DD2434/FDD3434 Machine Learning, Advanced Course
Assignment 1B, 2023

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Deadline, see Canvas

Read this before starting

There are some commonalities between the problems and they cover different aspects of the course and vary in difficulty, consequently, it may be useful to read all of them before starting. Also think about the formulation and try to visualize the model. You are allowed to discuss the formulations, but have to make a note of the people you have discussed with. You will present the assignment by a written report, submitted before the deadline using Canvas. You must solve the assignment individually and it will automatically be checked for similarities to other students' solutions as well as documents on the web in general. Although you are allowed to discuss the problem formulations with others, you are not allowed to discuss solutions.

From the report it should be clear what you have done and you need to support your claims with results. You are supposed to write down the answers to the specific questions detailed for each task. This report should clearly show how you have drawn your conclusions and explain your derivations. Your assumptions, if any, should be stated clearly. Show the results of your experiments using images and graphs together with your analysis and add your code as an appendix.

Being able to communicate results and conclusions is a key aspect of scientific as well as corporate activities. It is up to you as an author to make sure that the report clearly shows what you have done. Based on this, and only this, we will decide if you pass the task. No detective work should be required on our side. In particular, neat and tidy reports please!

Each problem 1.1-1.4 can give 15 points (60 points for in total). The grade thresholds of assignments 1B and 2B are given below. Note that you can have 30 bonus points from assignment 1A and 2A.

D 30 points.

C 50 points.

B 70 points.

A 90 points.

These grades are valid for assignments submitted before the deadline, late assignments can at most receive the grade E, which makes it meaningless to hand in late solutions for this assignment.

Good Luck!

1.1 CAVI for Earth quakes

In an area with frequent earthquakes emanating from K super epicentra, we gather seismographic data on the strength, S_n, and the 2D-coordinates, X_n, of each outbreak. We introduce a class variable, Z_n, with a categorical distribution parameterized by π, which assigns the nth observation to a super epicentra. We model $S_n|Z_n = k, \lambda_k$ as a Poisson random variable with super epicentra specific intensity, λ_k, and $X_n|Z_n = k, \mu_k, \tau$ as a 2D Normal r.v. with super epicenter specific mean vector $\mu_k = (\mu_0, \mu_1)$ and precision matrix set to $\tau \cdot I$, where I is the 2D identity matrix. We set a 2D Normal prior on μ_k with mean vector $\nu = (\nu_0, \nu_1)$ and precision matrix $\rho \cdot I$. We set a Gamma prior on λ_k with shape parameter α and rate parameter β. The remaining parameters are treated as constants.

Question 1.1.1: *Draw the DGM of the model described above.*

Question 1.1.2: *Simplify the expression of* $\log p(X, S, Z, \lambda, \mu|\pi, \tau, \alpha, \beta, \nu, \rho)$ *in terms of known pdfs/pmfs.*

Question 1.1.3: *Use the mean-field assumption* $q(Z, \mu, \lambda) = \prod_n q(Z_n) \prod_k q(\mu_k)q(\lambda_k)$ *and CAVI update equation and derive the optimal variational distributions and parameters of* $q(Z_n)$, $q(\mu_k)$ *and* $q(\lambda_k)$

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1.2 VAE image generation

Notebook "1B-VAE.ipynb" contains a partially completed implementation of a VAE for the MNIST dataset. Answer the questions 5.1 and 5.2 by reporting your derivations and the other questions by inserting your code into the relevant functions. Follow the guidelines in the notebook to train the model and generate images.