A Flexible Space-Time Scan Statistic for Disease Outbreak Detection and Monitoring

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OBJECTIVE

This paper proposes a flexible space-time scan statistic for early detection of disease outbreaks.

BACKGROUND

A time periodic geographical disease surveillance system based on a cylindrical space-time scan statistic proposed by Kulldorff[1] has been used extensively for disease surveillance along with the SaTScan software. This statistic is based on a circular spatial scan statistic. On the other hand, many different tests have been proposed to detect purely spatial disease clusters. In particular, some spatial scan statistics such as those developed by Duczmal and Assunção(2004), Patil and Taillie(2004), and Tango and Takahashi(2005) are aimed at detecting irregularly shaped clusters which may not be detected by the circular spatial scan statistic. However, due to the unlimited geometric freedom of cluster shapes, these statistics have a risk to detect quite large and unlikely peculiarly shaped clusters. A *flexible spatial scan statistic* proposed by Tango and Takahashi[2], which has been used along with FleXScan software[3], has a parameter K as the pre-set maximum length of neighbors to be scanned, to avoid detecting a cluster of unlikely peculiar shape. The flexible spatial scan statistic can be easily extended to space-time alerting methods in syndromic surveillance.

METHODS

A *flexible space-time scan statistic* which we propose in this paper imposes a three dimensional prismatic window where the arbitrarily shaped base represents space and the height represents time. For any given region i and the pre-set maximum geographical length K, we create the set of arbitrarily shaped bases consisting of k connected regions ($1 \leq k \leq K$) including i, which are restricted to the subset of the K-nearest neighbors to the region i. This restriction can avoid detecting a cluster of unlikely peculiar shape. Since we are interested in detecting only clusters that are alive or present at the time t_P of monitoring in syndromic surveillance system, we consider only 'alive' clusters that are detected in the following T time intervals:

$$[t_P - T + 1, t_P],\ [t_P - T + 2, t_P], \ldots,\ [t_P, t_P]$$

where T is the pre-specified maximum temporal length of clusters. In total, a very large number of different but overlapping windows are created, each with a different set of neighboring three dimensional areas and each being a possible candidate area containing a disease outbreak.

RESULTS

Daily syndromic surveillance data in Massachusetts, USA, were used to illustrate the proposed test statistic. The performance of the proposed space-time scan statistic was compared with that of the cylindrical scan statistic, using the benchmark data provided by Kulldorff et al.[4]. As expected, the flexible space-time scan statistic has higher power for detecting disease outbreaks in very irregular shaped areas, while the cylindrical scan statistic has higher power for circular and other compact shaped areas.

CONCLUSIONS

The flexible space-time scan statistic is well suited for detecting disease outbreaks in non-circular areas.

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