DD2434/FDD3434 Machine Learning, Advanced Course
Assignment 1A, 2024

Jens Lagergren

Deadline, see Canvas

Read this before starting

You will present the assignment by a written report in PDF format, submitted before the deadline using Canvas. The assignment should be done in groups of two, 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 other groups, you are not allowed to discuss solutions, and any discussions concerning the problem formulations must be described in the solutions you hand in (including which group you discussed with).

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!

The grading of the assignment 1A, 2A and 3A will be as follows,

E 30-44 points, with least 10 points from each Assignment.

D 45-60 points, with least 10 points from each Assignment.

- All points over 30 will be counted as bonus points for assignment 1B and 2B.

Good Luck!

1.1 Dependencies in a Directed Graphical Model

Consider the graphical models shown in Figures 1 and 2. You merely have to answer "yes" or "no" to each question.(1 point per correct answer)

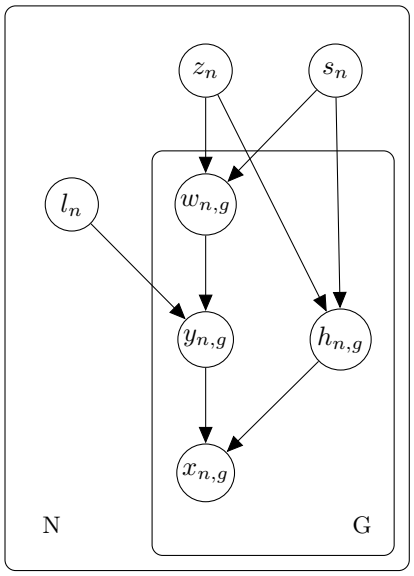

Figure 1: Graphical model of single-cell variational inference (scVI).

Question 1.1.1: *In the graphical model of Figure 1, is* $w_{n,g} \perp w_{n,g+1} \mid s_n$*?*

Question 1.1.2: *In the graphical model of Figure 1, is* $l_n \perp w_{n,g} \mid x_{n,g}$*?*

Question 1.1.3: *In the graphical model of Figure 1, is* $z_n \perp x_{n,g} \mid w_{n,g}, h_{n,g}$*?*

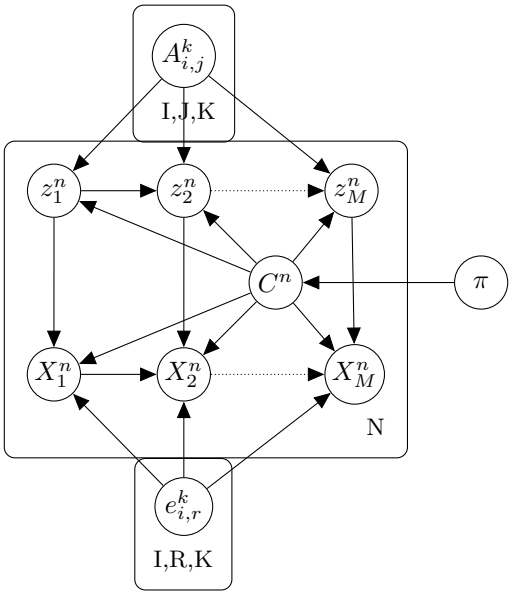

Figure 2: Graphical model of a mixture HMM

Question 1.1.4: *In the graphical model of Figure 2, is* $z_1^n \perp z_M^n \mid C_n, A_{1:I,1:J}^{1:K}$*?*

Question 1.1.5: *In the graphical model of Figure 2, is* $X_1^n \perp X_M^n \mid X_2^n,\ C^n$*?*

Question 1.1.6: *In the graphical model of Figure 2, is* $C^n \perp C^{n+1} \mid z_{1:M}^n, X_{1:M}^n$*?*

1.2 CAVI

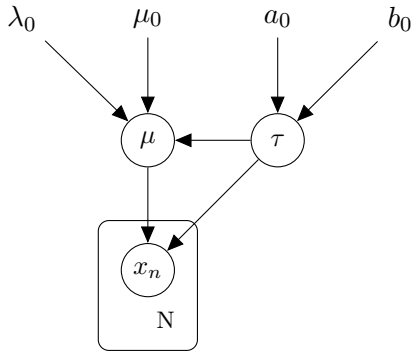

Figure 3: DGM

Consider the model defined by Equation (10.21)-(10-23) in Bishop, for which DGM is presented in Figure 3. We are here concerned with the VI algorithm for this model covered during the lectures and in the book.

Question 1.2.7: *Implement a function that generates data points for the given model. Set* $\mu = 1$, $\tau = 0.5$ *and generate datasets with size N=10,100,1000. Plot the histogram for each of 3 datasets you generated. (1 points)*

Question 1.2.8: *Find ML estimates of the variables* μ *and* τ*. (1 points)*

Question 1.2.9: *What is the exact posterior? (Show your derivations.) (2 points)*

Question 1.2.10: *Implement the VI algorithm for the variational distribution in Equation (10.24) in Bishop. Run the VI algorithm on the datasets. Plot the ELBO results. Compare the inferred variational distribution with the exact posterior and the ML estimate. Visualize the results and discuss your findings. (10 points)*