Exploring and Visualizing Variation in Language Resources

Peter Fankhauser*, Jörg Knappen†, Elke Teich†

* Institut für Deutsche Sprache (IDS)
R 5, 6-13, 68161 Mannheim, Germany
fankhauser@ids-mannheim.de
† Universität des Saarlandes
Universität Campus A2.2, 66123 Saarbrücken, Germany
j.knappen, e.teich@mx.uni-saarland.de

Abstract
Language resources are often compiled for the purpose of variational analysis, such as studying differences between genres, registers, and disciplines, regional and diachronic variation, influence of gender, cultural context, etc. Often the sheer number of potentially interesting contrastive pairs can get overwhelming due to the combinatorial explosion of possible combinations. In this paper, we present an approach that combines well understood techniques for visualization heatmaps and word clouds with intuitive paradigms for exploration drill down and side by side comparison to facilitate the analysis of language variation in such highly combinatorial situations. Heatmaps assist in analyzing the overall pattern of variation in a corpus, and word clouds allow for inspecting variation at the level of words.

Keywords: Language Variation, Corpus Comparison, Visualization

1. Introduction
Language resources are often compiled for the purpose of variational analysis, such as studying differences between genres, registers, and disciplines, regional and diachronic variation, influence of gender, cultural context, etc. Often the sheer number of potentially interesting contrastive pairs can get overwhelming due to the combinatorial explosion of possible combinations. For example, the LOB/Brown family of corpora (Hinrichs et al., 2010) compiled for synchronous and diachronic analysis of British and American English comprises 2 x 2 x 15 subcorpora – 2 for British vs. American English, 2 for the two time slots 60s and 90s, and 15 registers. This in principle allows for 3600 (asymmetric) contrastive pairs. Even when focusing on only one contrastive aspect – region or time – and taking symmetry into account, this leaves 2 x 152 synchronous pairs among registers, such as A (Press Reportage) vs. K (General Fiction) in British English in the 60s, 2 x 15 diachronic pairs, such as A in the 60s vs. A in the 90s in British English and another 2 x 15 pairs comparing individual registers between British English and American English, which still adds up to 510 potentially interesting pairs of contrast.

In this paper, we present an approach that combines well understood techniques for visualization heatmaps and word clouds with intuitive paradigms for exploration drill down and side by side comparison to facilitate the analysis of language variation in such highly combinatorial situations.

2. Approach
2.1. User Interface
Figure 1 provides an overview of the user interface. At the top, there are three heatmaps. The left heatmap visualizes the overall distance for all 4x4 pairs of British English (60s and 90s) with American English. This heatmap serves for drilling down to particular pairs for closer inspection. The two drill downs 1 (for GB 61 vs. US 61) and 2 (for US 61 vs. GB 61) are displayed in the middle and right heatmaps, which visualize the distances between the individual registers (A – R) for British English in the 60s vs. American English in the 60s, and vice versa. Distance colors range from greenish to reddish; the color keys to the left and to the right provide more detail.

The left heatmap illustrates that the diachronic difference within a regional variety is generally smaller than the synchronous difference between British and American English, with the largest difference between US 91 and GB 61. The two detailed heatmaps clearly show the general divide of informational production (H and J) and to a lesser extent Press: (A – C) vs. involved production (the fiction registers K through P). This general divide holds also for other combinations of region and time, i.e. the overall pattern of the register heatmaps is similar for all 4x4 combinations of region and time.

Each heatmap also weights words for the currently selected pair of subcorpora, visualized by word clouds. The size of a word corresponds to its contribution to the distance, its color corresponds to its relative frequency in the selected (sub)corpus, ranging from blueish to reddish, as the color keys indicate. Both, size and color are scaled logarithmically. Word clouds for the main diagonal show the word weights for the selected subcorpus in comparison to the rest of the corpus (not shown in Figure 1), otherwise they show the word weights for the selected pair of corpora. The word cloud to the left shows words generally typical for British English as opposed to American English in the 60s, the other two word clouds zoom in on this comparison on the specific contrast of H (Miscellaneous) for British English (60s) vs. American English (60s), and vice versa. As can be seen words typical for British English comprise spelling variants (colour, labour, centre, defence, towards),
topical words (britain, british, london), but also indications for grammatical preferences (have, been, should, be). The word clouds for $H$ show similar kinds of differences with a notable focus by topical words on civil matters in British English vs. military matters in American English. The colors panel to the top right in Figure 1 currently allows to choose between two color schemes, $rbow$ for visualizing relative difference by a divergent color map, $ryb$ as an alternative color scheme for red-green blind people. The $p$-value panel to the middle right allows to filter words in the word clouds by different levels of significance, by default 0.05 (95% confidence). Note that “significance” levels 0.25 and 0.5 are highly unusual and practically disregard significance, nevertheless, in some situations they can give interesting insights.

The two drill down word clouds are selected not only on the basis of the selection in the drill down heatmaps, but also on the basis of the selected overall contrastive pair in the left heatmap. This coordinated selection allows for easily exploring a particular register variation between British and American English across time.

For example, Figure 2 gives the typical words for British vs. American English in the 90s – again a mixture of spelling variants, topical words, and grammatical preferences, e.g., the overrepresentation of the, they, which in British English compared to American English. Conversely, the corresponding diachronic contrast between the 60s and the 90s within British English in Figure 3 is mainly about topical words, including years around the 60s and the 90s respectively.

Finally, every selection setup gets a unique URL by means of a so called fragment identifier for further reference.

2.2. Corpus Representation and Distance Measure

The individual corpora are represented by means of unigram language models smoothed with Jelinek-Mercer smoothing:

$$p(w) = (1 - \lambda)\hat{p}(w) + \lambda\hat{c}(w)$$

where $\hat{p}(w)$ is the observed probability of the word of the subcorpus (its relative frequency as the maximum likelihood estimate), $\hat{c}(w)$ is the observed probability of the word in the entire corpus, and $\lambda = 0.05$. For a discussion of more smoothing methods for unigram language models see, for example, (Zhai and Lafferty, 2004).

On this basis, the distance between corpora $(P$ and $Q)$ is measured by relative entropy $D$, also known as Kullback-Leibler Divergence:
3. Related Work

While we are not aware of any visualization of language variation targeting specifically the explorative analysis of variation among many possible pairs of contrast, there do exist a number of approaches with similar goals. Here we can only give an exemplary selection; for a comprehensive overview see, for example, TAPOr 2.0 (Text Analysis Portal for Research). The MONK workbench (Unsworth and Mueller, 2009) allows to compare pairs of corpora using Dunning’s log-likelihood ratio (Dunning, 1993) for word weighting. Apart from the different distance measure (relative entropy as opposed to log-likelihood ratio), the main difference of our approach is that we combine the macro perspective of overall distance with the micro perspective of individual word weights to allow for an explorative analysis of variation. The Voyant Tools (Sinclair et al., 2012) provide a plethora of explorative visualizations for text, including word clouds, co-occurrences, and word trends based on frequencies. The focus of these tools, however, lies on summarizing and visualizing one text or corpus, rather than on exploring variation among corpora.

At a very general level, the presented system has taken inspiration from Hans Rosling’s forward thinking Gapminder project, which showcases explorative visualization of multivariate data in the field of economics. In the longer term, a Gapminder perspective on variation in language resources is certainly worthwhile to explore.

4. Summary and Future Work

In this paper we have introduced an approach for exploring and visualizing variation in language resources which in particular takes into account the combinatorial explosion of contextual dimensions. By combining heatmaps and word clouds it follows the four mantras of scientific data visualization (Shneiderman, 1996; Keim et al., 2006): (i) analyze the data first (ii) show the most important features (iii) zoom, filter, and analyze further (iv) show details on request.

In (Fankhauser et al., 2014) we describe the integration of word clouds with the IMS Open Corpus Workbench (Evert and Hardie, 2011; Hardie, 2012), which generates queries to the REST-API of CQP Web. This allows to easily inspect particular words in their context, and deploy CQP Web’s visualization tools for further analysis.

Future work will be devoted to technical as well as methodological issues: Apart from the integration with a concordance search engine such as CQP Web, we also want to support family of corpora (each of the 4 corpora has about 1 million tokens) on a moderately equipped laptop. We plan to make both, the pipeline for computing distance matrices and word weights, and the user interface in javascript available as open source.
importing external corpora and exporting distance matrices and word weights for analysis with other tools. Moreover, we want to experiment with other visualization mechanisms for the distance matrices, such as dendrograms and scatter plots.

On the methodological side the main challenge lies in supporting a broader variety of feature sets beyond simple unigram language models. This includes latent language models such as topic models (Blei et al., 2003) and hidden markov models (Goldwater and Griffiths, 2007), but also enriched representations such as part-of-speech tagging, and other extensions of unigram models. Such richer feature sets allow to focus the analysis by means of feature selection, but also bear new challenges in measuring and visualizing the contribution of features to a contrast at hand.

5. References

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