BioCaster: detecting public health rumors with a Web-based text mining system

Nigel Collier1,2,*, Son Doan1, Ai Kawazoe1, Reiko Matsuda Goodwin1,3, Mike Conway1, Yoshio Tateno4, Quoc-Hung Ngo5, Dinh Dien5, Asanee Kawtrakul6, Koichi Takeuchi7, Mika Shigematsu8 and Kiyosu Taniguchi8

1National Institute of Informatics, ROIS, 2PRESTO, Japan Science and Technology Corporation, Tokyo 101-8430, Japan, 3Department of Anthropology, Lehman College, CUNY, NY 10468-1589, USA, 4National Institute of Genetics, ROIS, Mishima 411-8540, Japan, 5University of Science, Vietnam National University at HCMC, Vietnam, 6NECTEC and the Department of Computer Engineering, Kasetsart University, Bangkok, Thailand, 7Okayama University, Okayama 700-8530 and 8National Institute of Infectious Diseases, Tokyo 162-8640, Japan

Received on June 11, 2008; revised on October 7, 2008; accepted on October 9, 2008

Advance Access publication October 15, 2008

Associate Editor: Jonathan Wren

ABSTRACT

Summary: BioCaster is an ontology-based text mining system for detecting and tracking the distribution of infectious disease outbreaks from linguistic signals on the Web. The system continuously analyzes documents reported from over 1700 RSS feeds, classifies them for topical relevance and plots them onto a Google map using geocoded information. The background knowledge for bridging the gap between Layman’s terms and formal-coding systems is contained in the freely available BioCaster ontology which includes information in eight languages focused on the epidemiological role of pathogens as well as geographical locations with their latitudes/longitudes. The system consists of four main stages: topic classification, named entity recognition (NER), disease/location detection and event recognition. Higher order event analysis is used to detect more precisely specified warning signals that can then be notified to registered users via email alerts. Evaluation of the system for topic recognition and entity identification is conducted on a gold standard corpus of annotated news articles.

Availability: The BioCaster map and ontology are freely available via a web portal at http://www.biocaster.org.

Contact: collier@nii.ac.jp

1 INTRODUCTION

Informal data on the distribution of disease outbreaks is published in many forms and languages on the World Wide Web, but manual surveillance methods are costly and time consuming. Identifying positive linguistic signals and correctly interpreting the geo-temporal dynamics of pathogen spread remain key challenges for text mining. The difficulty of the task is characterized by (i) the massive volume of data, (ii) the need to interpret information as early as possible in the outbreak cycle when reliable facts tend to be scarce, (iii) the need to understand texts in many languages and (iv) the ambiguity inherent in natural language text.

To meet these challenges, several publicly supported Web-surveillance projects have been established that involve a greater or lesser degree of automated monitoring of public health threats including MedISys (http://medusa.jrc.it) (EU), GPHIN (Canada) and Argus (http://biodefense.georgetown.edu/projects/argus.aspx) (USA). Additionally, ProMed-mail (http://www.promedmail.org) is a widely acknowledged manually curated system that provides reports by public health experts. Other systems which are close to the one we present are EpiSpider (http://www.epispider.org) and HealthMap (http://www.healthmap.org) both of which collect news from the Internet about human and animal health and plot the data on a Google Maps mashup.

BioCaster is a non-governmental public health surveillance system characterized by its open ontology-centered approach and a priority for Asia-Pacific languages and health hazards. Specific advantages of BioCaster are that it brings together within a single system (i) text mining techniques, such as entity recognition which aim to generalize to previously unseen terms and expressions, (ii) text-level recognition of severity indicators, such as international travel or the contamination of blood products, (iii) ontology-based inferencing to fill in the gaps, e.g. between a mentioned pathogen and the unmentioned disease that caused it or between symptoms and diseases and (iv) direct knowledge of term equivalence within and across languages.

2 METHODS

Figure 1 shows a high-level view of the information flow through the system which is built on a Linux-based NPACI Rocks cluster for high-throughput semantic analysis.

Currently BioCaster ingests documents through RSS feeds. Each hour a purpose built news aggregator script written in Perl identifies novel links from over 1700 feeds. Sourced documents are then cleansed and put into the cluster queue. Automatic classification of the reports for topical relevance using a naïve Bayes algorithm then acts as the gate-keeper for further levels of processing. For relevant documents named entity recognition is then performed for 18 term types based on the BioCaster ontology (BCO) (Collier et al., 2007).
The development of the named entity recognition schema and module was reported in Kawazoe et al. (2006) based on formal concept analysis. We used an annotated corpus of 200 news articles as training data and the NER system using a support vector machine (SVM) achieved an F-score of 76.97% for all NE classes.

Evaluation of topic classification was presented in Conway et al. (2008). The experiments used the BioCaster gold standard corpus which includes 1000 annotated news stories as training data. The classification model we found to achieve highest accuracy is based on naïve Bayes using raw text, n-grams, semantic tag-based features and χ-squared feature selection. The system achieved an accuracy score of 94.8% (F-score 0.93, Recall 0.97, Precision 0.89), outperforming an SVM with accuracy of 92.1% (F-score 0.89, Recall 0.90, Precision 0.88) due to its superior recall—a key requirement for a surveillance system.

Evaluation of the ontology was done informally using corpus coverage of terms. During a 32-week period we observed the percentage of English terms mentioned in 29,443 positive reports with coverage estimated at 78% of diseases, 69% of pathogens and 76% of symptom terms found at least once.

Future quantitative evaluation will focus on the effectiveness of domain-specific signals against human standards, such as ProMed and WHO reports.

4 CONCLUSIONS
BioCaster, in operation since 2006, is an ontology-enabled text mining system developed to enhance early detection of infectious disease outbreaks by experts. Additionally, it offers an intuitive mapping interface for the general reader as well as an openly available ontology for community reuse. Future work will focus on extending coverage to new languages and public health threats.

ACKNOWLEDGEMENTS
We would like to thank John McCrae at NII for his work on implementing and extending SRL in Java.

Funding: Japan Science and Technology Agency (JST); the Japan Society for the Promotion of Science (18049071); Research Organization of Information Systems (ROIS).

Conflict of Interest: none declared.

REFERENCES
Collier, N. et al. (2007) A multilingual ontology for infectious disease outbreak surveillance: rationale, design and challenges. J. Lang. Resour. Eval. DOI: 10.1007/s10579-007-9019-7.
Conway, M. et al. (2008) Classifying disease outbreak reports using n-grams and semantic features. Proceedings of the 3rd International Symposium on Semantic Mining in Biomedicine (SMMB 2008) (in press).
Feldman, R. et al. (2001) A domain independent environment for creating information extraction modules. In Proceedings of the International Conference on Information and Knowledge Management (CIKM-01), pp. 586–588.
Kawazoe, A. et al. (2006) The development of a schema for the annotation of terms in the BioCaster disease detection/tracking system. In Proceedings of the International Workshop on Biomedical Ontology in Action (KR-MED 2006), pp. 77–85.