Beta Process Nonnegative Matrix Factorization for Music

Advanced Machine Learning Course Project

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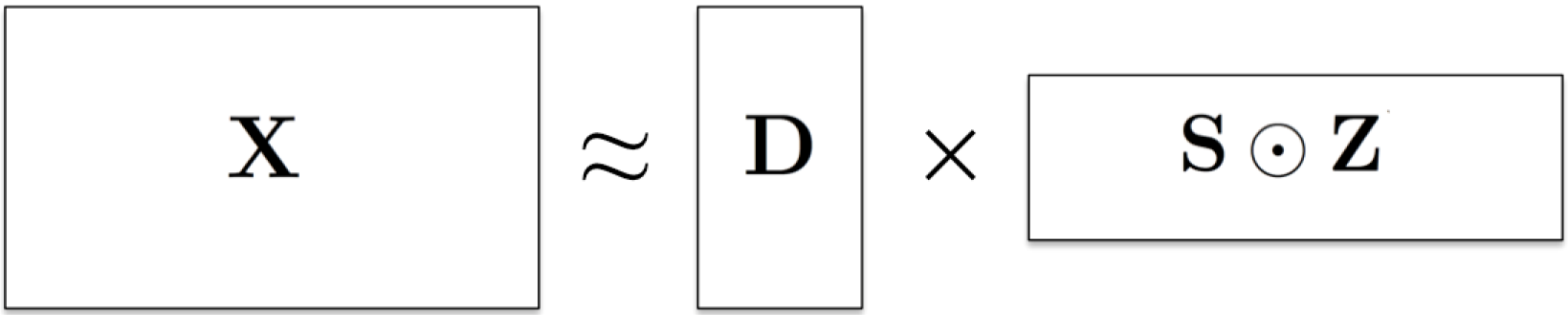
Problem Setting



$$\mathbf{X} = \mathbf{D}(\mathbf{S} \odot \mathbf{Z}) + \mathbf{E}$$

Input Spectrogram: $\mathbf{X} \in \mathbb{R}_+^{F \times T}$

Dictionary (Codebooks): $\mathbf{D} \sim \exp\{\mathcal{N}(0, \mathbf{I})\} \in \mathbb{R}_+^{F \times K}$

Activations: $\mathbf{S} \in \mathbb{R}_+^{K \times T}$ s.t. $S_{k,t} \sim \text{Gamma}(\alpha, \alpha / S_{k,t-1})$

Sparse Binary Masks: $\mathbf{Z} \sim \text{Bernoulli}(\boldsymbol{\pi}) \in \{0, 1\}^{K \times T}$

Beta Process Prior: $K \to \infty$

Variational Inference (Mean Field)

Nonnegtive $\rightarrow$ Nonconjugate $\rightarrow$ No close-form VB

- Solution: Laplace Approximation Variational Inference

$$
\begin{aligned}
q(\theta) &\propto \exp\{\underbrace{\langle \log P(\mathbf{X}, \Theta) \rangle_{-\theta}}_{f(\theta)}\} \\
&\approx \exp\left\{ f(\hat{\theta}) + \frac{1}{2}\big(\theta - \hat{\theta}\big)^T H(\hat{\theta})\big(\theta - \hat{\theta}\big) \right\} \\
&\propto \mathcal{N}\Big(\hat{\theta}, -H(\hat{\theta})^{-1}\Big)
\end{aligned}
$$

Preliminary Result