Chapter 1: GIS and its uses in Historical Research

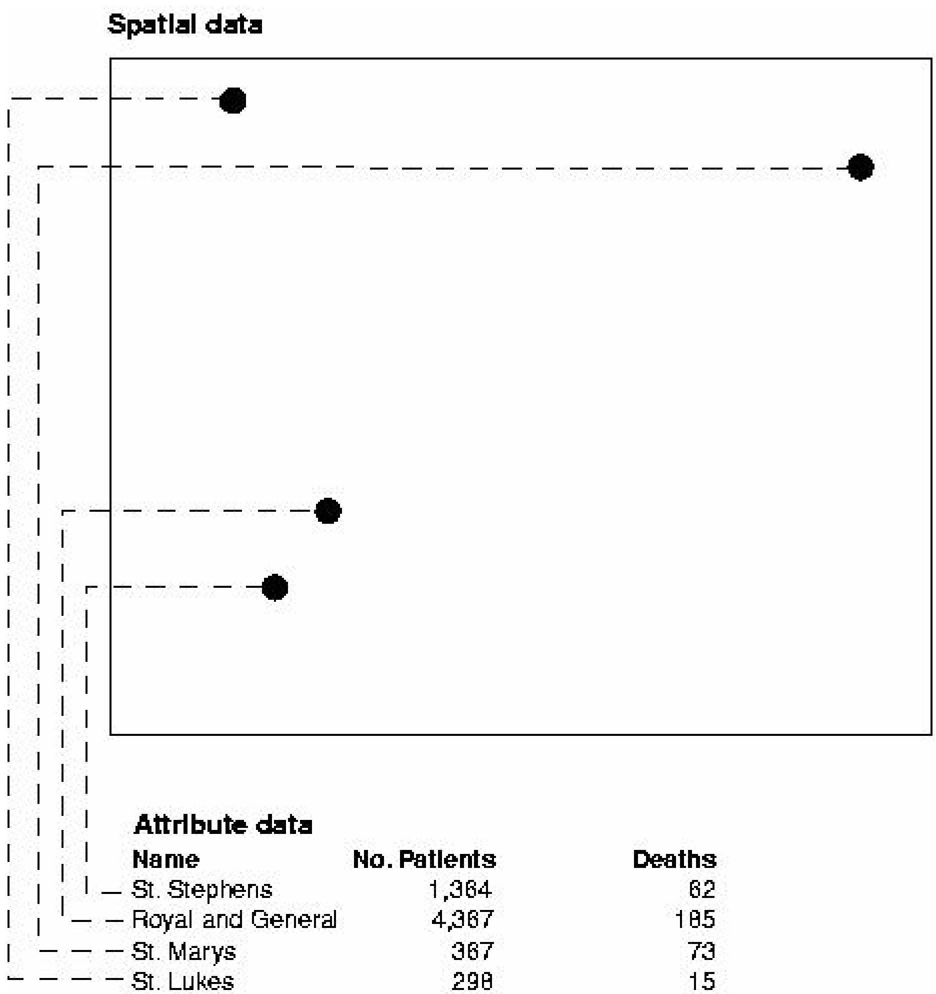
1.1 Introduction

This guide is written for historians and others with an interest in the past who want to use Geographical Information System (GIS) in their work. It covers both creating GIS databases, and exploiting the information held within them. A minimum of jargon has been used throughout and an extensive glossary is provided in Chapter 10. No prior knowledge of GIS has been assumed. In a short text such as this it is impossible to give a comprehensive treatment to most of the themes introduced. Instead, the aim is to highlight the main themes and provide references that allow the reader to follow them up in more detail. There is an extensive literature on GIS but the literature on using GIS in historical research is currently limited. Anne K. Knowles's book (Knowles 2002) marks the first edited collection of case studies on historical applications of GIS and is highly recommended to anyone with an interest in the field. Beyond this, the literature on using GIS for historical applications is widely scattered. This guide attempts to bring this literature together to illustrate how historians have used GIS. To this end each chapter provides summaries of case studies and details further reading on historical examples. As this literature is limited, some studies are quoted in more than one chapter but no study is used as a key reference more than once. The aim is to give the reader an understanding of both the structure of GIS, namely the way that it models the world, and an idea of the mentality that should be followed when using GIS for historical research.

1.2 The terminology of GIS

An examination of the basic GIS texts will give many different definitions for GIS. The reason for this is that there are two basic ways of approaching GIS. It may be regarded from a tools-orientated point of view that explores how the software models the world, or from an approach-orientated point of view that explores what GIS allows us to do.

The tools-orientated approach describes GIS from the point of view of the software, for example, *ArcGIS* or *MapInfo*. These are often regarded as complex computer mapping programs. This is a misapprehension: GIS software combines computer mapping functionality with a form of *database management system* (DBMS) such as *Dbase*, *Microsoft Access*, or *Oracle*. Computer mapping systems such as *Adobe Illustrator* or *CorelDraw* are designed to produce high-quality graphical output. They include functionality such as the ability to draw features, move features from one location to another, change shading and line width, and so on. Although some, but by no means all, of this functionality will be found in GIS software, it is more helpful to think of GIS as a spatially referenced database. As such, the data are represented in two ways. Firstly, there are rows of data found structured in the same way as in a conventional database. In GIS terminology this is called *attribute data*. Many GIS software packages allow attribute data to be stored in conventional database management systems such as the ones described above. The special feature of GIS software is that each row of attribute data is also represented by a spatial feature that is represented by coordinates and is thus mappable. This spatial feature will be a *point*, a *line*, a *polygon* (the technical term for an area or zone) or a *pixel* depending on the type of data it is representing. This is termed the *spatial data.* Using this combination of attribute and spatial data *GIS data* combine information on what an object is with information on where it is located for each feature in the database.



[The basic structure of GIS]

The fact that there are both spatial and attribute data allows the database to be exploited in more ways than a conventional database allows, as GIS provides all the functionality of the DBMS and adds spatial functionality. For example, a user has a conventional database consisting of data on hospitals. The columns in this database include the name of the hospital and the numbers of patients, deaths, and so on. There is one row of data for each hospital. In the GIS this becomes the attribute data. The spatial data in the GIS are a point location for each hospital stored as a *coordinate pair* but represented on screen using a dot or another form of point symbol. The basic structure of this is shown in Figure 1.1. This combined representation of the study area opens up a whole new range of possibilities that neither a DBMS nor a computer mapping system could handle on their own: for example, the GIS allows us to draw the locations of all the hospitals, click on one of them, and have the system list its name and other attribute data. It could also select only the hospitals with, for example, over 1,000 patients. In a conventional database all we can do with this information is list the data for the hospitals concerned. In a GIS we can do this, but we can also draw where they are, or perhaps draw all of the hospitals using different shadings to indicate their different sizes. In contrast to a conventional DBMS, therefore, GIS allows us to gain an understanding of the geography of the phenomenon we are studying. Unlike a computer mapping system, GIS provides the underlying data that form the patterns shown on the map.

The tools-orientated approach shown above demonstrates that GIS software can be regarded as a spatially referenced database. It is able to map the data and also to query it spatially, asking questions such as 'what is at this location?' that a conventional database would be unable to answer. An approach-orientated definition asks how we can make best use of this dual-component data model. This involves considering both the benefits and the drawbacks of including location into our exploration of patterns. In the GIS literature this approach has become known as *Geographical Information Science* (GISc), and Siebert (2000) refers to 'spatial history' in very much the same way. This approach uses GIS as part of the process of exploring change geographically and temporally. 'Historical GIS' is also a term that is becoming increasingly used to describe approaches to historical research involving the use of GIS (Knowles 2000).

One other term that also needs defining in this section is the word *space*. Among the GIS community this term is used in a very similar way to the term *location*. Spatial data are data that refer to locations, and where a GIS book might say 'consider the role of space', a historian may well say 'consider the role of location'. There is, in fact, a slight difference in definition as space is a scientific way of defining location, usually through a coordinate system, thus 'a location in space' usually means a location that can be defined using one or more coordinates.

1.3 Uses of GIS

There are three basic roles that GIS can be used for: as a spatially referenced database; a visualisation tool; and an analytic tool (Gregory *et al*. 2001) A spatially referenced database allows us to ask questions such as 'what is at this location?', 'where are these features found?', and 'what is near this feature?'. It also allows us to integrate data from a variety of disparate sources. For example to study the dataset on hospitals described above, we might also want to use census data on the population of the areas surrounding each hospital. Census data are published for districts that can be represented in the GIS using polygons as spatial data. As we have the coordinates of the hospitals and the coordinates of the district boundaries we can bring these data together to find out which district each hospital lay in, and then compare the attribute data of the hospitals with the attribute data from the census. We may also want to add other sorts of data to this: for example data on rivers, represented by lines; or wells, represented by points, to give information about water quality. In this way information from many different sources can be brought together and interrelated through the use of location. This ability to integrate is one of the key advantages of GIS.

Once a GIS database has been created, mapping the data it contains is possible almost from the outset. This allows the researcher a completely new ability to explore spatial patterns in the data right from the start of the analysis process. As the maps are on-screen they can be zoomed in on and panned around. Shading schemes and classification methods can be changed, and data added or removed at will. This means that rather than being a product of finished research, the map now becomes an integral part of the research process. New ways of mapping data are also made possible, such as *animations*, *fly-throughs* of virtual landscapes, and so on. It is also worth noting the visualisation in GIS is not simply about mapping: other forms of output such as graphs and tables are equally valid ways of visualising data from GIS.

Although visualisation may answer some of the question, more rigorous investigation is often required. Here again GIS can help. The combined spatial and attribute data model can be used to perform analyses that ask questions such as ‘do cases of this disease cluster near each other?’ in the case of a single dataset; or ‘do cases of this disease cluster around sources of drinking water?’ where more than one dataset are brought together. To date, this form of analysis has been well explored using social science approaches to quantitative GIS data. It has not been so well explored using humanities approaches to qualitative data, but this is one area where historians are driving forward the research agenda in GIS.

1.4 Problems with GIS

It is important to note at an early stage that there are also serious limitations to GIS. These fall into four main classes: problems to do with the GIS data model; problems to do with the data themselves; problems with the academic paradigm; and practical problems.

Spatial data consist of one of four types of *graphic primitive*, namely: points; lines; polygons, or pixels. Where the data have precisely defined locations that realistically represent the features to be modelled, GIS is a powerful tool. Other data cannot be adequately represented spatially in this manner. This may be because the data do not fit the four types of graphical primitives well, or because the data are imprecise, a problem that GIS cannot cope with easily. For example, GIS is well suited to modelling hospitals and census districts in the manner described above, but is not well suited to representing the catchment areas for the hospitals where these are poorly defined and overlap heavily with surrounding catchments.

Secondly, the data themselves can also cause problems. Much historical data will be taken from historical maps, which may not be accurate, and the representation of features from these maps in the GIS at best will only be as accurate as the original source. In reality they are likely to be worse, as new errors are added when the data are *captured* (or transcribed, to use the historical term). Many of the clues about the accuracy of the original source will be lost when the data are captured. An obvious example is that if a feature is represented on a map by a crude, hand-drawn, thick line we may question its accuracy. In the GIS this will simply appear as a digital line like any other. Less obvious, but at least as important, is the scale of the source map: a map is only ever accurate within the limitations of its scale. In a GIS, however, we are able to zoom in hard or to integrate data taken from maps with very different scales. This demands more from the data than the original map or maps were designed to accommodate and may lead to inaccuracy, error and misunderstanding. Although historians will be familiar with issues associated with the accuracy of transcriptions, GIS is particularly demanding of the accuracy of its source data, as will be described in section 3.4.

Thirdly, the academic origins of GIS were located within technological advances in the earth sciences. Its role in academic geography has yet to be fully established, and history trails some way behind this. Through the 1990s there was considerable debate in geography about whether GIS offered a cohesive, scientific framework that could re-unite the subject, or whether it was a return to a naively positivist agenda. From the historian's point of view, GIS offers new tools, new techniques and new approaches. These approaches must be used critically and should complement traditional ideas, approaches and concerns.

The final set of limitations on GIS is practical. GIS software is expensive and may be difficult to use. The cost of GIS hardware has fallen over recent years but can still have a high price, and GIS data are often financially expensive to buy and capturing them yourself is costly in time as well as money. People with GIS training are often very employable and thus expensive. As a result, entering into GIS is often more costly than originally anticipated and should be done with care.

1.5 The GIS learning curve

Moving into GIS requires a long and sometimes daunting learning curve. It involves learning new technology, acquiring or building spatially referenced databases, and learning a new approach to investigating the patterns within those databases. Once the need for a GIS has been identified, most GIS projects will go through three distinct stages. The first stage is the resource creation phase. In this stage the hardware, software, staff, and spatially referenced databases are acquired. As is described in Chapter 3, building spatially referenced databases is a particularly slow and costly operation. These costs should not be underestimated, and may rightly act as a deterrent when the use of GIS is being considered.

The second stage usually involves basic mapping and querying of the spatially referenced database, using the kind of techniques described in Chapter 4 and the early sections of Chapter 6. In this stage the GIS adds new options and new functionality to a project, and allows the exploration of spatial patterns and spatial relationships held within its data. This stage can be reached quite quickly once the database has been built, as the techniques used are well developed and basic to most GIS software packages.

In the third stage the use of GIS becomes more sophisticated. This involves the use of more complex explorations, analyses and visualisations.

The researcher will often devise new techniques and methodologies appropriate to their own specific data and research questions. This can involve sophisticated visualisations, as described in the latter sections of Chapter 6, and the use of more complex quantitative and qualitative analyses that attempt to explore the data through all three of their components: namely attribute, space and time, as is described in Chapters 7 and 8. In this stage the GIS is no longer simply a tool but also becomes an explicit part of the research agenda.

From this discussion it should be apparent that running GIS projects is a middle- to long-term process with long lag times before the full rewards of the initial investments are realised. This fundamentally influences who should and should not get involved in using GIS. Healey and Stamp summarise this succinctly when they state 'GIS is not suitable for "one-off" map production or short-term investigations but is ideal for the steady and meticulous development of geographically referenced data resources that can be utilized for a variety of purposes over a period of years. The initial investment will pay handsome dividends in the medium term.' (Healey and Stamp 2000, 590).

1.6 Conclusions

At the heart of GIS is a very simple model that provides a location in space for every feature in the database. This model originated from the integration of database management systems with computer mapping systems, developments that originated in IT and with the needs of the earth sciences in mind. This deceptively simple model, however, opens up a wealth of possibilities in terms of our ability to handle data: depending on which way you approach it, it allows us to put data on the map or to populate the map with data. At a very basic level this allows us to explore data through space and attribute simultaneously. This opens up a wide new potential for research. The key to this is the integration of data. Having both a spatial and attribute component allows disparate data to be integrated simply through their locations in space. It also allows the data to be analysed in ways that are far more sophisticated and powerful than was previously possible, and it allows the data to be visualised in far more effectively than was previously possible. There are, however, limitations and problems to this: the spatial component of data are complicated, the ways in which we can analyse and visualise data in this framework are not yet fully understood, and the technology and the data are expensive. There is no doubt, however, that GIS has arrived and that while the technology may change over time, the approaches to investigating data and the potentials this opens up to gain increased understanding from these data are here to stay.

Further reading from Chapter 1:

References giving in **bold** are key references.

Definitions of GIS

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See also the introductory texts on GIS detailed in Chapter 2.

The role of GIS in historical research

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Healey, R.G. and Stamp, T.R., 2000. Historical GIS as a foundation for the analysis of regional economic growth: theoretical, methodological, and practical issues. *Social science history*, 24, 575-612. See also chapter 4.

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