

DD2434 - Machine Learning, Advanced Course
Assignment 1A

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November 2023



1 Exponential Family

1.1 Question 1.1

$$\begin{aligned}
 p(x|\theta) &= h(x) \exp(\eta(\theta) \cdot T(x) - A(\eta)) \\
 &= h(x) \exp(\eta(\lambda) \cdot T(x) - A(\eta(\lambda))) \\
 &= h(x) \exp(\log \lambda \cdot x - A(\log \lambda)) \\
 &= h(x) \exp(\log \lambda \cdot x - \lambda) \\
 &= h(x) \exp(\log \lambda \cdot x) \exp(-\lambda) \\
 &= e^{-\lambda} \frac{\lambda^x}{x!}
 \end{aligned} \tag{1}$$

We can see that the distribution correspond to a Poisson distribution of parameter λ .

1.2 Question 1.2

$$\begin{aligned}
 p(x|\theta) &= h(x) \exp(\eta(\theta) \cdot T(x) - A(\eta)) \\
 &= \exp(\eta([\alpha, \beta]) \cdot [\log x, x] - A(\alpha - 1, -\beta)) \\
 &= \exp([\alpha - 1, -\beta] \cdot [\log x, x] - \log \Gamma(\alpha) + \alpha \log(\beta)) \\
 &= \exp((\alpha - 1) \log x - \beta x - \log \Gamma(\alpha) + \alpha \log(\beta)) \\
 &= \frac{\beta^\alpha}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x}
 \end{aligned} \tag{2}$$

We can see that the distribution correspond to a Gamma distribution of parameters α and β .

1.3 Question 1.3

$$\begin{aligned}
 p(x|\theta) &= h(x) \exp(\eta(\theta) \cdot T(x) - A(\eta)) \\
 &= \frac{\exp(\eta([\mu, \sigma^2]) \cdot [x, x^2] - A(\eta([\mu, \sigma^2])))}{\sqrt{2\pi}} \\
 &= \frac{\exp([\frac{\mu}{\sigma^2}, -\frac{1}{2\sigma^2}] \cdot [x, x^2] - A([\frac{\mu}{\sigma^2}, -\frac{1}{2\sigma^2}]))}{\sqrt{2\pi}} \\
 &= \frac{\exp(\frac{\mu x}{\sigma^2} - \frac{x^2}{2\sigma^2} - \frac{\mu^2}{2\sigma^2} - \log \sigma)}{\sqrt{2\pi}} \\
 &= \frac{\exp(-\frac{(x-\mu)^2}{2\sigma^2})}{\sigma\sqrt{2\pi}}
 \end{aligned} \tag{3}$$

We can see that the distribution correspond to a Normal distribution of parameters μ and σ^2 .

1.4 Question 1.4

$$\begin{aligned}
 p(x|\theta) &= h(x) \exp(\eta(\theta) \cdot T(x) - A(\eta)) \\
 &= 2 \exp(\eta(\lambda) \cdot x - A(\eta(\lambda))) \\
 &= 2 \exp(-\lambda x - A(-\lambda)) \\
 &= 2 \exp\left(-\lambda x + \log\left(\frac{\lambda}{2}\right)\right) \\
 &= \lambda e^{-\lambda x}
 \end{aligned} \tag{4}$$

We can see that the distribution correspond to a Exponential distribution of parameter λ .

1.5 Question 1.5

$$\begin{aligned}
 p(x|\theta) &= h(x) \exp(\eta(\theta) \cdot T(x) - A(\eta)) \\
 &= \exp(\eta([\psi_1, \psi_2]) \cdot [\log x, \log(1-x)] - A(\eta([\psi_1, \psi_2]))) \\
 &= \exp([\psi_1 - 1, \psi_2 - 1] \cdot [\log x, \log(1-x)] - A([\psi_1 - 1, \psi_2 - 1])) \\
 &= \exp((\psi_1 - 1) \log x + (\psi_2 - 1) \log(1-x) - \log \Gamma(\psi_1) - \log \Gamma(\psi_2) + \log \Gamma(\psi_1 + \psi_2)) \\
 &= \frac{\Gamma(\psi_1 + \psi_2)}{\Gamma(\psi_1)\Gamma(\psi_2)} x^{\psi_1-1} (1-x)^{\psi_2-1}
 \end{aligned} \tag{5}$$

We can see that the distribution correspond to a Beta distribution of parameters ψ_1 and ψ_2 .

2 Dependencies in a Directed Graphical Model

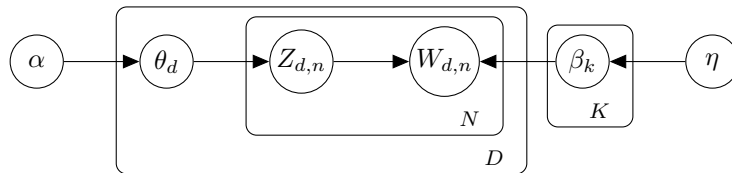
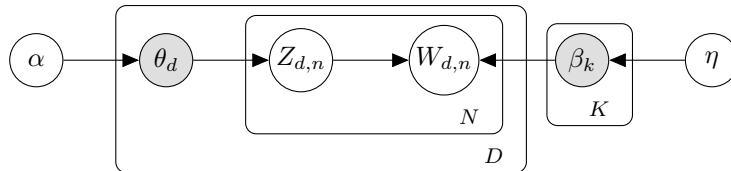


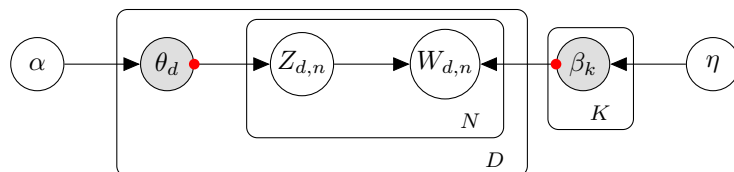
Figure 1: Graphical model of smooth LDA.

2.1 Question 2.6

The bayes net take this form :



Then, if we use the method using the d-separation, we obtain this :



Therefore, we can see that $W_{d,n} \perp W_{d,n+1} | \theta_d, \beta_{1:K}$ is false.

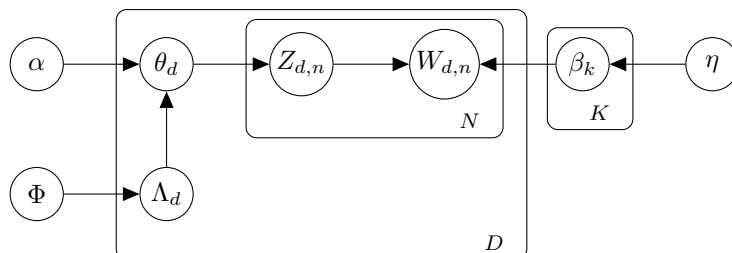


Figure 2: Graphical model of Labeled LDA.

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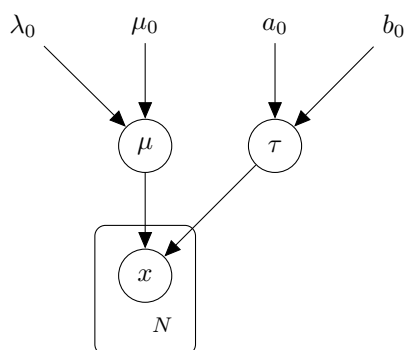


Figure 3: DGM