

Natural Language Processing for Safer Radiotherapy

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Background

- Reporting and investigating unintended incidents and accidents, as shown in Figure 1, can help prevent them from recurring.
- Reporting an incident involves describing it in free-form text, which is difficult to analyze in large amounts.

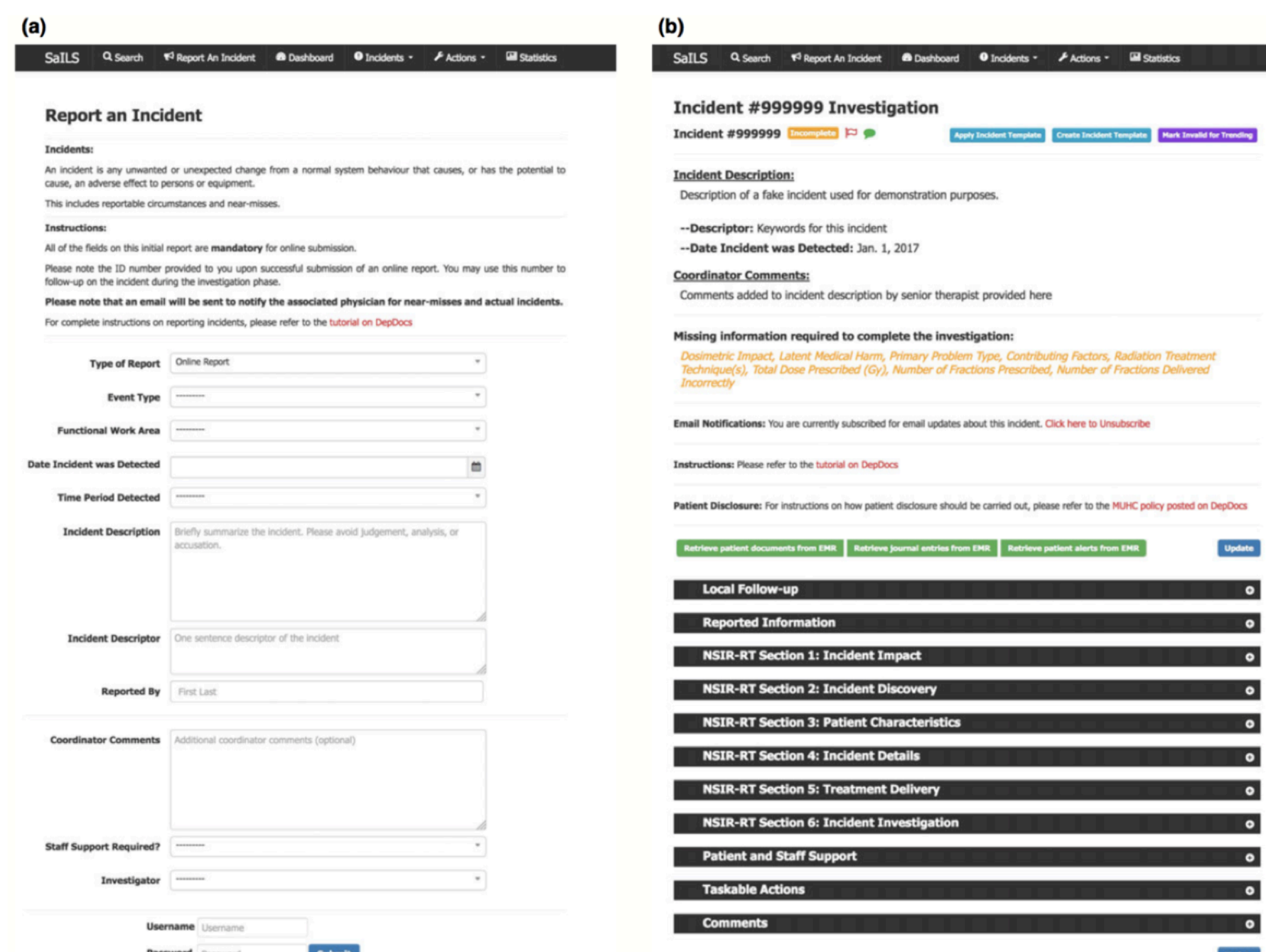


Figure 1: Reporting and investigation interface of the Safety and Incident Learning System¹ as implemented at the McGill University Health Centre in Montreal

Objectives

- Help label incidents by their process step, problem type, contributing factors, and overall severity using supervised learning.
 - Determine the probability of each label being correct.
 - Order the labels by probability in a dropdown menu.
- Discover new problem types and contributing factors using unsupervised learning.
 - Group together similar incident descriptions labelled as "other."
 - Interpret the groups as possibly new problem types and contributing factors.

Methods

- Natural Language Preprocessing
 - Preprocessed the incident descriptions through machine translation, abbreviation expansion, auto-correction, and linguistic normalization.
 - Generated descriptive statistics that helped to specify the parameters of the word embedding models used in subsequent steps.
- Supervised Learning
 - Assembled over 200 multi-output ensemble regressors by bagging, boosting, and stacking over 60 regressors from Sklearn², XGBoost³, and Keras⁴.
 - Tuned the ensemble regressors using grid-search, and cross-validated them by how close to the top they placed the correct labels in the dropdown menu.
- Unsupervised Learning
 - Tuned a latent Dirichlet allocation model using ldatuning⁵'s multi-metric⁶⁻⁹ grid-search over the number of groups to best fit the incident descriptions labelled as "other," as shown in Figure 2.
 - Interpreted the groups of similar incident descriptions as possibly new problem types and contributing factors in an interactive visualization by LDavis¹⁰.

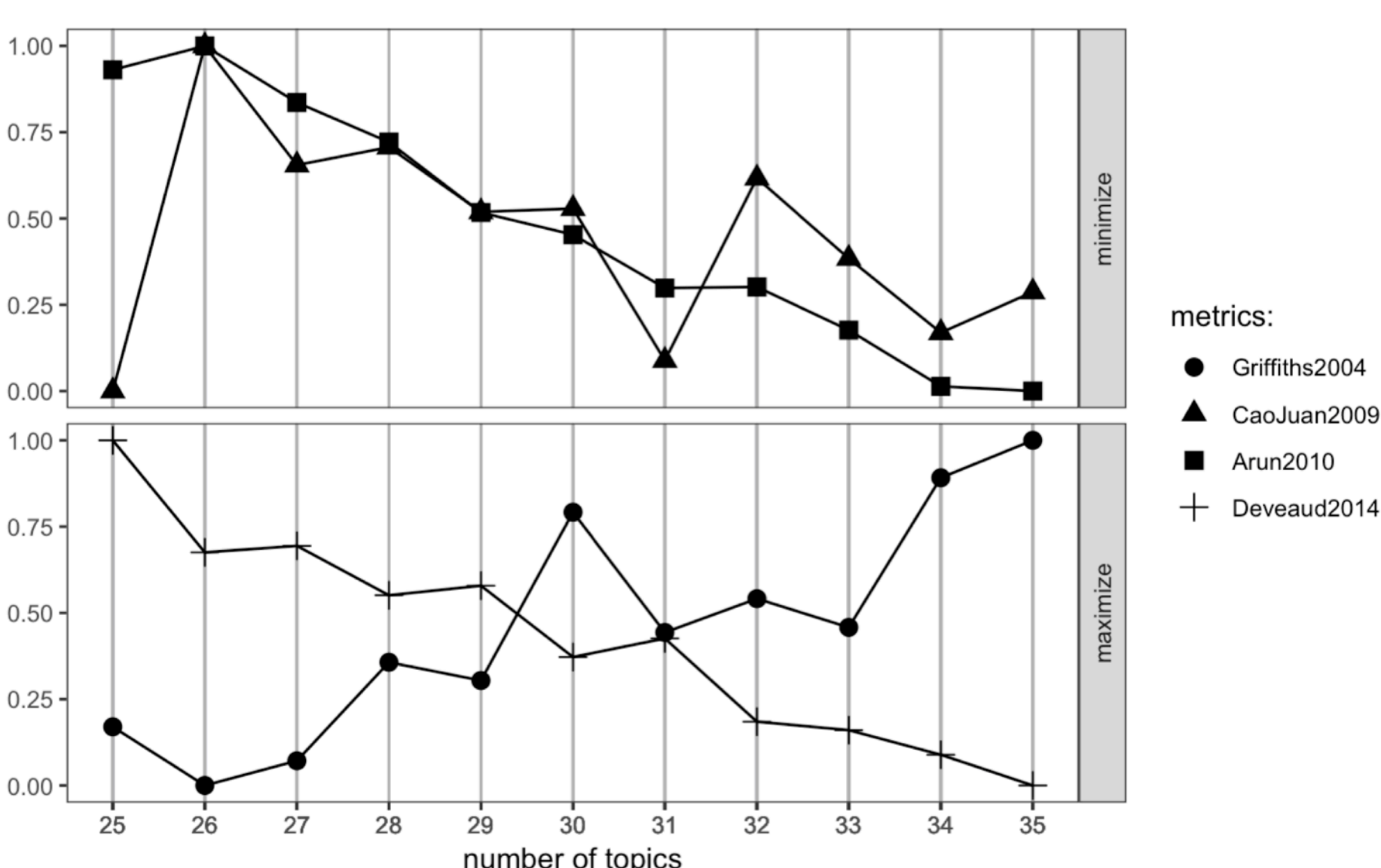


Figure 2: Multi-metric grid-search reveals 30 possibly new problem types or contributing factors in the incident descriptions labelled as "other."

Results

- Natural Language Preprocessing
 - The average incident description is 3.01 ± 3.05 sentences long.
 - 20 incident descriptions are in French.
 - 34.82%, 40.32%, and 7.18% of the incidents have N/A or "other" for process step, problem type, and contributing factors, respectively.
- Supervised Learning
 - The best ensemble regressor was assembled by bagging and stacking a ridge regressor, a support vector regressor, a passive aggressive regressor, a random forest regressor, a gradient boosting regressor, and a long short-term memory recurrent neural network.
 - The best ensemble regressor placed the correct labels on average 1.6th, 2.4th, 5.3rd, and 1.1th among the 9 process step, 24 problem type, 21 contributing factors, and 4 overall severity labels, respectively.
- Unsupervised Learning
 - 30 groups best fitted the incident descriptions labelled as "other."
 - The interactive visualization of the groups showed which incidents recurred the most, and how they are related to other incidents, as shown in Figures 3-4.

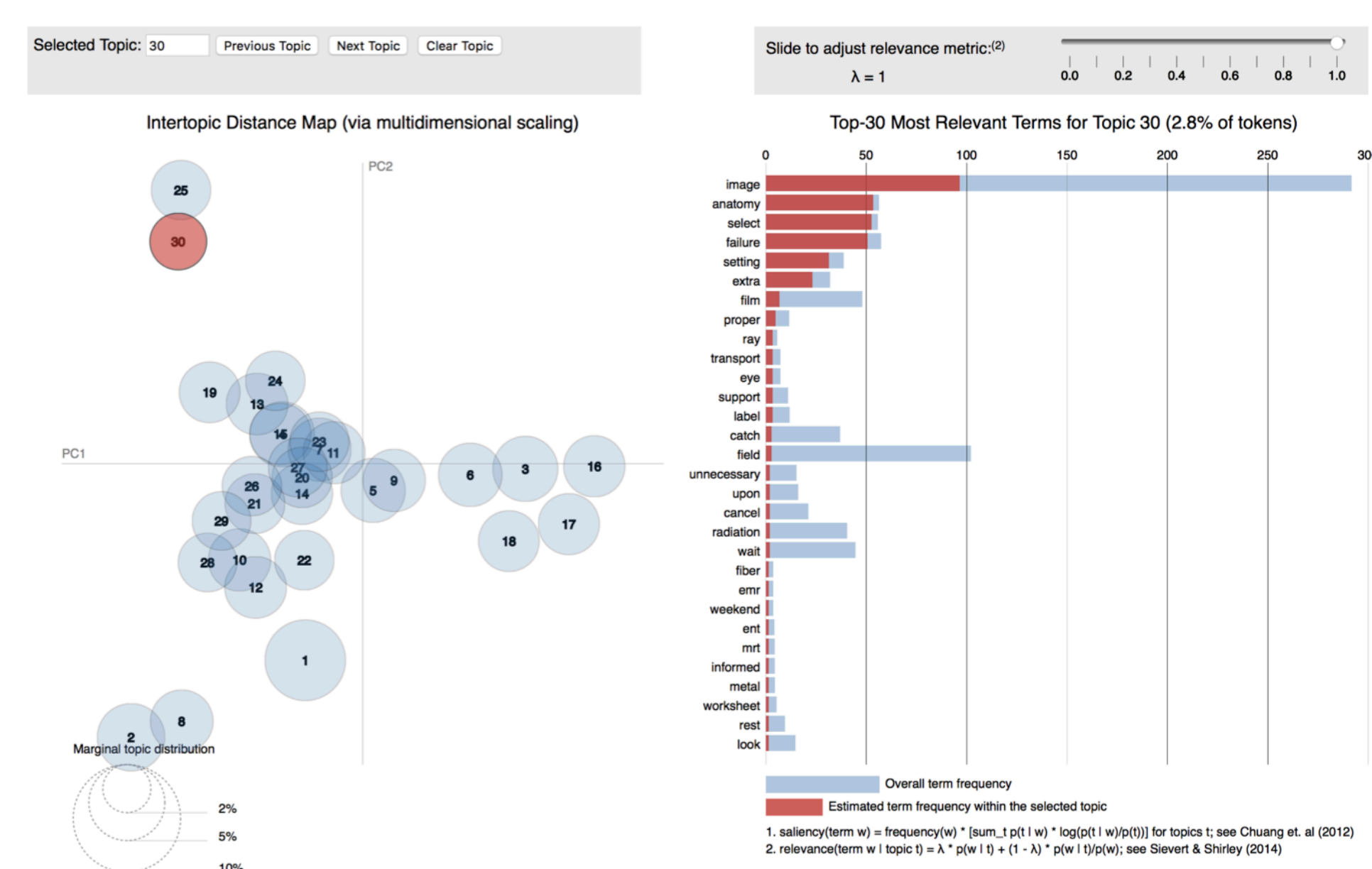


Figure 3: Group 30 reveals that extra images were taken due to failure to select anatomy settings.

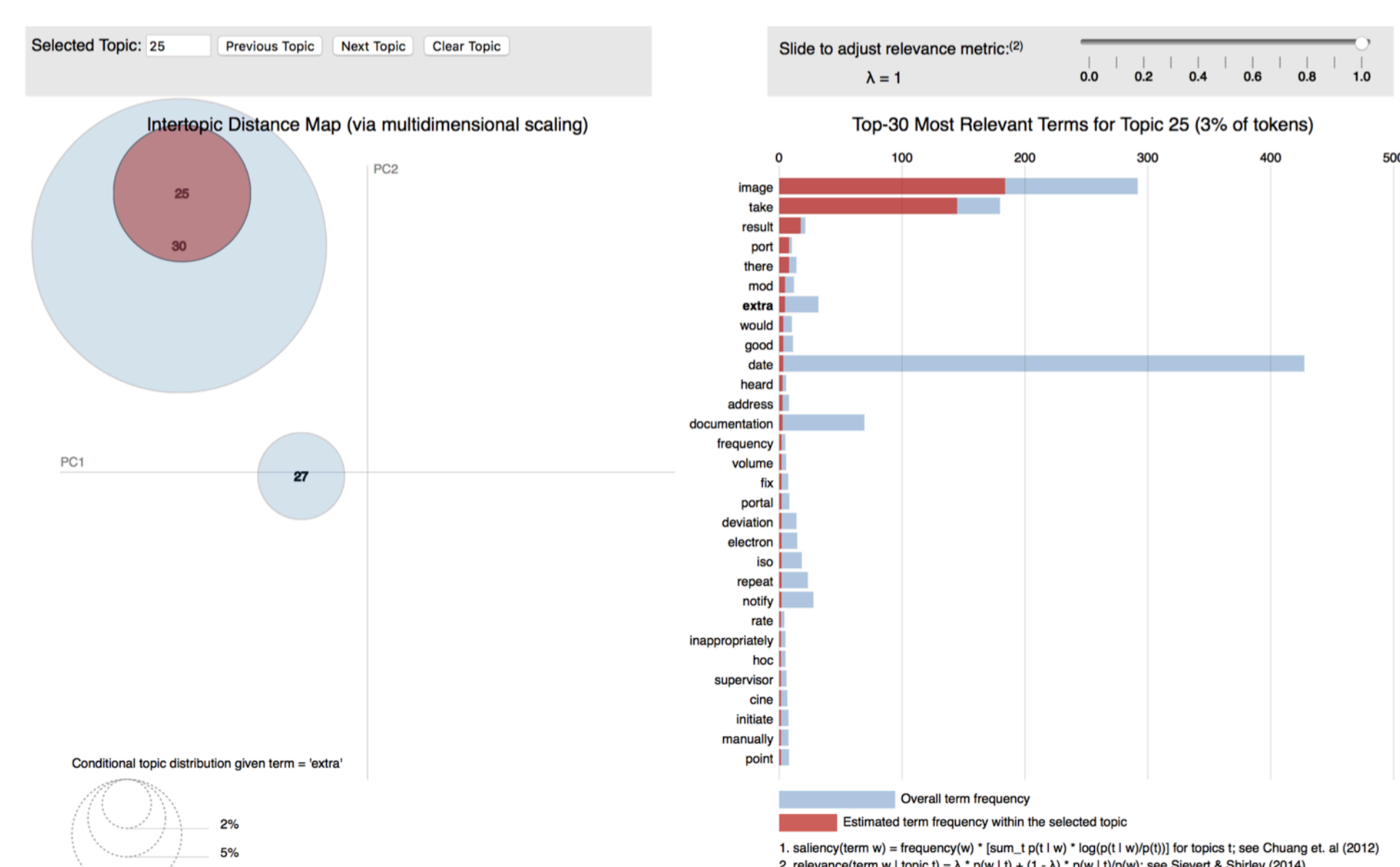


Figure 4: Group 30 shares the word "extra" with group 25, which reveals that extra port images were also taken.

Conclusion

- Natural language processing can help label incidents and discover new problem types and contributing factors.
- More generally, it enables the comprehension of large numbers of incidents without investigating each.

References

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