Pólya Urn Latent Dirichlet Allocation

using sparsity to reduce MCMC complexity in natural language processing

Alexander Terenin
Imperial College London

Joint work with Måns Magnusson,
Leif Jonsson, and David Draper

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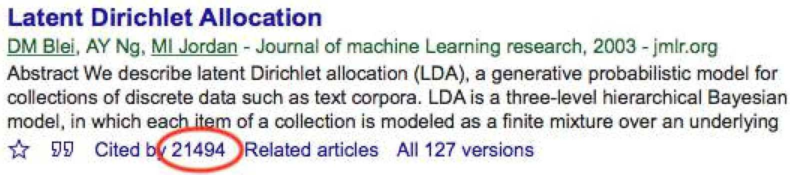
Latent Dirichlet Allocation



Latent Dirichlet Allocation

DM Blei, AY Ng, MI Jordan - Journal of machine Learning research, 2003 - jmlr.org

Abstract We describe latent Dirichlet allocation (LDA), a generative probabilistic model for collections of discrete data such as text corpora. LDA is a three-level hierarchical Bayesian model, in which each item of a collection is modeled as a finite mixture over an underlying

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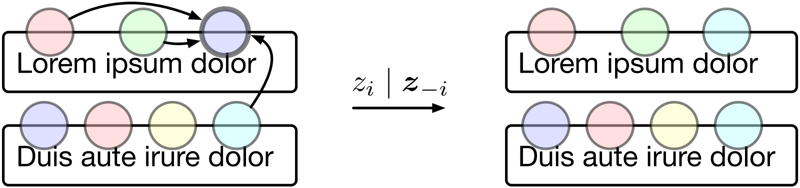
The canonical topic model – everybody uses it!

This work: compute as fast, parallel, and principled as possible

Sparse Fully Collapsed Gibbs Sampling (previous state-of-the-art)



Lorem ipsum dolor

Duis aute irure dolor

$\xrightarrow{z_i \mid \boldsymbol{z}_{-i}}$

Lorem ipsum dolor

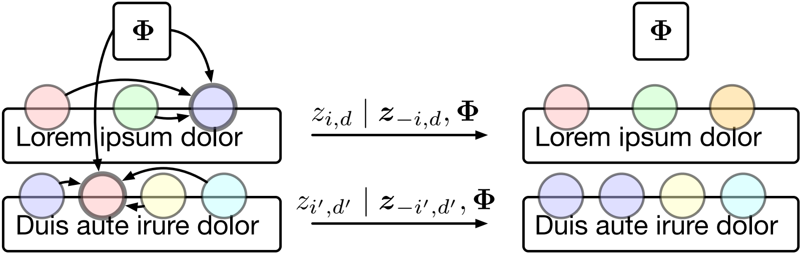
Duis aute irure dolor

✓ Relatively fast

☒ Sequential

☒ Not fully sparse

Sparse Partially Collapsed Gibbs Sampling


$\boldsymbol{\Phi}$
Lorem ipsum dolor
Duis aute irure dolor
$z_{i,d} \mid \boldsymbol{z}_{-i,d}, \boldsymbol{\Phi}$
$z_{i',d'} \mid \boldsymbol{z}_{-i',d'}, \boldsymbol{\Phi}$
$\boldsymbol{\Phi}$
Lorem ipsum dolor
Duis aute irure dolor

✓ Massively parallel

☒ Large dense matrix

☒ Still not fully sparse

Pólya Urn LDA

Dirichlet

$$\boldsymbol{x} = \left[\frac{\gamma_1}{\sum_{i=1}^{k} \gamma_i}, .., \frac{\gamma_k}{\sum_{i=1}^{k} \gamma_i}\right]$$

$$\gamma_i \sim \mathrm{Gamma}(\varpi F_i, 1)$$

Dense

$$\rightarrow$$

Poisson Pólya Urn

$$\boldsymbol{y} = \left[\frac{\tilde{\gamma}_1}{\sum_{i=1}^{k} \tilde{\gamma}_i}, .., \frac{\tilde{\gamma}_k}{\sum_{i=1}^{k} \tilde{\gamma}_i}\right]$$

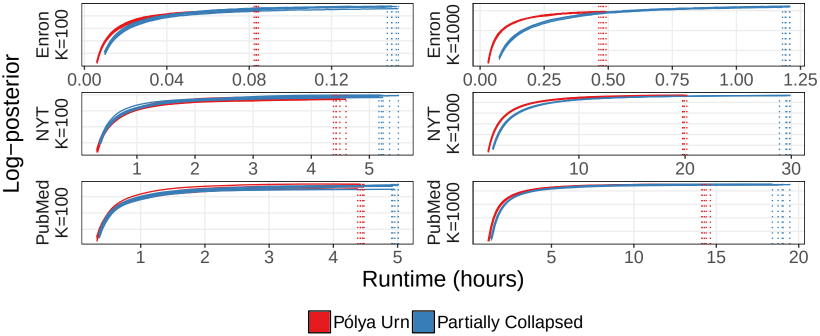
$$\tilde{\gamma}_i \sim \mathrm{Poisson}(\varpi F_i)$$

Sparse

Theorem. Let $\boldsymbol{x} \sim \mathrm{Dir}(\varpi, \boldsymbol{F})$ and $\boldsymbol{y} \sim \mathrm{PPU}(\varpi, \boldsymbol{F})$. Then for all $\boldsymbol{F}$ we have $||\boldsymbol{x} - \boldsymbol{y}|| \to 0$ as $\varpi \to \infty$ in the Levy-Prokhorov metric.

✓ Dense matrix $\boldsymbol{\Phi}$ becomes sparse

Performance



✓ Faster runtime with no discernible loss in topic quality

A. Terenin, M. Magnusson, L. Jonsson, and D. Draper. Pólya urn latent Dirichlet allocation: a doubly sparse massively parallel sampler. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2018. Accepted, to appear. Available at: arXiv:1704.03581.