Chapter 6: Visualisation from GIS

6.1 Introduction

The map is an absolutely integral part of GIS and the use of maps to explore and present GIS data and the results of GIS-based analysis, is an absolutely core part of the GIS toolbox. It is also important to remember that visualisation in GIS is about more than simply mapping: graphs, tables, and all the more conventional methods of displaying data are also valid and useful tools. This chapter will, however, focus on mapping. In GIS mapping is used to describe and suggest explanations for the spatial impact of the subject of interest. This re-opens an enormous amount of potential to explore and explain the geography of a wide range of historical themes, an approach that has arguably been over-looked in the past. This chapter aims to show how, through a combination of mapping and thinking spatially, new understanding can be developed.

6.2 Mapping and cartography in historical research

The map is a powerful way of presenting the information held within spatially referenced data to an audience. Cartography is an academic discipline in its own right with a long history. It is both a science and an art. From a scientific perspective, its role is to present features on the earth's surface to an audience in an accurate and objective manner. From an artistic perspective, its role is to present this information in a way that is both communicative and pleasing to the eye. These two roles are sometimes contradictory, and it requires skilled use of cartographic principles to balance them.

Most GIS software packages make it easy to produce basic maps as it is a core part of their functionality. This means that almost as soon as the data are in a GIS format, researchers are able to explore them through maps. The maps can be refined and re-drawn multiple times as part of the research process, giving the researcher the ability to gain a thorough understanding of the spatial patterns that the data contain. At the end of the research process, production of maps for publication either on paper, or more recently electronically becomes a relatively simple process.

This means that historians wanting to use GIS need to learn the basics of cartography so that the maps they create and interpret lead to improved understanding rather than misleading or causing confusion. In this chapter it is only possible to explain briefly a few basic rules about how good quality maps can be produced. Many good guides to cartography are available, the bibliography lists some of them.

A map can be regarded as a simplified abstraction of the world. It presents complex information about one or more phenomena in an understandable manner, and is also a valid picture of the underlying data. To do this effectively it is important to follow a number of general rules:

1. The map should contain as much detail as is necessary but not so much that the pattern becomes obscured, cluttered or over-complicated.

2. A map should stand alone and be understandable without referring to the accompanying text. To this end it needs a title, a legend and representation of scale. The legend should explain all symbols and shading used on the map.

3. The method of symbolisation used should be appropriate for the data being represented. GIS usually simplifies this. Points are usually represented by point symbols, polygons are represented using *choropleth maps*, and continuous surfaces are often represented using *isolines* (for example, contours to show relief).

4. The symbols and shading used should be as self-explanatory as possible to minimise the amount of times that the user needs to refer to the legend. For example, water features should be coloured blue.

5. If a shading scheme is used to represent a hierarchy, the features at the bottom of the hierarchy should be shaded in the lightest colours, those at the top in the heaviest, and there should be a clear and self-apparent progression up the hierarchy. Thus if data are classed into values less than 10, 10 to 20, 20 to 30 and so on, the “less than 10” class will normally have the lightest shading and the shadings will become darker as the values get higher. This attracts attention to the highest values.

6. Where a continuous variable, such as the unemployment rate, is sub-divided into discrete classes, care should be taken in both the choice of the number of classes and in how they are defined. In general, for grey-scale maps no more than four or five classes should be used. Where colour is available this may be increased if necessary

but never to more than ten. The intervals should not be arbitrarily chosen but should rely on some characteristics of the data. Examples include putting equal numbers of observations in each class; using equal intervals (for example if the range of a variable is from 0 to 20 and four classes are required the breaks would fall at 5, 10, and 15); using the mean and a standard deviation either side of the mean, and so on. The choice depends on the frequency distribution of the data, with heavily skewed datasets being among the most difficult to represent. Evans (1977) provides a detailed discussion of this.

6.3 Developing understanding from basic mapping through GIS

Although it is rarely efficient to create GIS data simply to produce a map, once data are in GIS formats their potential use for mapping purposes becomes enormous. In particular, once it is easy to map a dataset then exploring the geography within the data becomes easy. A simple example of this is provided by Spence (2000a). He has a single layer of spatial data showing a simplification of the administrative geography of London in the 1690s. Linking this to taxation data allows him to explore the social geography of London at the time. This is done by following themes such as household rents, business rents, household densities, distribution of households by gender, location of widows, and so on. Producing maps also allows possible explanations to be developed: for example, Spence finds high concentrations of widows in the City and to the east of London. He speculates that there may be different explanations for this in these two areas. In the wealthy City it may reflect the dominance of males as property holders in this area, even after the men concerned had died. In the less affluent east, however, he speculates that this may reflect the dangers of the types of employment available to men from this area.

Mooney (2000) follows a similar approach. He links spatial data consisting of registration districts in London in the late 19th century to data on admissions to various hospitals. He uses this information first to describe the patterns of admissions to the London hospitals, and then to attempt to describe the spatial patterns of various diseases in the metropolis at that date. In the same volume, Galloway (2000) investigates London's national importance as an economic centre in the medieval period. This is done by producing dot maps of a variety of debt statistics from around 1400 to illustrate the economic interactions between London and the rest of England.

These three essays are all good examples of how basic mapping and thinking spatially can provide new insights into a discipline without the need for complex analyses.

6.4 Producing atlases from GIS

Extending the above approach allows atlases to be produced using a small amount of spatial data coupled to a wide variety of attribute data. A good example of this is Woods and Shelton (1997). They use a single generalised layer of 19th century registration district boundaries in England and Wales to produce an atlas of mortality in Victorian times. By looking at the spatial pattern they are able to provide new insights into phenomena that have a pronounced geographical pattern. This atlas shows the importance of spatial detail and the power of maps to present it. There were over 600 registration districts in England and Wales in the Victorian era, and the maps shade all of them. This allows the authors not only to comment on the general patterns, but also on specific details and exceptions. When looking at infant mortality in the 1860s, for example, the authors note that the maps show a general pattern of high rates in urban districts and lower rates in rural ones. Looking in more detail reveals exceptions to this; for example, there were high rates found in rural areas around the Wash, in Lincolnshire and East Yorkshire, and in Cornwall. This kind of detail is readily apparent from maps but is difficult to spot in other ways.

The atlas of the Great Irish Famine by (Kennedy *et al*. 1999; see also Chapter 5) follows a similar approach, but rather than using a single layer of spatial data they use different layers for different dates. By mapping changing housing conditions they show that on the eve of the famine the lowest quality housing, mud huts and similar constructions, were concentrated in the west of Ireland where they could form up to 50% of the housing stock. In the east, housing of this quality was less common. The poor who lived in this housing were the most seriously affected by the famine, so as the famine progressed this class of housing all but disappeared in the east, while in the west its importance also declined but to a lesser extent.

In the above examples the atlases produced are cartographically simple products based around choropleth mapping. GIS can also contribute to atlases that are more sophisticated cartographically. Here, rather than linking a large number of attribute datasets to a limited number of spatial layers, the GIS becomes a database of the spatial features that will be used in the atlas and allows them to be combined to produce highly sophisticated cartographic products significantly more cheaply than through traditional methods. A good example of this is volume II of the *Historical Atlas of Canada* (Louis 1993), which was produced using *ArcInfo*. Pitternick (1993) explains the advantages that using this software gave to this volume, compared with volumes I and III which used more traditional methods.

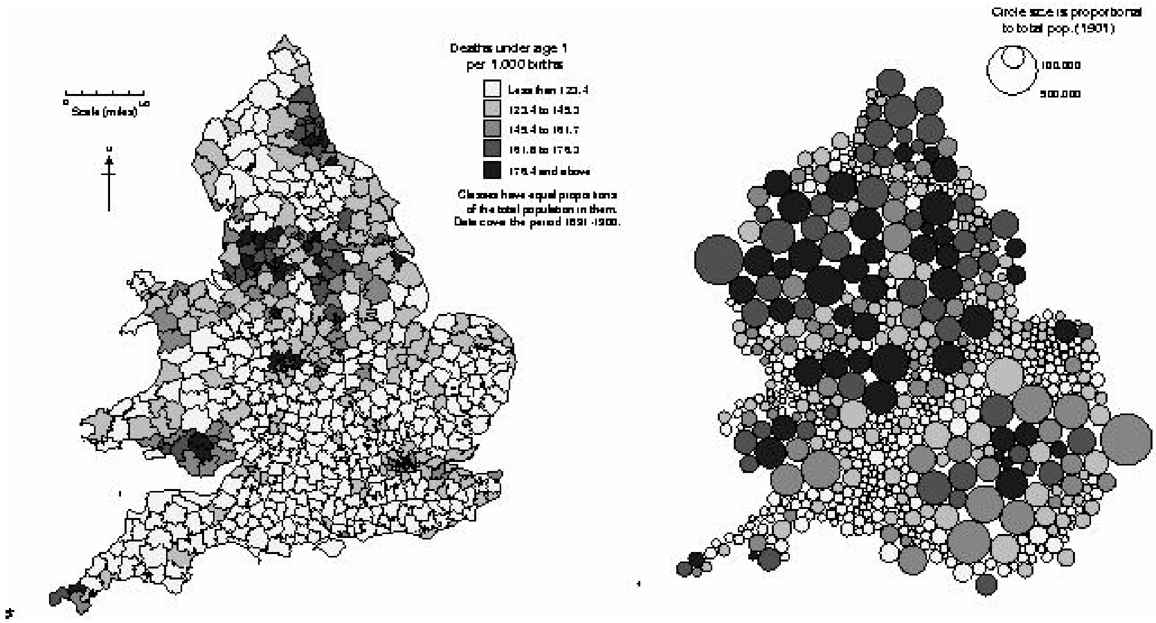
6.5 Electronic visualisation from GIS

With a paper atlas, the authors produce maps with accompanying text, and perhaps some diagrams, and use these to tell a story. Electronic media and GIS allow the author to present the user with the spatial and attribute data and allow the user to produce maps and diagrams themselves. This allows them to explore the data and, perhaps, tell their own story or investigate the places and themes they are most interested in. Effectively this involves giving the user prepared spatial and attribute data held in a software package that has the basic mapping and querying facilities of GIS software but is easy to use and, perhaps, steers the user down certain routes. A good example of this approach was produced by Gatley and Ell (2000). They produced a system on CD-ROM that contains a variety of census, poor law and vital registration data from 1801 to 1871. The statistics provide the attribute data, with polygons representing the administrative units providing the spatial data. The package allows the user to query the data to produce maps, graphs, pie-charts, and other diagrams. If the user creates maps, the shading and class intervals can be changed and individual polygons can be queried. In the United States, the Great American History Machine (Miller and Modell 1988) was intended to be a similar system. This held census data and statistics from the presidential elections from 1840 to 1970 at county-level, giving over 3,000 units. Users were free to use these data to produce choropleth maps of their own to explore the data. Unfortunately, this system was never properly published commercially.

Mapping of this type may also be made available over the internet. A good example of this is the North American Religion Atlas (NARA, see http://www.religionatlas.org/) which allows users to map religious adherence in the United States at county level from 1971 to the present.

6.6 Other forms of mapping

Although choropleth maps are a highly effective way of communicating information from polygon-based data they do have certain drawbacks. A major problem with many administrative geographies is that the largest administrative units tend to be sparsely populated rural units, while the smallest tend to be densely populated urban areas. This means that the map can distort the pattern as it emphasises the areas in which few people live while almost obscuring the areas containing most of the population. One way around this is to distort the map pattern to make the polygon sizes proportional to the size of their population rather than their surface area. A map of this sort is called an *area cartogram*. Dorling (1994; 1996) presents a method where each polygon is converted into a circle whose size is proportional to its population (or any other variable). The position of the circles is then moved to prevent circle overlap while attempting to keep a circle as close as possible to its neighbours. Dorling (1995) presents an atlas of modern Britain based almost entirely on cartograms but is otherwise very similar to the atlases described above. More recently Gaster *et al*. (2004) have developed a method of producing cartograms that preserve the connectivity between polygons, thus removing the need to convert areas to dots.



[Choropleth and cartogram representations of infant mortality in England and Wales, 1890s]

Cartograms can be criticised as they are an unfamiliar representation of space and it can be difficult to establish exactly where a place is on the map. Gregory *et al.* use choropleths and cartograms together in their study of changing patterns of poverty (Gregory *et al*. 2000). Figure 6.1 gives an example of this showing registration district-level infant mortality in the 1890s. From the choropleth map it appears that the highest rates of infant mortality are relatively rare. The cartogram gives a very different impression by showing that because high rates of infant mortality were largely an urban phenomenon, a large proportion of the population were in fact affected by these rates. In actual fact, the shading scheme used by these maps puts approximately the same number of people into each of the five classes.

6.7 Moving and interactive imagery

Animation is an area that has much to offer historians. Traditional paper-based cartography is poor at presenting change over time, while animations clearly have the potential to do so. If one aim of GIS is to be able to explore and present data with the maximum amount of both spatial and temporal detail possible, then this may seem like an ideal way of approaching the subject. There are a large number of modern file formats that allow the researcher to create animations, from *animated GIFs*, where a number of GIF images are stitched together sequentially, through to more complex video formats such as *AVI* and *MPEG*. While the technical issues associated with producing animations are well developed, the cartographic issues are still at an early stage. As a result, researchers working in this field need to be careful to remember that the aim of producing animations is the same as with any other type of mapping: to produce a clear and understandable abstraction of the data and the patterns held within them. It is easy to become seduced by fancy graphics that convey little of real value, and the cartography of animation is, as yet, poorly understood.

A good example of the effective use of animations to help understanding is their use in Cunfer's (2002, see also Cunfer, 2005) work on the causes of the Dust Bowls on the Great Plains in the United States. He argues that dust storms were more widespread over space and time than has been previously been acknowledged. He demonstrates that they occurred in areas that had not been extensively ploughed and argues that drought rather than insensitive agriculture were the root cause of the major dust storms. By animating his data he is able to demonstrate this link over time and space.

Moving imagery can be used to do more than simply present time series. It can also be used to change view points or even to fly-through virtual landscapes. A good example of this is provided by Harris (2002). He is researching an ancient burial mound and sacred space in Moundsville, West Virginia, and wanted to re-create the landscape that would have existed around the mound. By combining historical and archaeological evidence on the ancient landscape with modern data on relief he is able to create a digital terrain model of the landscape. This is draped with a representation of the possible land cover of the time. The user is then able to zoom in and out of the landscape and fly-through it to view it from any angle or perspective that they are interested in. As with animations, this is an interesting research area but efforts must be put into conveying information to the user and not simply producing fancy graphics with gimmicky file formats.

There has been increasing interest over time in mapping on the Internet. Three good examples of this being done include the North American Religion Atlas described above, Schaefer's (2004) online GIS of the tithe survey of Britain, and the Vision of Britain through Time project that has been putting data from the Great Britain Historical GIS (described in chapter 5) onto the internet making extensive use of maps and graphs.

6.8 Conclusions

Mapping and visualising data and exploring them spatially allow new insights into the patterns contained within those data. This is an area that has traditionally been under-exploited by historians and it is hoped that the developing use of GIS will lead to an increased awareness in the importance of space and geographical patterns among those conducting historical research. The ease of mapping and visualising data within GIS is leading to a change in the role of the map. Already, GIS has moved the map from an end product of a piece of research to an integral part of the process. Increasingly, it is leading to a changing role of authorship. Traditionally research papers and atlases present a map prepared by the researcher together with some text in which the researcher explains what he or she believes the map shows. Now, CD-based products and internet-based resources mean that the researcher is no longer attempting to tell the whole story, instead the "author" makes the resources available to users (or readers) who interrogate the data themselves and use them to tell their own story.

The final word in this chapter, however, must be a word of warning. Maps distort and maps lie. Whether you are producing maps yourself or interpreting information from other people's maps, it is important to have a grasp of the basics of cartography to be able to differentiate between the distortions that the map contains (deliberately or accidentally) and the real story that the data have to tell.

Further reading from chapter 6:

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