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Geographic and Network Surveillance for Arbitrarily Shaped Hotspots

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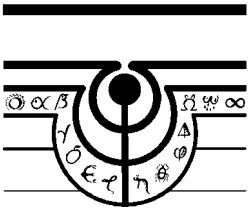

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Geographic and Network Surveillance for Arbitrarily Shaped Hotspots

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We propose a decision support framework for geographic and network surveillance, featuring methods for hotspot detection, prioritization, and early warning. Application to cyber security is discussed, among others.

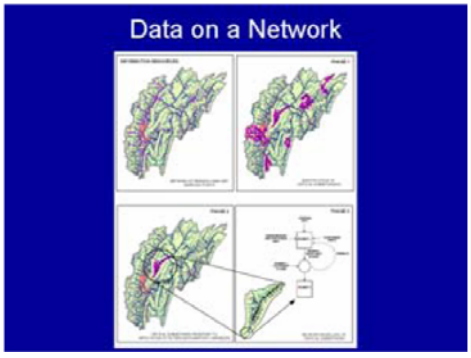
Additional Key Words and Phrases: Upper level set scan statistic, Posets, Probabilistic finite state automata.

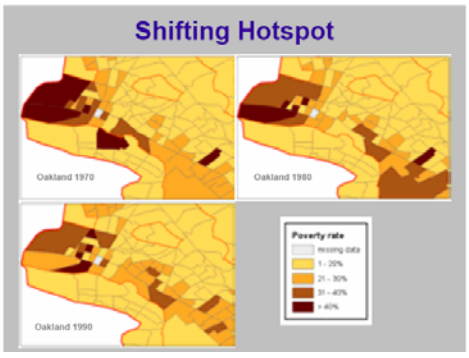
In response to an ever increasing volume of georeferenced data, government agencies require a new generation of decision support systems for early detection, surveillance, and prioritization of hotspots. Hotspots are unusual phenomena, anomalies, aberrations, outbreaks, or critical areas. Government agencies require hotspot delineation and prioritization for etiology, management, and early warning.

With support from the NSF/DG program, we have developed a decision support framework for geographic and network surveillance. Our framework will be illustrated in a number of case studies, including the ones relevant to homeland security:

1. Cyber security and computer network diagnostics;
2. Drinking water quality and water utility vulnerability;
3. Disaster management: Oil spill detection monitoring, and prioritization.

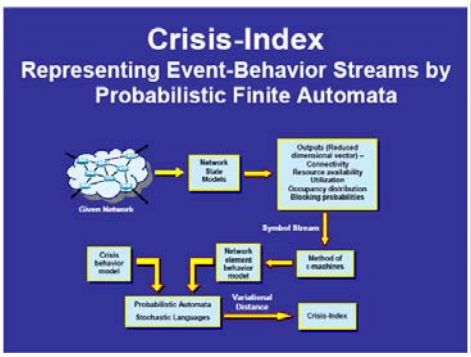
Our framework features a novel *upper level set scan statistic* (ULS) system to delineate arbitrarily shaped hotspots in both spatial and temporal dimensions [Patil and Taillie 2004a]. This approach may be applied to irregular networks, such as those formed by streams (see below), political units, social networks, and the internet. When applied to data collected over both space and time, the ULS scan statistic system may be used to detect shifting hotspots (see below), coalescence of neighboring hotspots, or their growth.

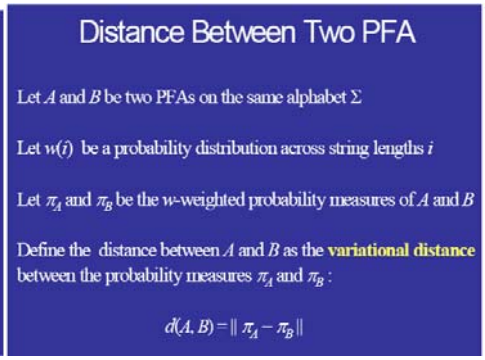




We also propose a novel prioritization scheme based on multiple indicators that does not require the reduction of the data to a single index. This *poset prioritization and ranking system* features Haase diagrams describing the partial ordering of data, linear extension decision trees illustrating admissible rankings among hotspots, and cumulative rank functions for hotspot prioritization [Patil and Taillie 2004b].

Protecting the nation's computer networks from cyber attack is an important homeland security priority requiring diagnostic tools for detecting security attacks and infrastructure failures. We propose a *probabilistic finite state automaton* (PFSA), describing a network element as obtained from its data stream output. The variational distance between the stochastic languages generated by normal and crisis automata may be used to form a crisis index. The ULS scan statistic may be applied to crises indices over a collection of network elements for hotspot detection. These hotspots and their prioritization can be used to detect coordinated attacks geographically spread over a network. Additional applications of PFSA include the tasking of self-organizing surveillance mobile sensor networks, geotelemetry with wireless sensor networks, videomining networks, and syndromic surveillance in public health.





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