Comparison of Aberration Detection Algorithms for Syndromic Surveillance

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Objective

This paper describes a study of various aberration detection algorithms currently used in syndromic surveillance and one based on artificial neural networks developed at Guelph. The goal of the research is not to select one "*winning*" algorithm but to instead understand the characteristics of the algorithms so that a systems designer can successfully use all of these algorithms in an outbreak detection system.

Background

There are a number of aberration detection algorithms being used to analyze emergency department (ED) time series data. When a system for detecting outbreaks is designed, one of the major tasks is the choice of detection algorithm. But on what basis is an algorithm to be selected and is it possible that there is no clear "*winning*" algorithm? Could the proper approach be to employ multiple algorithms and use some form of decision system to combine their outputs based on their detection characteristics?

Methods

The CDC Early Aberration Reporting System (**EARS**) uses several variations of the Cumulative Sum (**CuSum**) algorithm to detect abnormalities in time series data based on recently encountered data[1].

Similar to the functionality of the CuSum algorithms used in EARS, a simple moving average (**MA**) can be used to detect changes in time-series data. By applying the moving average algorithm to a set of training data, various thresholds can be tested that yield the smallest number of errors. This threshold can then be used on a previously unseen testing data set and the number of errors recorded.

The SAS statistical software package provides built-in CuSum functionality[2]. It is important to note that this version of CuSum is best suited to weighted data and would likely prove more valuable in a situation where various events are given different weightings.

The neural network used in this testing is a back-propagation trained feed-forward perceptron network. For information about the artificial neural network technique please refer to [3].

The outputs of these algorithms were compared to each other using two different types of test data: 1) simulated data with identified outbreaks and 2) a real-world data set obtained from hospitals in the Kingston, Ontario, Canada area [4]. The time to detection, number of outbreak "*alarms*" and false positives and negatives were compared. Since we do not have a test set that can stand as a "*gold standard*", as far as real outbreak data are concerned, we will look for agreement between the algorithms to represent a high probability that a significant event was flagged.

Results

The first set of artificial data reveals that the CuSum algorithms are fast to detect but generate an extreme number of false positives **(FP)**. The following table shows the average results for 3 repetition tests on 100 years of data [**Out** = number of outbreaks].

	Out	FPs	FNs	Time to Detect
EARS C1	365	256.3	21.0	3.49
EARS C2	365	207.7	0.7	3.43
EARS C3	365	462.0	0.0	3.27
SAS	365	1879.6	225.4	3.39
MA	365	148.0	100.4	5.90
ANN	365	69.0	43.2	3.43

The real-data study also revealed that the CuSums (C1, C2, C3) in EARS are good at fast detection (between 1 and 3 days faster) but they have an extremely high FP rate. The neural network, moving average and the SAS CuSum tended to agree with each other most of the time in this test, resulting in very similar time to detection and FP rates.

Conclusions

As one would suspect, there was no single, clear winner amongst the algorithms but this study does expose the methodology to be used to determine the, characteristics of these algorithms. This knowledge can be used to inform the design of syndromic surveillance systems.

References

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