

Using Historical GIS to understand space and time in the social, behavioural and economic sciences: A white paper for the NSF

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Abstract

The importance of space and time to research within and across a wide range of disciplines has long been recognised. Continuing this tradition, in its call for visionary white papers NSF states, “The landscape is vast and complex, stretching across temporal and spatial dimensions and multiple levels of analysis... in a dynamic and fragmented yet interconnected world.” Historical Geographical Information Systems (HGIS) has the potential to create truly interdisciplinary understanding of spatio-temporal processes and the connections and disruptions between them across multiple scales. As a method, HGIS is proving increasingly effective in exploiting space and time, place and period, drawing upon a wide variety of quantitative and qualitative sources. HGIS has gained practitioners in many disciplines, including geography, political science, history, economics, sociology and environmental history. In these fields and others, it is generating cross-disciplinary research. Funding research and increasing capacity in this field will result in a step-change in our understanding not just of the past but of how societies and economies have developed to reach their current situation.

Research challenges and capabilities

Too often our understanding of the processes that drive social, behavioural or economic phenomena are undermined by an insufficient accounting of the importance of time and space in jointly shaping those processes. This lack of attention is not due to ignorance, but because of the inherent difficulty of conducting truly “four-dimensional” analysis. For decades, the usual approach has been to simplify analysis by studying space and time independently. When these dimensions are studied together, analysts have had to use time slices – moments frozen in time – and have usually aggregated data into convenient spatial units, such as states, rather than using the most detailed levels of data available. Not surprisingly, these approaches often arrive at over-simplified conclusions or mistaken interpretations because the analysis fails to catch potentially significant variations within those aggregates or between one time slice and the next. Missing important detail is only part of the problem. The bigger issue is our inability to trace connections and discontinuities at the scale where the process operates and the relations between processes at different scales.

This problem is not new. Literatures in many disciplines argue that we need a better understanding of spatio-temporal processes. Scholars in the social sciences have been slow to answer this need chiefly because of the difficulties posed by the large volumes of data and the complexity required to document social phenomena over both space and time. Today, developments in Geographic Information Systems (GIS) and Geographic Information Science (GISc) provide us with the tools. Historical GIS, sometimes called “spatial history,” has demonstrated the feasibility of integrating time and space across datasets that seemed incompatible. It can be applied to an endless array of subjects and questions. Basic capabilities include mapping the constituent elements of social processes singly and in combination; running spatial statistics and spatio-temporal as well as conventional aspatial statistics; and analyzing data at various scales or granularities, from the individual to the nation, from hour-to-hour intervals to year-to-year, or by the decade or century. This flexibility offers many disciplines the potential to re-examine traditional orthodoxies, and to explore completely new questions that until now have been beyond our grasp or imagination.

Context

Much of the early work in this field focused on developing demographic databases of national censuses, which are quantitative and explicitly geographical sources. This led to the creation of the U.S. National Historical GIS, the Great Britain Historical GIS, and similar

cyber-infrastructures. A myriad of other databases now cover topics such as transport networks, industrial development, the layout and social patterning of cities, agricultural land use, risks and perceptions of risks. Some of these have been developed for specific research objectives, others are more generic. In all cases, these databases have been, and are expected to continue to be, expensive to produce and difficult to preserve. Many are relatively simple to integrate with each other, allowing new questions to be asked, such as the relationship between railroad construction, migration, and industrialization. The recent development of freely available gazetteers such as GeoNames and World Gazetteer makes it possible to convert almost any dataset that contains place names into a point-based GIS dataset. Beyond this, early work in the automated extraction of place-names from texts has shown much promise in allowing us to convert unstructured texts – including corpus of newspaper articles, contemporary government documents, or entire books – into GIS components. Reaching beyond its origins in “the quantitative”, GIS is thus increasingly able to handle and integrate qualitative sources. Visual evidence, particularly from maps, can further be integrated with numeric data and text. This developing capability is expanding the research domain of HGIS and spurring researchers to incorporate a rapidly growing array of sources. GIS is also an extremely effective mechanism for disseminating complex information to users beyond the academy. The success of online GIS-based systems such as Social Explorer in the United States and Vision of Britain in the United Kingdom demonstrates this.

Among developments in computer science that will contribute to HGIS, three areas look particularly promising. The first is user-generated content, where data are posted to websites. GIS can track these postings in time and space, providing a framework for ethical academic analyses of content and the behaviours of those who post and consult online information. The second is the development of location aware devices such as smart phones which, because they know where they are through a GPS (Global Positioning System) receiver, can be used as research tools in their own right by allowing researchers to document present and past environments while “in the field.” GPS devices are already being used to create large spatio-temporal databases with great potential for studying the patterns of everyday life, mobility, urban design, and food deserts. The third, data mining, is better established but still has much to offer for exploring and exploiting large spatio-temporal databases. The long-term potential is to explore trillions of pages of content from Google Books and elsewhere in conjunction with other sources.

More important than the creation of databases and interpretive resources, or improvements in preservation and dissemination, is the enormous potential of HGIS to generate new research questions that provoke fresh insights throughout the social, behavioural, and economic sciences. While growing numbers of social scientists are making good use of GIS, few have grappled with the spatio-temporal problem we consider most important. To date, few have utilized the most distinctive power of GIS, namely, visualizing and analysing data in its geographic context, which invariably raises questions and prompts spatial thinking. Lessons learned by practitioners of HGIS apply to any study that considers change over space and time, whether in the immediate past that we normally call the present or the more distant pasts we label as history.

Disciplines

Historical GIS is inherently interdisciplinary, combining technical expertise in GIS with the spatial perspective of geographers, the temporal perspective of historians, and topical knowledge in specialties as diverse as employment, smelting, mothering, architecture, the Holocaust, and policing. As large textual databases become available and our ability to analyze them improves, more researchers will venture to cross the qualitative/quantitative divide. While this interdisciplinarity is a key strength, it is worth considering how GIS has affected a wide range of different disciplines.

Demography. There is enormous potential to gain an improved understanding of long-term demographic processes including mortality, health inequalities, migration, fertility, and their interactions. Considerable progress with contemporary as well as historical relevance has already been made in some of these areas.

Economics. HGIS allows a better understanding of the relationship between micro- and macro-economic processes by, for example, revealing how firms' behaviour differed between regions in response to technological change or economic shocks. A more obvious and general advance is the ability to redress the long neglect of space in economics.

Sociology. Attention in this subject initially focussed on cities and their development over time. Some studies tracked properties or moves of individuals over relatively short spans, while others employed census tract aggregates to explore decade-by-decade changes over a century or more. Issues such as residential segregation have a particularly rich potential.

Political science. Since people vote in well-defined electoral districts, and at well-defined moments and intervals, scholars (and newscasters) have moved quickly to explore shifts in voting patterns in relation to human behaviour, changes in economic and social conditions, international events, and modes of communication. The contextual analysis HGIS supports is particularly important here.

Transport and mobility studies. The capacity for integrating large amounts of data to answer inherently spatial questions makes GIS admirably suited for studies of changes in transport, mobility, and communication. The European Science Foundation has already recognised this in supporting a major Collaborative Research Project using GIS to study transport and development across Europe under its *Technology and the Making of Europe* Eurocores program. At the same time, the work of time geographers such as Mei-Po Kwan has considered everyday mobilities through time and space exploring, for example, the daily movements of Muslim women around Columbus, Ohio.

Environmental history. This has been a major area of research in HGIS and one that has produced important revisionist studies such as Cunfer (2005), which upends the interpretation that over-ploughing caused the Dust Bowl by showing that climatic conditions better explain the location and severity of dust storms. Physical and biological scientists are increasingly interested in such work as they recognize that historical data are crucial for establishing baselines to measure climate change. These connections offer unprecedented opportunities for collaboration between the “hard” sciences and social sciences, with GIS as the common platform and vehicle for integration and analysis. Such collaborations have already emerged in studies of land-use, hydrology, and mercury contamination in the Amazon basin, and in the re-tracing of languages, blood groups, and variant forms of diseases at global, regional, urban, and neighborhood scales.

Geography. GIScientists are now very interested in issues common to HGIS research. Having developed a number of time-and-space models under the rubric of temporal GIS, they are seeking historical applications to test those models. More generally, geographers and cartographers who use GIS are increasingly concerned with developing more nuanced ways to deal with uncertainty and metadata, both of which can benefit from the methods and experience of HGIS. With the use of GIS for environmental challenges, a generational split into “physical” and “human” geography has in the last ten years yielded to intense collaborations.

History. As the above suggest, the potential applications of GIS to historical topics are legion. The success of HGIS in interdisciplinary organizations such as the Social Science History Association and the European Social Science History Conference particularly illustrates how HGIS can generate new research agendas.

Implications for further research

Use of GIS is an acknowledgement that every place differs from every other place, and that each historical instantiation of a place will differ from those that precede or follow. GIS is a tool built to recognise difference and explain diversity. Beyond stressing the pertinence of space, GIS does not impose a particular approach or topic on the researcher. The tool enables scholars to understand their data in a more sophisticated way. Beyond this, there are a number of more specific implications. One is the ability to make better use of large databases that contain some sort of locational component, even if it is as simple as a place name. Another is the ability to integrate databases based on location. This is what makes it possible to combine, for example, data from newspaper accounts of dust storms with climatic data from weather stations and soil types from USDA maps. All the disciplines listed above have the potential to enrich one another. For example, economy, society, transport, demography, politics, and environment are all linked in space and in time. By bringing databases and scholarship together under a GIS umbrella, we gain a more holistic understanding of these processes and their interactions. GIS also enables one to integrate data collected at various scales. A large-scale census study may identify broad trends over a wide area but will usually be limited in its explanatory power. A more localised study of a specific place may offer convincing local explanations but lack context. Bringing the two together allows the researcher to appraise the representativeness of case studies and ground-truth findings at broader scales.

Achieving the potential of HGIS requires action beyond HGIS as well as within it. Scholars need more open source software options, better interoperability, and fuller access to geo-referenced datasets and data digitized at public expense. Young scholars in particular need to gain academic credit for creating complex cyber-infrastructures. Within HGIS, fostering the uptake of this revolutionary technology requires cross-disciplinary training in GIS and geovisualization, hardware, post-docs, lab space, and technical and administrative support. Practitioners of HGIS need color in print media, fast-turnaround electronic media, and support for short-term exchanges of personnel. Most importantly, they require funding for

projects that delve into spatial and temporal processes. This is the time to seek common ground and coherence in fields at risk of fragmentation, HGIS offers a model for how to proceed.

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