Automated Compositional Change Detection in Saxo Grammaticus' *Gesta Danorum*

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Outline

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Saxo's *Gesta Danorum*

Saxo Grammaticus

- A medieval writer (c. 1160 - post 1208) that represent the beginning of the modern day historian in Scandinavia.
- Saxo's history of the Danes *Gesta Danorum* ("Deeds of the Danes") is the single most important written source to Danish history in the 12^{th} century.
- *Gesta Danorum* is tendentious, contains elements of fiction, and its compositions has been an academic subject of debate for more than a century.

Composition debate

- Debate regarding the bipartite composition *Gesta Danorum*
  1. is the transition between the old mythical and new historical parts located in book eight, nine, or ten?
  2. is this transition gradual (continuous) or sudden (point-like)?
- combine NLP and IR with time series analysis in order to propose a solution.

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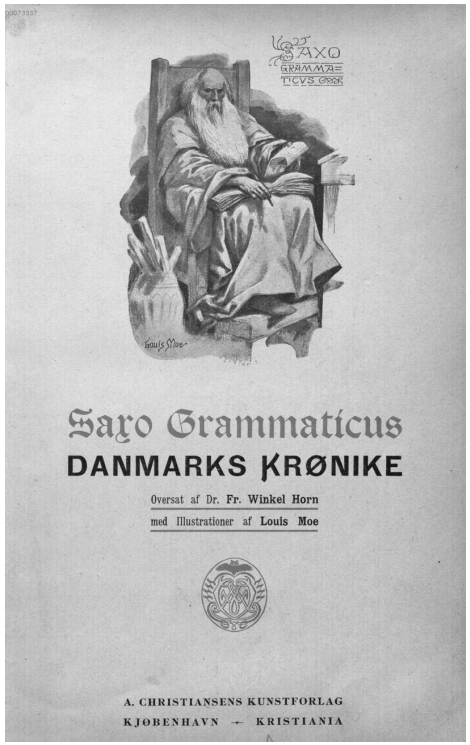
Data

Data set

- all sixteen books of *Saxos Danmarkshistorie* translated from Latin by Peter Zeeberg and published by Det Danske Sprog- og Litteraturselskab and G.E.C.Gads Forlag in 2000.

Normalization

- books were concatenated and sliced in non-overlapping windows at a size of 50 sentences
- unigrams were casefolded and numerals removed
- data-specific frequent words were removed



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Naive baseline model

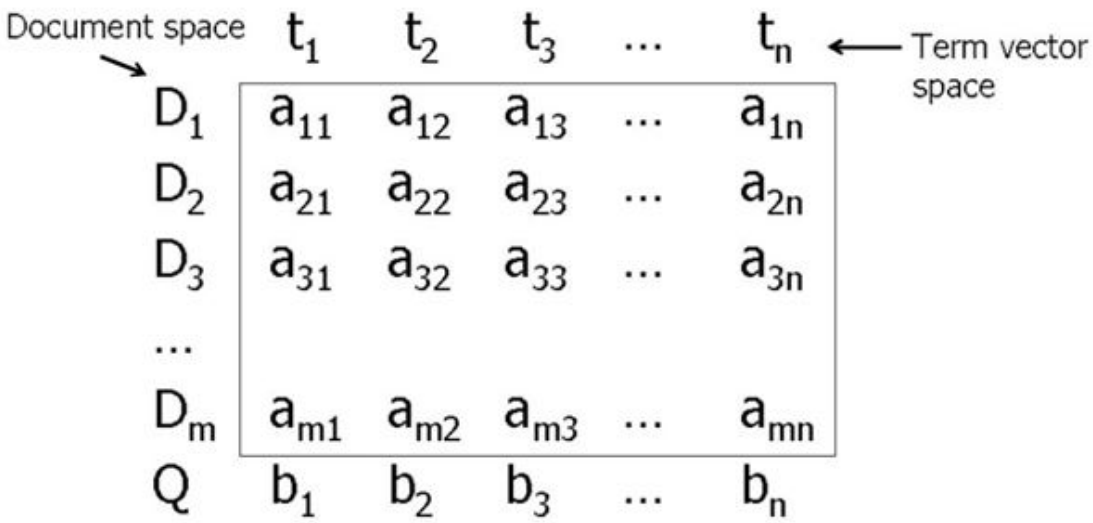

Figure 1: Geometrical document representation, where each document is a high rank word vector over the full vocabulary.

Alternative model

Algorithm 1 Classical LDA

1: **for** *each* $k = 1...T$ **do**
2: *choose* $\phi_k \sim Dir(\beta)$
3: **for** *each* d *choose* $\theta_d \sim Dir(\alpha)$ **do**
4: **for** *each token* $i = 1...N_d$ **do**
5: *select a* $z_i \sim Mult(\theta_d)$
6: *select a* $w_i \sim Mult(\phi_{x_i})$
7: **end for**
8: **end for**
9: **end for**

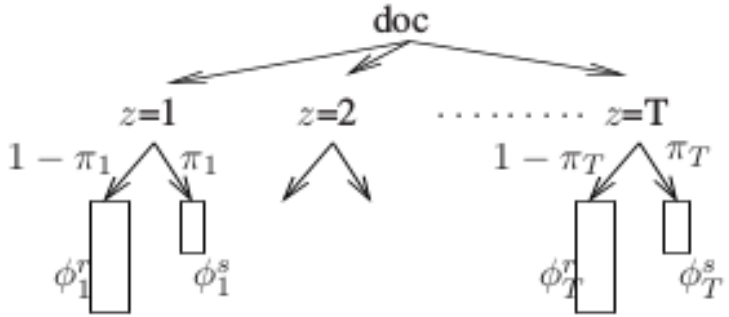

Figure 2: In LDA each document is represented as a low rank dense vector (i.e., a probability distribution over a small set of latent topics). Seeds improve both topic-word distributions and to improve document-topic distributions

Jagarlamudi, J., Iii, H. D., & Udupa, R. (2012). Incorporating Lexical Priors into Topic Models. Proceeding EACL 12, 204–213

Document distance and change detection

1. Distance D between every combination of two document slices s_1 and s_2 is computed for the baseline model using cosine distance D_C:

$$D_C(s_1, s_2) = \frac{s_1 \cdot s_2}{\| s_1 \| \| s_2 \|} \tag{1}$$

and the alternative model using relative entropy D_{KL}:

$$D_{KL}(s_1 \mid s_2) = \sum_{i=1}^{n} s_{i1} \times \log_2 \frac{s_{i1}}{s_{i2}} \tag{2}$$

2. A semantic change signal Δ_D was estimated for each model by averaging over the distances from slice s^j the preceding slices from $s^1 \ldots s^{j-1}$:

$$\Delta_D(s_j) = \frac{1}{N} \sum_{i=1}^{j-1} D(s_j, s_i) \tag{3}$$

3. Two change detection techniques, a mean- and variance-shift technique, were applied to each signal in order to identify statistically reliable change points in their respective mean and variance at an α-level of .01.

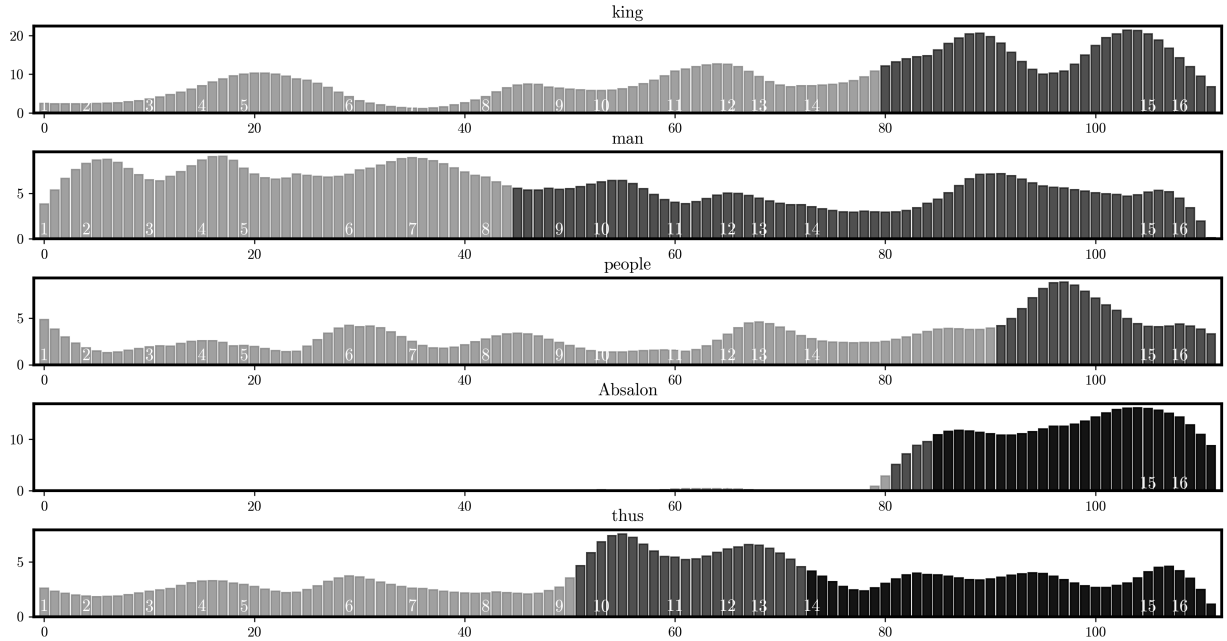

Figure 3: Keyword/entity counts with a mean-shift model. Notice that Archbishop Absalon is introduced in book 14.

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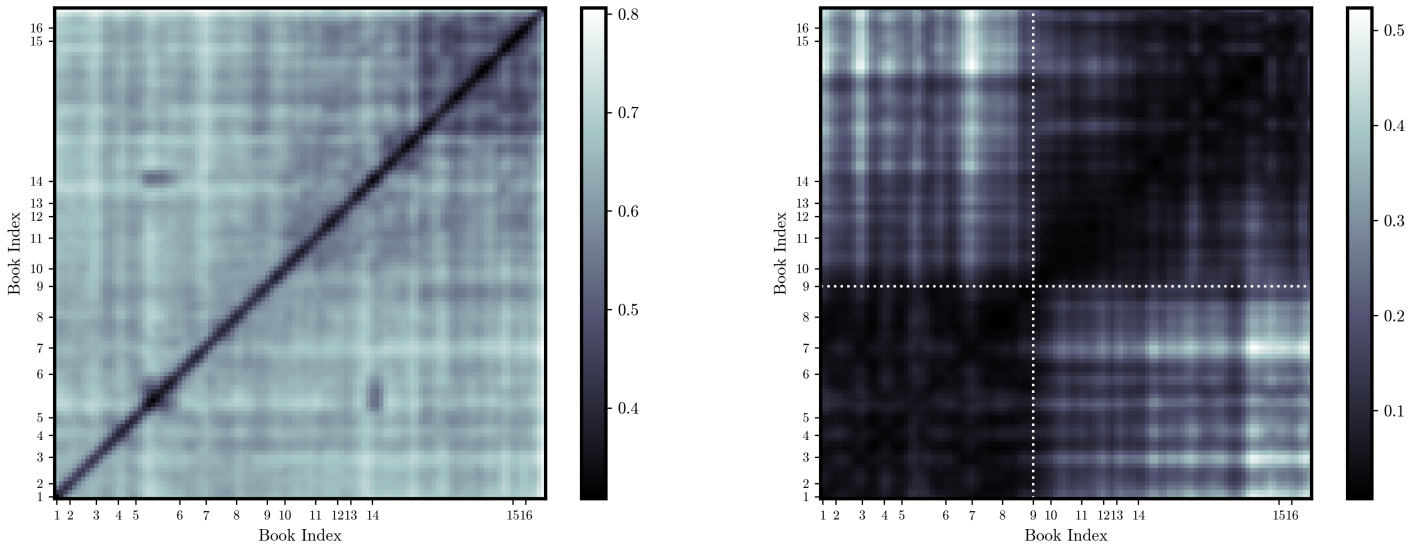

Figure 4: Distance matrices for baseline (left) and alternative (right) models. Left pattern can be explained by the burstiness of language, while the right pattern indicates a bipartite structure. Notice books rectangle from book 14-16 on the left.

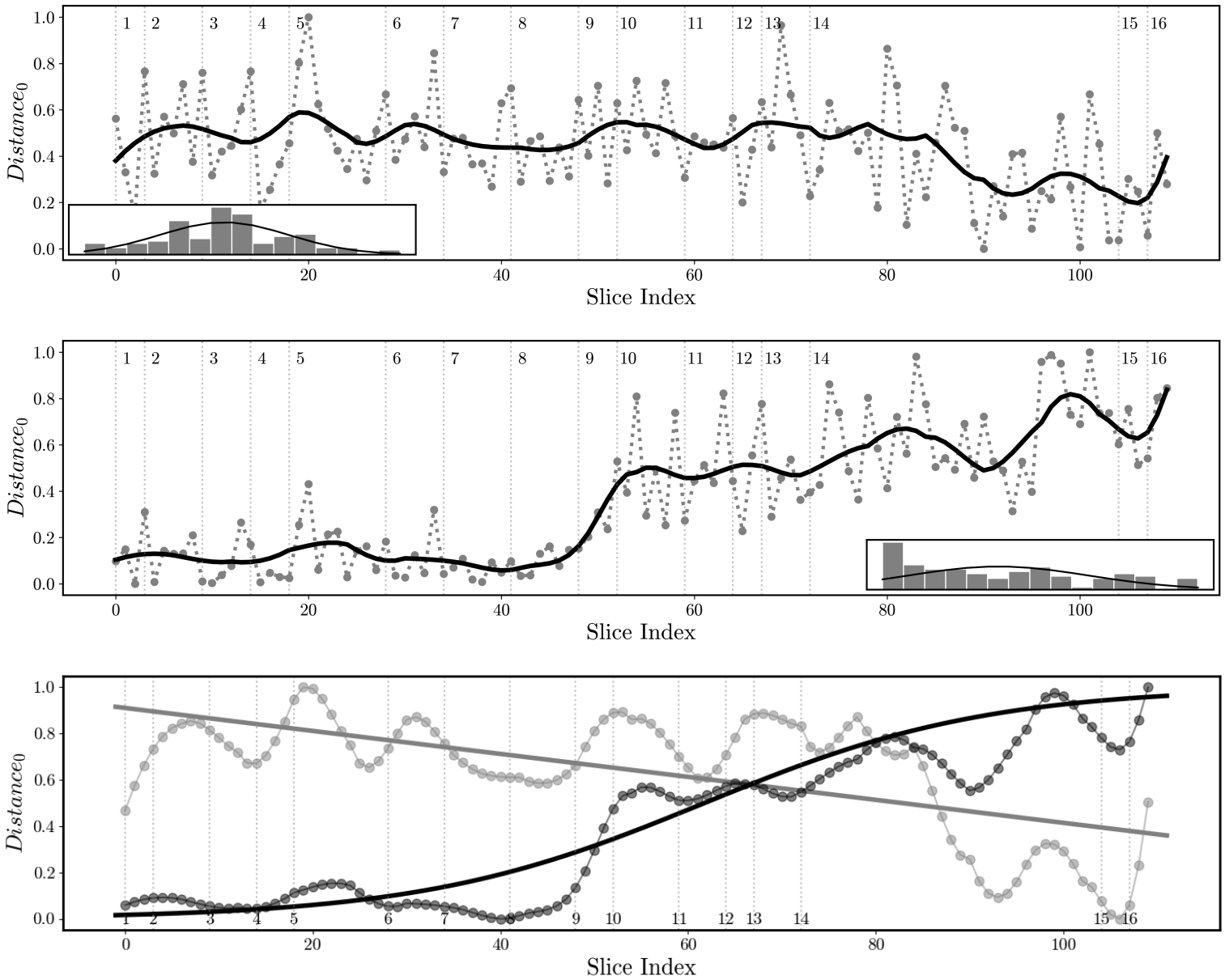

Figure 5: For the baseline model a no-change model explains more variance $R^2 = 0.52$ than the sigmoid model $R^2 = 0.02$. The pattern is reversed for the contrast model, where the sigmoid model explains more variance $R^2 = 0.93$ in comparison with the linear model $R^2 = 0.86$

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Summary

Findings

- Baseline shows no reliable change
- Alternative show gradual change starting in book 8 (latter part) and ends in book 10
- Greatest rate of change in book 9
- Both models indicate change in book 14

Interpretation

- strongest support for the continuous transition claim
- although the book 14 is the second book dealing with Saxo's contemporaries, it introduces Archbishop Absalon
- baseline favors text slices that are strictly similar, while the alternative is sensitive to relational similar slices
- LDA gives us a simple technique for clustering documents on a set of hidden topics, which when combined with time series analysis offers great potential for historical research

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A collaborative approach to research & development

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