

L9.1 SLAM Fundamentals Quiz

1. Which statement correctly distinguishes online SLAM from full SLAM?

- A) Online SLAM estimates only the current pose and the map; full SLAM estimates the whole trajectory and the map
- B) Online SLAM estimates the whole trajectory, while full SLAM estimates only the map
- C) Online SLAM uses a prior map, while full SLAM builds the map from scratch
- D) Online SLAM works only with cameras, while full SLAM works only with LiDAR

2. Why does dead reckoning from wheel odometry drift without bound?

- A) The wheels slip only at high speed, and slip errors cancel at low speed
- B) Odometry has a constant bias that can be removed once by calibration, so the drift is bounded
- C) Each step integrates noisy velocity and yaw-rate readings, so errors accumulate and nothing corrects them
- D) Odometry measures absolute position, but the map frame is shifted

3. What is the role of the front-end in a SLAM system?

- A) It optimizes the pose graph with Gauss-Newton
- B) It turns raw sensor data into constraints (feature matches, scan matches, loop candidates) for the back-end
- C) It stores the final map and renders it to the user
- D) It controls the vehicle to follow the estimated trajectory

4. An EKF-SLAM state contains the 2-D robot pose (x, y, θ) and $N = 10$ point landmarks (2 values each). What is the size of the state vector?

- A) 13
- B) 20
- C) 33
- D) 23

5. How does the cost of one EKF-SLAM update grow with the number of landmarks N ?

- A) About $O(N^2)$, because the full covariance matrix has $(3 + 2N)^2$ entries that must be updated
- B) About $O(\log N)$, because only the observed landmark is updated
- C) About $O(1)$, because only the pose is updated
- D) About $O(N)$, because each landmark is independent

6. Why do the landmark estimates in EKF-SLAM become correlated?

- A) The measurement noise of different landmarks is always correlated
- B) The motion model couples the landmarks to each other
- C) They were all observed from the same uncertain robot pose, so errors in the pose affect every landmark
- D) Landmarks are initialized at the same position

7. In a 1-D EKF-SLAM example the predicted measurement is $\hat{z} = m - x = 4.8 - 3.0 = 1.8$ m, but the sensor returns $z = 1.6$ m. What is the innovation?

- A) +0.2 m
- B) -0.2 m
- C) +1.6 m
- D) -1.8 m

8. A scalar Kalman update has predicted variance $P = 0.4$ and measurement variance $R = 0.1$. What is the Kalman gain $K = P / (P + R)$?

- A) 0.25
- B) 0.4
- C) 0.5
- D) 0.8

9. A 2-D innovation has Mahalanobis distance $d^2 = 7.2$. The 95 % χ^2 gate for 2 degrees of freedom is 5.99. What should the filter do with this candidate?

- A) Reject it as a match for this landmark (it is outside the gate)
- B) Accept it, because $d^2 > 1$ means the measurement is reliable
- C) Accept it and double the measurement noise
- D) Accept it but update the landmark with a smaller gain

10. What is the main danger of nearest-neighbor data association in EKF-SLAM?

- A) It makes the covariance matrix singular after every update
- B) If two landmarks are close, the wrong one may be chosen, and the EKF cannot undo the wrong update
- C) It requires a LiDAR sensor, which is not always available
- D) It increases the motion noise at each step

11. What is the key idea of FastSLAM (Rao-Blackwellization)?

- A) Replace the robot motion model with a neural network
- B) Use one large Gaussian over the pose and all landmarks, as in EKF-SLAM
- C) Sample the robot path with particles; given a path, the landmarks are independent, so each particle keeps small independent EKFs
- D) Optimize all poses at once with Gauss-Newton

12. What does particle depletion mean in FastSLAM?

- A) The particles run out of memory when N becomes large
- B) The particles' weights all become exactly zero
- C) The landmarks disappear from the map when they are not observed
- D) After repeated resampling most particles descend from a few ancestors, so the diversity of path hypotheses is lost

13. In graph SLAM, what do the nodes and the edges represent?

- A) Nodes are robot poses (and optionally landmarks); edges are constraints from odometry or observations such as loop closures
- B) Nodes are sensors; edges are cables between them
- C) Nodes are time steps; edges are the particles
- D) Nodes are landmarks only; edges are the robot trajectory

14. In the graph-SLAM cost $F(x) = \sum e_{ij}^T \Omega_{ij} e_{ij}$, what does the information matrix Ω_{ij} express?

- A) The error between the estimated and the true pose
- B) The number of landmarks seen from node i and node j
- C) How confident the measurement is: a large Ω forces the optimizer to satisfy that constraint more closely
- D) The time between the two measurements

15. What does one Gauss-Newton iteration on a pose graph solve?

- A) The equation $x = H^{-1}b$, in one step, for any nonlinear problem
- B) The linear system $H \Delta x = -b$, with $H = \sum J^T \Omega J$ and $b = \sum J^T \Omega e$, then updates $x \leftarrow x + \Delta x$
- C) A particle weight update followed by resampling
- D) A Kalman prediction followed by a gating test

16. A 1-D pose graph has $H = \begin{bmatrix} 100 & -50 \\ -50 & 150 \end{bmatrix}$ and $b = (0, 30)$. What is $\Delta x = -H^{-1}b$? (Hint: $H^{-1} = \begin{bmatrix} 0.012 & 0.004 \\ 0.004 & 0.008 \end{bmatrix}$)

- A) $(-0.12, -0.24)$
- B) $(0.12, 0.24)$
- C) $(-0.30, -0.15)$
- D) $(0, -30)$

17. Why is the matrix H of a pose graph sparse?

- A) Because most poses are exactly zero
- B) Because the information matrices Ω are diagonal
- C) Because Gauss-Newton removes small entries after each iteration
- D) Each edge connects only two nodes, so only the blocks of connected node pairs are nonzero

18. Why must the first pose (or a prior) be fixed in a pose graph that has only relative constraints?

- A) To make the optimization converge faster, but it is never required
- B) Relative constraints do not define a global frame, so H is singular: the solution is determined only up to

a rigid transform

C) To reduce the number of loop closures that must be detected

D) Because the first pose is the only one with a measurement

19. A single false loop closure with a large information matrix is added to a pose graph. What is the most likely result, and what is a standard defense?

A) Nothing changes, because the other edges outvote it; no defense is needed

B) Only the two connected poses move; a bigger map fixes it

C) The whole map is distorted; a robust loss (e.g., Cauchy or Huber) or consistency check down-weights the bad edge

D) The optimization always diverges; the only remedy is to reduce the number of poses

20. What does ATE (absolute trajectory error) measure, compared with RPE (relative pose error)?

A) ATE measures global consistency of the whole trajectory after alignment; RPE measures local drift over a fixed interval

B) ATE measures only the rotation error; RPE measures only the translation error

C) ATE is computed without ground truth; RPE needs ground truth

D) ATE and RPE are the same quantity expressed in different units