



# A SPACE TIME CLUSTERING METHOD FOR CRIME SURVEILLANCE

**Marcelo A. Costa, Sérgio Henrique Rodrigues Ribeiro**



*Laboratório de Estatística  
Espacial*

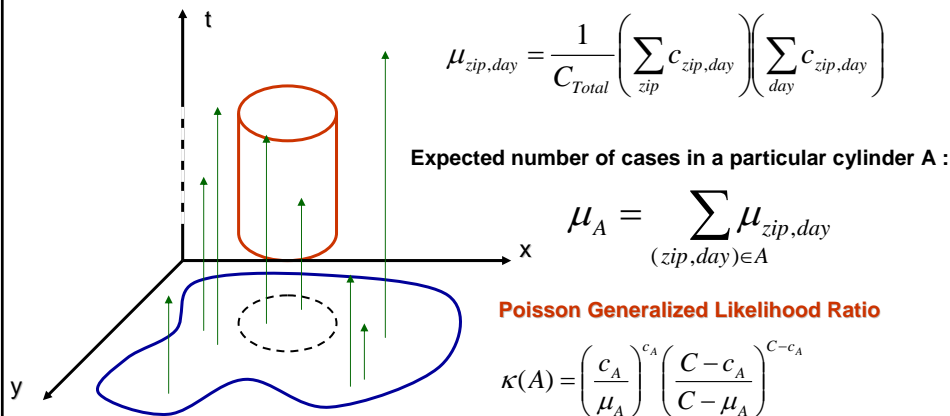
## Motivation

- Criminal events such as robberies or assaults peculiarly behave as epidemic events and thus, statistical tools of epidemiological surveillance can be used in this context.
- Such surveillance systems usually require information on the population under risk. However, when it comes to urban centers or downtown areas, population at risk is the population in transit in the region and not the residents.
- When information about the population at risk is limited or absent, the alternative is to estimate the expected number of cases from historical data.

## Objective

- To propose a daily based surveillance system for point patterns of crimes using a modified version of the space-time permutation procedure for irregular cluster detection.

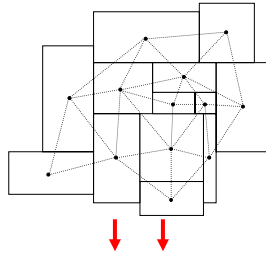
## Space Time Permutation (Cylinder)



M. Kulldorff, R. Heffernan, J. Hartman, R. Assunção and F. Mostashari.  
*A Space-Time Permutation Scan Statistic for Disease Outbreak Detection.*  
 PLoS Med 2(3), 2005.

## Constrained Spanning Trees – MLink (Maximum Link)

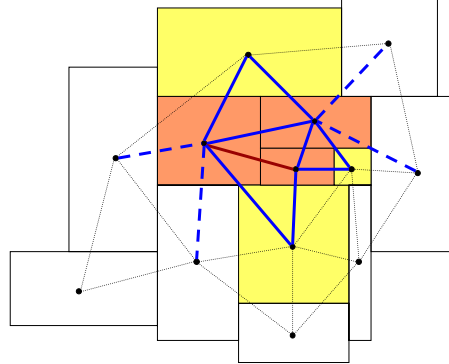
### Growing Process



### Adjacency Information

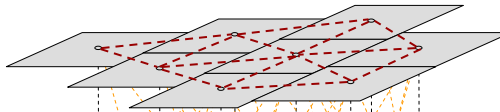
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02860 02864 02906
02864 02860 02019 02093 02762
02895 02864 01504
02019 02864 02093 01504
02093 02864 02762 02056 02035
02762 02864 02093
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02703 02860 02864 02760 02048
02739 02770
    
```

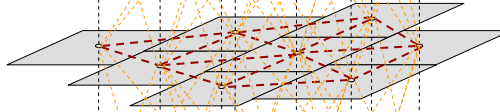


## Irregular in Space and Time

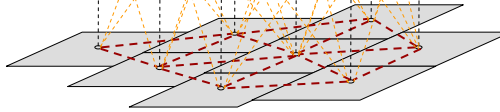
time = 2



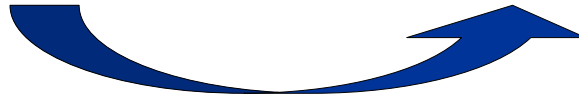
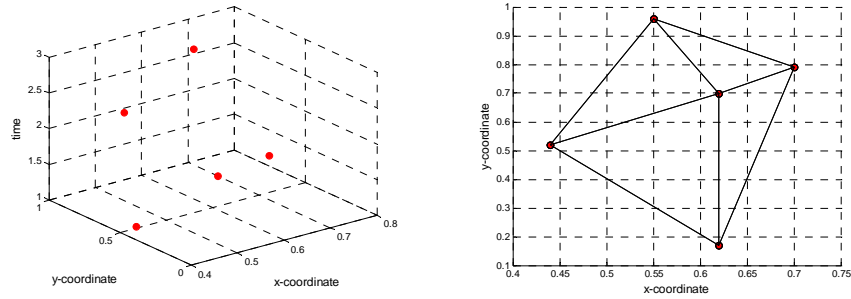
time = 1



time = 0

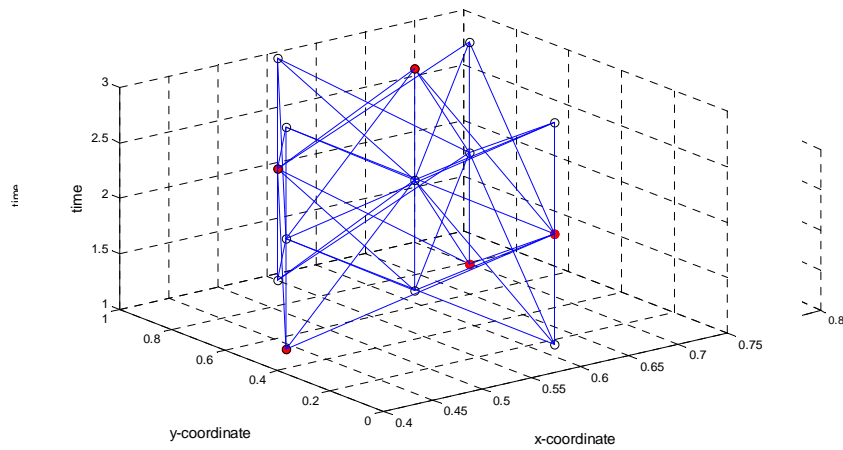


# The Graph Structure



**Delaunay Triangulation**

# Creating the 3-Dimensional Graph

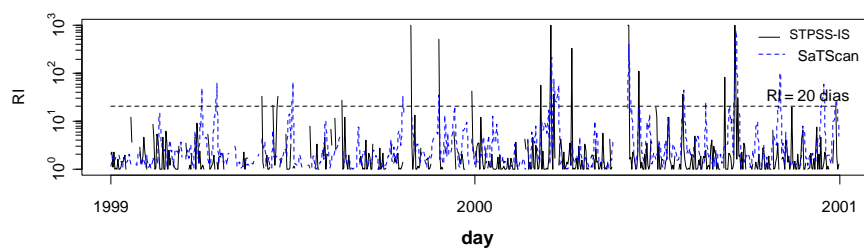


## Parameters

- Using historical cases from 1999 to 2000 we mimic a daily prospective surveillance system.
- A prior analysis showed that the number of events is higher during weekends and, in addition, differentiated for Saturdays and Sundays. **Based on this analysis we included a weekday variable (1 : regular weekdays, 0 : weekends).**
- Three values for the historical window were evaluated: 45, 60 and 90 days.
- The maximum temporal cluster was set as 7 days.
- The number of Monte Carlo simulations used was 9,999.
- The cylinder space-time permutation (STP-SaTScan) method was applied to the data set as a comparison.

## Detected Signals

### Surveillance System

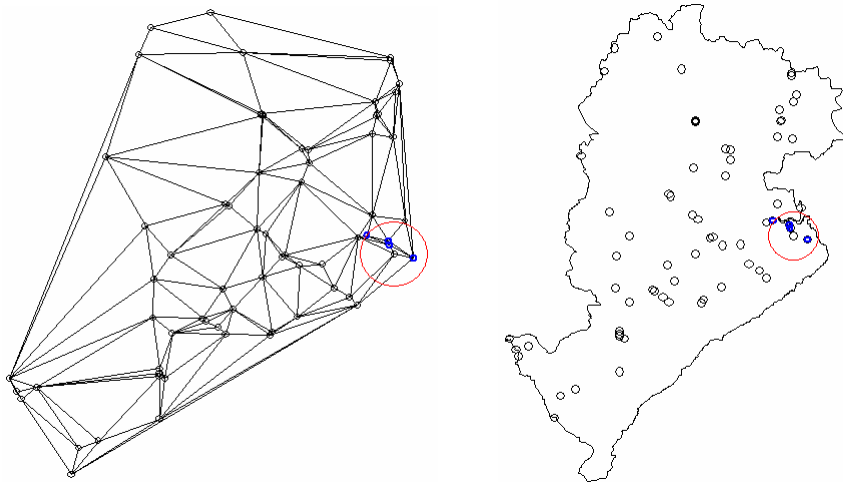


- The **STPSS-IS method detected 23 clusters with p-values below 0.05** under the null hypothesis of no clusters.
- Among those, 10 signals have recurrence intervals (RI) greater than 100 days.
- **The STP method detected 29 signals**, 8 of them with RI greater than 100.
- **On average, the STPSS-IS detected smaller clusters, irregularly shaped. Most of significant clusters found by STPSS-IS are portions of clusters detected by STP.**

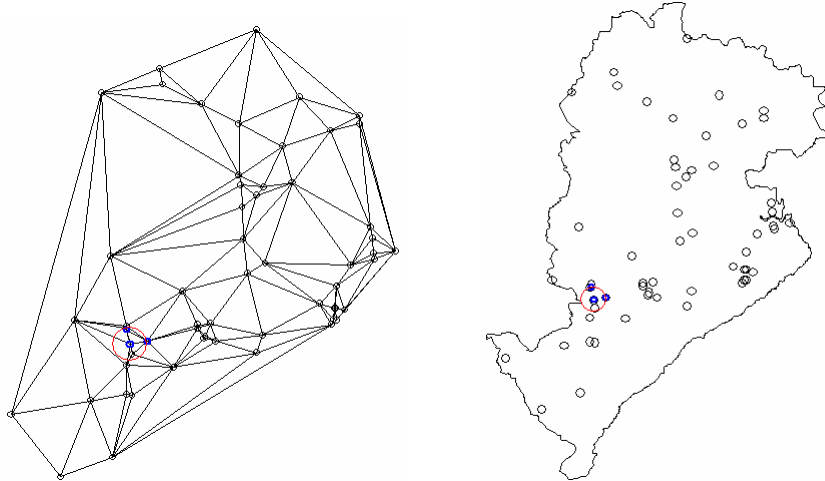
## Detected Signals

Signal	Method	Temporal Length	Observed	Expected	RR	p-value	Recurrence Interval
11/26/1999	STPSS-IS	3	2	0.12	17.00	0.0030	333.67
	SaTScan	7	3	0.47	6.38	0.0291	34.36
3/17/2000	STPSS-IS	2	2	0.08	24.67	0.0080	125.12
	SaTScan	2	3	0.24	12.50	0.0052	192.31
3/20/2000	STPSS-IS	2	3	0.28	10.67	0.0280	35.75
	SaTScan	2	3	0.28	10.71	0.0133	75.19
6/3/2000	STPSS-IS	2	3	0.20	15.18	0.0010	1001.00
	SaTScan	2	3	0.20	15.00	0.0025	400.00
9/18/2000	STPSS-IS	2	4	0.26	15.13	0.0010	1001.00
	SaTScan	2	4	0.39	10.26	0.0028	357.14
9/19/2000	STPSS-IS	3	3	0.21	14.27	0.0180	55.61
	SaTScan	3	4	0.41	9.76	0.0013	769.23
12/28/2000	STPSS-IS	1	2	0.14	14.33	0.0490	20.43
	SaTScan	4	5	1.14	4.39	0.0366	27.32

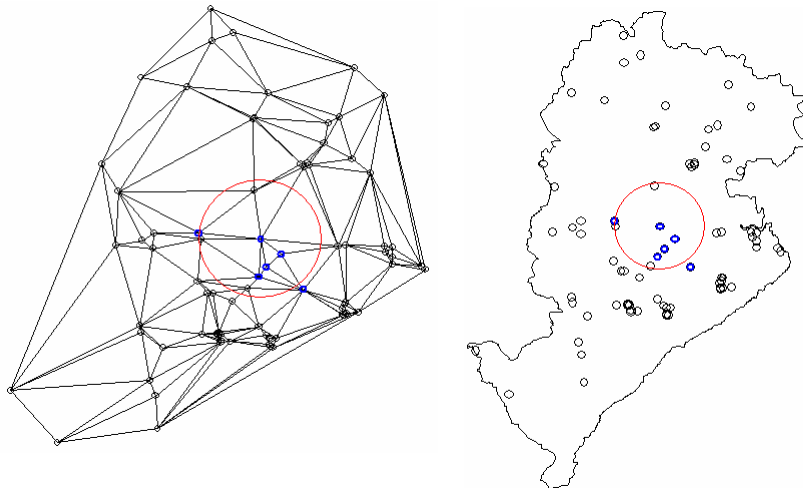
## Detected Signal: 03/17/2000



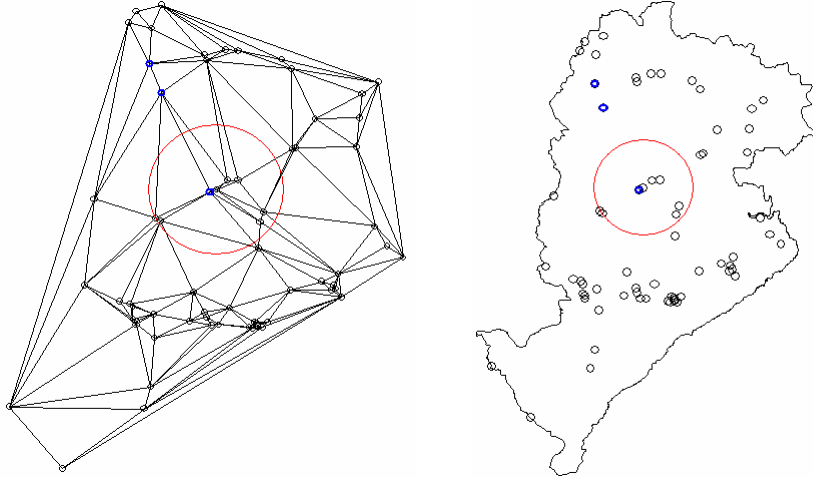
**Detected Signal: 06/03/2000**



**Detected Signal: 09/18/2000**

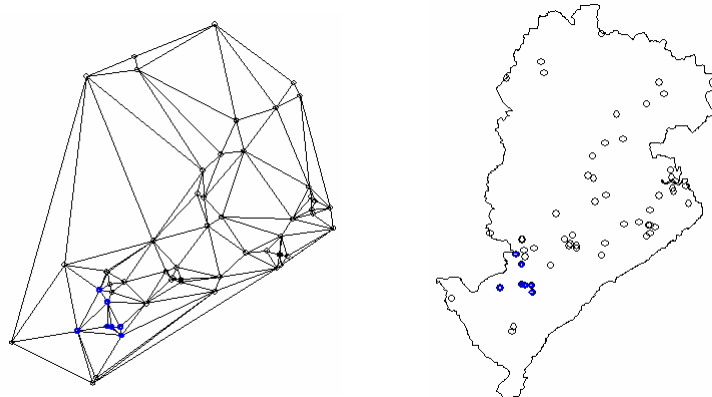


## Detected Signal: 12/28/2000



## STPSS-IS Detected Signal

day	ndays	observed	expected	rr	pvalue	RI
6/13/2000	3	3	0.2019	14.8571	0.0090	111.22



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## Conclusions

- The STSS-IS method generates cluster candidates whose shapes can be compared to information such as roads or landscape.
  - In addition, the temporal behavior of the shape indicates if the cluster is currently growing or vanishing.
  - Results show that the method can be applied to daily surveillance of crimes.
  - The method can be easily extended for surveillance in a variety of applications where historical cases of point events are available.
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## References

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  - Okabe A, Boots B, Sugihara K and Chiu S N, *Spatial Tessellations: Concepts and Applications of Voronoi Diagrams*, Wiley, 2000.
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