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Cartographic connections – the digital analysis and curation of sixteenth-century maps of Great Britain and Ireland

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Summary: Understanding the processes by which early maps were created and the interconnections of maps and map makers is key to broadening our knowledge of map history and cartographic science. This paper draws on data collected across three UK research projects centred on analysing, untangling and evaluating the relationships between maps and map makers of sixteenth-century Great Britain and Ireland. Using GIS, ‘Place’ features (written in Latin, Gaelic, Welsh and English) derived from a large suite of maps were digitised and added to one centralised geo-historical gazetteer. Employing robust quantitative methods including statistical regression procedures, distortion measures and displacement modelling, the maps were analysed and compared to reveal significant insights into the cartographic connections and the map making processes of Renaissance Europe. The paper also illustrates a common goal of these projects, to ‘curate’ early maps by enabling accessibility to cartography and associated data through online resources. The paper highlights that digital methods and curation, used in combination with more traditional forms of qualitative enquiry, provide a new instrument for deciphering and conserving histories of cartography.

Introduction

The sixteenth-century in Europe is recognised as a hugely important and formative time for the development of cartography. This era was described by Pickles (2003: 97) as “a radical transformation in map consciousness...”, so much so that by the end of the fifteenth-century the existence of approximately a dozen maps of England jumped to two hundred in the first half of the sixteenth-century, and then increased four-fold to eight hundred by the end of the sixteenth-century (Harvey 1993). While historians of cartography rightly recognise the continuities in maps and map-making from earlier centuries and their continued influence on the Renaissance (Dalché 2009; Lilley 2013), there is no doubt the sixteenth-century flourishing of cartography owed much to innovations in technologies of cartographic production and circulation. The role of engraving, printing and distribution networks, the implementation of indirect surveying techniques through triangulation and the thirst for maps and map-making to aid state-building, all fed into the expansion and extension of cartography in Europe through the early-modern period.

Yet, despite these known and well-charted trends in cartographic innovation and change, little detail is known of the methods and practices of the era’s map-makers (Andrews 2009). Few practitioners documented their methods, and while numerous treatises on surveying, and numerous detailed maps of the period, testify to the industry of sixteenth-century map-makers of Europe, it is rare to find contemporaries detailing how specific maps were produced. So how can

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we in the twenty first-century begin to untangle these early cartographic constructions? It is to address this challenge—of finding out more about the processes of map-making—that the digital approaches have much to offer; through digitising historic maps by using Geographical Information Systems (GIS), and analysing quantitatively the otherwise qualitative basis of historic maps.

The following account draws on a number of funded research projects, led by a group of geographers based at Queen’s University Belfast (UK), which since 2005 have examined, in detail, 24 ‘general maps’ (see Appendix 1) produced in late-medieval and early-modern Britain and Ireland showing these two neighbouring islands. With their shared, though complex histories, and their interconnected politics and cultures, the maps produced of Britain and Ireland of the sixteenth-century often depicted both islands on a single map sheet (see the *Angliae Figura*, c.1537 for one example). In other cases, the islands are mapped separately, one of Britain and one of Ireland, sometimes with portions of the neighbours’ coastlines shown but few other details. Some of the most historically significant and celebrated examples of these maps include those of George Lily, Humphrey Llwyd, Christopher Saxton, and Laurence Nowell, as well as anonymous examples such as the *Angliae Figura* and ‘post-Lythe’ maps. The likely mutual influence and networks of these map-makers over the course of the sixteenth-century remains uncertain, despite a considerable amount of scholarship dedicated to their maps.

Through combining three research projects¹ involving the authors of this paper—one a doctoral project on early maps of Ireland, a second project funded by the Leverhulme Trust, called ‘Mapping Lineages’, and a third, funded by the Arts and Humanities Research Council (AHRC), on the maps of Humphrey Llwyd—we have the potential to begin to unlock the linkages, connections and underlying cartographic practices of sixteenth-century map-makers in Britain and Ireland. The projects also share a common methodological basis, using digital technologies, and it is this that makes possible the integration of their datasets for the purposes of exploring cartographic connections, as set out in our paper here.

Methods and techniques

The digitisation of a corpus of sixteenth-century maps involves firstly the acquisition of a high resolution digital scan of the cartography, ideally 600dpi as a minimum. This image is imported into ESRI’s ArcMap (ArcGIS[®] is our preferred GIS platform and software but this analysis could also be conducted in free GIS software such as QGIS), and the size of the map image is set in mm. This essential stage in the process allows the distances between places shown on the historic maps to be calculated and their x, y positions on the map image determined in ‘historic map space’. Within the GIS, the map features—settlements, rivers, coastlines, roads, etc—are vectorised, and attribute data compiled. For digitising the locations of settlements shown by maps, the mid-point of each place icon is used. Attribute data is then attached to this point. These attributes include: (1) the place-names as they are recorded on the map; (2) the modern place-names; (3) modern

¹ Research project 1: ‘Mapping Space: towards a quantitative methodology for exploring maps and mapping in early modern Ireland, c.1630-1610’. A doctoral thesis carried out at Queen’s University Belfast, funded by the Department of Education and Learning, NI, and completed by Dr Catherine Porter (2014).

Research project 2: ‘Mapping Lineages: Quantifying the Evolution of Maps of the British Isles’, Leverhulme Trust (project RPG-2015-274).

Research project 3: ‘Inventor of Britain: The Complete Works of Humphrey Llwyd’. Arts and Humanities Research Council (project ref: AH/P00704X/1).

geographic coordinates and; (4) ‘historic map space’ coordinates. The names on maps vary in language, Latin, English, Welsh and Gaelic being most often used. Where place-names appear in multiple languages extra columns are added to the attribute table to record each version of the place-name. Also, some maps in the corpus show damage prior to digitisation, and as a result, in a few cases it is difficult to discern place-names. Where this is the case, a note of this is made in the attribute table.

With the combined corpus of late-medieval and early-modern maps and place-names from the three projects a considerable geographical database has resulted - the first digital geo-historical gazetteer compiled *from maps* of Britain and Ireland. The database of places resulting from this digitisation of the map corpus now also allows analysis of the variations between maps. For instance, we can determine which places were selected to be mapped by the maps’ makers, and which places were not included. This is very informative in seeking to understand the ways in which maps were copied from one cartographer to another, or where innovations took place, as map-makers adopted more original approaches, including field-survey rather than compilation from existing maps. Already our analysis shows that the latter seems to be the case with Christopher Saxton’s map of Wales for example, produced only a few years after Humphrey Llwyd’s and Laurence Nowell’s cartography, yet much more detailed and including many more place-names compared to Saxton’s precursors.

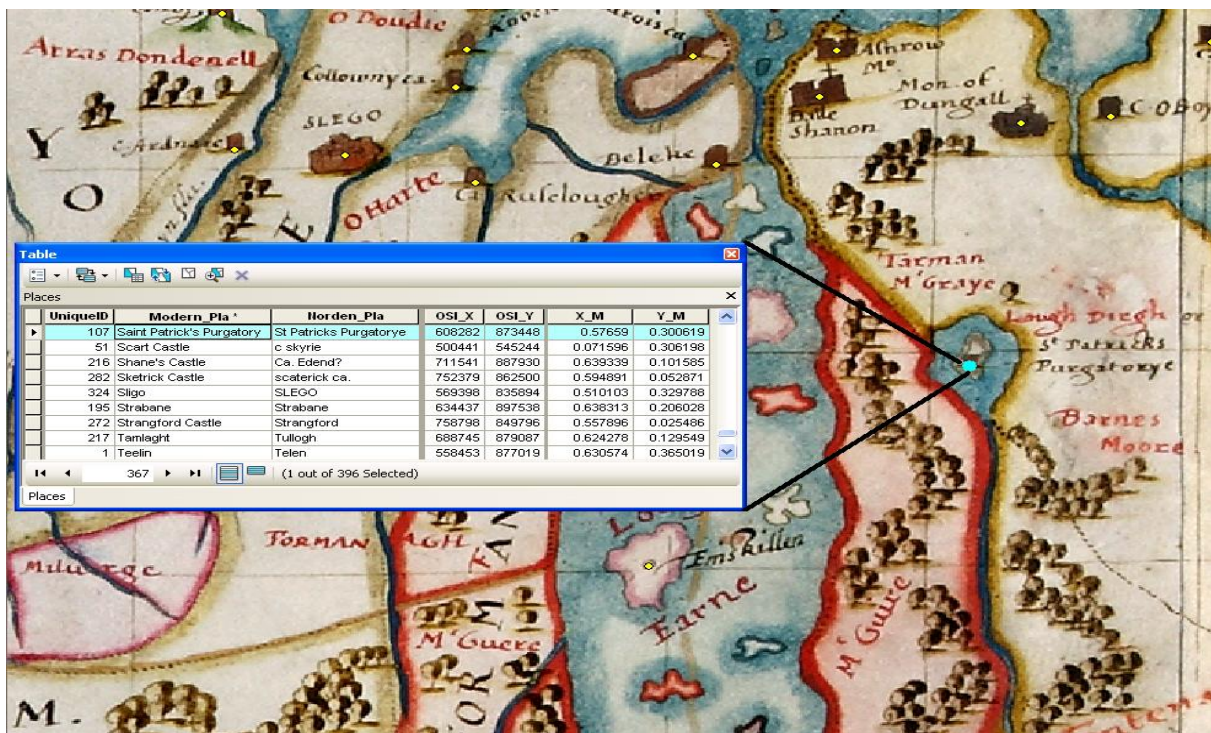


Figure 1: The attribute table from John Goghe’s map of Hibernia (c.1567) showing Saint Patrick’s Purgatory and its associated attribute data.

Assessing the presence or absence of place-names on maps is only one way to determine possible relationships between maps and map makers. With digitisation / vectorisation of map-features complete, it is possible to analyse the geographical positioning of places shown by the maps in the corpus. Here, regression techniques are particularly informative, revealing relative positional accuracy in maps, in terms of the map’s positioning of towns and cities, for example (Lilley & Porter 2013; Lilley & Lloyd 2009; Lloyd & Lilley 2009). The process involved is a statistically

simple one; By correlating the positions of places as shown by the historic map (using the x, y coordinates in ‘historic map space’) against the known positions of the same places (using modern geographic coordinates) we can analyse how the siting of place varies across the map. Firstly, linear regression of the two sets of coordinate data for each of the places on the historic maps can be used to highlight outlying data. This is useful to determine which places on the historic map are located some distance from where one might expect. The drawback of linear regression is that only the eastings or northings data can be assessed at any one time. Secondly, to assess all coordinate data simultaneously, bidimensional regression, developed by Tobler (1966; 1994) is employed. This form of regression derives the coefficient of determination (r^2) by assessing the relationship between two sets of points across two planes or spaces and is used here to reveal how historic maps differ internally in their positioning of places.

The bidimensional regression correlations can also be modelled graphically using a software called MapAnalyst® (Jenny 2006). Options such as Distortion Grids and Displacement Vectors are used to reveal the geographic characteristics of a particular map - its genetic make-up as it were, and to identify its cartographic originality and individuality. Comparing these outputs and regression analyses across a corpus of maps also then begins to reveal how closely some maps (and thus their makers) are related, thus hinting at copying and compilation between map makers. In other examples there are few common geographic patterns evident between maps, suggesting no direct linkage, and so more suggestive, then, of innovation in cartographic practice and production. The comparative approach also can be used to examine trends in cartographic innovation over time and space during the sixteenth-century. What has emerged so far from the application of these techniques to analyse maps of Ireland and Britain is a far from progressive trajectory of map-making; map-accuracy does not improve in a linear fashion over the decades, but rather sometimes there are advances in terms of cartographic accuracy, and sometimes the opposite, as a later map appears to be a retrograde step.

Preliminary results

The analyses of maps of Britain—those by Lily, Llwyd, Saxton and Nowell, for example—is still ongoing. Already the maps have been digitised and fully vectorised and some preliminary regression analyses undertaken. Further advanced, however, are the analyses of the maps of early-modern Ireland, undertaken by Porter (2014), and a sample of these is considered here to illustrate the methodological points made above. The three maps included by way of a sample are John Goghe’s map of Hibernia (c.1567), the so-called ‘Post-Lythe’ map (late sixteenth-century), and John Norden’s map of Ireland (c.1610), shown here in terms of their chronological lineage (Figure 2).

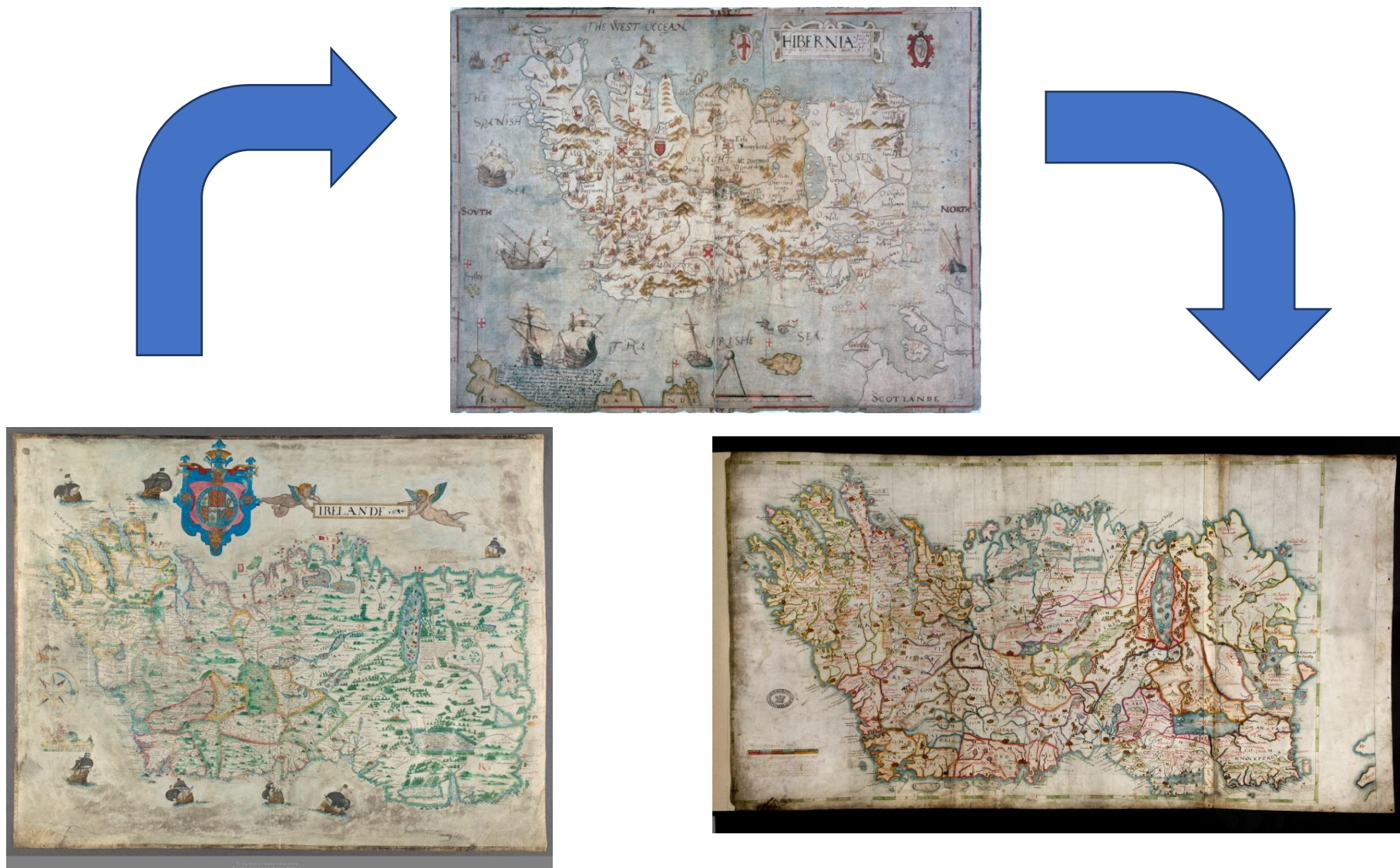


Figure 2: example maps under analysis: John Goghe's map of Hibernia (c.1567), the 'Post-Lythe' map of Ireland (late 16th century) and John Norden's map of Ireland (c.1610).

As well as places, the vectorisation of these maps in ArcGIS included topographic features such as rivers, coastlines and islands (see Figure 3), as these also have potential for spatial analysis using statistical methods.

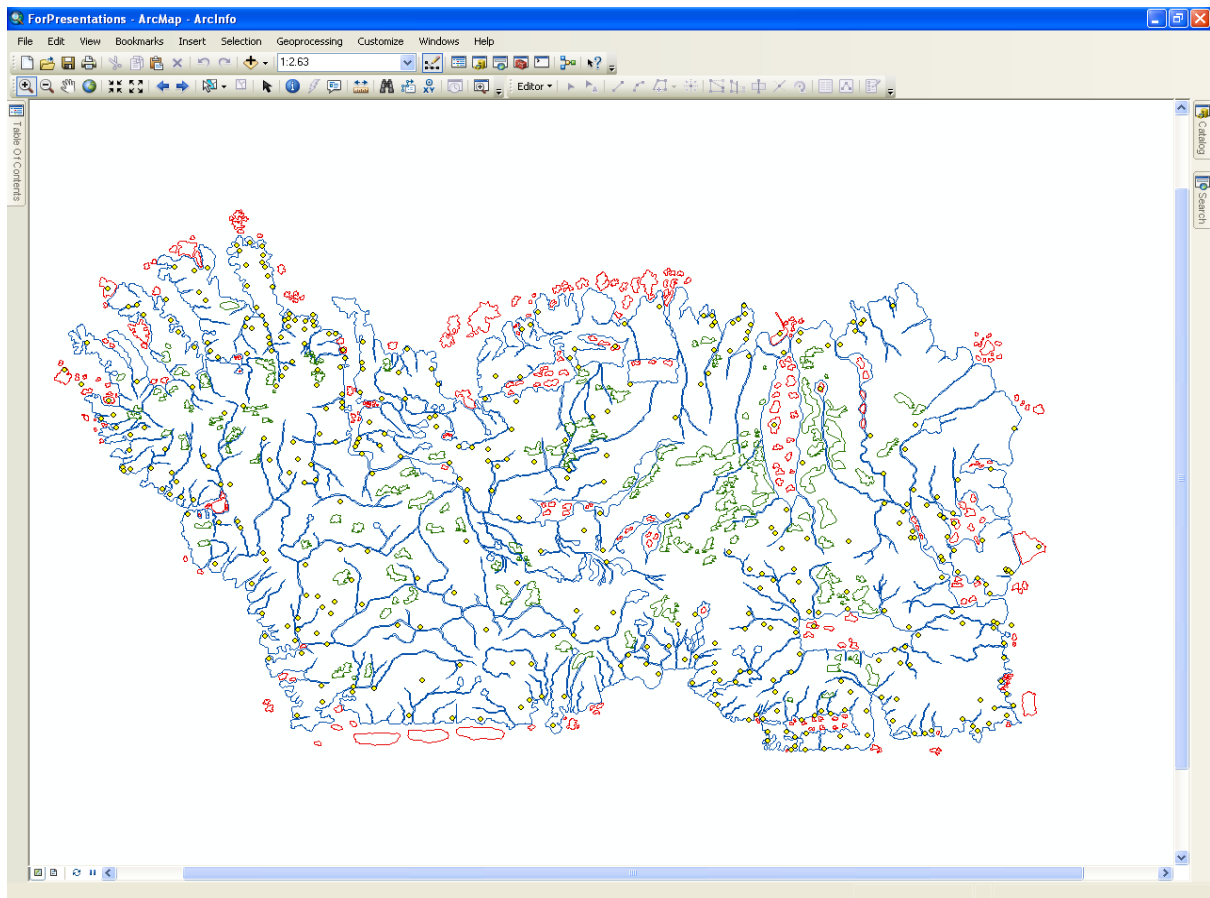
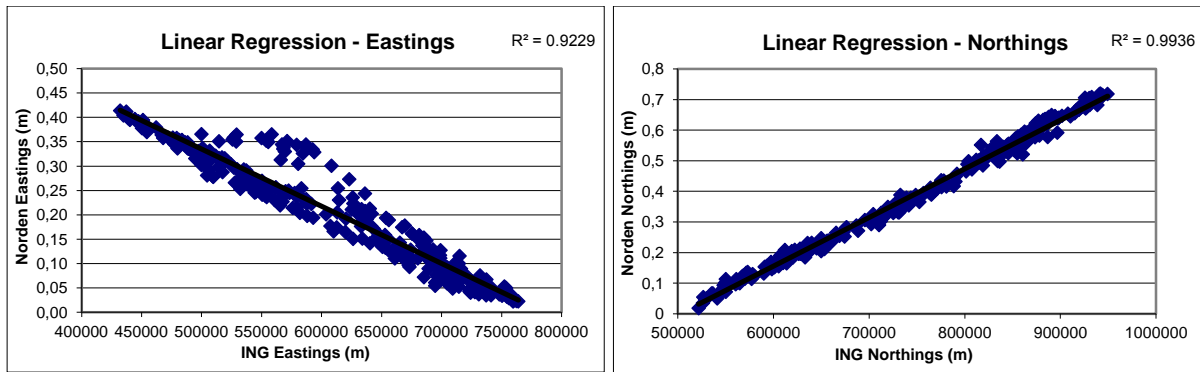


Figure 3: Vectorisation of features on John Norden's map of Ireland, *'The plot of Irelande with the Confines'*, (c.1610). TNA MPF 1/67. Places are shown in yellow. Note that the original map is orientated with west to the top.

It is the positioning of places (digitised as yellow dots in Figure 3) that is crucial in the analysis of the maps, for it enables the positional accuracy of the maps to be examined using the regression techniques outlined above. The results of these regression analyses for the Norden map are given next. Using the two sets of coordinates for each place, two linear regression plots for the Norden map (Figures 4 & 5) were created to compare the coordinates derived from historic 'map space' with Irish National Grid (ING) coordinates for each place shown by the map. The derived r^2 values indicate a strong relative match between northing values (0.9936), and slightly less for easting values (0.9229), so Northing positions of places are therefore more relatively accurate than their corresponding Eastings. Some clear outlying places are also evident from the Eastings plot and these include Asseroe Abbey, Ballyshannon, Donegal Town and Belleek, all located in the north west of Ireland.



Figures 4 & 5: Linear regression of the easting coordinate for each place on John Norden’s map of Ireland (left) and Linear regression of the northing coordinate for each place on John Norden’s map of Ireland (right).

A further indication of the Norden map’s relative accuracy in positioning of places across Ireland can be shown using the Distortion Grid created using MapAnalyst (Figure 6).

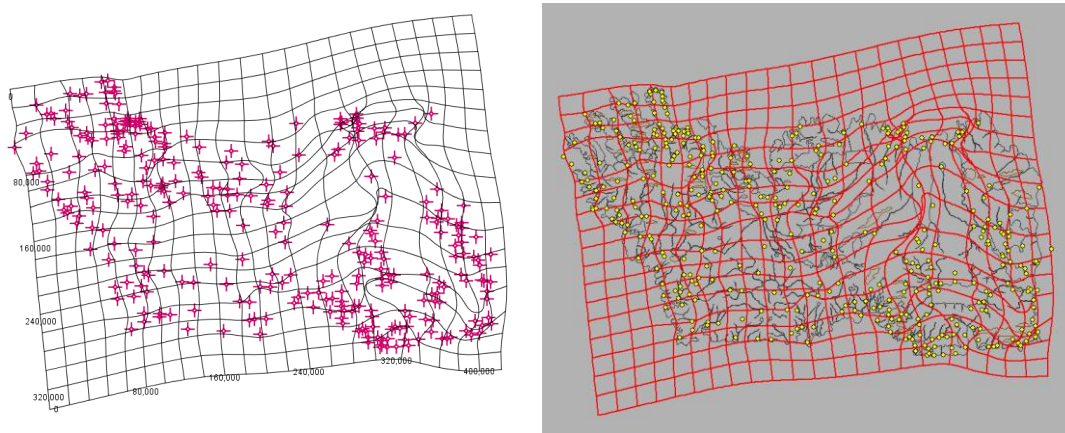


Figure 6: Distortion grid produced by MapAnalyst® (left); distortion grid imported into ArcMap (right).

The deflection in the grid mesh to the north-west of Ireland is pronounced (note the map has west to the top, so Ireland appears to be on its ‘side’), compared to the southern and easterly parts of the island, where a tighter grid suggests a greater degree of positional accuracy in this part of Norden’s map of Ireland. What accounts for such internal variations across the map is of interest, and may be explained by variations in the map-maker’s knowledge of the location of places across Ireland at this time, either based upon first-hand survey, or from compilation from earlier maps. The latter can be examined by comparing the Distortion Grid derived for Norden’s map with those of his predecessors (Figure 7).

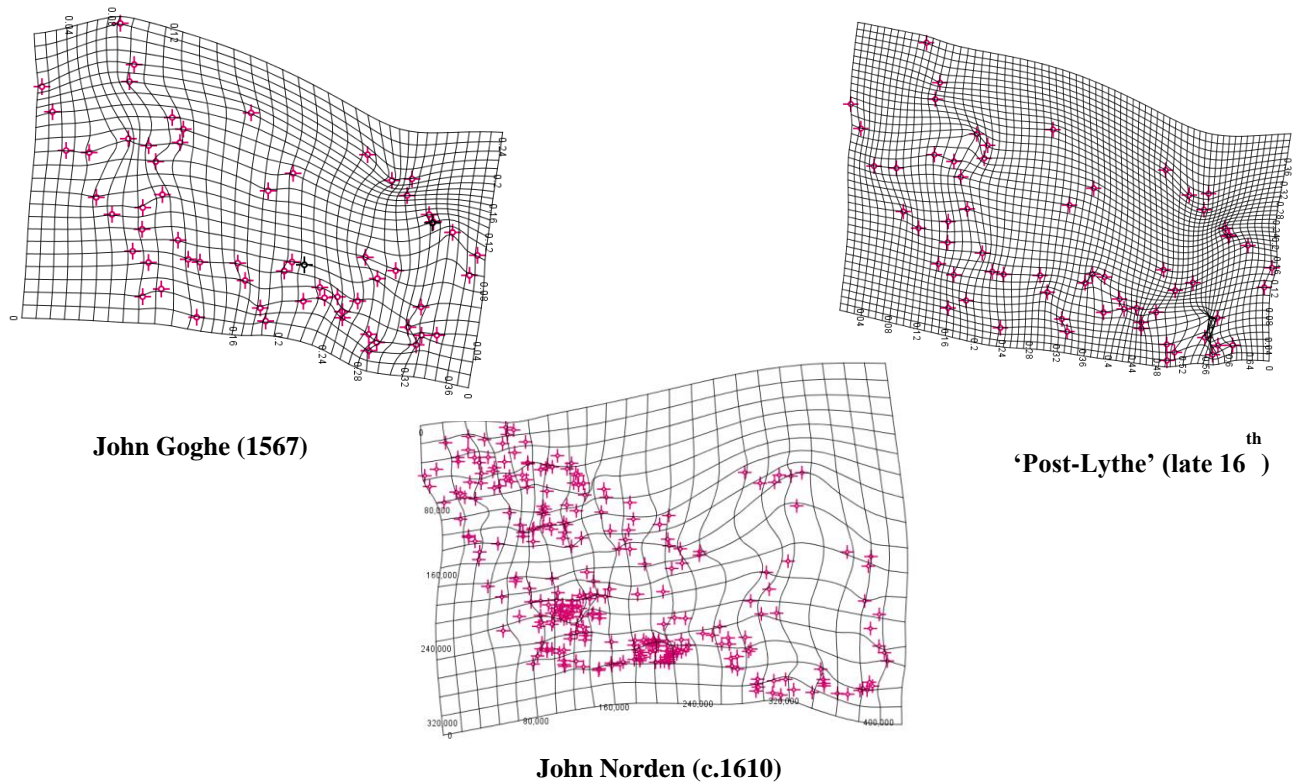


Figure 7: Distortion grids derived from the John Goghe (1567), 'Post-Lythe' (late 16th century) and John Norden (c.1610) maps of Ireland.

This comparison shows some consistent patterns in distortion across the three maps, across the sixteenth-century, but also some patterns particular to the individual maps. For example, the particular distortion for north-east Ireland on the 'post-Lythe' map, which seems more pronounced compared with the earlier and later maps of Goghe and Norden. Little is known of the 'post-Lythe map' and its maker, including its date, and these analyses help to begin to reveal insights into the map by revealing something of its relationship to other maps of Ireland. A further expression of the differences between the maps can be gained from the regression analyses of each, and the r^2 values for each when compared.

| | R ² value |
|-----------------------------|----------------------|
| Goghe vs modern | 0.974 |
| Post-Lythe vs modern | 0.9854 |
| Norden vs modern | 0.986 |

| | R ² value |
|-----------------------------|----------------------|
| Goghe vs Norden | 0.986 |
| Post-Lythe vs Norden | 0.9976 |
| Goghe vs Post-Lythe | 0.92 |

Table 1a & 1b: Coefficient of determination derived from map comparisons between Goghe, 'Post-Lythe' and Norden.

The results of these analyses (Table 1a) reveal the positioning of places as shown on the historic maps compared to their modern geographic locations, and here the Norden map appears to have an r^2 close to its predecessors. This suggests little innovation overall across the three maps. The results (Table 1b) also indicate that there is a strong correlation between the 'post-Lythe's' map positioning of places compared to the Norden map, indicating perhaps a degree of compilation by the latter of the former, as a source. The Goghe map, however, seems to show less in common

with the later ‘post-Lythe’ map. Using these analyses, we can therefore begin to build up a picture of the relationships between map and map-makers of early-modern Ireland.

Overall, it should be noted that these preliminary results are indicative, and indeed suggestive, of patterns that deserve closer inspection and assessment, using a combination of the quantitative analyses of the maps based on the digital datasets (illustrated here), and qualitative analyses based on a close prosopographical and historical study of the maps and their makers.

Curating the maps

In digitising the sixteenth-century map corpora, the main aim has been to use the quantitative analyses as a means of furthering our understanding of map relationships, however, in addition to this, the creation of a much-needed early modern place-name gazetteer for Britain and Ireland provides a new and exciting prospect for place-centred historical research. But the digital gazetteer, the related analyses and associated historical findings on cartographic relationships is only one part of the map ‘curation’ these joint projects offer. Moreover, ‘curating’ the map datasets provides a basis for making these available via online resources, an intended outcome of the three projects, and building on an earlier map digitisation project focused on the fourteenth-century ‘Gough Map of Great Britain’, created in a partnership with the Bodleian Library, Oxford, the custodians of the map (see goughmap.org and Lilley et al. 2009). For the maps of Humphrey Llwyd, an Esri Story Map Journal has been created (Figure 4) and plans for the project on Llwyd’s maps include extending this through educational outreach, in collaboration with the National Library of Wales. Through these online mapping resources, the aim is to enable users to engage more deeply and meaningfully with historic maps, interacting with their cartographic content in ways that go beyond simply viewing these as online images. This digital curation process is as important to the three projects as the analyses of maps made possible by the applications of GIS outlined earlier.

A story map

Inventor of Britain: The Complete Works of Humphrey Llwyd

Humphrey Llwyd of Denbighshire (1527-68) ranks among the leading figures of the Welsh Renaissance. His maps and treatises on Welsh and British geography were admired and printed by the great Dutch atlas-maker Abraham Ortelius. Author of the first book on the history and topography of the entire island of Britain, Llwyd coined the fateful phrase “the British empire”; his work provided the cornerstone for an emerging vision of a unified, expansive, British state. His remarkable book collection still lies at the heart of one of Britain’s central institutions, the British Library.

In the decades after his death, Llwyd’s literary influence in both England and Wales was



Figure 4: The ESRI Story Map Journal for the AHRC project, ‘Inventor of Britain: The Complete Works of Humphrey Llwyd’ (<http://go.qub.ac.uk/InventorOfBritain>).

Conclusion

The research in this paper presents the largest ever study of early maps by combining more traditional approaches with modern digital technologies. Whilst much analysis is still to be undertaken, the digital methods used in these projects to study sixteenth-century maps of Britain and Ireland are yielding interesting new insights into the development of maps and the innovations of map-making during the Renaissance. Digital methods and curation, used in combination with more traditional forms of qualitative enquiry, thus provide a new instrument for deciphering histories of cartography. The approach enables us to begin to quantify the cartographic ‘revolution’ often attributed to this era in the history of cartography, and suggest instead a story of ‘evolution’, of selective borrowing between cartographers, and different episodes of ‘progress’ across the century. Complex lineages between maps and map-makers are evident, with no simple linear progress evident in map-making, which is useful for helping us to better understand cartographic genealogies of maps of Britain and Ireland, not just for the 1500s but for earlier and later periods too.

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See also:

<http://go.qub.ac.uk/InventorOfBritain>

<http://www.goughmap.org/>

Appendix 1

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