**Poster III-38**

## Neutral Models for Pattern Recognition on Remotely Sensed Imagery

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A new generation of remote sensing hardware is providing high spatial resolution, hyperspectral imagery that documents the environment with unprecedented spatial and spectral detail. This quantum leap in resolution has enormous potential for improving our ability to document, monitor and model environmental risks thought to be associated with adverse health outcomes (Jacquez, Marcus et al 2002). Realization of this potential depends critically on our ability to recognize spatial patterns on these extraordinarily large, multivariate images. This requires fast computational algorithms for simulating realizations (images) consistent with spatial and multivariate structure expected under realistic neutral models. Only with such realizations can we make probabilistic statements regarding observed spatial patterns.

Complete Spatial Randomness (CSR) is the null hypothesis employed by most, if not all, statistical tests for spatial pattern, and is the workhorse of almost all spatial statistical software. Examples of statistics used in these tests include spatial autocorrelation (*e.g*. Moran's *I*); its local counterpart (*e.g*. LISA); geographic boundary statistics (*e.g*. boundary count and mean length), and a host of techniques for identifying hot spots, cold spots and foci. While CSR is useful in some situations, it is not a relevant null hypothesis for highly complex and organized systems such as those encountered in the environmental and health sciences including fields such as spatial epidemiology and exposure assessment. For such fields CSR is not relevant because spatial randomness rarely, if ever, occurs – some spatial pattern is almost *always* present. Hence rejecting CSR has little scientific value because it does not describe any plausible state of the system. The term "*Neutral Model*" captures the notion of a plausible system state that can be used as a reasonable null hypothesis (*e.g*. "background variation"). The problem then is to identify spatial patterns *above and beyond* that incorporated into the neutral model, enabling, for example, the identification of "hot spots" *beyond* background variation in a pollutant.

This SBIR project is developing neutral models for simulating realizations of high resolution, hyperspectral imagery that captures biologically relevant aspects of the spatial and multivariate structure observed on the original image. Three algorithms have been developed and tested: (1) A genetic algorithm that mutates image generating equations, and is called Symbolic Regression (SR); (2) A geostatistical simulation algorithm called Sequential Gaussian Simulation (SGS); and (3) A method similar to simulated annealing called Conditional Pixel Swapping (CPS) (Liebisch, Jacquez et al 2003). These techniques were used to produce alternative realizations of target images that retained realistic spatial and multivariate structure on the target images. Test imagery included fluorescent microscopy images of actin filaments, landsat imagery of Midwest landscapes, Ikonos imagery of San Francisco Bay, and high resolution hyperspectral imagery of Yellowstone National Park. When used in pattern detection, the neutral models were able to identify objects, boundaries, edges, and patches on target imagery that were statistically significant, indicating the action of complex biological interactions *above and beyond* those captured in the neutral imagery.

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**References**

1. Jacquez, G. M., W. Marcus, R. Aspinall and D. Greiling. 2002. "Problems and opportunities in the analysis of high-resolution hyperspectral imagery for risk assessment." Special issue of the Journal of Geographical Systems (Volume 4)
2. Liebisch, N, G. M. Jacquez, P. Goovaerts and A. Kaufmann. (In Press). "New methods to generate neutral images for spatial pattern recognition", Lecture Notes in Computer Science, Springer (In Press).