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Simulation-based Testbed for Bio-Surveillance Systems

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Objective

To develop a software toolset to serve as a flexible test environment for bio-surveillance systems by injecting controlled, simulation-based, data modifications into a variety of traditional and non-traditional bio-surveillance sources.

Introduction

The U.S. Defense Threat Reduction Agency (DTRA) is funding multiple development efforts directed at enhanced platforms to support bio-surveillance analysts under their Bio-surveillance Ecosystem (BSVE) program. These efforts include well-integrated user interface systems and advanced algorithmic concepts to facilitate analysis of diverse, pertinent data sources including traditional bio-surveillance data sources as well as social media inputs. A central challenge in this development effort is a practical, effective, method to test these prototype systems. This presentation discusses a simulation-based testbed to allow quantitative evaluation of analytical methods through controlled injection of simulated outbreak-related information into test data streams.

Methods

In the testbed, a Markov-model type simulation (SEIRS Model) is used, initially, as the primary tool to simulate the outbreak of a disease. The software is designed to permit straightforward extensions to more sophisticated outbreak models. Based on the simulated outbreak progression, conditional probability models are used to simulate various reporting activities that may result. These reports may include internet data sources, such as social media interactions from affected individuals, and more traditional syndromic and notifiable disease reporting. The data streams used by the prototype systems are proxied and the data are adjusted to reflect the simulated outbreak using custom software.

Results

The simulation-based bio-surveillance testbed provides a versatile tool to test prototype systems by allowing the test and evaluation team full control over the nature of the simulated outbreak with full understanding of the associated "ground truth" for the injected data. By varying the characteristics of the outbreak and the relative likelihoods of reporting in various data streams, it is possible to explore the effectiveness of prototype systems at detecting and characterizing disease outbreak events.

Conclusions

The simulation-based testbed systematically tests the performance of bio-surveillance systems to assess performance with respect to detection sensitivity (i.e., ability to detect small outbreaks) and ability to characterize the extent and nature of the outbreak. It facilitates comparisons among alternate systems on an equitable and well-controlled basis. In addition to its utility in a developmental context, the testbed may also be valuable during acquisition decisions. The simulations and models are written so that the infrastructure can easily be extended to new data sources. In such situations, an acquiring agency might apply the testbed to compare the performance of competing systems and contrast performance over a range of situations of interest.

Although developed primarily to test bio-surveillance system prototypes, the testbed is likely adaptable to other applications that focus on the analysis of multiple data streams.

Keywords

biosurveillance; testbed; simulation

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