The book then continues with a sequence of six chapters offering an understanding of cities: their increase in size and population; the definition of their limits and hierarchies; their form and functions; their daily flows and rhythms; their transformation over time through sprawl, densification or regeneration; and the impact of technological waves that currently culminate in the smart city. This is offered in a masterful multi-layered narrative – fitting the complexity of the subject matter – that interweaves the physical and the digital, the static and the dynamic, and the past and the present, in a way that is capable of engaging readers from a broad spectrum of disciplines working on the city, and providing a breadth of understanding that is not readily found elsewhere. Batty looks at history for the origins of the phenomena, concepts, theories and technologies being introduced, uncovering interesting links and references. This highlights that the most advanced technological transformations of today are rooted in tradition and are part of the process of urbanization that has been developing for millennia. In this respect, the book is accompanied by a rich notes section (pp. 221–51), a natural outcome of the need to bring up facts, stories, and references of the past and present, without digressing into often interesting details in the main text.

Some themes dominate, often formulated as challenges: namely, that there will be more and larger cities, but more population will be living in small and medium-sized cities that should receive increased attention; that it is important to consider the connections between cities and regions; that we need to develop complex network models that integrate different types of networks (for example, social, economic, infrastructural, communications and environmental) that constitute the city; and finally, that time, at different scales and in different cycles, is a force that must be considered. The final chapter does not offer a vision of the future city. Instead it prompts the reader to take on these challenges if we are to address the major problems facing future cities, in terms of climate, economy, health or society.

While those working on urban morphology have a rich set of references and tools to understand the physical form and processes of formation of cities, including more recent computational and mathematical models (D'Acci, 2019), they might be less prepared to deal with the fast temporal dynamics of the present that are changing the way we work, travel, communicate, shop or learn, which will influence the future of cities. In embracing the challenge to study these dynamics, they can contribute to shaping the smart city, which is rich in technology and big data, but lacks a coherent theory of the city to give useful purpose and meaning to the rich analytics available. In return, urban morphology can play a central role in inventing future cities.

References

Batty, M. (1976) *Urban modelling: algorithms, calibrations, predictions* (Cambridge University Press, Cambridge).

Batty, M. (2013) *The new science of cities* (MIT Press, Cambridge, MA).

D'Acci, L. (ed.) (2019) *The mathematics of urban morphology* (Birkhäuser, Springer Nature Switzerland, Cham).

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The mathematics of urban morphology, edited by *Luca D'Acci*, Birkhäuser, Springer Nature Switzerland, Cham, Switzerland, 2019, 564 pp. ISBN 978–3–030–12380–2.

The editor of this book, Luca D'Acci, provides a rich overview of the quantification of urban form using mathematical models. The book is organized in six parts, covering fractals, cellular automata, spatial networks, complexity, other forms of quantification, and interdisciplinary commentaries. Exploring urban morphology using more abstract and mathematical methods is relatively new, as Michael Batty points out in his Foreword, in which he highlights the pioneering work on the quantitative approach by the Centre for Land Use and Built Form Studies in the 1970s. About 30 years ago, in the wake of complexity theory, the mathematical approach developed further, with emphasis on transformation of urban form rather than on the description of its geometry.

In the first part, discussing fractals, the majority of contributions discuss the counter-cumulative distribution of city sizes (and other elements), all ending up showing that these distributions follow Zipf's Law. This means that they fit power law

distributions where the most frequent element occurs approximately twice as often as the second most frequent element, three times as often as the third most frequent element, and so on. Hsu and Zou relate the power law distribution to the theory of central places and Nilsson and Gil show that the degree to which the distribution fits a power law depends on the level of planning relative to the organic growth of cities.

The much smaller second part moves from these more descriptive models to simulation and forecasting models using cellular automata (CA). Such models use simple rules that aim to reflect the complexity of real systems. Antoni *et al*. discuss the sizable gap between the theory of CA and the forecasting of land-use changes, and why often 'constraint CA' is used, coupling CA with other models.

The third part deals with networks and covers both very basic network metrics, such as the contribution by Boeing, discussing the ratio between walking and Euclidean distance, referred to as circuity. Further, two papers discuss extensively the foundations of *space syntax* analysis, the measures used and a summary of applications. Space syntax originates in a field of mathematics known as *graph theory* that deals with the study of topological relationships. In a book with mathematics in its title, this approach could have been more emphasized.

The fourth part, entitled 'complexity', raises the question as to the extent to which complexity is also pertinent to the earlier papers. The contribution by Jiang could have been included in the part of the book that deals with networks, and the one by Bellomo and Terna reads like an introduction to the whole book.

The fifth part is a series of interesting but rather *ad hoc* ideas about mathematical morphology. Schirmer and Axhausen discuss clustering analysis and develop a multiscale approach. Huynh and Marshall *et al*. discuss the development of geometric metrics of urban form, such as measures of dispersion and compactness. These two contributions can be said to come closest to the early work of Martin and March (1972) at the Centre for Land Use and Built Form Studies. Two contributions (Raimbault and Burger *et al*.) discuss the relation between spatial and non-spatial attributes; the latter highlighting the need to discuss these separately as they are not necessarily showing identical patterns.

This bridges nicely to the last, sixth part of the book. Here, the humanistic and multidisciplinary commentaries emphasize the need for a dialogue between experts from urban morphology and mathematics. In particular, Conzen issues a challenge for the field of urban morphology, by calling for a truly comparative study using different methods and approaches, including the ones discussed in this book. This is in line with several editorials in this journal by Whitehand and, to quote Batty in his Foreword, 'considerable learning about how far each approach enriches our understanding of cities would be the result.'

D'Acci has with this book provided a useful overview of the mathematical models used in relation to urban morphology. I do not completely agree with Batty that it also provides a good overview of the field of urban morphology, largely due to the structure of the book in which mathematical methods and their discussion dominate, while discussions within the larger field of urban morphology do not always come through. This contributes to a missed opportunity to provide a common ground for mathematical urban morphology, much needed to deepen the collaboration between experts from urban morphology and mathematics. Most papers jump directly to specialized discussions on specific mathematical issues, with some exceptions, such as the contribution of Clarke on CA, Rashid on space syntax, and especially Bellomo and Terno, introducing more general characteristics of mathematical models to study urban form. Such common ground could have been a good starting ground for the work ahead, as Conzen has so nicely pointed out in his contribution in part six. Moreover, this could have contributed to the powerful statement made by Moudon and Lee (2009), where the argument is made for studying the urban environment quantitatively as it offers urban designers the opportunity to practice their art with due precision.

Having said this, the book also fills an apparent gap in the literature, coupling urban morphology and mathematics. It is to be hoped that this can be the start of a long series of books and papers where this 'new' direction in urban morphology can flourish and provide knowledge about how cities can be developed in more sustainable trajectories. This could provide an evidence base to ensure that urban development takes measurable steps to improve urban areas in relation to such matters as social integration, biodiversity and resilience, rather than acting as a *tick box exercise* that meets policy obligations on paper but does not deliver in practice.

Last, but not least, something that becomes apparent when reading this book is the richness

that the methods provide to conduct serious *comparative* research across blocks, neighbourhoods, cities, regions and countries. This would tackle one of the other challenges repeatedly discussed by Whitehand in the editorials of this journal. The methods proposed in this book can definitely contribute here.

References

Martin, L. and March, L. (1972) *Urban space and structures* (Cambridge University Press, Cambridge).

Moudon, A. V. and Lee, C. (2009) 'Urbanism by numbers: a quantitative approach to urban form', in Tatom, J. and Stauber, J. (eds) *Making the metropolitan landscape: standing firm on the middle ground* (Routledge, New York) 57–77.

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Mapping society: the spatial dimensions of social cartography by *Laura Vaughan*, UCL Press, London, UK, 2019, 300 pp. ISBN 978–1–78735–306–0.

Mapping society uses maps to present a history of ethnic, racial, and religious differences and conflicts, and health disparities, in cities. It considers nineteenth-century urban England and the then fast-growing US cities, two areas where social inequalities seem to have been frequently and systematically recorded in texts and graphics earlier than anywhere else. The book expands the documentation of Charles Booth's work on urban poverty and that of the early New York housing reformers. Author Vaughan also takes the study beyond the Anglo-Saxon world to consider other cultures and geographies, including in France and Eritrea.

Vaughan's approach is within the confines of contemporary social cartography, which concentrates less on recording the general human environmental condition than on capturing places of deprivation. She shows how, almost 2 centuries ago, social scientists used maps both to describe elements of deprivation and to advocate the remediation of social inequalities. As the book subtitle indicates, Vaughan's theoretical outlook is the spatial dimension of deprivation, addressing the need for what she terms 'rethinking urban social problems spatially' (p. 208). Some of the historical cases presented in the book are re-analysed using contemporary methods based on space syntax theories of movement, land use and activities, accessibility, and social class. These analyses show that deprivation can be detected in the spatial configuration of streets and neighbourhoods.

The material presented leads Vaughan to muse about the intrinsic value of maps and cartography to describe a phenomenon critically. She reviews the different tools and means that cartographers have at their disposal to describe a phenomenon. She introduces and discusses mapping as a form of 'visual rhetoric', where such techniques as 'linguistic colour' are used. It is interesting to read that early social cartographers collected the data in the field themselves, acting as participant observers (as in the case of W. E. B. Du Bois). Others, like Booth, either directly hired surveyors who 'walked' the streets, or they worked indirectly through existing institutional settings, such as schools, piggy backing on data collected by inspectors who checked on children's school attendance. Today's data collection methods in social cartography seem to have expanded quite radically with disenfranchised people themselves being empowered to map the environmental conditions that negatively impact them.

Vaughan and the publishers have produced an attractive book as they skillfully transformed the rather stern maps made by social scientists (who were not necessarily visually and graphically trained) into appealing images. However, the figure captions remain insufficient to interpret the images – and legends are either missing or difficult to read – forcing the reader to navigate back and forth between the text and the graphics. Given that the maps are a central element of the book, more complete captions and legends would have better supported a reader wanting to focus on the graphics and to scan them for close comparison.

Overall, the topic, scope, and design of the book makes it an excellent 'easy read', especially for those of us who love maps. In addition, the book's contents offer a significant scholarly contribution to documenting the beginnings of modern social cartography. The narrative format mixes traditional approaches and techniques borrowed from the humanities and social sciences. The core technique is the use of case studies, which are largely organized chronologically and by domain (for example, poverty and race). However, considering