A Framework for Evaluating Temporal Alerting Algorithms Used in Syndromic Surveillance Systems

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OBJECTIVE

This abstract describes a suite of software utilities that have been developed for systematically evaluating the detection performance and robustness of univariate temporal alerting algorithms used in syndromic surveillance systems.

BACKGROUND

Alerting algorithms used in syndromic surveillance systems are typically evaluated by quantifying their detection performance using metrics such as specificity, sensitivity, and timeliness [1–3]. However, another important aspect of algorithm performance that has received less attention is robustness with respect to temporal patterns and pathological defects in the data streams being processed.

METHODS

In order to facilitate the evaluation of alerting algorithms in terms of both detection performance and robustness, the ESSENCE Univariate Alerting Algorithm Test Framework (EUA2TF) has been developed. EUA2TF is a suite of MATLAB utilities that comprises the following principal components: (1) a data simulation module that is used to generate data libraries containing various time series of daily count data, (2) a testing module that causes the time series from one or more data libraries to be processed by the alerting algorithms being tested, (3) an analysis module that causes the alerting algorithm outputs to be evaluated in terms of detection performance and robustness, and (4) a reporting module that enables the key performance metrics for multiple alerting algorithms to be compared.

Using this framework, a number of different data libraries have been simulated, representing various average count rates and variance-to-mean ratios. The time series contained in these libraries include a wide variety of outbreaks (upsurges of varying magnitude and duration), temporal patterns (seasonal, day-of-week, and holiday fluctuations), and pathological defects (startups, outliers, dropouts, and steps). For each of these test cases, algorithm performance is characterized by processing the associated time series and then calculating several representative metrics based on the algorithm outputs. Robustness metrics include the time required in order to achieve steady-state behavior following a transient event, as well as the sensitivity and specificity observed during such a transitional period. The key performance metrics for one or more alerting algorithms are then displayed in reports that enable algorithm performance to be quickly assessed.

Additionally, the architecture of EUA2TF is sufficiently flexible to allow new data libraries, analysis methods, performance metrics, and reporting formats to be added in the future, as needed.

RESULTS

In order to demonstrate its capabilities, EUA2TF is used to compare the performance of the principal alerting algorithm used in ESSENCE to the performance of the EARS C1, C2, and C3 algorithms. In general, all four alerting algorithms perform competitively in terms of specificity and timeliness of detection. However, the ESSENCE algorithm is generally more sensitive to upsurges and is more robust with respect to outlying data points, data startups and dropouts, and day-of-week and holiday fluctuations in the data.

CONCLUSIONS

EUA2TF facilitates the systematic evaluation of candidate alerting algorithms under a wide range of controlled operating conditions. It enables the development of alerting algorithms that are more effective, efficient, and robust by helping to identify their strengths and weaknesses prior to implementation.

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