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Machine Learning for Robotics and Computer Vision
Winter term 2015

Homework Assignment 6

Topic: Sampling methods and Variational Inference
January 18th, 2016

Exercise 1: Particle Filter

Theory:

a) What kind of spaces can we explore with a particle filter?

b) What kind of distributions can we approximate with a particle filter?

c) In a Monte Carlo localization problem what do the particles and the particle weights represent?

Programming : Implementing a particle filter for global localization.
Assume we have a robot in a 2D world of size 100m x 100m. The world is cyclic so if the robot crosses some border it ends up on the opposite side. There are four landmarks in this world at positions (20,20), (80,20), (20,80) and (80,80). The robot can measure its distance to each of the landmarks through its sensor and thus it estimates its true position using a measurement model with $\sigma_{sense} = 3$. This time our robot's state is described by 3 variables, x, y and θ (orientation). The robot's motion model consists of noise $\sigma_{tra} = 0.1$ for the translational motion and $\sigma_{rot} = 0.05$ for the rotational motion.

- Implement a function *move* that takes as arguments a turning angle and a forward motion distance.
- Implement a function *sense* that computes the estimated distance to the landmarks.
- Implement the function *measurement_prob* that computes the likelihood of a sensor measurement.
- Implement the function *resample* using the low variance method from the lecture.

Initialize the robot randomly and use a particle set of 1000 particles. Compute the mean error (between particles and true state). Let the robot move, turning by 0.1 radians and moving 5 meters forward. Compute the new weights and resample. Compute the mean error again. Iterate.

Exercise 2: Gibbs sampling

Show that the Gibbs sampling algorithm satisfies detailed balance:

$$p^*(z)T(z, z') = p^*(z')T(z', z)$$

Exercise 3: Kullback-Leibler divergence

a) What does the KL divergence describe? Is it symmetric? Why?

b) Compute the KL-divergence of two univariate normal distributions.
What if they have the same mean? What if they have the same variance?

c) Consider a factorized variational distribution $q(Z)$. By using the technique of Lagrange multipliers, verify that minimization of $KL(p||q)$ with respect to one of the factors $q_i(Z_i)$ keeping all other factors fixed, leads to the solution:

$$q_j^*(Z_j) = \int p(Z) \prod_{i \neq j} dZ_i = p(Z_j)$$

The next exercise class will take place on **February 5th, 2016**.

For downloads of slides and of homework assignments and for further information on the course see

`https://vision.in.tum.de/teaching/ws2015/mlcv15`
