Assignment #4

Robotics WS18/19
Group: 4_Fri_J

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A. Bayes

1. *Claim.* $P(\text{open} \mid z = 42) = \frac{3}{4}$.

   Proof. Applying Bayes' rule we obtain

   $$P(\text{open} \mid z = 42) = \frac{P(z = 42 \mid \text{open})\, P(\text{open})}{P(z = 42)}.$$

   In order to compute $P(z = 42)$, we first observe that by the properties of the probability measure P we find

   $$\begin{aligned} P(z = 42) &= P(z = 42, \text{open}) + P(z = 42, \text{closed}) \\ &= P(z = 42 \mid \text{open})\, P(\text{open}) + P(z = 42 \mid \text{closed})\, P(\text{closed}), \end{aligned}$$

   also using that for general sets A, B with $P(B) > 0$ we have $P(A \mid B) := \frac{P(A,B)}{P(B)}$. Since the task states that the door "can only be either completely open or completely closed", we further know

   $$P(\text{open}) + P(\text{closed}) = 1.$$

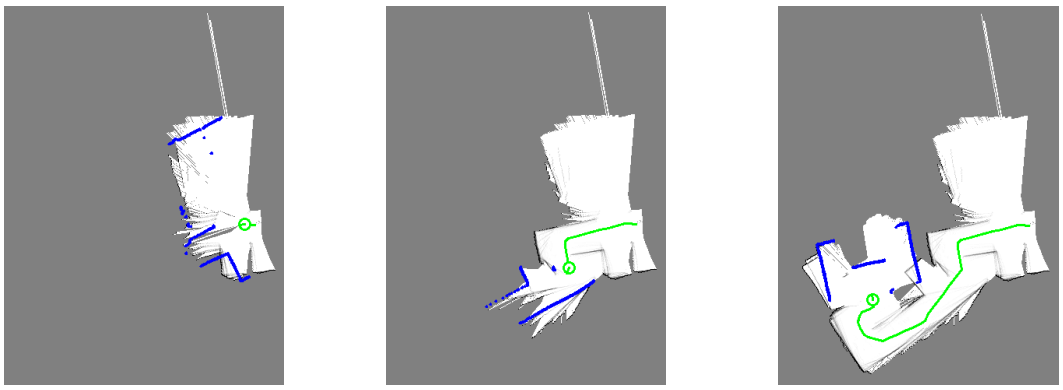
   Combining our three previous results yields

   $$P(\text{open} \mid z = 42) = \frac{P(z = 42 \mid \text{open})\, P(\text{open})}{P(z = 42 \mid \text{open})\, P(\text{open}) + P(z = 42 \mid \text{closed})\Big(1 - P(\text{open})\Big)},$$

   which we can explicitly compute with the given values from the task. So finally we obtain $P(\text{open} \mid z = 42) = \frac{3}{4}$. □

B. Mapping with Raw Odometry

2.



(i) After 2 seconds (ii) After 8 seconds (iii) After 20 seconds

Figure 1: The map building process.

3. The assumed change in the robot's state after a move command relies only on the odometry model. Since the latter is not exact due to slippage of the wheels, inclination and character of the ground, actuator inaccuracies, etc., it can only provide a probability distribution on where the robot will be after moving. Therefore the assumed and actual position diverge as time increases, when moving the robot. Additionally, the data produced by the laser sensor might not be completely correct either. False or inaccurate measurements can further distort the map.

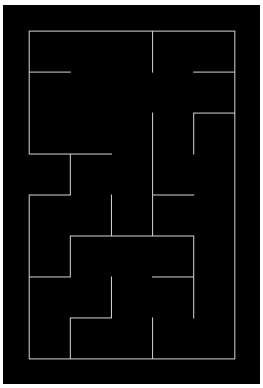
   To receive better results, one could improve the robot's knowledge about its own position respectively the applied motion model. This could be realized

   - with a loop closure,
   - by using landmarks in the map,
   - by building the map and estimating the robot's state at the same time, like e.g. done in Task C,
   - or by adding more sensors to the robot like a camera or a GPS sensor.

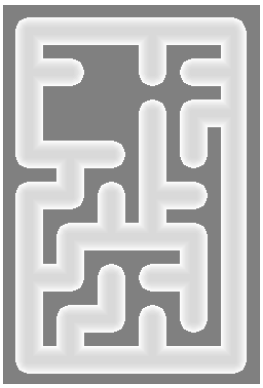
   In addition one could, if the opportunity is given, take multiple estimations of the map and therewith decide for the most likely one (e.g. using heuristics like assuming walls to be straight).

C. Monte Carlo Localization: Particle Filter

4. (c)



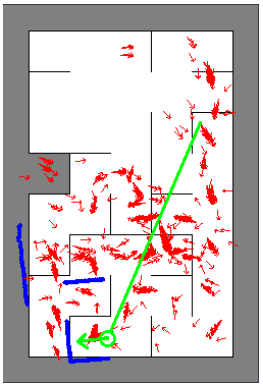
(i) The map



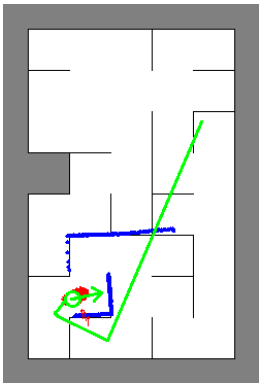
(ii) The likelihood field

Figure 2: Two versions of the maze map.

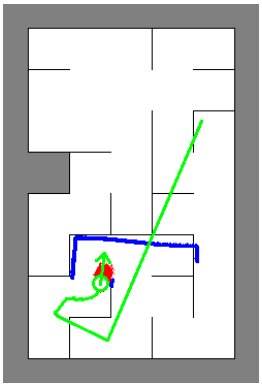
6. (a)



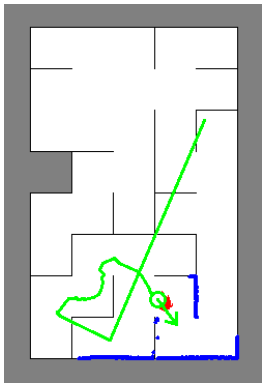
(i) After 5 seconds



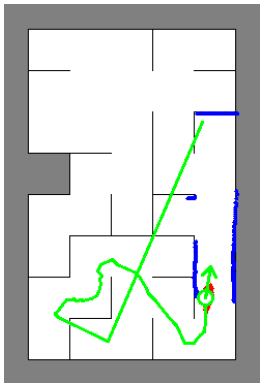
(ii) After 10 seconds



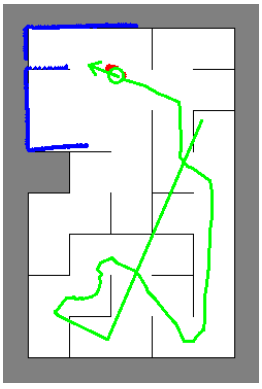
(iii) After 14 seconds



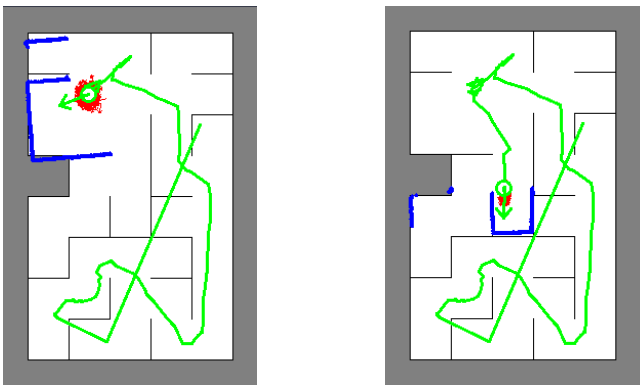
(iv) After 20 seconds



(v) After 30 seconds



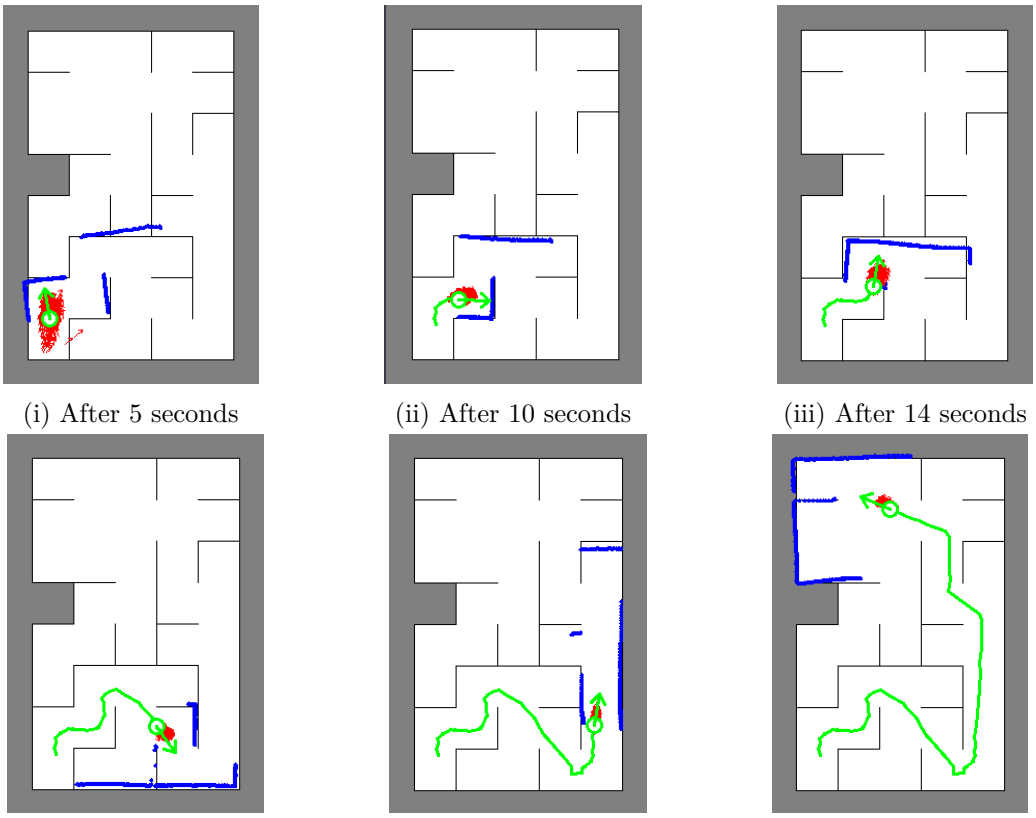
(vi) After 42 seconds



(vii) After 60 seconds (viii) After 75 seconds

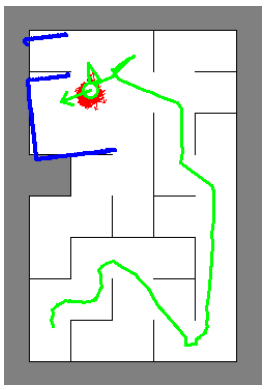
Figure 3: Eight time steps showing the map with particles, estimated robot pose and robot path for a uniformly distributed particle set.

6. (b)

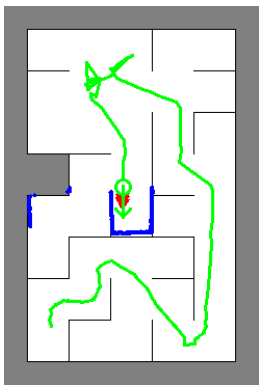


(i) After 5 seconds (ii) After 10 seconds (iii) After 14 seconds

(iv) After 20 seconds (v) After 30 seconds (vi) After 42 seconds



(vii) After 60 seconds



(viii) after 75 seconds

Figure 4: The map with particles, estimated robot pose and robot path for a Gaussian distributed particle set.

Appendix

Student Name	(A)	B1	B2	(B3)	C1	C2	C3	C4	C5	C6
Abhiraj Bishnoi		x	x		x	x	x			
Fynn Boyer		x	x		x	x	x	x	x	x
Karsten Eckhoff		x	x		x	x	x	x	x	x
Philipp Willmroth					x	x	x	x	x	x