Lecture Notes in Geoinformation and Cartography
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Dirk Burghardt
Cécile Duchêne
William Mackaness *Editors*

Abstracting Geographic Information in a Data Rich World

Methodologies and Applications of Map Generalisation

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Editors

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Editors
Dirk Burghardt
Department of Geosciences
Institute of Cartography
Dresden
Germany

William Mackaness
Geographical Information Science
School of Geosciences
Edinburgh
UK

Cécile Duchêne
IGN COGIT Laboratory
Saint-Mande
France

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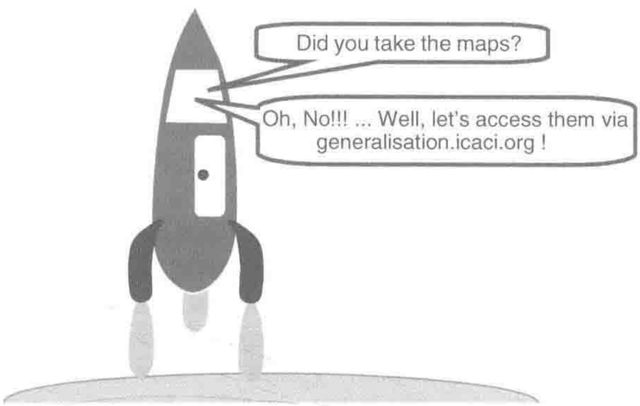
Preface



As I carefully read this book, I am wondering if we have reached the happy moment of generalisation 3.0... well not exactly, but perhaps we are not so far from it. Indeed, if you start reading this book from the end (the very impressive Chap. 11) you would see the tremendous progress made by our scientific community since 1991. Why 1991? Because 1991 is THE landmark year of our generalisation bible: 'Map Generalisation' edited by Buttenfield and McMaster. Suggesting that the history of map generalisation began in 1991 is of course very unfair but this book was simply fantastic since it contained all the very necessary seedlings from which today's results have grown. Written by many young geographers and computer scientists, this 1991 book was definitely full of ideas (please read it).

Then the ICA played an important role. From the beginning, in 1992, the ICA working group on generalisation led by Robert Weibel was very dynamic. Nearly every year a workshop was organised where researchers, engineers and even vendors came from all over the world, to share ideas, debate and even compete on the subject. After Robert Weibel's term (1992–2003), William Mackaness and myself carried on organizing meetings through the umbrella of the ICA (2003–2007). This synergy carried on thanks to Sébastien Mustière and William Mackaness (2007–2011) and is still going on with Dirk Burghardt, Cécile Duchêne and William Mackaness from 2011.

In 1999, during the ICA conference in Ottawa, a project was proposed to write a collective ICA book on generalisation that recorded the progress made between 1991 and 1999. The project was postponed but William Mackaness and I decided to take on the challenge. We added Tiina Sarjakoski to the team to boost our efforts and arbitrate over our usual French and English confrontations! "Generalisation of geographic information: cartographic modelling and applications" was born in 2007, after three very pleasant years of collaborative working (please read it too). It contained 17 chapters written by people from a very wide variety of nationalities: Canada, Denmark, England, Finland, France, Germany, Netherland, Switzerland and USA. The 2007 generalisation book was completely different from the 1991 one! For more than ten years (from 1991 to 2003), many algorithms and even platforms—from vendors or research laboratories—were developed, more teams were working on the subject, and we started also to include ideas and the first results related to real-time generalisation, open generalisation systems, on demand mapping and 3D generalisation. The concept of Multi-agent systems was used by the generalisation research community and the first results from National Mapping Agency production lines were presented. Many of the results presented in 2007 have been widely used and improved upon. Thus if you read Chap. 11 of the 2013 book, you will definitely see the progress made since 1991 and even since 2007. The 65 pages of this Chap. 11 are delicious because many of our propositions are today used to produce maps in different countries. Progress is ongoing reflected in the quote from this chapter: "Please be aware that the facts reported in this chapter are up to date in 2013, but might evolve quite quickly since the developments in generalisation are currently particularly active in several NMAs". But enough pleasure! Let us reflect on some other salient points of this new generalisation book.

The first interesting point to note is the discussions in several chapters of how generalisation connects back to cartography. Of course, generalisation is a cartographic process—if not THE cartographic process (see the publications of E. Imhof, J. Bertin, R. Cuenin or E. Spiess for example). But over these last 20 years, the complexity of processing digital data and developing sophisticated algorithms and processes shadowed the cartographic inheritance of generalisation. Thus it is interesting to read Chap. 2 or Chap. 10 where even R. Brunet and the Chorematic maps are quoted. Here, we touch on the point that we represent the geographical space for humans, not for computers. A very different task from this is to use digital data to compute important information (such as the shortest path from A to B). These are two very different tasks. Our goal is to propose the best representation of space according to specific needs and this requires optimal generalisation and symbolisation. Generalisation is necessary for human cognition.

The second point I want to make is the imminent arrival of generalisation 3.0 (the one that includes not only people in contact with one another but also the semantic web and the Internet of things). Chap. 5 for example illustrates new needs and challenges coming from the multitude of data sources, and the heterogeneity of data. Chap. 7 proposes ideas to use and chain processes wherever they are coming from. This requires new ontologies (such as those described in

Chap. 3). Thus these chapters are proposing new ideas that might be the seedlings for a 2020 book on generalisation!

Last but not least, is the quality of the various states of the art contained in this book. It is enhanced by the original structure of most chapters where the first part is devoted to state of the art and the second is centred on the presentation of some current works which illustrate very nicely the state of the art. Chapters on operators Chap. 6, evaluation Chap. 9 and terrain generalisation Chap. 8 show great maturity of our discipline and will definitely help researchers and engineers wishing to learn more about our domain.

What else is there to say? Read and enjoy!

Paris, France, July 2013 Anne Ruas

Acknowledgments

This book reflects the energies and endeavours of the many members of the ICA Commission on Generalisation and Multiple Representation. This international group is made up of researchers, practitioners, academic institutions and Mapping Agencies. In addition to all those who have variously contributed to this book, the editors would particularly like to thank Anne Ruas for her review of the book and the writing of the Preface. We would like to thank the ICA Executive Committee for encouraging us to write this book. We are also grateful for funding from the ICA and the British Cartographic Society for covering the costs of an editorial meeting in Dresden. The editors are very grateful to Jantien Stoter as Chair of the EuroSDR Commission on Data Specifications for co-organising the NMA Symposium in Barcelona in 2013. All participants from this symposium helped provide some of the material presented in Chap. 11. We would like to acknowledge contributions from the many participants of past ICA Generalisation Workshops—particularly those in Moscow 2007, Montpellier 2008, Zurich 2010, Paris 2011, Istanbul 2012 and Dresden 2013; this book reflects many of the ideas and discussions presented at these events.

The book reflects a collective endeavour between authors, co-authors, editors, internal reviewers and publishers. We are particularly grateful to the external reviewers of the book—Liqiu Meng, Sébastien Mustière and Robert Olszewski. Thanks too to the technical employees of TU Dresden Uta Heidig and Peggy Thiemt for their administrative services and support in editing the book. We are also grateful for the professional involvement and cooperation of Agata Oelschläger, Gopinath Chandrasekar and Shine David from Springer. Finally we would like to thank our colleagues, friends and family for their forbearance in this somewhat lengthy journey!

Contents

Chapter 1
Map Generalisation: Fundamental to the Modelling and Understanding of Geographic Space

William Mackaness, Dirk Burghardt and Cécile Duchêne

Abstract It would be a mistake to see map generalisation merely as the automation of a set of cartographic practices. The process of representing various geographies at different levels of detail goes to the heart of geographical understanding. Comprehension and context comes from being able to examine information at multiple levels of detail. An automated environment that can support such interaction depends upon a rich understanding of the qualities, behaviours and relationships among the various geographic phenomena that are being mapped. In this chapter we seek to explore the complexity of map generalisation, reflecting on the impact of the changing ways in which we gather and interact with geographic information. This in turn provides a justification for the structure of the book which is then summarised in the second half of this chapter.

1.1 Map Generalisation: Why So Complex?

"Nothing is less real than realism. Details are confusing. It is only by selection, by elimination, by emphasis that we get to the real meaning of things." So said Georgia O'Keeffe (Stuhlman 2007, p. 22) in a 1922 interview with the New York Sun. She is considered to be one of the twentieth Century's greatest artists and her thinking reflects the idea of the close association between the process of

W. Mackaness (✉)
School of GeoSciences, The University of Edinburgh, Edinburgh, UK
e-mail: william.mackaness@ed.ac.uk

D. Burghardt
Dresden University of Technology, Dresden, Germany
e-mail: dirk.burghardt@tu-dresden.de

C. Duchêne
Laboratoire COGIT, IGN, Paris, France
e-mail: cecile.duchene@ign.fr

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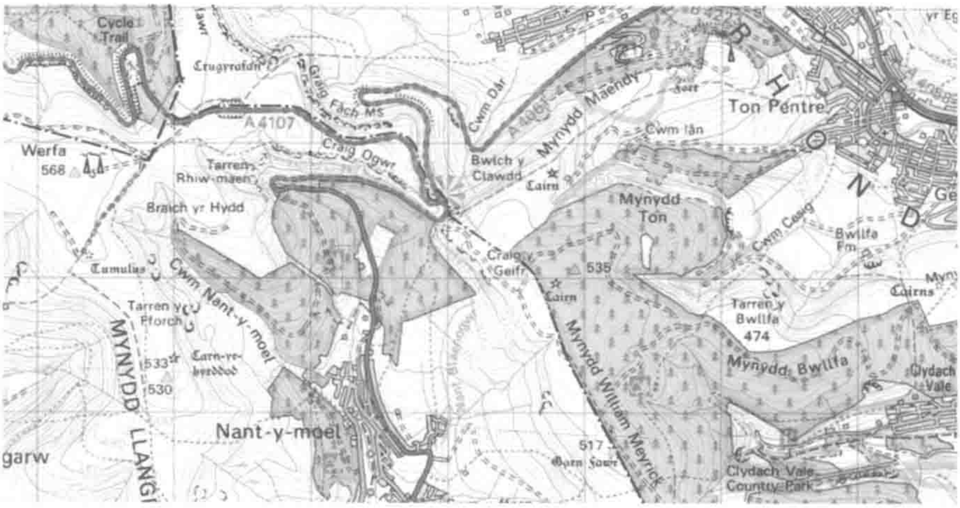

Fig. 1.1 Not lines, points, text and polygons but a 'landscape of relationships' (Crown Copyright: Ordnance Survey; OS/EDINA supplied service)

abstraction and the search for truth. A similar line of thinking is reflected in Krippendorff's assertion that design is about 'making sense of things' (1989); and more broadly it is worth noting Muller's (1991) argument that from an epistemological perspective, generalisation is 'a process which attempts to establish the universality of a statement' (p. 457). Maps in their incongruous forms (Ormeling 2013) reflect that search for truth—seeking to be 'faithful' in their conceptualisation of what is important and giving emphasis to a particular set of real world relationships. This is the foundation point of map generalisation.

When we come to explore the topic from a pragmatic perspective, we often present this process as being made up of a modelling component and a cartographic component. The complexities of map generalisation lie in modelling this abstractive process via these two components. The modelling side requires us to make explicit a subset of all the relations that might variously exist between one geographic phenomenon and another. The cartographic component is concerned with the rendering of that subset of relations through the symbolisation of various geographic entities. The aim is for the resulting map to convey those relationships elegantly and efficiently through their simple arrangement and juxtaposition. There is no need to write on the map that 'this is close to that', or 'this line connects these stations' because (hopefully) the creator and the user have a shared understanding of what those symbols represent and how they behave and interact with one another. At its simplest, we might say that the map is made up of a set of symbolised primitives (points, lines, areas and text), but this is not what the user 'sees'. What the user 'sees' is the geography of the world through that arrangement of simple data types. For example, the user does not see a 'line' but a twisted road climbing steeply over mountain passes connecting remote villages that are sometimes cut off in the winter (Fig. 1.1). Long ago, research into map generalisation accepted that high levels of automation could only be achieved if we

Fig. 1.2 Missing the context: A map that is correct, yet has little meaning

explicitly modelled such behaviours and relationships among such geographic entities. Long ago, researchers abandoned the idea that it was sufficient to see map generalisation as a set of geometric operations applied to a set of primitives.

Our capacity to interpret the landscape in which we find ourselves depends on a successful mapping between the real world and the abstracted view that we call 'the map'. This in turn requires that there is a shared understanding between the cartographer and the map user, of the symbology that is used. It is also a requirement that the cartographer preserves a sufficient proportion of those relationships that the map user is readily able to move between the real and abstracted view. In other words, that there is sufficient context to give meaning to that abstraction (Fig. 1.2). The complexity arises in finding a compromise between the choice of entity, their form and detail of representation, and the space available in which to display them (the scale of the map). It is this idea of trying to model 'compromise' that produces such a breadth of potential solutions.

1.2 The Map as a System of Relationships

A well designed map is a silent record of the many relationships that exist between the entities mapped. It is delicious to watch and hear map users give voice to those properties as they jab and finger the surface of a map! A well-designed map enables us to comprehend the rich and intricate properties of that place; these are semantic properties that are metric, topological and Gestalt[1] in form. From looking at a map we can describe various relationships between entities in terms of alignments, clusters, distances, angles, and extents. And we can use topological descriptors to describe their connectivity, adjacency and containment relationships (for example). Thus when thinking about the map generalisation process, it is

[1] Gestaltism is the idea that the human eye sees a collection of objects in their entirety before perceiving their individual parts.

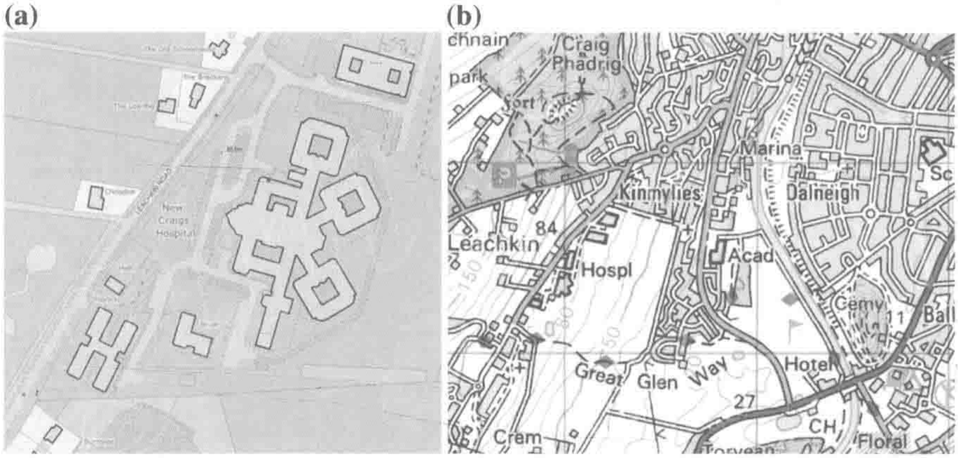

Fig. 1.3 A hospital in Inverness: Different scales in order to discern *different* patterns, *different* relationships, among *different* entities (Crown Copyright: Ordnance Survey; OS/EDINA supplied service)

useful to think of a map as a 'system of relationships' (rather than view the problem as one of object manipulation) and for map generalisation to be thought of as the process by which we manipulate those relationships. This is precisely why there is so much interest in ontological modelling among map generalisation researchers. Couclelis (2010) presents ideas of ontologies of geographic information sufficient to allow us to represent entities as hierarchical composites, thus reflecting the connections among the functionalities and scale interdependencies of geographic entities. Such ontologies provide a framework by which we can construct and manipulate these relationships; it also enables us to 'build a bridge between spatial reasoning and spatial database approaches' (Masolo and Vieu 1999, p. 235). Couclelis goes on to argue that we need a conceptual vocabulary linking purpose, function and granularity. It is exciting to observe that increasingly these ideas are being explored within the map generalisation research community because what complicates (and thus distinguishes) map generalisation from other types of modelling is the fact that it must deal with these conceptual transitions across scale, and must also seek to link 'purpose, function and granularity' in the construction of the map. Muller referred to these conceptual transitions when he wrote about 'crossing conceptual cusps' as we move from the very detailed (large scale mapping) to the very coarse or granular (small scale) mapping. As we change scale, we can no longer preserve the detail; and so by definition neither can we continue to include all the relations that were conveyed at the large scale. As one set of relations 'disappear' from the map, so a new set of relations take their place; a set of relations only revealed at the smaller scale.

For example at one scale we might convey the curvilinear arrangement of a set of buildings alongside a road, but at a smaller scale, this pattern is subsumed by the more dominant relationship between, say, the building blocks and the road network, or the suburb's relation to the city centre (Fig. 1.3b). Indeed this is precisely