

DD2434 - Machine Learning, Advanced Course  
Assignment 1B

Tristan Perrot  
tristanp@kth.se

November 2023



## Contents

<b>1</b>	<b>CAVI for Earth quakes</b>	<b>3</b>
1.1	Question 1.1 . . . . .	3
1.2	Question 1.2 . . . . .	3
<b>A</b>	<b>Appendix</b>	<b>5</b>
A.1	Question 1.2 . . . . .	5

# 1 CAVI for Earth quakes

## 1.1 Question 1.1

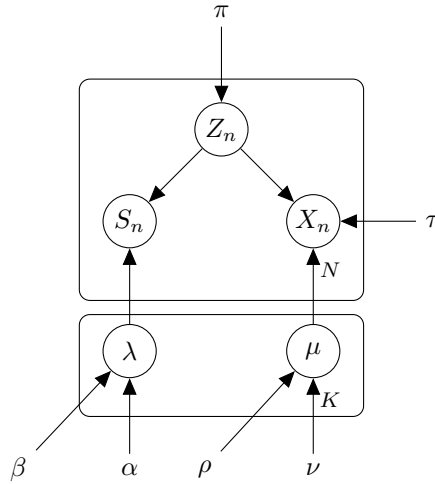


Figure 1: Directed Graphical Model for the Earthquake problem

## 1.2 Question 1.2

Here, we know these distributions:

- $p(Z_n|\pi) = \text{Categorical}(\pi)$
- $p(S_n|Z_n = k, \lambda_k) = \text{Poisson}(\lambda_k)$
- $p(X_n|Z_n = k, \mu_k, \tau) = \text{Normal}(\mu_k, \tau \cdot I)$
- $p(\mu_k|\nu, \rho) = \text{Normal}(\nu, \rho \cdot I)$
- $p(\lambda_k|\alpha, \beta) = \text{Gamma}(\alpha, \beta)$

Where,  $\rho$  and  $\tau$  define precision and not standard variation. Then we have:

$$\begin{aligned}
 \log p(X, S, Z, \lambda, \mu|\pi, \tau, \alpha, \beta, \nu, \rho) &= \log p(X|S, Z, \lambda, \mu, \pi, \tau, \alpha, \beta, \nu, \rho) \\
 &\quad + \log p(S, Z, \lambda, \mu|\pi, \alpha, \beta, \nu, \rho) \\
 &= \log p(X|Z, \mu, \tau) + \log p(S|Z, \lambda, \mu, \pi, \alpha, \beta, \nu, \rho) \\
 &\quad + \log p(Z, \lambda, \mu|\pi, \alpha, \beta, \nu, \rho) \\
 &= \log p(X|Z, \mu, \tau) + \log p(S|Z, \lambda) + \log p(Z|\pi) \\
 &\quad + \log p(\lambda, \mu|\alpha, \beta, \nu, \rho) \\
 \log p(X, S, Z, \lambda, \mu|\pi, \tau, \alpha, \beta, \nu, \rho) &= \log p(X|Z, \mu, \tau) + \log p(S|Z, \lambda) + \log p(Z|\pi) \\
 &\quad + \log p(\mu|\nu, \rho) + \log p(\lambda|\alpha, \beta)
 \end{aligned} \tag{1}$$

Where:

$$\begin{aligned}\log p(X|Z, \mu, \tau) &= \sum_{n=1}^N \sum_{k=1}^K \log p(X_n|Z_n = k, \mu_k, \tau) \\ \log p(S|Z, \lambda) &= \sum_{n=1}^N \sum_{k=1}^K \log p(S_n|Z_n = k, \lambda_k) \\ \log p(Z|\pi) &= \sum_{n=1}^N \log p(Z_n|\pi) \\ \log p(\mu|\nu, \rho) &= \sum_{k=1}^K \log p(\mu_k|\nu, \rho) \\ \log p(\lambda|\alpha, \beta) &= \sum_{k=1}^K \log p(\lambda_k|\alpha, \beta)\end{aligned}\tag{2}$$

## A Appendix

### A.1 Question 1.2

```
import matplotlib.pyplot as plt
import numpy as np
from scipy.stats import gamma, norm
from scipy.special import psi
np.random.seed(14)

def generate_data(mu, tau, N):
    # Insert your code here
    D = np.random.normal(mu, np.sqrt(1/tau), N)

    return D

MU = 1
TAU = 0.5

dataset_1 = generate_data(MU, TAU, 10)
dataset_2 = generate_data(MU, TAU, 100)
dataset_3 = generate_data(MU, TAU, 1000)

# Visualize the datasets via histograms
# Insert your code here
fig, axs = plt.subplots(1, 3, figsize=(12, 4))
axs[0].hist(dataset_1, bins=20)
axs[1].hist(dataset_2, bins=20)
axs[2].hist(dataset_3, bins=20)
plt.tight_layout()
plt.savefig('12_data.png')
plt.show()
```