

## Machine Learning for Computer Vision Winter term 2017

February 6, 2018  
Topic: Sampling methods

### Exercise 1: Gibbs sampling

Show that the Gibbs sampling algorithm satisfies detailed balance:

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

### Exercise 2: Particle Filter

#### Theory:

- What kind of spaces can we explore with a particle filter?
- What kind of distributions can we approximate with a particle filter?
- 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  $\theta$  (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.