} = \frac{0.1 * 0.6}{0.1 * 0.6 + 0.8 * 0.4} = \frac{3}{19}$$

5.If a robot observes a landmark L1 at distance 6m and with a degree 90 counterclockwise of his heading, then he observes a landmark L2 with a distance 8m and the angle to the landmark is unknown. The distance between two landmarks is 10m. How many can the robot be

- 1
- 2
- 3
- 4
- none

6. Ultrasonic sensor is affected by

- beam reflected by obstacles
- max range measurement
- cross talk
- all of the above
- none

7. Probabilistic robotics

- 1- perception by state estimation
- 2- action by utility optimization
- 3- models uncertainty in actions and measurements using calculus probability theory
- 4- all
- 5- none

8.EKF is

- 1- Approximate to two taylors terms
- 2- slower than UKF by constant factor because it needs sampling
- 3- can work with non linear processes as long as they can be linearized
- 4- all
- 5- none

9. Particle depletion

- 1- can cause important samples to be lost by chance
- 2- result in redundant samples
- 3- can be solved by selective resampling
- 4- all
- 5- none

10. Kalman gain

- 1- measure how much we trust the sensor
- 1- if sigma_observation = 0, K = 1
- 3- if sigma_ observation = inf (standard deviation), K = 0
- 4- all
- 5- none

11,12,13.Suppose a stationary robot has a noisy distance sensor which reports distances to a wall with standard deviation σsensor = 3 m (Gaussian noise). Suppose the Gaussian robot belief about its distance to the wall is 10 m with σbelief = 1 m before making a measurement. What should the belief of the robot about the wall distance be after incorporating a measurement of 11 m distance?
Compute corrected mean and corrected standard deviation and kalman gain !

(Copied from Exam Test (Masters) but with σsensor = 3 m instead of 2m
https://drive.google.com/drive/folders/1BaAORYZM1-TZbudiNDS8hpQmpfDdnyuK)

14….. Is an inherited uncertainty
- Robot motion
- Sensor measurements
- EKF
- None
- All

15. Occupancy maps
- represents the material
- Each cell represents the reflectance and the map represents material such as glass
- Each cell states the occupancy probability and can converge to 0 or 1
- All
- None

16. ROS is open source meta OS used for hardware abstraction and makes robot software development easier (حاجة كده)
- True
- False

17. ROS bags are used to replay experiments
- True
- False

18. Odometry model motion has … elementary motions
- two
- three

- four
- five

19. Mapping is used for
    1. navigation
    2. motion calibration
    3. industrial factories
    4. all
    5. none

20. A* disadvantages
    1. don’t respect robot kinematics
    2. overestimates distances to obstacles
    3. doesn’t consider the goal
    4. its randomness makes the path not optimal
    5. none

21. The equation for incorporating measurements (Bayes recursive update rule)

$$
\begin{aligned}
P(x \mid z_1, \ldots, z_n) &= \frac{P(z_n \mid x) P(x \mid z_1, \ldots, z_{n-1})}{P(z_n \mid z_1, \ldots, z_{n-1})} \\
&= \eta P(z_n \mid x) P(x \mid z_1, \ldots, z_{n-1}) \\
&= \eta_{1 \ldots n} \left[\prod_{i=1 \ldots n} P(z_i \mid x) \right] P(x)
\end{aligned}
$$

22.landmark based fast SLAM rao blackwellization equation
answer:

$$
\begin{aligned}
& p(x_{0:t}, m_{1:M} \mid z_{1:t}, u_{1:t}) = \\
& \qquad p(x_{0:t} \mid z_{1:t}, u_{1:t}) \, \underline{p(m_{1:M} \mid x_{0:t}, z_{1:t})}
\end{aligned}
$$

23. Cognitive robotics can deal with …. In dynamic real world environments
    1. unpredictable
    2. predictable
    3. well understood
    4. All of the above
    5. None of the above

24.
https://courses.cs.washington.edu/courses/cse571/22sp/homeworks/A1.pdf
Bayes rule question clean dirty tiles
1.2

25. What is the step that does not exist in the 5D path planning algorithm?
    1. Use A* to find a path in the <x,y>-space using the updated grid map
    2. A* search in the full 5D <x,y,θ,v,ω>-configuration space
    3. Use heuristic navigation function to drive fast in the right direction
    4. Find a trajectory by planning in this restricted <x,y,θ,v,ω>-space using 2D value iteration as heuristic
    5. none

26. Collision avoidance depends mainly on ..
    1. map
    2. sensor data
    3. motion commands
    4. all
    5. none

27. Data association is
    1. tracking different hypothesis to associate landmarks to them in EKF SLAM
    2. linking observations to landmarks
    3.
    4. not an issue for single modal ..
    5. none

28. Kalman Filter

1. Assumes gaussian world
2. Can handle nonlinear systems
3. Assume arbitrary distributions
4. all
5. None

29. possible source of motion uncertainty in wheeled robot
    1. bump
    2. Uncalibrated joints
    3. Uncalibrated manipulators
    4. all
    5. none

30. SLAM
    1. mapping is done first
    2. mapping and localization accuracy depend on each other.
    3. localization and mapping are sequential
    4. all
    5. none

31. According to Markov assumption …
    1. current measurement depends only on the previous state
    2. current state depend only on the previous state
    3. current measurement depends only on the current action
    4. all
    5. none

32. In kalman prediction correction cycle ..
    1. the new belief is between the old belief and the belief plus the measurement
    2. the predicted uncertainty is smaller than the old uncertainty since we incorporate new actions
    3. the correction step moves the mean using the action (ta2reeban)
    4. all
    5. none

33. Physical interpretation of a max range measurement …
    1. Beam wasn't reflected back
    2. Bean hit an unknown obstacle
    3. .
    4. All
    5. None

34. To solve the kidnapped robot problem..
   1. Insert a fixed number of random samples periodically.
   2. Apply scan matching
   3. Insert a number of random samples proportional to the number of particles.
   4. All
   5. None

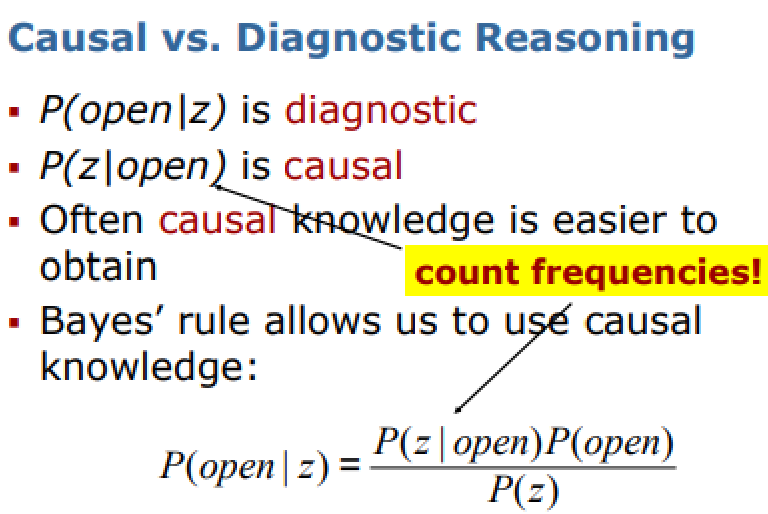
35. Scan matching is used to ..
   1. Correct the odometry before using it in fastSLAM prediction step.
   2. Maximize likelihood of the current pose relative to the previous pose and map.
   3. Apply local consistent pose corrections.
   4. All.
   5. None.

Final 2021:

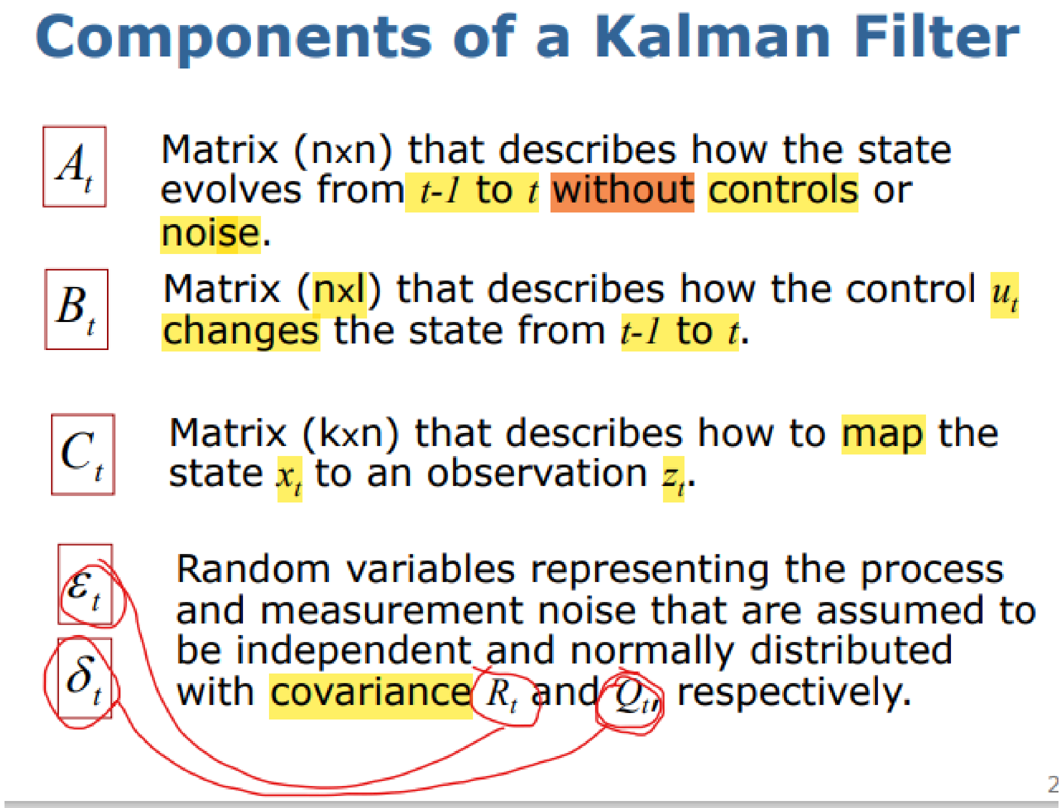
1) explain the difference between diagnostic reasoning and causal reasoning with the help of an example.

Causal: P(z|x), just counting frequencies.

Diagnostic: P(x|z)



2) explain A, B , C , epsilon and sigma in the kalman filter.



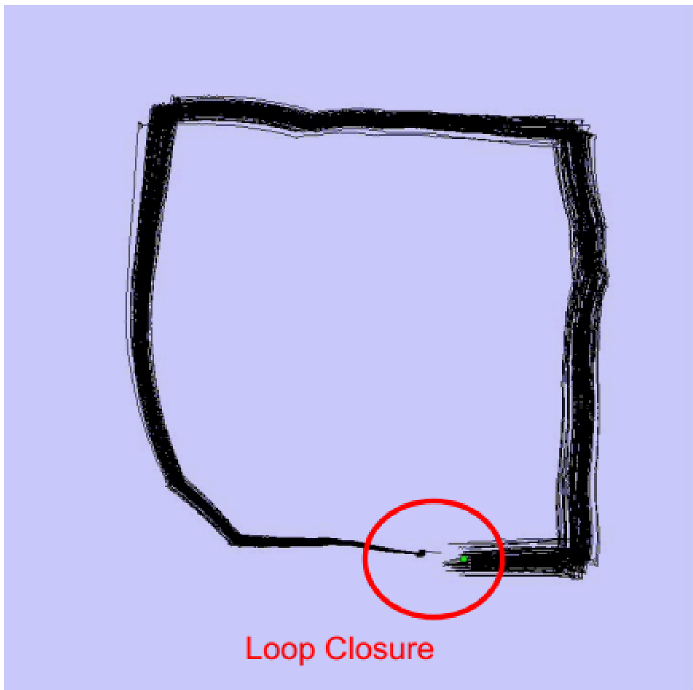
مسألة 3) kalman filter 1D زي بتاعت ال exam test

mu = 11 and std = 1 and sensor readings = 9 and

4) why closed loop is important in fastSLAM

I can not find it in the FastSLAM lec , but maybe he wanted to say “Loop closing in SLAM :-

Grid-Based FastSLAM with Scan-Matching



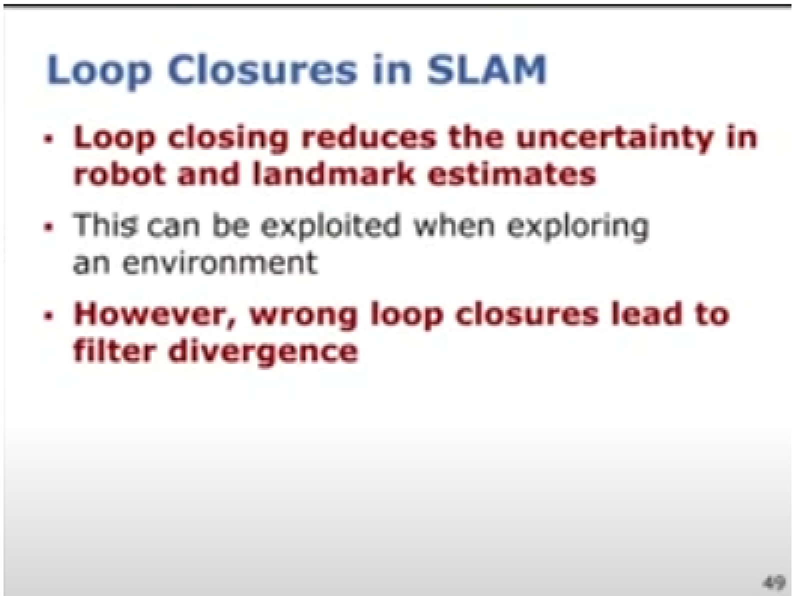
Courtesy:
Dirk Hähnel

13

Loop Closing

- Recognizing an already mapped area
- Data association under
  - high ambiguity
  - possible environment symmetries
- **Uncertainties collapse after a loop closure** (whether the closure was correct or not)

46



5) describe the 5 stages of EKF slam.

6) Why resampling is dangerous in fast slam, describe a method to overcome that.?

Because it may make important samples to get lost (particle depletion)

May cause redundant samples to solve it use selective resampling

7) Briefly sketch a situation where the endpoint model and the beam-based sensor
model (ray casting) give qualitatively different results.

8) write the equation of rao blackwellization in fast slam

$P(x_{0:t},m_{1:M} \mid z_{1:t},u_{1:t}) = P(x_{0:t} \mid z_{1:t},u_{1:t}) * Pi(P(m_i \mid x_{0:t},z_{1:t})$

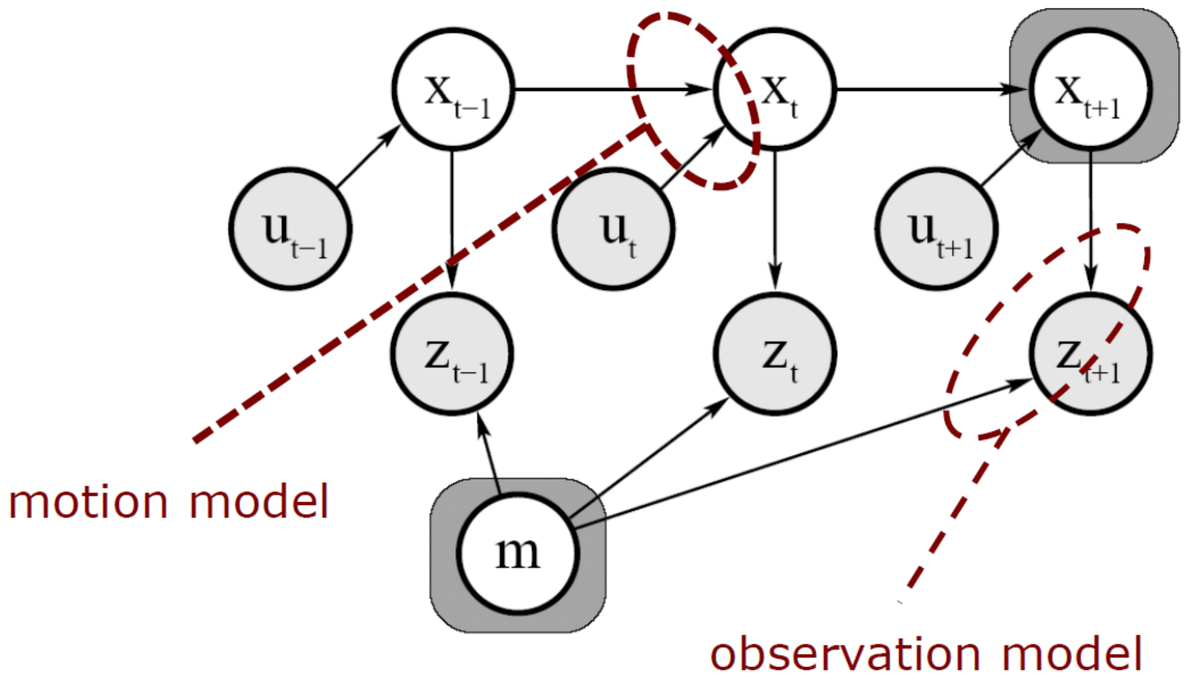
Rao-Blackwellization for SLAM

Factorization of the SLAM posterior

$$
\begin{aligned}
p(x_{0:t}, m_{1:M} \mid z_{1:t}, u_{1:t}) = \\
& p(x_{0:t} \mid z_{1:t}, u_{1:t})\; p(m_{1:M} \mid x_{0:t}, z_{1:t}) \\
& \underbrace{p(x_{0:t} \mid z_{1:t}, u_{1:t})}_{\text{particle filter similar to MCL}} \prod_{i=1}^{M} \underbrace{p(m_i \mid x_{0:t}, z_{1:t})}_{\text{2-dimensional EKFs!}}
\end{aligned}
$$

9) explain rao blackwellization in fast slam.
10) Explain why SLAM is considered as chicken-egg problem
11) EKF slam state representation

Motion and Observation Model



12) Posterior representation in EKF SLAM

$$\mu_t = \bar{\mu}_t + K_t(z_t - h(\bar{\mu}_t))$$
$$\Sigma_t = (I - K_t H_t)\bar{\Sigma}_t$$

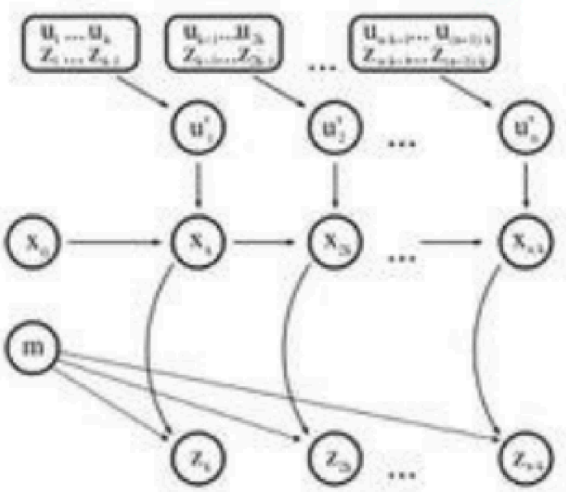
13) Explain odomery components given (x,y,theta @t and x,y,theta @t+1)
14) Given a landmark component Lx,Ly and robot pose(x,y,theta) how to determine distance and theta between this robot and landmark
15) What is the usage of motion sensor p(x|ut,z,m) at particle filter
16) importance weighting (how is it done)
17) Why is SLAM called a chicken and egg problem? متكررة فوق
18)If robot pose is (x, y, theta), and there is a landmark at (Lx, Ly), at what distance and orientation the robot believes that the landmark is?
19) explain how endpoint model models p(z|x)
20) Why cannot fastSLAM be used in grid-based maps? How can we solve the problem? (i.e. DBN of sequence of actions in slides)

Grid-Based FastSLAM with Improved Odometry

- Scan matching provides a **locally consistent** pose correction
- **Idea:** Pre-correct short odometry sequences using scan matching and use them as input to FastSLAM
- Fewer particles are needed, since the error in the input in smaller

[Hähnel et al., 2003]

Graphical Model for Mapping with Improved Odometry



Credit Exam 2022:

- Difference between casual and diagnostic reasoning
- Explaining A B C & noises terms in Kalman filter
- Perform correction step in EKF
- Explain the odometry model and sketch the idea
- Given pose(x, y, theta) and landmark (Lx, Ly) calculate r and theta
- Give one drawback and one advantage of discrete filter
- Give an example of when the endpoint model and beam-based model will give different results
- Write the formula or Rao-Blackwillizatio.21 متكررة في فاينل
- How belief state in EKF Slam looks
- Write the stages of the EKF slam cycle
- How to calculate importance weights for samples in the particle filter
- Why resampling is dangerous, explain how to overcome the problem
- Explain the counting model with equations
- Why loop closing is important in SLAM
- Why do we use scan matching in grid-based SLAM
- Why SLAM is considered a chicken-egg problem
- What are the components of 5D planning and is it still necessary to compute a 2D path in 5D path planning? , explain
- Give a situation DWA fails with sketches

Credit Exam 2021: **Sol is here: Final**

Q1) Compare Between Traditional Robotics & Cognitive Robotics.

Q2) What's the probability of the floor being clean P(xt = clean) given that the action performed was clean and knowing that:

$P(x_t = clean | u = clean, x_{t-1} = dirty) = 0.45$

$P(x_t = clean | u = clean, x_{t-1} = clean) = 0.9$

$P(x_t = dirty) = 0.8$

Q3) Explain prediction—correction cycle in your own words.

Q4) Explain Kalman Filter. (there was a 1D problem missing)

Q5) Explain the Counting Model.

Q6) Explain the Odometry Model.

Q7) Compare between Counting Model & Occupancy Grid Model.
Q8) Compare between UKF and KF, sketch the idea of UKF.
Q9) Describe FastSLAM
Q10) What is the problem of Particle Filters in Grid-Based FastSLAM?
Q11) Explain Rao-Blackwellization. متكررة في فاينل 21 مينستريم
Q12) Explain errors in wheeled robots.
Q13) Explain end-point model.
Q14) Explain Beam-Based Model.
Q15) Compare between Particle Filters and Kalman Filters.
Q16) What are the components of the Beam-Based Model?
Q17) Explain the problem of the kidnapped robot.

It refers to a scenario where a robot is suddenly moved to an unknown location without its knowledge. This unexpected displacement can significantly disrupt the robot's ability to accurately determine its own position in the environment.(اعتقد الاجابة محتاجة تفسير اكتر شوف الكومنت)

Q18) – Q20) are missing