

Toward a Geographically-Integrated, Connected World History: Employing Geographic Information Systems (GIS)

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Abstract

Over the past decade, historical groups, ranging from the Organization of American Historians to the World History Association, have called for research and teaching focused on the ways that the history of any place has been shaped by the place's interactive connections to other geographic locations. This work demands the aggregation and connection of a huge amount of information, which is increasingly possible due to advances in information management technologies. Geographic Information Systems (GIS) appears to be a particularly attractive technology for data management, visualization, and analysis by world historians. However, historians relying on existing off-the-shelf GIS software must exercise care that the technology does not begin to control their questions. Instead, historians must shape the software development agenda to get what they need to pursue the issues they feel are most important for understanding world history. To expose the limitations and possibilities of current GIS, this article presents the research difficulties of two giants of the field who did not use this information technology, Joseph R. Levenson and Andre Gunder Frank. On the basis of this discussion, the article suggests how GIS can be used effectively to create a more geographically-integrated, connected world history, which can be queried at any scale from the global to the individual in order to improve understanding.

Connecting Places; Aggregating Themes

In the new century, historians increasingly argue that the history of a geographical place, no matter how large or small, cannot be adequately understood without taking into account how it has been connected to other locations.¹ However, perhaps in part because of humans' weak cognitive capacity to grasp spatial relationships, historians have failed to prepare useful ways to analyze such connections. Moreover, the social and cultural environments of even a small human community are quite complex, and historians have not developed effective ways to organize, think about, integrate, and present so many variables. This article will offer an approach that will make possible real world historical research,

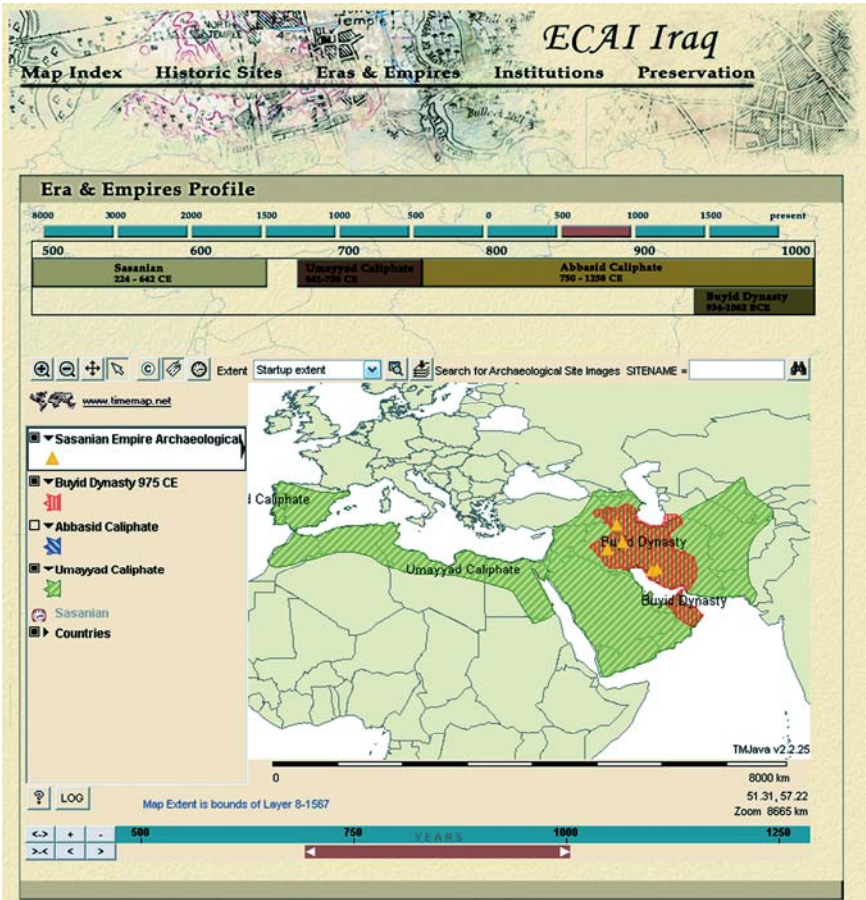


Fig. 1. ECAI (Electronic Cultural Atlas Initiative) Iraq. Shows a historic visualization using *TimeMap*. Information available for viewing is listed on the left, and the user activates data by clicking on the box to the left of the data name. Image and permission to use it provided by Dr Ian Johnson, Director, Archaeology Computing Laboratory, University of Sydney.

which is both geographically-integrated and connected, whose results can be expressed concisely and clearly to researchers and students.

Over the past decade, major changes in communications and information management technologies have transformed global business and research practices. Historians' efforts to integrate information geographically by place and to connect places demand the aggregation and connection of a huge amount of information, and the contemporary global transformation has brought possible assistance. Among widely utilized information technologies, Geographic Information Systems (GIS) appears to be particularly attractive for data management, visualization, and analysis by world historians (Fig. 1). However, historians relying on existing

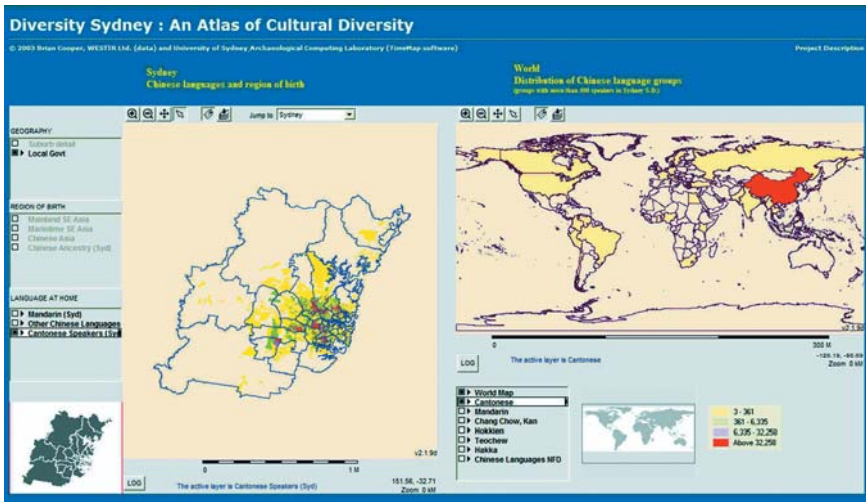


Fig. 2. Diversity Sydney: An Atlas of Cultural Diversity. Shows visualizations at both a local and a global scale. Sydney's connections to the world can be displayed on the basis of the languages spoken by its residents. This visualization deals with speakers of Chinese languages, and the information about Cantonese speakers is activated, showing both Cantonese speakers in Sydney and the distribution of Cantonese speakers throughout the world. Image and permission to use it provided by Dr Ian Johnson, Director, Archaeology Computing Laboratory, University of Sydney.

off-the-shelf GIS software must exercise care that the technology does not begin to control their questions. Instead, historians must shape the software development agenda to get what they need to pursue the issues they feel are most important for understanding world history. To expose the limitations and possibilities of current GIS, this article presents the research difficulties and conceptual vocabularies of two quite different intellectual giants among world historians who did not use this information technology, Joseph R. Levenson and Andre Gunder Frank, who specialized in intellectual history and economic history respectively. In realizing his analytical goals, each of these scholars encountered significant problems, which are common to real world history based on establishing connections and interactions among geographic locations. On the basis of this discussion, I suggest how GIS can be used effectively to create a more geographically-integrated, connected world history, which can be queried at any scale from the global to the individual to improve understanding (Fig. 2).

The Importance of Connections in World History: Joseph R. Levenson

World historians trying to understand how geographically-integrated history and GIS technology might fit into their work would do well to read Joseph Levenson's trilogy *Confucian China and its Modern Fate* because

there may be no better explanation of the importance for historical understanding of grasping connections. Levenson opened the trilogy's first volume, *The Problem of Intellectual Continuity* (1958), with an introduction entitled 'The Special and General Historical Quests'. For the epigraph he chose a brief parable from Alfred North Whitehead's 1929 book *Process and Reality*. Whitehead wrote, 'A traveller, who has lost his way, should not ask, "Where am I?" What he really wants to know is, Where are the other places? He has got his own body, but he has lost them'.² In the two decades after World War I, Whitehead, a prominent English mathematician, physicist, and philosopher, published a series of books, of which *Process and Reality* was one of the most sophisticated, to explain the significance of the new physics, and of Albert Einstein's theory of relativity in particular, for analytical thought. Despite the passage of almost eight decades since the publication of the cited book, few historians realize the degree to which their conceptual perspectives were developed and justified on the basis of now superseded ideas about the physical universe, which means that the results of historical research of even high quality often fall well short of adequate explanation. Whitehead precisely encapsulated the fundamental point in the parable Levenson selected. Existing works in history and the social sciences offer deficient explanations of historical process because they suffer from what Whitehead called the 'fallacy of misplaced concreteness', which he argued is involved when, in Newtonian physics, it is claimed that an atom could be defined and understood on the basis of its 'simple location' in spatial-temporal terms, assuming that this abstraction of a bit of matter from its context actually provides a description of concrete reality. Instead, a description of reality demands attention to the way the atom is connected to other bits of matter. Levenson tried to write history in a way that avoids the 'fallacy' Whitehead defined.

Levenson was an intellectual historian, although he rightly insisted that his field was only 'an avenue of entry'.

'Out there', in the history men make, the web is never rent, and intellectual, social, political, economic, cultural threads are interwoven. In the specialized approach, one tampers with the unity of nature; but the end is, to restore the whole in comprehensible form.³

Moreover, it was not just a question of pulling together the research results from these different fields; Levenson clearly felt that the 'comprehensible form' had to include the world. 'For something is emerging', he wrote, probably sometime in 1962, 'that really can be called world history, not just the sum of histories of separate civilizations'.⁴ Levenson's great contribution to world history was the skillful application of Whitehead's insight about the proper basis of analysis to the history of ideas. In his introductory comments following the quotation of Whitehead's traveler's parable, he stated:

An idea is always grasped in relative association, never in absolute isolation, and no idea, in history, keeps a changeless self-identity. An audience which appreciates that Mozart is not Wagner will never hear the eighteenth-century *Don Giovanni*. . . . Vocabulary and syntax, then, may remain the same, late and soon, but the statement changes in meaning as its world changes. . . . An idea, then, is a denial of alternatives and an answer to a question. What a man really means cannot be gathered solely from what he asserts; when he asks and what other men assert invest his ideas with meaning. In no idea does meaning simply inhere, governed only by its degree of correspondence with some unchanging objective reality, without regard to the problems of its thinker.⁵

Levenson did not limit his treatment of those ‘problems’ to a dialectic clash of contrasting ideas. When discussing the acceptance of ‘Western’ ideas by some Chinese intellectuals, he stressed the emotional context of such debates.

And no one is so ethereal, so cleanly delivered from native soil and the limited culture which formed him, that he can see its relative disqualification with perfect equanimity. Man is not a neutral machine, calmly recording right answers; if a foreign answer is to be intellectually accepted as right, the native culture’s emotional claims must somehow be squared.⁶

This perspective provided the core of Levenson’s arguments about the rejection of Christianity by westernizing iconoclasts and about the appeal to many of them of communism in its Marxist-Leninist form.

What followed, sustained through three mutually reinforcing volumes, was a brilliant display of how much better Chinese history could be understood by employing this relational, connected approach. I have some doubts in places about his results, but ultimately, Levenson is important because he provided a type of abstraction that shows what we should be doing to get at the real world of the past.⁷ However, Levenson’s own approach works in part because of his ability to establish and control relationships in sentences that many editors and readers would reject because of their length and complexity. When he summarized how the end of Monarchy fundamentally transformed the thought of Confucianists, Levenson wrote:

When republican ‘men of the future’ set the pace, they not only abandoned traditionalism on their own account, but transformed the traditionalism of those who never joined them, turning it into nostalgia which is thirst for the past, not a life-giving fluid itself.⁸

Or to present an even longer, more convoluted example, in an apparent explanation of his earlier treatment of the ‘little life’ and ‘empty career’ of the ‘small Confucianist’ Liao P’ing,⁹ Levenson argued:

And so the historian, by abjuring judgement in his ambiguous way, has a chance to be an alchemist. With an even-handed allocation of historical significance, he treats unequal quantities with equal *historical* respect. And thereby he may be converting dross (by his contemporary standards of

judgement which are *not* abjured) into the gold of a work of historical art. The historian's task, his golden opportunity, is to make what seems not valuable into the invaluable. Perhaps his comprehension, when formed into his creation, will make memorable the works and days which value-judgement, unmitigated by historical judgement, would leave neglected. Thus, far from being a relativist in a nihilistic sense, he seeks to create something in the here and now out of the nothing of the *historically* significant. His creativity makes it historically *significant*, and his own creative act, by submitting itself to judgement, confirms judgement as meaningful instead of confounding it as vain.¹⁰ [emphasis in original]

This dependence for success on his personal prose style suggests that he developed a technique which would be difficult to duplicate. GIS offers historians the possibility of establishing and presenting connections within a changing, complex system in ways less dependent on a style that would be hard to master and employ.

From the perspective of geographically-integrated history, Levenson did not tie his account closely enough to place. 'China' represents a huge territory, as large as Europe or South Asia. Although 'China' served as an imagined place for Confucian intellectuals and Chinese nationalists, it is also a collection of geographic locations where the people Levenson discussed lived and worked. Lacking a firm tie to place, Levenson's account often appears to float above the 'native soil' and everyday life to which Chinese intellectuals were rooted emotionally, whether Confucianists or Nationalists.

Moreover, his presentation of process is too often dependent on the use of abstract entities that are reified into actors, particularly in the case of the principal dichotomies around which he builds each volume. At some point he became aware of the problem because in the General Preface of the 1968 trilogy, he insisted:

Accordingly, when I conjure up dichotomies . . . these are offered, not as stark confrontations really 'there' in history, but as heuristic devices for explaining (not conforming to) the life situation. Only categories clash, categories of explanation. What they are used to explain is the overlapping, intermingling, noncategorical quality of minds, situations, and events. Antitheses are *abstractions* [my emphasis], proposed only to let us see how, and why, their starkness in definition is mitigated in history.¹¹

But too often, Levenson's categories duplicated those central to aspects of classical social theory, as in the cases of traditional/modern, aristocracy/bureaucracy, or feudalism/absolutism, for example. Levenson himself emphasized¹² that although we note the relational nature of the interpretive schemes employed by other, unfamiliar peoples, we too often unquestioningly take our own as rational, 'trans-historical absolutes', 'the norm of norms', which Levenson correctly felt no one possesses.¹³ It is too much to expect that Levenson's readers, and often the author himself, would accept, in the face of their continual reification, as only abstractions not

in the real world the conceptual terms that most other scholars presented as descriptive of that world. In the end, even a thinker and writer of Levenson's talent could not hit upon a way 'to restore the whole in comprehensible form'.¹⁴ Three decades later, Andre Gunder Frank would offer another type of relational, connected approach designed to provide a vision of a world history that would be more than 'the sum of the histories of separate civilizations'.

The Importance of Connections in World History: Andre Gunder Frank

In his book *ReORIENT: Global Economy in the Asian Age* (1998), Andre Gunder Frank explained why, in the quest for a type of history that allows us better to understand the real world, the major works of 'classical' social theory, themselves the descendants of the Newtonian revolution, have to be consigned to the bibliography of those books that must be read to understand the ideas of a particular era while offering little help in our quest to grasp world history. Frank had not read Levenson's masterpiece,¹⁵ but he offered a way out of some of the analytical problems for which Levenson never discovered a satisfactory solution. But Frank admits that he really does not know how to undertake the 'holistic global analysis' he advocates.

Frank was as determined as Levenson to reject approaches to world regions that postulated the existence of some perpetual civilizational essence, which shaped and continues to shape the destiny of each. However, he did so much more conscious than Levenson of the need for a radical rejection of classical social theory with its prominent Marxian and Weberian roots. Despite having influenced and collaborated with Immanuel Wallerstein, Frank targeted Wallerstein's thesis about the modern world system for challenge. Wallerstein published, beginning in 1974, a detailed three-volume history, in which he combined the usually antagonistic elements of modern social theory associated with Karl Marx and Max Weber into a coherent discussion of the development of Capitalism in Europe out of the so-called crisis of Feudalism and the subsequent incorporation of the world's other regions into an increasingly global Capitalist world system.

By the beginning of the 1990s, Frank had developed serious reservations about the idea of a modern world system, much to Wallerstein's obvious disgust.¹⁶ While Levenson's 'avenue of entry' into history was the study of ideas, Frank's was economics, the field in which he received his Ph.D. from the University of Chicago in 1957. *ReORIENT* was part of a complex research program based on Frank's more recent view that geographically large economies, among them ones that have extended over major portions of Afroeurasia during the last 5000 years, have characterized much of world history. If true, this observation would negate the uniqueness of Wallerstein's modern world system and cast

doubt on many of the theoretical foundations of the social sciences and historical scholarship from the Enlightenment until now.

Frank attacked all 'Eurocentric' claims that 1500 represented a sharp break and opened a new age in which unique European characteristics (for example, rationality and efficiency) and institutions (for example, private property rights and political freedom) permitted that region to be the birthplace and center of 'Capitalism', born of a transition from 'Feudalism', which then spread through the incorporation of other regions (labeled as backward, stagnant, stationary, and traditional) into a European (and later Europeanized North American) dominated system. Instead, he described 1400–1800 as a period in which the pre-existing Afroeurasian (and increasingly global) economy expanded, but primarily in Asia where India and especially China were the principal regions for productivity and competitiveness. Because Europe retained its marginal position in the patterns of global interaction, the point at which to mark a new historical period is not the usual 1500, when Europe's rise to world hegemony and its reputedly distinctive forms of state-building and capitalism supposedly began, but 1400 when Asia's major regions, especially China, began to expand more rapidly in production, commerce, and population than anywhere else. Europeans covered their region's deficiencies, represented by its chronic balance of payments deficits, through the infusion of American precious metals.¹⁷ Just as its design had changed in the past, the always unequal structure of interactions among regions 'inflected' or 'inclined' about 1800 to Europe's and then North America's advantage,¹⁸ a pattern which Frank suggested may now be shifting again toward East Asia. This outright rejection of the building blocks of so many theses of European 'exceptionalism' and the 'rise of the West' provides an impressive foundation from which to build an alternative vision to those associated with classical social theory.

Thus, Frank undermined existing claims of European exceptionality, theories about the origins of Capitalism, and theses about 'modes of production' designed to preserve prevailing views of a dynamic, rational 'West' contrasted to a stagnant, traditional non-West (whether called Orient, East, or Third World). He argued that because during the period 1400–1800, there existed a world economy that profoundly shaped developments in all of its parts and the relations among them, the evidence about no region's history can be understood without employing a 'holistic global analysis', an alternative perspective that demands a reassessment of periodization, the nature of continuity and change, the form of historical explanation, and the way research questions are posed. He described the necessary approach as a three-legged stool for which the supporting analyses would focus on (1) ecological, economic, and technological aspects; (2) political/military interactions; and (3) social, cultural, and ideological issues. However, Frank acknowledged that he did not know how to integrate all of the relevant factors into the necessary

‘globological’ analysis.¹⁹ He did not carry his critique to any examination of the theory of the State, and he ignored the many phenomena usually labeled ‘culture’. He did not know how to deal with the cognitive habits of mind or interpretive perspectives of the cultural environment and their possible role in shaping human action.²⁰ Frank concentrated on the economic part of the first leg, because he felt it is the most neglected, and admitted after the book’s publication that in doing so, he gave too little attention to environmental history.

In his reflections on Frank’s work even before the publication of *ReORIENT*, world-systems Sociologist Albert Bergesen argued provocatively that the demand that all attempts to explain historical processes had to start from a focus on world history entails significant consequences for social theory. He felt that Frank was showing, through the description of cyclical economic and political tendencies common to widely separated population centers, that the basic unit of analysis must be spatially large interactive networks. Painting the research environment as one in which perspectives associated with Marx and Weber are increasingly found wanting, Bergesen asserted that the situation mandates the interrogation of existing concepts and theories and the creation of a ‘post-world-system theory’, which he feels Frank began.²¹

The great problem with Frank’s vision is that it provides little scope for human agency, which is central to Levenson’s trilogy. The decisive, creative actions of individuals appear ground down by the relentless, pulsating movements of a global economy. Moreover, although this economy may be greater than the sum of its parts, these local parts interact with, and therefore clearly influence, the nature of the economy as a whole. But how does one analyze and then write about such interactions among connected geographic locations? It is the contention of this article that Geographic Information Systems (GIS) offers researchers the possibility of developing the geographically-integrated, connected world history, which is necessary to understand the histories of any of the world’s locations and individuals.

GIS and the Aggregation of Information by Place

The utility of GIS in business and government makes it ubiquitous in our lives, but most historians do not know the technology exists and frequently confuse it with Global Positioning Systems (GPS). In the early years of its development, GIS was used to explore complex interactions in the natural environment and to organize military information. Although its history has been suppressed on its Web site, ESRI, the major GIS software producer, gets this strange name from the original one, Environmental Systems Research Institute. The name became limiting as the technology came to be used for so many tasks. Oversimplifying a bit, the standard GIS data model organizes information into layers, with each

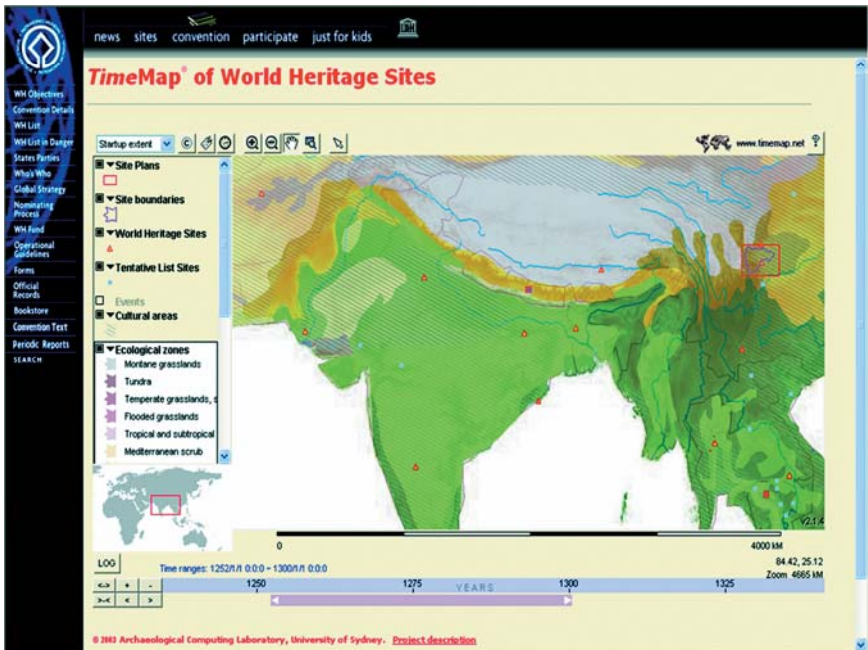


Fig. 3. *TimeMap* of World Heritage Sites. Shows these sites in the context of ecological zones. Each type of information is contained in a distinct layer, and the user builds the visualization by overlaying one layer over another. Other data sets could be imported and used as layers to provide additional context to the sites. Among the tools above the map are those for zooming in and out. Notice the time bar below the map, which can be moved left or right to select data about sites from different chronological periods. Image and permission to use it provided by Dr Ian Johnson, Director, Archaeology Computing Laboratory, University of Sydney.

layer dedicated to a particular type of data (Fig. 3). The user overlays data layers on the computer screen in order to visualize relationships among them. The system is a ‘geographic’ one because all of the information must be *georeferenced* on the basis of place and the geographic coordinates of longitude and latitude in decimal degrees.²² By organizing information in this form, the user can recombine and disaggregate data, display selected features, and explore what is known in ways that facilitate analysis of complex problems, such as the potential impact of adding more livestock to a grazing allotment, and expose unexpected spatial relationships. The usual form of visualization is a cartographic one of some sort, and the user can easily print maps to facilitate planning and presentations to policy-making groups. This was the GIS I learned in 1998, and I arrived at those first workshops in search of a way to comprehend complex information environments that had troubled me for decades.

At the beginning of my graduate studies in 1966, a professor told me that I should read Fernand Braudel’s *La Méditerranée et le monde méditerranéen à l’époque de Philippe II* because my graduate adviser, the Italian economic

historian Domenico Sella, was closely associated with the ‘*Annales* School’. Moreover, I wished to study the western Mediterranean and plunged into this 1949 book with considerable enthusiasm despite its imposing length.²³ As I read Braudel’s attempt to integrate the slow changes in the Mediterranean’s geographic form, climate, and flora and fauna with the faster alterations in human socio-economic relations and the specific events of the sixteenth century, I struggled to visualize how these different layers of the account fit together and how people maintained connections among the various economic and political centers. In an effort to integrate better the elements of Braudel’s account, I obtained a topographical map of the Mediterranean Basin and tried to sketch the various types of information on transparencies with outline maps of the same scale and projection. The effort produced nothing more than a visual mess, which also failed to capture the considerable dynamism of Braudel’s story. Moreover, I repeatedly felt frustrated that I could not easily examine particularly interesting segments of my visualizations at a larger scale.²⁴

Despite this failure, I tried the technique again in 1983 on a hot, sleepless night in Murcia, Spain. This time, I was investigating the development of a cohesive oligarchy in southeastern Castile and wanted to *see*, literally, how my different types of data went together. I was particularly interested in the social networks among individuals, families, and communities. Even for this more spatially restricted story, no useful result emerged. Yet when I told this story early in 1998 during an online discussion with Andre Gunder Frank of possible titles for his forthcoming book *ReORIENT*, historical geographers Martin Lewis and Kären Wigen, who were participants, wrote me independently of each other to explain that a method existed to undertake the type of visualization I had earlier attempted. They recommended that I try GIS as an information integration and visualization tool, which facilitated the analysis of spatial relationships. The following June, I participated in my first GIS workshops and quickly saw that the software provided an aesthetically attractive means to visualize and analyze some of my data.

Because visualization has not been significant in the discipline of history, I should emphasize that visualizations of information are *abstractions*, which provide useful approximations of the real world. Like the articles and books written by historians, which are also abstractions, cartographic and other visualizations should be judged on the degree to which they correspond to available evidence and increase our understanding of reality. Visualization reduces the cognitive weight on the analyst or learner when the quantity of information, both quantitative and qualitative, is great, a problem is complex, and alternative solutions are numerous and surpass the capabilities of human reason.²⁵ GIS permits the visualization of the complex interactions among different types of data at varying scales, and visualization is likely to be the only effective means for the comprehension

and communication of the spatial-temporal form of the world and its processes. World historians will need concise, clear, and striking visualizations to implant their concerns and conclusions within the discipline of history, to teach what we have learned, and to project our perspectives about significant problems into public forums. Particularly when founded on some form of cartographic representation, visualization, by engaging the remarkable human visual system, draws students and those who attend public meetings or lectures more quickly into discussion and analysis, better supports their memory of significant details, and more rapidly increases their thinking performance and learning than consideration of the same issues without the use of visualization. The creation of a GIS-based visual display is an 'information design decision' made to preserve the complex, dynamic, multi-dimensionality of interactions and to avoid teleological accounts and the reification of entities like the 'State' as historical actors causing change. Written accounts too often force such multi-dimensional interactions into a two-dimensional, linear narrative, which deforms the understanding of reality.²⁶

Although pleased with the aggregation on the basis of place of information about multi-layered human communities, I recognized that the GIS I learned was inadequate for some of my research. The GIS 'view' was static, and historians deal with dynamic processes of change over time. The only 'connections' between locations were roads and public utilities such as gas and water lines, and these representations did not help me visualize interactions. Moreover, while completing workshop exercises related to weed abatement and the location of retail stores, I struggled to devise ways to integrate multiple voices and individual experiences. When I discovered other historians who used GIS, they were often products of geography departments whose research frequently concentrated on just the issues of environmental conditions, land use, demography, and the spatial distribution of phenomena such as voting, languages, religions, economic activities, crime, and components of the built environment for which GIS was being used to deal with contemporary matters. Attracted by what is done by the larger GIS community, their work dealt mostly with 19th- and 20th-century themes about which they could find data similar to that used by other GIS professionals. In its existing form, GIS permits the creation of striking 'snapshots' of complex patterns of relationships from different periods of interest. Perhaps the most useful to historians for such visualizations is the *TimeMap*TM software created by Ian Johnson and his collaborators at the University of Sydney's Archaeology Computing Laboratory.²⁷ The interface includes a 'time bar' so that users can move through data from various time frames (see this tool in Fig. 3). These studies using current GIS software, usually lumped into the category of 'Historical GIS', frequently provided valuable insights, which became apparent through geographic visualization, but I felt that more could be done with GIS that would be useful to historians.

Also, unless a means could be found to represent in a GIS project the interactive connections among places, it would be impossible to integrate these existing studies of local, national, or regional topics into a real world history.²⁸

As I read more about GIS, I discovered that others using the software were developing ways to integrate into databases the expressions of multiple voices and experiences, which I needed to do in my work. I taught a comparative course on the creation of countries on the basis of written constitutions, and as a long-time human and civil rights activist, I had become particularly interested in the remarkable South African constitution of 1996, which is characterized by a very inclusive bill of rights and a determination to restore land to displaced and fragmented indigenous groups. Therefore, I was struck by the GIS work of Trevor Harris of West Virginia University and his research colleagues. To capture different understandings of the land's meaning, in reference to sacred places for example, they embedded into the data for different places various documents and eventually, in a presentation I saw Harris give in January 2000, video clips of elders describing what the land had meant to their people.²⁹ I soon learned, particularly from Harris, that GIS was also being used to facilitate popular participation in various planning and community development activities.³⁰ A historian could integrate historic texts, documents discussing data problems and significance, photographs and other images, audio and video clips, and visualizations of the activities of individual men and women into a GIS database. I recognized that I possessed a means for the aggregation of historic information on the basis of geographic location, which provided a rich ethnographic context for understanding the variables shaping human action in a particular location, for using multiple methods of interpretation, and for inserting historic concerns into contemporary community life (Fig. 4). Over time, historians will be able to correct and expand the data sets aggregated in GIS databases, and to obtain the information necessary for world history, the discipline will be transformed into one characterized by collaboration and data sharing.³¹ To escape the apparent limitations of 'Historical GIS' practice, I began to refer to what I wanted done as 'Geographically-Integrated History'.

Geographically-integrated history and GIS offer a way forward to significant improvements in the comprehension of history at all academic levels and in the public arena. In order to provide leadership for this journey, my colleague Laura Woodworth-Ney and I designed in 2002 a new type of internship-based graduate program focused exclusively on the use of aggregated, georeferenced information and GIS for historical research and teaching.³² As we conceptualized the program we wanted, we were able to extract from the geography literature critical of GIS as a supposedly 'positivist' tool some useful research ideas. Unfortunately, so much of this writing is informed by essentialist dualisms and the failed

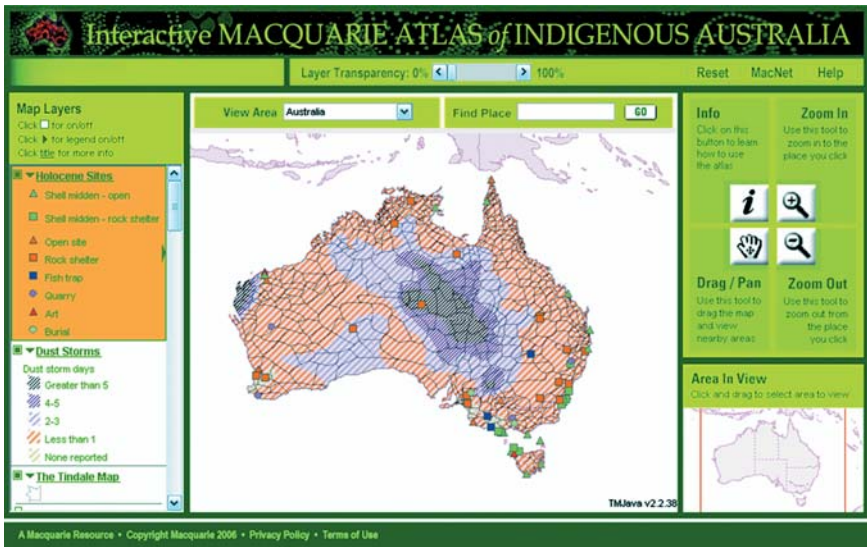


Fig. 4. Interactive Macquarie Atlas of Indigenous Australia. Although the visualization shown here presents Holocene archeological sites in relationship to prevailing weather conditions (dust storms), this Web site could present a great deal of information about indigenous peoples by including icons linking to photos, documents, images of artwork, and audio and video clips, which would allow their living descendents to offer their perspectives. Image and permission to use it provided by Dr Ian Johnson, Director, Archaeology Computing Laboratory, University of Sydney.

theory gods of psychoanalysis and Marxism that it offers little concrete guidance to researchers.³³ In general, historians do not show interest in creating universal, law-like generalizations, and on the basis of our backgrounds and activities, Laura and I had already recognized the need to represent qualitative data and multiple perspectives, including spatial and temporal ones, in GIS-based research and visualizations. Both of us have been active in a community historic preservation movement, which aims to revitalize the downtown area and surrounding core neighborhoods. For over 30 years, I have held a variety of leadership positions in the Branch for southeastern Idaho of the National Association for the Advancement of Colored People (NAACP), of which I am the immediate past president and a current executive committee member. This organization, which is the oldest NAACP Branch in the state, focuses primarily on acts and patterns of discrimination directed against African Americans and Hispanics. I am bi-lingual and a member of ISU's Latino Studies faculty. Laura is the immediate past co-director of the Women's Studies program (and current History Department chairperson), and she is an expert on our region's Native American history, maintaining excellent relations with cultural and political leaders of the large Fort Hall Reservation just a few miles north of the main university campus. One

of our primary motivations in creating such a unique graduate program is to draw more women and minorities into a technologically rich educational and employment environment in which these groups are currently underrepresented. We expect that our multiple community contacts will provide some exciting historical internship possibilities for the graduate students and interested undergraduates.³⁴

GIS and Interactive Connections

Joseph Levenson showed historians can only understand the meaning of an idea, action, or institution by exploring the interactive connections which shape the processes that constitute reality. Andre Gunder Frank argued that geographic locations have been linked to geospatially large systems and that the dynamic connections of places to a system and each other continuously shaped the history of each location all of the time. GIS could aggregate information by place to provide a basis for multidimensional, multivariate analyses, but unless this information technology's data model permitted representations of networked economic, sociopolitical, and cultural interactions among locations in the world, it would not serve as an effective tool for real world history. It should occasion no surprise that GIS software developers have paid no attention to the needs of historians, and adapting their commercial products for historical research and teaching is often a frustrating experience. GIS does a pretty good job of organizing information to reveal the form of the world, but the tool provides weak support for understanding the world's processes.³⁵

To get what world historians want from GIS, we must define the nature of the geographic connections we wish to explore. For reasons presented by historical geographers Martin Lewis and Kären Wigen,³⁶ it is necessary to begin by disaggregating the huge entities, such as China and India, with which Levenson and Frank often played. Instead, one should start with a particular region, a Fukien or Orissa, or perhaps a particular commercial, manufacturing, administrative, or cultural center and its hinterland, a Zhangzhou or Hughli. Then we must identify the interactive economic, political (including military and ecclesiastical), and information networks continuously linking the locus to other loci (Fig. 5). Changes in the pattern and intensity of these networks shape changes within all of the connected places. Because of the inadequate theoretical tools available, we can arrive at an understanding of historical process only by beginning with a description of such interactions.³⁷ I prefer to begin such description by defining what Wigen once proposed calling 'world networks history', in which one first seeks the greatest spatial extent of the 'patterned interactions' of any particular locus and then compares the local developments of the places linked by such interactive networks. Real world history involves a concentration on regular, interaction networks of varying density linking loci over an often global space.³⁸ These networks

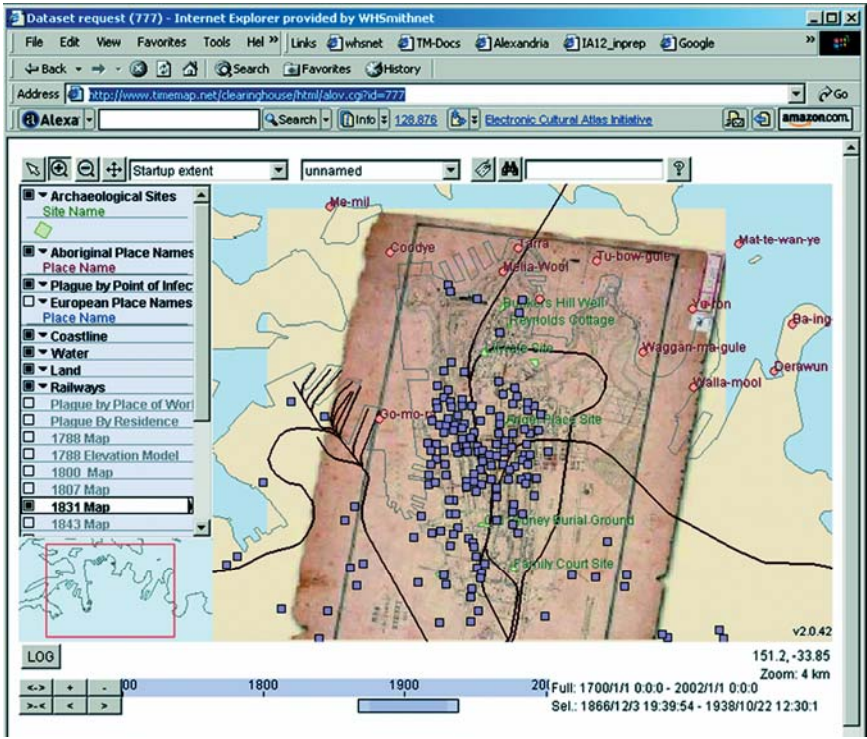


Fig. 5. Connections and Disease. Among the things that move along the networks linking geographic places are disease organisms. A user has obtained a plague epidemic data set for Sydney sometime between 1866 and 1938, which shows the presence of plague by point of infection. Such a data set would include *metadata* providing information about the data, such as the nature of the documentary sources from which the information was derived. In the visualization, this and other data sets overlay an 1831 map of Sydney, which shows how historic cartography might be employed in a GIS project. Notice how archaeological sites and indigenous places have been georeferenced to the historic map. Image and permission to use it provided by Dr. Ian Johnson, Director, Archaeology Computing Laboratory, University of Sydney.

of interactions evolve and transform the contexts and nature of human action. Major changes in the nature and pattern of interactive networks should be the bench marks of periodization, for these changes reshape the social and cultural environments of human action in each of the interlinked loci, while at the same time, the interactive density and design of the networks themselves respond to 'local' action.

Fortunately for historians, major economic sectors also want to know what moves through networks connecting places. For example, the use of GIS will expand to the extent that this information technology can meet the needs railroad and package transportation companies to visualize movements within their complex operations. To meet this demand, the major GIS software company ESRI has begun to use object-oriented

computer programming to capture such flows in both space and time. Because applications will often need to be customized for a particular user, ESRI has started using an open-source programming language, Python, which reveals its code to those who want to contribute to shaping this GIS environment.³⁹ Instead of freezing visualization into static representations of information at different points of time, the possibility now exists to visualize even fairly complex historic processes over any time period.⁴⁰

In order for historians to benefit from this development of spatio-temporal dynamics, appropriate mathematical models must become part of the GIS in order to represent information properly in databases. This will not be easy for two reasons. First, the number of appropriate existing spatial models is inadequate to deal with human social and cultural environments.⁴¹ In many cases, these will have to be developed through collaboration between historians and mathematicians. Second, complex, dynamic, non-linear processes are probably much more common in the natural world than simple, linear ones, and non-linear dynamics is a challenging area for modelers. Although it is not possible to explain the matter in this article, such models will serve as useful analytic tools for historians in general and world historians above all. They can compensate for the often fragmented, incomplete, variable, imprecise, heterogeneous, generally 'messy' data with which most of us work, which includes information that does not fit easily into a tabular database.⁴² Even more importantly, organizing information within an appropriate model will help world historians deal with a common complaint when they deal with major transformations such as that suggested by Levenson's title *Confucian China and its Modern Fate* or that of the world economic system around 1800. In the face of a large number of variables, world historians struggle to explain how systems that were stable for centuries would, in a relatively short period of time, become unstable and then reorganize into a quite different system. One of the most prominent experts on this type of system, Hermann Haken, has explained that in any dynamic, non-linear system, probably only a few variables are responsible for the system's stability even if it is a high dimensional one. When they become unstable, the entire system moves into a period of instability characterized by the emergence of new forms and the organization of another system, which is qualitatively different from its predecessor.⁴³ Although the crucial variables of a system may not be obvious and the nature of the system that replaces it will provide no clues to what they might be, the interpretive task of historians will be much more manageable than if the explanation of transformation had to take account of all of a system's variables.

To take advantage of the emerging information management possibilities of GIS, world historians must break with the model, typical of history as a discipline, of the single researcher who masters all of the sources and techniques necessary to solve his or her chosen problem. Because such

individual mastery is impossible, even for a world history project dealing with a short chronological period, historians will have to collaborate. This collaboration must be truly interdisciplinary, involving not only groups of historians but also experts in other social sciences, ecology, geosciences, cartographic and graphics design, computer science, and mathematics, and it will entail joint publication. By breaking down the barriers of specialization, these collaborations should lead to the emergence of new ideas.

Historians will have to take the initiative to create this new disciplinary order by taking GIS in new directions and forcing change. In order to explore how such a collaborative research community might be created and managed, I have initiated a project within a program of the EUROCORES (European Collaborative Research) Scheme of the European Science Foundation. The program is entitled 'The Evolution of Cooperation and Trading' (TECT). Classical economic and evolutionary theory focuses on competition, but cooperation is widespread in the natural world and among humans. TECT projects explore the fit between existing theory and data about cooperation in exchanges at various scales. I called my project 'Dynamic Complexity of Cooperation-Based Self-Organizing Commercial Networks in the First Global Age', the official acronym for which is *DynCoopNet*. The DynCoopNet collaborative research community, which now numbers over 40 researchers in sixteen countries on five continents, will spend three years studying at various scales the notably high levels of cooperation among merchants and others within the trading networks of the first world economy, 1400–1800. Understanding human cooperative behavior in trading activities requires the use of both quantitative and qualitative information about the period's social and cultural environments of human action, and DynCoopNet's research questions reflect the multivariate nature of our topic. One of our major hypotheses is that in the world economy of the first global age, as cooperating commercial partners elaborated more complicated networks to preserve flexibility to handle disruptions in the circuits of commodity, capital, and information flows, the greater complexity led to the emergence of new forms, resulting in transformations (bifurcations) that qualitatively altered the system, which ultimately led to a second global age in which the cooperative commercial behavior of the earlier system was marginalized (as in the case of today's *hawala* networks in the Indian Ocean region). The DynCoopNet community includes lots of historians to share sufficient historical expertise and data, researchers from other social sciences, GIS experts, cartographic and visualization designers, and mathematical modelers. GIS will serve as our tool to manage the necessarily large, digital, spatial database, which will include tabular data, texts, images (especially of historic cartography), and 'smart documents' to explain the sources of the data and expose the conclusions of expert analysts from different disciplines. We will create an interactive web portal to permit researchers to work with this material (Fig. 6) and a true



Clearinghouse Search

Fig. 6. Electronic Cultural Atlas Initiative (ECAI) Clearinghouse. This *TimeMap* portal allows users to locate available data sets, which can be shared over the Internet. Notice that the user can visualize data availability simultaneously by geographic region and time period. For the period selected, roughly 700 to 200 B.C.E., most of the 'ECAI clearinghouse' data sets deal with Afroeurasia. If the user had selected the 'David Rumsey map collection' and the period 1750 to 2000 C.E., the data visualization would display a heavy concentration of material about the Americas. Image and permission to use it provided by Dr Ian Johnson, Director, Archaeology Computing Laboratory, University of Sydney.

spatiotemporal GIS to facilitate data mining and the visualization and dynamic analysis of the evolution of the complex world system of the first global age.⁴⁴

With the integration in a GIS of the multiple types of information about geographic locations and interactive networks, GIS becomes a tool for thought, for fusing holistically an increasingly complicated information environment. When their information is organized in this form, historians find it much easier to recombine and disaggregate data, to display selected features, and to explore interactively what is known in ways that expose unexpected relationships and facilitate analysis of complex problems. Moreover, because GIS software permits the alteration of the scale at which the data is examined, historians will be able to work out specific cases in great detail. World history, as an intellectual enterprise, cannot be defined solely in terms of a unified approach moving toward very general, abstract understandings of large-scale spatial and temporal patterns,

however important this framework may be for grasping the histories of particular places and the connections among them.⁴⁵ We will still want detailed narratives about those places and the people who lived and visited there in order to understand how their histories were shaped by their interactive connections to other places and people.

It will be exciting to be a historian in the 21st century. Geographically-integrated history and GIS will play important roles as historians transform the ways they work and interact over the next decade in the face of the massive changes in the global economy and communications. Historians can and must embrace new forms of research organization and rapidly evolving types of information management and analysis, for historical scholarship and thought are not necessarily tied to traditional forms of individual research projects and monograph publication. The alterations will unsettle us, but if history as a discipline is to retain a viable place in the academy and public intellectual life, we must embrace change and shape it to serve our needs.

Short Biography

J. B. Owens's research has focused on the cultural, economic, and social contexts shaping the exercise of political authority in the Kingdom of Castile during the period 1400–1700, and, as a vehicle for studying world history, on non-linear, dynamic change in complex human communities, particularly the global Hispanic Monarchy, which integrated the domains of the Iberian crowns of Aragon, Castile, and Portugal. His pioneering 1980 book, *Rebelión, monarquía y oligarquía murciana en la época de Carlos V*, stimulated numerous publications by others on Spain's municipal oligarchies during the first global age and contributed to the debate over the rebellion of the *comuneros*, 1520–21, and its impact. In addition to articles and reviews, he published another book in 2005, *'By My Absolute Royal Authority': Justice and the Castilian Commonwealth at the Beginning of the First Global Age*, which argues that perceptions of royal judicial administration shaped the degree of collaboration with the Crown by the kingdom's politically important groups. For almost a decade, he has explored smuggling networks within the global Hispanic Monarchy and the use of Geographic Information Systems (GIS) for the organization and analysis of information. With Laura Woodworth-Ney, he is the co-creator of an innovative, GIS-based Master's degree program in geographically-integrated history, in which he teaches cartographic visualization and the use of GIS in historical studies. With colleagues at the Universidad Politécnica de Madrid, he is developing a GIS-based digital atlas of Roman Catholic devotional shrines within the territory of the modern country of Spain from the early Middle Ages until 1970. He has recently held fellowships from the National Endowment for the Humanities (2004–05) and the John Simon Guggenheim Memorial Foundation

(2005–06). At the termination of the latter, he formed a multidisciplinary, multinational collaborative research community to use GIS for the study of the role of cooperation among merchants and others during the first global age, 1400–1800. This project is a component of a program of the EUROCORES (European Collaborative Research) Scheme of the European Science Foundation, which is entitled ‘The Evolution of Cooperation and Trading’ (TECT). Owens’s support for this project comes from the U.S. National Science Foundation. Before coming in 1975 to Idaho State University, where he presently teaches, Owens taught at New York University and Lehigh University. He was named ISU’s Distinguished Researcher in 2002. He holds a B.A. from Oberlin College and an M.A. and Ph.D. in History from the University of Wisconsin–Madison.

Notes

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¹ Organization of American Historians, *LaPietra Report: A Report to the Profession*, 2000, <http://www.oah.org/activities/lapietra/final.html>, accessed on April 30, 2007. This document constitutes a devastating attack on the way U.S. history is generally taught. Its central point is that because the history of any place has been profoundly shaped by the way that place is connected to other locations and the changes in the pattern of those interactions over time, you cannot make sense of U.S. history without taking into account the ways in which the country has been linked to other places in the world. For a more recent expression of similar concerns, see the online documents from the research agenda symposium ‘Research in World History: Connections and Globalizations’, which was held in Boston, November 1–12, 2006, <http://www.worldhistorynetwork.org/dev/conference.htm>, accessed on May 28, 2007.

² As quoted by J. R. Levenson, *Confucian China and its Modern Fate: The Problem of Intellectual Continuity* (Berkeley, CA: University of California Press, 1958), xxvii.

³ J. R. Levenson, *Confucian China and its Modern Fate: A Trilogy* (Berkeley/Los Angeles, CA: University of California Press, 1968), General Preface, xi.

⁴ J. R. Levenson, *Confucian China and its Modern Fate: The Problem of Monarchical Decay* (Berkeley, CA: University of California Press, 1964), viii.

⁵ Levenson, *Problem of Intellectual Continuity*, xxviii–xxix. Levenson’s fascination with Mozart served as a unifying theme for a memorial volume; see M. Meisner and R. Murphy (eds.), *The Mozartian Historian: Essays on the Works of Joseph R. Levenson* (Berkeley/Los Angeles, CA/London: University of California Press, 1976).

⁶ *Ibid.*, xxxii–xxxiii.

⁷ In my book ‘By My Absolute Royal Authority’: *Justice and the Castilian Commonwealth at the Beginning of the First Global Age* (Rochester, NY: University of Rochester Press, 2005), I apply Levenson’s relational approach, and especially the second volume, *Problem of Monarchical Decay*, to an analysis of the exercise of political authority by Castile’s rulers from the fifteenth to the seventeenth century, for whom similar claims of despotic power have been made.

⁸ Levenson, *Problem of Monarchical Decay*, 139.

⁹ Levenson, *Problem of Historical Significance*, 3–15.

¹⁰ *Ibid.*, 90.

¹¹ Levenson, *Trilogy*, xi.

¹² For his short essay on the subject, see Levenson, *Problem of Historical Significance*, 85–92.

¹³ *Ibid.*, 87.

¹⁴ Levenson, *Trilogy*, xi.

¹⁵ I provided Frank with a brief description of Levenson's approach from which he extracted Whitehead's concept of the 'fallacy of misplaced concreteness', which was a phrase Frank particularly liked.

¹⁶ See I. Wallerstein, 'Hold the Tiller Firm: On Method and the Unit of Analysis', in S. K. Sanderson (ed.), *Civilizations and World Systems: Studying World-Historical Change* (Walnut Creek, CA: AltaMira, 1995), 239–47.

¹⁷ Frank erred in neglecting the development of other American resources, which by the 18th century had given merchants based on both sides of the Atlantic other ways to interact with African and Asian economic zones, especially around the Indian Ocean.

¹⁸ Frank often talked as though the world system had been the same one for thousands of years, with nothing more than a shifting center. It was as though he thought of this system metaphorically as a kind of net or web, which extended over a large geographic area, with greater densities of production and population and greater trade flows represented by thicker nodes and connecting fibers. Therefore, the major shift in the world economy about 1800 represented a redesign of this web, which he sometimes described as an 'inflection' or 'inclination' of the system, placing the thicker nodes and connecting fibers in the North Atlantic world rather than in Asia. At some level, he recognized that this mental model interfered with his ability to explain this shift in the economic center of the world system because from the mid-1990s, he kept asking me to offer an alternative vision of the system. His interpretive difficulties showed up in a much more pronounced way as he worked on a sequel to *ReORIENT*, which focused on the 19th and early 20th centuries. He lacked effective information management tools to deal with the world system as a complex, dynamic, non-linear one in which periods of instability led to the emergence of new forms and a fundamental, qualitative transformation to a different system. In the next section, I discuss how GIS might be used to understand this type of system and its transformation during a period of instability to a different system.

¹⁹ A. G. Frank, *ReORIENT: Global Economy in the Asian Age* (Berkeley/Los Angeles, CA: University of California Press, 1998), 340–1.

²⁰ Frank repeatedly taunted me to demonstrate how political institutions and cultural perspectives shaped human action in significant ways in the first global age. Owens, 'By My Absolute Royal Authority', constitutes my response. Although Frank read drafts of earlier versions of some chapters, he died five months before the book's publication and was, therefore, unable to subject it to a critical review.

²¹ A. Bergesen, 'Let's Be Frank about World History', in S. K. Sanderson (ed.), *Civilizations and World Systems: Studying World-Historical Change* (Walnut Creek, CA: AltaMira, 1995), 195–205. Also, see Bergesen, 'Pre vs. Post 1500ers', *Comparative Civilizations Review*, 30 (Spring 1994): 81–90.

²² For a clear synthesis of work on georeferencing and the implications of the concept, see L. L. Hill, *Georeferencing: The Geographic Associations of Information* (Cambridge, MA: MIT Press, 2006).

²³ At about the same time, a second, revised edition was being published by Armand Colin in Paris in two volumes, but this version had not yet reached the University of Wisconsin library.

²⁴ In cartography, larger scale maps are those that show a smaller geographic area in order to include greater detail and precision. For example, a 1 : 5000 map of a city and its surrounding area is of a larger scale than a 1 : 2,500,000 map, which might be used to represent an entire country. At least in teaching, historians make heavy use of maps, often without enough understanding of cartography to make such instruction as effective as it might be. For a 'short course' on the subject, I recommend reading two books by Mark Monmonnier: *How to Lie with Maps*, 2nd ed (Chicago: University of Chicago Press, 1996); *Mapping it Out: Expository Cartography for the Humanities and Social Sciences* (Chicago: University of Chicago Press, 1993).

²⁵ For a classic discussion of visualization, see R. Arnheim, *Visual Thinking* (Berkeley/Los Angeles, CA: University of California Press, 1969).

²⁶ For these points, I draw on D. J. Staley, *Computers, Visualization, and History: How New Technology will Transform our Understanding of the Past* (Armonk, NY: M. E. Sharpe, 2003). On the importance of designing 'a network-like visual display' of historic information, see Staley's pioneering article, 'Designing and Displaying Historical Information in the Electronic Age', *Perspectives: American Historical Association Newsletter*, 36/9 (1998): 40–4. The phrase 'information

design decision' is from page 41 of this article where Staley offers valuable comments about *information*. My comments on visualization are heavily influenced by the work of Mark Gahegan. In the bibliography, see the articles by Gahegan; Gahegan and O'Brien; Gahegan, Wachowicz, Harrower, and Rhyne; Guo, Gahegan, MacEachren, and Zhou; MacEachren, Gahegan, and Pike; MacEachren, Gahegan, Pike, Brewer, Cai, Lengerich, and Hardisty.

²⁷ <http://www.timemap.net>, accessed on April 30, 2007. I am grateful to Ian Johnson for providing the images that accompany this article.

²⁸ For a detailed treatment of how one can use currently available GIS software for historical research, see I. N. Gregory, *A Place in History: A Guide to Using GIS in Historical Research* (Oxford: Oxford Books, 2002), <http://ahds.ac.uk/history/creating/guides/gis>, accessed on September 10, 2007. For valuable collections of articles, see A. K. Knowles (ed.), *Past Time, Past Place: GIS for History* (Redlands, CA: ESRI Press, 2002); Knowles (ed.), *Emerging Trends in Historical GIS*, special issue of *Historical Geography*, 33 (2005). In the bibliography, see the following notable publications: Ayers and Rubin; Campbell; Cunfer; Donahue; Healey; Heasley; McCormick; Ramankutty and Foley; Siebert; Thomas and Ayers. For examples of GIS-based research projects that are available online, see in the bibliography the *Salem Witch Trials Documentary Archive and Transcription Project* and the *Valley of the Shadow: Two Communities in the American Civil War*. For examples of large infrastructure projects, see in the bibliography the *China Historical GIS* and the *Great Britain Historical GIS*.

²⁹ Much of this demonstration was based on a paper, 'Community-integrated GIS for Land Reform in Mpumalanga Province, South Africa', that Daniel Weiner and Trevor Harris presented in June 1999 to the International Conference on Geographic Information and Society at the University of Minnesota, Minneapolis. On the basic concepts of this type of work, see T. M. Harris, D. Weiner, T. Warner, and R. Levin, 'Pursuing Social Goals through Participatory GIS: Redressing South Africa's Historical Political Ecology', in J. Pickles (ed.), *Ground Truth: The Social Implications of Geographic Information Systems* (New York, NY: Guilford, 1995), 196–222; T. Harris and D. Weiner, 'Empowerment, Marginalization and Community-Integrated GIS', *Cartography and Geographic Information Systems*, 25/2 (1998): 67–76.

³⁰ See D. Weiner, T. Harris, and W. Craig, 'Community Participation and Geographic Information Systems', in W. J. Craig, T. M. Harris, and D. Weiner (eds.), *Community Participation and Geographic Information Systems* (London: Taylor and Francis, 2002), 3–16. This collection contains a number of interesting papers on this subject.

³¹ As is common in many other disciplines, historians will deposit copies of their data sets in online repositories to make them available to others. As an example of such an institution, see the Inter-University Consortium for Political and Social Research (ICPSR) of the University of Michigan's Institute for Social Research (ISR; <http://www.icpsr.umich.edu/>). Like researchers in other disciplines that rely on shared data, historians will have to develop standards for data sharing and joint publication.

³² Information about this program, the M.A. in Historical Resources Management, can be obtained by visiting the Web site of the History Department of Idaho State University at www.isu.edu/history/ or by contacting the graduate program director, Kevin Marsh marskevi@isu.edu.

³³ Frank does a pretty good job of explaining the deficiencies of Marxism and other linear theories of the development of the state, capitalism, civilizations, and the modern individual. One of the best written exposés of psychoanalysis by an expert on serious mental illness is E. F. Torrey, *Freudian Fraud: The Malignant Effect of Freud's Theory on American Thought and Culture* (New York, NY: HarperCollins, 1992). A favorable overview of this geographic literature by an insider is E. Sheppard, 'Knowledge Production through Critical GIS: Genealogy and Prospects', *Cartographica*, 40/4 (2005): 5–21. An excellent review of feminist critiques of GIS is provided by M.-P. Kwan, 'Feminist Visualization: Re-Envisioning GIS as a Method in Feminist Geographic Research', *Annals of the Association of American Geographers*, 92/4 (2002): 645–61. Kwan uses her literature review to launch a discussion of her own fascinating work on visualizing in both space and time the everyday activities of women. Sheppard identifies himself with the critical theory of the Frankfurt School. This body of thought is a good example of the use of multiple *ad hoc* explanations to salvage failed theories, Marxism and psychoanalysis, to the point where they become irrefutable and, therefore, useless. The only sensible thing to do is walk away.

³⁴ In 2003, our department added Kevin Marsh, an environmental historian concerned about how decisions are made about wilderness and forest management, who is graduate program director, and Erika Kuhlman, who replaced Laura as co-director of Women's Studies and leads the department's program to design interactive, GIS-based modules to support standards-based secondary school history instruction, enhance spatial awareness, and disseminate an understanding of GIS technology. Both are active in community organizing to revitalize urban core neighborhoods. Kevin recently published a brief overview of 'The Triangle' area, which was Pocatello's most ethnically diverse neighborhood for much of the city's history and the home of Idaho's largest African American population. In 2007, the department added to the graduate program faculty Sarah Hinman, an expert on the use of GIS to study historic public health problems in racially diverse U.S. cities. The department also includes Ronald Hatzenbuehler, an expert on database design and the use of quantitative data for historical research, Stephanie Christelow, an expert on Norman England who is interested in using GIS to visualize historic landscapes, and Allan Christelow, who works on both North and West Africa and whose research often focuses on the importance of place for an understanding of Islam.

³⁵ On this difficulty, see M. Goodchild, 'GIScience, Geography, Form, and Process', *Annals of the Association of American Geographers*, 94/4 (2004): 709–14; D. J. Peuquet, *Representations of Space and Time* (New York, NY: Guilford Press, 2002). For an overview of the problems driving current developments in GIS and cartographic visualization, see R. B. McMaster and E. L. Usery (eds.), *A Research Agenda for Geographic Information Science* (Boca Raton, FL: CRC Press, 2005).

³⁶ M. W. Lewis and K. E. Wigen, *The Myth of Continents: A Critique of Metageography* (Berkeley/Los Angeles, LA/London: University of California Press, 1997).

³⁷ On this point, see the argument in D. R. Ringrose, *Spain, Europe, and the 'Spanish Miracle', 1700–1900* (New York, NY: Cambridge University Press, 1996). This book deserves to be much better known by world historians. For a critique of Ringrose's method of describing interactions, see the review of J. B. Owens in *American Historical Review*, 102/3 (June 1997): 833–34.

³⁸ K. E. Wigen, 'Bringing the World Back in: Meditations on the Space-Time of Japanese Early Modernity', *Research Papers in Asian/Pacific Studies* (Durham, NC: Duke University, Asian/Pacific Institute, 1995).

³⁹ Python: <http://www.python.org/>, accessed on May 28, 2007.

⁴⁰ This visualization of change might be accomplished by animating the data or by using space as a metaphor for time to visualize change over time as change in some three-dimensional surface or geometric object.

⁴¹ For examples of possible mathematical expressions of the evolution of the complex human communities with which world historians deal, see in the bibliography the works by Dendrinos and Sonis; Hewings, Sonis, and Boyce; Puu; Rosser and Rosser; Sonis; Sonis and Hewings. These expressions do not neglect cultural factors. For example, Michael Sonis is engaged in an analysis of the diffusion of ideologies that help shape 'aggressive intolerance'; see M. Sonis, 'Major Actors in Innovation Diffusion Process', in M. Fischer and J. Froelich (eds.), *Complexity, Knowledge and Innovation Systems* (Berlin/Heidelberg/New York, NY: Springer-Verlag, 2001), 317–41.

⁴² Even in its static form, GIS software usually provided a number of interpolation tools to make use of incomplete data. In order to accomplish useful results with such fragmented and imprecise data, historians will often need to work in collaboration with experts on natural language, artificial intelligence, and advanced cognitive science. The issue is so important within Geographic Information Science that *uncertainty* has emerged as a significant research topic; see J. Zhang and M. F. Goodchild, *Uncertainty in Geographical Information* (London: Taylor & Francis, 2002).

⁴³ This type of process in dynamic, non-linear systems is clearly explained by Swedish economist Tönu Puu, with mathematical expressions, in chapter 12 of his *Attractors, Bifurcations and Chaos: Non-Linear Phenomena in Economics*, 2nd rev. ed (Berlin/Heidelberg: Springer-Verlag, 2003), and without the mathematical expressions, in chapter 7 of his *Arts, Sciences, and Economics: A Historical Safari* (Berlin/Heidelberg: Springer-Verlag, 2006). Hermann Haken's own statement of this principle of dynamic, non-linear systems is his *Advanced Synergetics* (Berlin/Heidelberg:

Springer-Verlag, 1983). An interesting 'Systems Thinking' software, STELLA, is produced by the company isee systems: <http://ahds.ac.uk/history/creating/guides/gis>, accessed on September 10, 2007 (I thank ESRI's Bob Booth for this valuable reference).

⁴⁴ The projects of the TECT program are funded by the European Science Foundation and the national funding agencies of participating countries. For my contribution, I will receive \$394,000 over three years from the U.S. National Science Foundation (NSF), for which I am very grateful.

⁴⁵ On such 'big history', see D. Christian, *Maps of Time: An Introduction to Big History* (Berkeley/Los Angeles, CA: University of California Press, 2004).

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