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Complex Systems, Smart Territories and Mobility

Sophie Hasiak, Nicolas Juste

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Complex Systems, Smart Territories and Mobility

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Foreword

Starting from a book written in 1985, the title of which was *Systems, networks and territories*,¹ we can ask about the progresses and blockages, which during the period have marked the scientific approach in the field of urban planning. Today, which obstacles have been overcome, which lockers keep closed? What perspective can be drawn? Is there a relation between those questions and the ambiguous status of planning in the present and in the future.

The *system approach*, undoubtedly powerful but still stammering in the field of planning at the time the book was published, knew rapid and remarkable progresses.² Recognition of the complexity of urban systems, space-time precise identification of their components, analysis of the processes and temporalities at stake within systemic processes, modelling always more effective. The development of computers', of algorithmic, access to larger amount of data helped very much. Work is still in progress and forecasts are promising.

Networks science was found on topology. The geographical concept has been enriched with the graph theory. The study of large networks, like in air transportation and other fields of application, gave results diffused by scientists like A. Barrabasi.³ Especially the role of scale-free networks was enlightened using computer algorithms. Biologists *imported* next from their science very interesting simulations about auto-organization or life networks mimicking transportation infrastructures.⁴

¹G. Dupuy, *Systèmes, réseaux et territoires*, Presses des Ponts et Chaussées, Paris, (1985).

²F. Varenne & M. Silberstein (dir.), *Modéliser & simuler*, tome 1, volume 2, *Epistémologies et pratiques de la modélisation et de la simulation*, Collection sciences et philosophie, Editions Matériologiques, (2013).

J. A. Sokolowski & C.M. Banks, *Principles of modeling and simulation: A multidisciplinary approach*, John Wiley & Sons, (2009).

³A. L. Barrabasi, *Linked*, *The New Science of Networks*, Perseus, 2002.

⁴A.Tero et al, *Rules for Biologically Inspired Adaptive Network Design*, *Science*, 22, Vol. 327, Issue 5964, (Jan 2010).

Ultimately, the doubt principally concerns *territories*. About territories science did not really progressed. Let's try to understand the deep reasons why. If we want really to go further that I did in my book of 1985, we should come back to a true definition of territory.⁵ Territory is generally considered as a place where an human community is living. The community can be so small as a family (including adults and children) or much larger as a tribe, a people. The availability of land and the membership are essential to guarantee the perpetuation of the community. Reactions of defense, aggressions are frequent, aimed to maintain or extend territories and are accompanied by rites of marking. An important issue is about the character, individual or collective, of the territory. If the territory is a collective one, the basis of a community life, a kind of governance should be associated to. This governance has in charge defining, enacting and enforcing rules like opening/closing, good use/bad use, etc. This concerns particularly the land used for the community life and is the goal of, for example, urban planning.

The ambiguity is between a territory in its basic meaning (ethological and then anthropological) and a territory in its historical meaning (legal and then institutional). Sometimes the legal/institutional meaning prevails. The meaning of territory is generally linked with the idea of Earth, of a geography with spatial boundaries. That helps to understand what is at stake with the territory. When it comes to a showdown with the *urban* it gets complicated. The city is an artefact with its limits. An agreement could be found with the concept of territory which also implies limits. But the modern *urban without limits* does not ever correspond to a territory. Here is an origin of a true epistemological difficulty. When re-editing in French in 1996 the text of Melvin M. Webber⁶ (first published in 1964 as 'The urban place and the non place urban realm', 1964), Françoise Choay pointed out very well this difficulty.⁷

Other scholars (including myself) tried to overcome the problem thanks to the concept of network. For them, the urban territory could be considered as a reticular one, a territory of networks, principally of transport. If we want to caricature, the car would have become today's urban territorial key. However, the survival of men in cities is not just about the networks. We do live from networks but networks have no limits. On the other hand, the governance of networks is problematic. Finally, one aspect remains without answer. Beyond the technical dimension of the historical networks which fabricated the modern city, what is the social meaning of the relations they allow. What about the Internet, Facebook or Twitter, social nor spatial networks without limits, who can seemingly today draw and redraw territories?

⁵G. Dupuy, *Géographie et Economie des réseaux*, Espace géographique, tome 22, n° 3, 1993 pp.193–209.

⁶M.M., Webber, *The urban place and the non place urban realm*, in *Explorations into Urban Structure* in M.M. Webber et al. ed., Pennsylvania, 1964.

⁷F. Choay, *Présentation de Webber Melvin M., L'Urbain sans lieu ni bornes*, éd. de l'Aube, La Tour d'Aigues, (1996).

Forty years ago the idea of territory was not consolidated. Borrowing to ethology, psychology, geographers offered useful but rudimentary conceptual tools about the cities, the regions and the nations. Basically a territory was defined as a living space for a community, regulated by a government. Regions were polarized or anisotropic.⁸ Large territories influenced smaller ones. Thereafter, scholars tried to give a more scientific consistency to this quite fuzzy notion. In the late 1980s, the fuzzy set theory seemed to be able to come to the rescue. Following great researchers in the field of operations research like Arnold Kaufmann, Christiane Rolland-May wrote an article on *Fuzzy set theory and its relevance in geography*.⁹ Nevertheless, the very optimistic conclusion of her article did not yield to convincing formulations. Later, globalization went quite everywhere. Monographies on metropolises show the reality of metropolitan territories.¹⁰ But scientists did not reach a systematization which would have been really useful.

Perhaps would it have been better for me not having used this notion of territory in the beginning of the 1980s when it was not enough solid. The word was nearly untranslatable into english. In the United States, the further researches have been more focused on Edge cities, on the effects of globalization on suburbanization, without the word territory being really used nor even pointed out.

Globalization came then and blurred the cards in the analysis so that today the concept of territory is hardly operative. Worse, when illuminated by the lights of the big data (as analysed, for instance, by Shelton and Zook, 2015¹¹) the territories become 'fluids'.

It seems to me that an author brought a remarkable contribution to the preceding reflections. His name is Robert Fishman. In his major book 'Bourgeois utopias', he described the processes of urban territories planning on a long term. His perspective, extended in later studies, combined the long-range history, sociological behaviour, social representations and planning processes.¹² Fishman made understand how deeply the concept of territory should be revisited further than what I had done in my book 35 years ago. Geographical, historical and anthropological dimensions of territories must be more investigated. It is a hard but priority task. Old (automobile) and new (NTIC) technologies have shaken territories. I personally worked on the subject writing books on *Automobile dependence*.¹³ My feeling is that, failing to recognize these realities, progresses in scientific study of systems. In

⁸L. Loeiz, De la commune à l'État : découpage administratif et polarisation de l'espace, *Economie et Statistique*, Année 1991, 245, pp. 19–31.

D. R. Seymour, The geographical significance of polarized regional growth, *Proceedings of the Pennsylvania Academy of Science*, Vol. 42 (1968), pp. 148–151, Published by: Penn State University Press, <https://www.jstor.org/stable/44112734>.

⁹C. Rolland-May, La théorie des ensembles flous et son intérêt en géographie, *L'espace géographique*, 16–1, (1987).

¹⁰L. Halbert, *L'avantage métropolitain*, Presses Universitaires de France, Paris, (2010).

¹¹T. Shelton et al., Social media and the city; rethinking urban socio-spatial inequality using user-generated geographic information, *Landscape and Urban Planning*, n° 142, (2015).

¹²R. Fishman, *Metropolis unbound: the new city of the twentieth century*, Flux, 1, (1990).

¹³G. Dupuy, *La dépendance automobile*, Anthopos, 1999, Paris.

conclusion, I shall evoke a theoretical approach which when combined with Fishman's ideas could bring to planning a powerful tool for rethinking land use and territories organization.

Another major contribution on territory analysis comes from Benoît Mandelbrot's Fractal theory based on old observations concerning scientific curiosities. In the 1900s, people like Pr Von Koch have investigated strange geometric figure which was called *Von Koch Snowflakes*. In the days of Von Koch none really know to where such discoveries could lead. Mandelbrot brought two important things. One was the disappearance of the frontier for geographic territories. The second was the maintenance of a sort of structure despite the geographic change of scales. First Mandelbrot made disappear or, better saying, has dissolved the geographic notion of a territory. This concept of a territory reappeared in other sciences like political science but not as a root of the geographic analyses. That means a strong trend towards the disappearance of the idea of spatial limit as a geographical frontier. The second thing brought by Mandelbrot was, thanks to fractional operations, the recurrence of the concept of discontinuities, so meaningful for geographers (fractals is a word very well chosen). So Mandelbrot is able to reintroduce a sort of structure despite the evolution of scales. The author of the book *Les objets fractals. Forme, hasard et dimension*¹⁴ showed it in a spectacular way about the Britain Coast but we can now see it both in the old curiosities mentioned above and even in the modern urban shapes (cf P. Frankhauser in the same book). Architects and geographers highlighted a major fact: all that contributes to make us perceive the space in which we live in a much more continuous manner despite the discontinuities introduced by the fractality brings us closer to reality. Fractal analysis helps to explain why the citizen browses the same territory, as consumer in a shopping centre, as an urbanite in a suburban area or as a tourist travelling around the country.

To conclude, 35 years after the publication of my book *Systems, networks, territories*, a clear progress appears both in the apprehension of systems and networks. On the other hand, the concept of territory remains, all things considered, difficult to handle, even if the fractal approach gives today a new interesting track.¹⁵

July 2020

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¹⁴B. Mandelbrot, *Les Objets fractals : forme, hasard et dimension*, trad., Flammarion, Paris, (1973).

¹⁵G. Dupuy (dir.), *Villes, réseaux et transport, le défi fractal*, Economica, Paris, (2017).

Preface

In the last few years, applications associated with Information and Communication Technologies (ICT) have made it possible—among other things—to collect volumes of data unprecedented in human history. The dynamic seems irreversible. With the mass of data available through ICT, it is now possible to access dimensions of knowledge that, though not hidden, could not be grasped in the same way in the past. They represent a step change in the availability of information. The question of how this information can be used for the benefit of territorial intelligence remains open. This expression, *polysemous and nomadic* as it is,¹⁶ is used in this book to refer to all the methods employed to feed into the decisions made by institutional and economic actors to foster the development of a territory.

Tackling the issue from a resolutely interdisciplinary perspective, we explore the theories and methods of complex systems in order to discuss how they can contribute in these new circumstances to territorial intelligence. What contributions can complex systems make to territorial intelligence and to the development practices in which it is embodied? This book is hence dedicated to that collective and plural approach.

As it becomes ever more possible to establish links between pathways, it seems desirable that this interconnection should be pursued as pertinently as possible. This requires us to consider developments of different kinds: (i) the modelling capacities opened up by complex systems; (ii) the need to make connections between the contributions of complex systems, processes and the practices of the actors of territorial intelligence so that the results do not stay ‘on the drawing board’ and are used, alongside other capacities (i.e. without replacing or supplanting other competences) and (iii) the epistemological and theoretical questions opened up by the new interdisciplinary nexus, especially regarding the notion of territory.

¹⁶Pelissier Maud, Pybourdin Isabelle, « L'intelligence territoriale. Entre structuration de réseau et dynamique de communication », *Les Cahiers du numérique*, 2009/4 (Vol. 5), p. 93–109. URL: <https://www.cairn.info/revue-les-cahiers-du-numerique-2009-4-page-93>.

The book was conceived with the aim of giving an account of these changes by (i) presenting recent developments in complex systems and networks and (ii) highlighting the contributors' irrefutable progress on territorial intelligence, in terms of support for decision-making or the provision of analytical tools that reflect reality in all its complexity. Finally, (iii) it invites readers not to lose sight of the fact that this exploration takes place within the context of an epistemological question around territory that remains highly topical. G. Dupuy reminds us of this in the foreword and other texts clearly illustrate the current situation around territory that still needs working on, caught as it is at the interface between actor networks and individual 'behaviours'.

The book thus seeks to draw attention to the fact that, with the introduction of ICT, particular caution needs to be exercised regarding the status of the large flows of data collected. True, these data reflect the actions of individuals, but they do not reconnect them to all the social 'envelopes' (categories, norms) to which they belong. To ignore this would be potentially damaging both scientifically and in terms of the contribution to territorial action.

In order to highlight the points emphasized in this preface, we have chosen to organize the book as follows.

We begin by providing three 'waymark-texts', written by authors whose work is seen as seminal in the field. The chapter by Denise Pumain, based on her own background, develops the three phases of a *theory of evolution of city networks*. Pierre Frankhauser, well known for his work on fractal geometry in geography and spatial planning, takes the approach called *Fractalopolis* and applies it to suburban growth. He shows how it can contribute to the definition of potential zones of urbanization by linking the needs of residents and environmental questions. Finally, Guy Melançon and his co-authors draw upon more abstract work on dynamic complex networks and their topological analysis. Their aim is both to identify and track the development of communities embedded in these networks, and to provide targeted tools of holistic visualization. Through their experiments, these authors provide a kind of roadmap. They show how the scientific framework has been and continues to be renewed, above all through advances in methods, and they highlight epistemological questions that need to be borne in mind.

We then introduced texts that illustrate the other end of the spectrum, insofar as they are the output of authors who focus particularly on the operational contexts of territorial intelligence, processes that are currently being implemented in different territories.

Simone Landini and Sylvie Ocelli, authors of the chapter on 4, work at the Piémont IRES (institute of economic and social research) on the implementation of the Mobility and Transport Plan. They describe an experiment conducted on the basis of and in support of public policy orientations aimed at reinventing methods to enable elected officials, experts and their staff to envisage key developments and

political priorities with a very long-term perspective (2050). Tamgram is a ‘tool for thinking about’ the organization and prioritization of goals and actions. The method used in the co-construction of this tool, whereby the input of the different actors is integrated into a model and the results fed back to them, is an interesting example of the engineering of complex systems.

Chapter 5: The Toulouse COMMUTE Project’ written by Philippe Dugot and Bruno Revelli does not precisely develop an approach based around complex systems, but describes a programme of observation of decision-making and negotiation between public and private actors on the subject of employee mobility in the northwest area of Toulouse. These actors both produce and hold the keys to mobility and transport infrastructure management. The description of the reality of the sets of actors, of travel habits and of the analytical perspective is particularly interesting in that it offers an approach to the reality of the interactions and a way to explore how the ‘smart city’ should be thought about in this environment, in particular, how to set it up. This chapter also shows how the complexity of the interactions between the actors sometimes make the hoped-for checks and balances difficult.

Chapter 6 written by Sophie Hasiak and Nicolas Juste tackles an important question for urbanism and mobilities, which is modal choice in the means of access to railway stations. The study starts from the principle that the focus cannot be on individuals’ behaviours and socio-economic origins, and that instead this modal choice is the result of the profiles of the stations themselves (i.e. their footfall, the density of the urban fabric around them, distance of access,...). The hypothesis is tested on data in the Paris region using a statistical analysis model called *beta*. The approach is thus clearly anchored in a territorial intelligence perspective. Finally, this approach can be interpreted as a way to monitor a complex system (in this case, the total set of individuals with varied behaviours and origins) via a few macroscopic parameters that describe station profiles.

We continue with texts that demonstrate the capacity of complex systems to fit into a territorial intelligence framework, on themes that are currently significant but not necessarily of immediate operational relevance.

Chapter 7 written by Ilyas Ed-daoui and his co-authors proposes a model of regional resilience based on systems-of-systems theory. The level of analysis here is not the individual but the workflows between components of systems, which might, for example, be companies. The scale of focus is groups of actors, and the aim is to assist them in decision-making.

Chapter 8 written by Françoise Lucchini and his co-authors demonstrates how Twitter data can be used to analyse mobility. It is an addition to more conventional approaches that undeniably improve our understanding of the territory, showing aspects that can only be revealed with the power of complex tools, in particular, dynamic graphs. It is a new facet, a new temporal pattern in the geography of individual urban trips (in this case, in Paris) that thus becomes available.

Chapter 9 written by Guillaume Cantin and Nathalie Verdière develops a mathematical model that provides theoretical grounding to the representation of the dynamics of complex systems of network interaction. The study analyses the impact of mobility from an epidemiological perspective, considering the spread of a vector-borne virus (the vector in this case being a mosquito). Individual behaviours are examined through mobility. The findings potentially offer assistance with decision-making in these contexts, particularly with limiting individual movement to contain the epidemiological phenomenon.

Chapter 10 written by Rodolphe Charrier and his co-authors proposes an extension to D. Helbing's social forces model, a seminal reference in the scientific community dedicated to modelling crowd behaviour by complex systems. The chapter looks at how individual nervousness spreads rapidly within a crowd through a phenomenon of propagation, for example, under the stress of an evacuation process. The resulting simulation could inform decision-making in response teams tasked with managing such a process.

Chapter 11 written by Valentina Lanza and co-authors looks at the dynamics of individual behaviours in situations of sudden disaster. A mathematical model is used to describe the interactions between subpopulations that characterize behavioural traits. The formalism here is thus a complex network system with built-in behavioural rules and seeks to inform the decision-making of operational teams tasked with managing a post-disaster crisis.

Finally, we conclude with two texts that illustrate what could be a middle way between the implementation of complex systems to the advantage of territorial intelligence, and the incorporation of the approach into territorial decision-making.

As Arnaud Banos and his co-authors write in the chapter 12, the aim is to suggest an innovative methodological toolkit for thinking about large-scale changes, in this case a region that operates without private cars. The shared construction of territorial intelligence is the core concern, with an emphasis not only on the possibilities offered by complex systems as tools for understanding the operation of the Paris region on the basis of a multiagent model, but also on using a serious game that everyone can play. This is a way to raise participants' awareness of the impact of their choices, of necessities and of adaptations.

Chapter 13 written by Paul Salze and his co-authors presents the results of the first phase of a long-term project. How can ecomobility be modelled? The chapter tackles the problem in all its complexity, using an integrative model to link the impacts of urban morphology (which can be produced synthetically) with three models of individual behaviour (economic, psychological or social) relating to the choice of commuting transport mode. By reconstructing the complexity of individual decisions, the model seeks to provide operational teams with tools for assessing the impact of the real-world application of ecomobility incentive measures.

By way of a final reminder, these chapters reflect the outcome of contributions by the plural community already described and of the interactions between disciplines. They illustrate how today’s research explores the multiple facets of territorial systems by using fractal-style analytical filters in order to reproduce their richness.

By way of a summing up, and to give shape to this scientific exploration, we offer a table that groups the chapters together, with the exception of the waymark-texts, and specifies how each chapter tackles, with varying degrees of intensity (0, X, XX in rising order of intensity), the four key themes that interact within the book: (i) the contribution of complex systems theories and methods of analysis, (ii) the process of the development of actions within the context of territorial intelligence, (iii) the inclusion of individual behaviours in acts or in speech that can be *tracked* by ICT and (iv) the strategies and actions of the institutional and economic actors, considered either individually or in networks.

| | (i) Complex systems | (ii) Territorial intelligence | (iii) Individual behaviours | (iv) Role of institutional actors |
|---------------------|---------------------|-------------------------------|-----------------------------|-----------------------------------|
| C4: Landini et al | XX | XX | 0 | X |
| C5: Dugot et al | 0 | XX | X | XX |
| C6 : Hasiak et al | X | XX | X | 0 |
| C7: Ed-daoui et al | XX | XX | 0 | X |
| C8: Lucchini et al | XX | X | XX | 0 |
| C9: Cantin et al | XX | X | X | 0 |
| C10: Charrier et al | XX | X | X | 0 |
| C11: Lanza et al | XX | X | X | 0 |
| C12: Banos et al | XX | XX | XX | X |
| C13 : Salze et al | XX | XX | XX | X |

We invite readers to combine these four keys themes through the chapters of this book, and thus to learn about the challenges, ideas, results and advances present in this domain.

Le Havre, France
 July 2020

Patricia Sajous
 Cyrille Bertelle

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