## c.3 Geographic Social Science

Many social processes play out over geographic space, as individuals and societies interact with the natural and built environments. Thus, placing social, behavioral, economic, and health information into a geographic context can lead to new insights regarding socioeconomic processes. NSF has recognized the value of spatially-integrated social science (Goodchild and Janelle, 2003), and research at Buffalo on this topic provides excellent opportunities for IGERT Trainees to learn about this important research area. As GISs have facilitated the storage, retrieval, and display of geographic information, there has been increasing recognition of the need for the *analysis* of that information, and its application to topics of societal concern. Efforts to improve methods of spatial modeling and spatial statistical analysis allow better estimation and understanding of the relationships between variables that have a spatial dimension and of the role of structural properties of spaces (for example, network versus two-dimensional space). Current geographic social science research by IGERT-affiliated faculty at Buffalo provides a good sample of the subject matter, and is being carried out by both social scientists and engineers. Students specializing in this topic will be directed primarily to the Centre for Advanced Spatial Analysis at University College, University of London, England for their International Research Internship experiences. Spatial analysis research at Buffalo will continue to include international collaborations that will provide international research internship opportunities for IGERT Trainees. We also have established links with the Center for Spatial Information Science at the University of Tokyo, and with many other international research centers related to this topic.

### c.3.1 Spatial Analysis and Statistics

New methods of spatial surveillance are being developed to facilitate the monitoring of geographic patterns, with the aim of providing quick detection of any emergent geographic clusters. These methods will integrate the methods of statistical process control used in quality control engineering with recent developments in spatial statistics. In particular, methods for tracking changes in *local statistics* (Anselin 1995; Ord and Getis 1995) are being developed by P. Rogerson (Geography) and his students. Local statistics measure spatial pattern on a local scale, and are appropriate for detecting geographic clusters and geographic pockets of spatial association. Although they have been widely developed and used during the last eight years, they have yet to be integrated into a monitoring context, to allow for study of changes over time.

Several recent projects at Buffalo have centered on the intersection of epidemiology, spatial statistics and analysis, and geographic information systems. These projects involve close interdisciplinary collaboration with researchers in the Department of Social and Preventive Medicine. The development of new spatial statistical methods for the detection of geographic clusters has been applied to the study of breast cancer in the northeastern U.S. (Han and Rogerson 2002). These methods have also been extended to allow for surveillance, so that new data may be analyzed as it becomes available, facilitating the quick detection of new geographic patterns (Rogerson 2001). Research at Buffalo on health-related topics is funded by the National Institutes of Health.

Research has also been conducted on the extraction of meaningful patterns among complex geographic events associated with multiple point locations (geospatial lines, Mark and Egenhofer, 1998; Mark *et al*., 2000), such as migration paths, journey to work, animal tracking data, and daily human travel activities. Multidimensional spatially-referenced databases have been examined using spatial data mining and knowledge discovery in databases, allied with highly interactive visualization tools (Thill *et al.,* 2003). These methods are used to detect changing rates of occurrence in many contexts, including the surveillance of chronic diseases such as cancer, emergency department surveillance, and monitoring of highway crashes or terrorist events.

Increasingly large spatial databases are available in digital form, but remain largely unexplored. Extraction of meaningful features from geospatial databases is a line of research that J.-C. Thill

(Geography) has pursued from several angles over the last decade, employing computational and statistical data analysis techniques and machine learning approaches. Future developments along these lines will be pursued and will touch on the closer integration of approaches traditionally aimed at either exploratory or confirmatory analysis, the explicit recognition of embedded multi-scale patterns and processes, and data mining on networks (the internet, air travel networks, etc.)

### c.3.2 Mobility and Location

Spatial information is quickly becoming a linchpin of mobile information technologies. The success of location-based services and information services deployed as part of Intelligent Transportation Systems will depend on solid knowledge about capture, storage, retrieval, and exchange of mobile locational information. Research has been initiated in several key areas of research including data accuracy and data standards for interoperability, fusion of elemental data to create marketable traffic information, and computational algorithms for multi-source data matching.

Other projects pertain to the new face of personal mobility and accessibility in an environment reframed by information technologies. A travel simulator has been designed and implemented as a data collection environment to analyze travel decisions and behaviors under controlled scenarios of information availability. Future enhancements of the simulator will enable the modeling of complex mobility and transportation systems, including in-vehicle navigation systems, incident notification systems, and other vehicle- and roadway-based telematics capabilities. Efficient decision-support systems for real-time vehicle routing, particularly well suited to emergency or potentially hazardous situations, have been designed and implemented. The availability of highly disaggregated, real-time spatial data offers great opportunities for future research in spatial analysis. Key challenges pertain to the fusion of data from multiple sources, the large volume of information, and the continuous flow of data (Thill, 2000).

R. Batta (Industrial Engineering) and P. Rogerson (Geography) are initiating a new research project on data analysis and solution methods for coverage models that arise in cellular communication. This project will investigate (i) effective data gathering techniques, and (ii) the creation and analysis of new and innovative coverage models, for the location/deployment of communication centers. There are two types of calls to be serviced, those with regular priority and those with higher priority (i.e., special calls). This project has its roots in the telecommunication industry, specifically that which relates to cellular communications. Quality of signal strength is a key customer-satisfaction factor, which needs to be addressed in the industry. Though the theoretical variation of signal strength with cell tower location is simply a function of the square of the distance from the cell tower, in practice there are many effects (terrain, foliage, interference with other devices, weather, buildings) that make the actual signal strength rather unpredictable. To get an accurate estimate of the actual values of signal strength an effective statistical sampling technique is needed. The first part of the proposed work is concerned with the development and testing of appropriate spatial statistic sampling techniques for measurement of received signal strength. We will build on preliminary studies that we have done in the Western New York area. The second part of the proposed work is related to the two major control mechanisms available to a cellular provider—locations of the cell towers and the dynamic reallocation of channel capacities. We have developed a preliminary mathematical programming model for this and have tested some solution techniques. We will use this as a basis to develop more sophisticated models and efficient solution techniques. Also, the data used in these models will be from the first part of our work, i.e., statistical estimates of the signal strength. The final part of the work will involve in the development of case studies based on the application area of automated call notification devices in automobiles (these trigger a cell call when an airbag deploys in a crash).

N. Shiode (Geography) also is conducting research in locational optimization: Identifying the preferable location under certain criteria has been one of the most imminent focal points of location theory for centuries, but we have yet to understand the complex mechanism of allocating facilities and interpolating the two-dimensional surface. This, however, is changing as we see rapid advancement of computational powers as well as the methodologies in GI Science, spatial economy, and computational geometry. This study derives a method for simultaneously optimizing the number and locations of new facilities in such way that we identify the threshold value for the introduction of new facilities among the existing competing facilities.

Both E. Zubrow (Anthropology) and N. Shiode (Geography) are conducting research regarding pedestrian movement. Zubrow's work on pedestrian movement mainly involves the context of archaeological sites. Given the structure of the built environment in some area, how would we expect the flows of pedestrians to take place and according to what theories and models would we want to direct the pedestrian traffic? The core of IGERT-Fellow Scott Branting's dissertation is to reconstruct movement of pedestrians who walked the paths and streets of prehistoric cities such as Kerkenes Dag. an ancient city comprising 250 plus hectares dating to about 550 B.C. in what is now Turkey.

Shiode also is involved in micro-scale pedestrian simulation: Studies in the fields of transport and urban planning have traditionally placed greater emphasis on traffic flows and public transportations and placed less attention to the pedestrian movements. This is surprising, given that most micro-scale activities involve walking. The recent increase in pedestrian behavior studies helps interpreting the local activities to some extent; and we have yet to build a reliable simulation model of urban transport that incorporates pedestrian movements. By combining GIS with the agent-based approach, we will produce a micro-scale model to simulate growth and activities in the local neighborhood.

### c.3.3 Policy-related Research

Munroe Eagles (Political Science; adjunct in Geography) is conducting research on electoral geography and voting behavior, and has applied GIScience principles to the study of political redistricting. Eagles also serves on the Ph.D. committees of several current IGERT Fellows working in information policy and societal impacts of GI technologies.

Lastly, E. Zubrow (Anthropology) has been conducting work on the spatial character of social policy focussing primarily on disability; several current IGERT students from anthropology and from geography have been involved in this research. Sponsored by a Canadian foundation, this project has several parts—mapping and creating an Atlas of Disability and Literacy for Canada, writing a major monograph on this subject, creating a grass roots spatially enabled web site, publishing four popular articles, and finally publishing a book. This line of research will be expanded to the US, Sweden, England and through the UN to a broader part of the world; there is a strong human rights element in this research, with a potential to merge GI and Society themes with core social science research.