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# Sparse stochastic inference for latent Dirichlet allocation

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## Abstract

We present a hybrid algorithm for Bayesian topic models that combines the efficiency of sparse Gibbs sampling with the scalability of online stochastic inference. We used our algorithm to analyze a corpus of 1.2 million books (33 billion words) with thousands of topics. Our approach reduces the bias of variational inference and generalizes to many Bayesian hidden-variable models.

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- References must include page numbers whenever possible and be as complete as possible. Place multiple citations in chronological order.

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```
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The footnote, “Preliminary work. Under review by the International Conference on Machine Learning (ICML). Do not distribute.” must be modified to “Appearing in *Proceedings of the 29<sup>th</sup> International Conference on Machine Learning*, Edinburgh, Scotland, UK,

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```
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The text of the paper should be formatted in two columns, with an overall width of 6.75 inches, height of 9.0 inches, and 0.25 inches between the columns. The left margin should be 0.75 inches and the top margin 1.0 inch (2.54 cm). The right and bottom margins will depend on whether you print on US letter or A4 paper, but all final versions must be produced for US letter size.

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The paper abstract should begin in the left column, 0.4 inches below the final address. The heading ‘Ab-

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<sup>1</sup>For the sake of readability, footnotes should be complete sentences.

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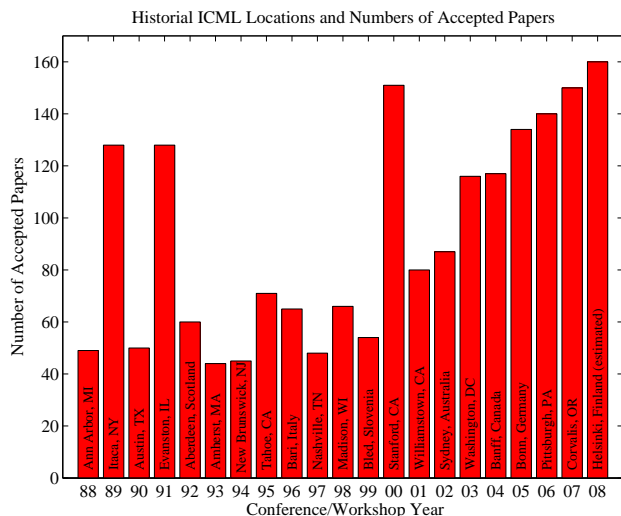


Figure 1. Historical locations and number of accepted papers for International Machine Learning Conferences (ICML 1993 – ICML 2008) and International Workshops on Machine Learning (ML 1988 – ML 1992). At the time this figure was produced, the number of accepted papers for ICML 2008 was unknown and instead estimated.

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## 2.7. Algorithms

If you are using L<sup>A</sup>T<sub>E</sub>X, please use the “algorithm-” and “algorithmic” environments to format pseu-

## Algorithm 1 Bubble Sort

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**Input:** data  $x_i$ , size  $m$

**repeat**

Initialize  $noChange = true$ .

**for**  $i = 1$  **to**  $m - 1$  **do**

**if**  $x_i > x_{i+1}$  **then**

Swap  $x_i$  and  $x_{i+1}$

$noChange = false$

**end if**

**end for**

**until**  $noChange$  is *true*

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Table 1. Classification accuracies for naive Bayes and flexible Bayes on various data sets.

DATA SET	NAIVE	FLEXIBLE	BETTER?
BREAST	95.9± 0.2	96.7± 0.2	✓
CLEVELAND	83.3± 0.6	80.0± 0.6	×
GLASS2	61.9± 1.4	83.8± 0.7	✓
CREDIT	74.8± 0.5	78.3± 0.6	
HORSE	73.3± 0.9	69.7± 1.0	×
META	67.1± 0.6	76.5± 0.5	✓
PIMA	75.1± 0.6	73.9± 0.5	
VEHICLE	44.9± 0.6	61.5± 0.4	✓

docode. These require the corresponding stylefiles, `algorithm.sty` and `algorithmic.sty`, which are supplied with this package. Algorithm 1 shows an example.

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You may also want to include tables that summarize material. Like figures, these should be centered, legible, and numbered consecutively. However, place the title *above* the table with at least 0.1 inches of space before the title and the same after it, as in Table 1. The table title should be set in 9 point type and centered unless it runs two or more lines, in which case it should be flush left.

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included in the style-file package to obtain this format.

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Authors should cite their own work in the third person in the initial version of their paper submitted for blind review. Please refer to Section 2.3 for detailed instructions on how to cite your own papers.

Use an unnumbered first-level section heading for the references, and use a hanging indent style, with the first line of the reference flush against the left margin and subsequent lines indented by 10 points. The references at the end of this document give examples for journal articles (Samuel, 1959), conference publications (Langley, 2000), book chapters (Newell & Rosenbloom, 1981), books (Duda et al., 2000), edited volumes (Michalski et al., 1983), technical reports (Mitchell, 1980), and dissertations (Kearns, 1989).

Alphabetize references by the surnames of the first authors, with single author entries preceding multiple author entries. Order references for the same authors by year of publication, with the earliest first. Make sure that each reference includes all relevant information (e.g., page numbers).

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We strongly encourage the publication of software and data with the camera-ready version of the paper whenever appropriate. This can be done by including a URL in the camera-ready copy. However, do not include URLs that reveal your institution or identity in your submission for review. Instead, provide an anonymous URL or upload the material as "Supplementary Material" into the CMT reviewing system. Note that reviewers are not required to look at this material when writing their review.

## Acknowledgments

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can (and probably should) include acknowledgements. In this case, please place such acknowledgements in an unnumbered section at the end of the paper. Typically, this will include thanks to reviewers who gave useful comments, to colleagues who contributed to the ideas, and to funding agencies and corporate sponsors that provided financial support.

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