A Temporal Method for Outbreak Detection Using a Bayesian Network

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Objective

A temporal method for outbreak detection using a Bayesian network is presented and evaluated.

Background

Non-temporal Bayesian network outbreak detection methods only look at data from the most recent day. For example, PANDA-CDCA (PC) [1] only looks at data from the last 24 hours to determine how likely an outbreak is occurring. PC is a Bayesian network disease outbreak detection system that models 12 diseases. A system that looks only at each day's data might signal an outbreak one day and not signal it the next. Cooper et al. [1] obtained such results when evaluating the ability of PC to detect a laboratory validated outbreak of influenza. We hypothesized that temporal modeling would attenuate this problem.

Methods

We developed a temporal method for outbreak detection using a Bayesian network. This method assumes the severity of the outbreak increase daily, and looks at data from the most recent *T* days. We developer a temporal outbreak detection system called PCT by applying this method to PC. We compared the abilities of PC and PCT to detect a laboratory validated outbreak of influenza in Allegheny County. Next, we tested directly whether PCT attenuates daily fluctuations by simulating outbreaks whose trend was to have the daily number of cases increase, but every other day the number decreased.

Results

Figures 1 and 2 show the probabilities of the Allegheny outbreak. On 11/30/2003 PC determined that the probability of an outbreak was 0.65, but after that its probability fluctuated greatly. On 11/30/2003 PCT determined that the probability of an outbreak was 0.99, and after that its probability stayed high.

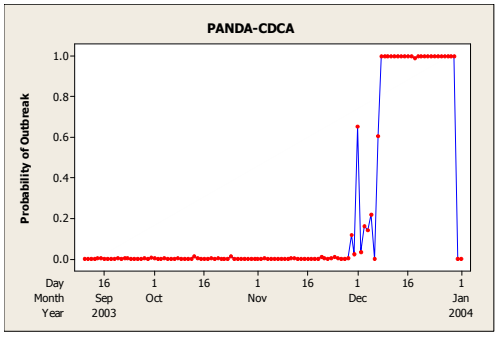

Figure 1 – PC's posterior probability of an outbreak.

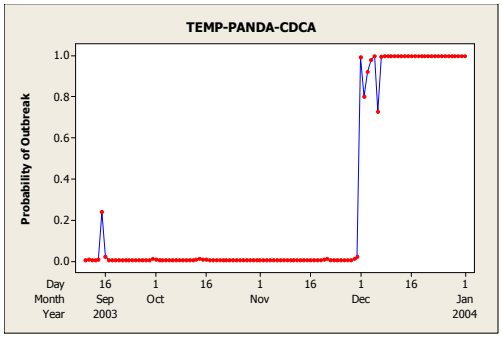

Figure 2 – PCT's posterior probability of an outbreak.

The following table shows the results of the simulations. These results clearly favor PCT.

Day	Avg. PC Probability	Avg. PCT Probability
1	0.0015	0.0035
2	0.0062	0.0054
3	0.4562	0.3939
4	0.0028	0.3479
5	0.9952	0.9965
6	0.3812	1.0
7	1.0	1.0
8	0.3801	1.0
9	1.0	1.0

Conclusions

Using retrospective data as a test bed, PCT detected an actual influenza outbreak as early as PC, but the posterior probability was stable 7 days before that of PC. We obtained similar results in simulation experiments. These results provide support that temporal modeling stabilizes appropriately the behavior of the system without compromising initial outbreak detection performance.

Acknowledgements

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References

[1] Cooper GF, Dowling JN, Lavender JD, Sutovsky P, A Bayesian Algorithm for Detecting CDC Category A Outbreak Diseases from Emergency Department Chief Complaints, Advances in Disease Surveillance 2007; 2:45."

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