Thesis Progress Meeting

J. Raimbault[1,2]

[1]Géographie-cités (UMR 8504 CNRS)
[2]LVMT (UMR-T 9403 IFSTTAR)

March 10th 2016

Achieved Work (by projects)

- Biblio/Meetings/Organisation [0.5w]
- Seminars : Cartha-géo-prisme ; mandatory English course [0.8w]
- Memoire [2.2w] (ETA 2w)
- Cybergeo Project [1.8w] (ETA 0.5w)
- Network-Density Statistics [1.2w] (ETA 0.5w)

Subject Construction

Definition of Territorial Systems ?

→ Raffestin Human Territoriality [Raffestin, 1988] to introduce the subject
→ Privileged role of Networks, following Dupuy *Territorial Theory of Networks* [Dupuy, 1987]
→ Reciprocally, debate on Structural Effects of Transportation Networks still active today [L'Espace géographique, 2014]

Preliminary def. of Territorial Systems. *Human Territories in and between which real networks exist.*

Subject Construction

Transportation Networks and Modeling

$\rightarrow$ Necessary role of transportation networks : choice to concentrate on these.
$\rightarrow$ Modeling approach because of explicative potentialities and powerful to validate/invalidate a theory, among others.
$\rightarrow$ Consequent set of literature from multiple domains and on multiple points of view.

General research Question. *To what extent a modeling approach to territorial systems as networked human territories can help disentangling complexly involved processes ?*

Theory : First Pillar

Networked Human Territories

$\rightarrow$ Raffestin approach to territory combined with Dupuy theory of networks.

Production and Organisation of human settlements and associated societies. Transactional networks induce real networks as soon as transactions are realized. Territories as networked places [Champollion, 2006].

Theory : Second Pillar

Evolutive Urban Theory

$\rightarrow$ City Systems as complex Adaptive systems, applied tu human settlements in general and thus territorial systems.

Cities as auto-organized complex systems [Pumain, 1997] ; positioned within Complex Systems Science [Pumain, 2003] ; provide explanation for scaling laws [Pumain et al., 2006] ; cities as adapters of social change (e.g. diffusion of innovation) [Pumain, 2010] ; importance of non-ergodicity [Pumain, 2012].

Theory : Third Pillar

Urban Morphogenesis

→ Morphogenesis as autonomous rules to explain growth of urban form. Used as the provider of modular decompositions.

Imported from integrative biology [Delile et al., 2016] ; used in diverse ways for cities [Bonin et al., 2012],[Makse et al., 1998]. System exhibiting morphogenesis as *autopoietic systems* [Bourgine and Stewart, 2004] : importance of boundaries.

Theory : Fourth Pillar

Boundaries and Co-evolution

→ Co-evolution as the existence of *niche*, consequence of boundary patterns.

Signal and Boundary theory of complex adaptive systems by Holland [Holland, 2012]. Co-evolution as dynamic interdependence and relative independence to exterior. Compatible with Pumain's approach to co-evolution : city system as a niche with its internal flows.

Theory : Specification

- Previous def. of territorial systems
- Modular decomposition and stationarity : existence of scales
- Feedback loops between and inside scales yield weak emergence, thus complexity
- Morphogenesis gives modular decomposition and co-evolution
- **Main assumption.** Necessity of Networks : networks are necessary component of co-evolutive niches.

Theory : Application

Directions to validate, invalidate, modify the theory :

- Disentangle circular causation, search for morphogenesis, etc. in empirical data
- Show the necessity of networks in toy-models
- In particular exhibit bifurcations due to networks (*emergence of real networks as extension of SimpopLocal ?*)
- Same on hybrid models

From Static Correlations to Dynamical Correlations

Assumptions on the spatio-temporal stochastic processes $Y_i\left[\vec{x},t\right]$:

1. Local spatial autocorrelation is present on a maximal span of l_ρ : for any $\vec{x}$ and t, $\left|\rho_{\|\Delta\vec{x}\|<l_\rho}\left[Y_i(\vec{x}+\Delta\vec{x},t),Y_i(\vec{x},t)\right]\right|>0$.
2. Processes are locally parametrized : $Y_i = Y_i\left[\alpha_i\right]$, where $\alpha_i(\vec{x})$ varies with l_α, with $l_\alpha \gg l_\rho$.
3. Spatial correlations between processes have a sense at an intermediate scale l such that $l_\alpha \gg l \gg l\rho$.
4. Processes covariance stationarity times scale as $\sqrt{l}$.
5. Local ergodicity is present at scale l and dynamics are locally chaotic.

Hyp. 1 yields sampling consistence ; 2 to 3 allow to compute intermediate spatial correlations comparable along large spatial scales ; 4 and 5 link temporal correlation to spatial correlation.

Road Network Simplification

OpenStreetMap Road Network analysis : computation of local network indicators

Europe OSM in Postgresql database (filtered on main roads only) : $\simeq$ 100Gb.
$\rightarrow$ must proceed to network simplification.

At the scale of density raster, extract links between raster cells centroids, construct network, iteratively delete node of degree, stored in Postgresql. Parallelized, country by country (3 weeks estimated computation time).

Next steps (until April 15th 2016)

- Theoretical Paper if not crazy ? [1w]
- Spatial Statistics / Case studies (Le Corre and Baffi data) [2w]
- Cybergeo et al. [1w]

References I

Bonin, O., Hubert, J.-P., et al. (2012).
Modèle de morphogénèse urbaine: simulation d'espaces qualitativement différenciés dans le cadre du modèle de l'économie urbaine.
In 49è colloque de l'ASRDLF.

Bourgine, P. and Stewart, J. (2004).
Autopoiesis and cognition.
Artificial life, 10(3):327–345.

Champollion, P. (2006).
TERRITORY AND TERRITORIALIZATION: PRESENT STATE OF THE CAENTI THOUGHT.
In International Conference of Territorial Intelligence, INTI-International Network of Territorial Intelligence, pages p51–58, Alba Iulia, Romania.

References II

Delile, J., Doursat, R., and Peyriéras, N. (2016).
Chapitre 17. modélisation multi-agent de l'embryogenèse animale.
Modélisations, simulations, systèmes complexes, pages 581–624.

Dupuy, G. (1987).
Vers une théorie territoriale des réseaux: une application au transport urbain.
In Annales de Géographie, pages 658–679. JSTOR.

Holland, J. H. (2012).
Signals and boundaries: Building blocks for complex adaptive systems.
Mit Press.

L'Espace géographique (2014).
Les effets structurants des infrastructures de transport, l'espace géographique 2014/1 (tome 43), p. 51-67.

References III

Makse, H. A., Andrade, J. S., Batty, M., Havlin, S., Stanley, H. E., et al. (1998).
Modeling urban growth patterns with correlated percolation.
Physical Review E, 58(6):7054.

Pumain, D. (1997).
Pour une théorie évolutive des villes.
Espace géographique, 26(2):119–134.

Pumain, D. (2003).
Une approche de la complexité en géographie.
Géocarrefour, 78(1):25–31.

Pumain, D. (2010).
Une théorie géographique des villes.
Bulletin de la Société géographie de Liège, (55):5–15.

References IV

Pumain, D. (2012).
Urban systems dynamics, urban growth and scaling laws: The question of ergodicity.
In Complexity Theories of Cities Have Come of Age, pages 91–103. Springer.

Pumain, D., Paulus, F., Vacchiani-Marcuzzo, C., and Lobo, J. (2006).
An evolutionary theory for interpreting urban scaling laws.
Cybergeo: European Journal of Geography.

Raffestin, C. (1988).
Repères pour une théorie de la territorialité humaine.