Models Coupling Urban Growth and Transportation Network Growth : An Algorithmic Systematic Review Approach

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Lost in Translation

Science is all about *perspective* [Giere, 2010]...

Antagonist perspectives ?

G. Caruso saturday : Spatial ABM and Urban economy should (have to) reconciliate !
but even economist disagree [Marchionni, 2004] : geo. eco. *vs* eco. geo.

Listen to your teachers !
F. Leurent : your traffic model is wrong because out-of-eq.
M. Barthelemy : now we build a rigorous "urban science", all existing modeling work is garbage.

That escalated quickly... scientific aggressivity ! [Dupuy and Benguigui, 2015]
→ Do we "really stand together" ? [Pavlidis et al., 2014]

Research context

Thematic framework of the study of *transportation-cities (land-use) interactions*, on which misleading conceptions dominate [Offner, 1993].

[Bretagnolle, 2009] draws powerful empirical conclusions and claims for a need of **modeling the co-evolution process**.

$\rightarrow$ *State-of-the-art of such an hybrid modeling ?*

Disclaimer : NOT a thematic presentation on network/urban coevolution but more an applied epistemological study.

Brief Litterature Review

- LUTI approaches : transport integrated but static network (reviews : [Chang, 2006, Iacono et al., 2008] [Wegener and Fürst, 2004]). Various refinements (e.g. [Delons et al., 2008] housing market), many aspects can be taken into account [Wegener et al., 1991]
- Network Growth : Economic network growth [Zhang and Levinson, 2007, Xie and Levinson, 2009] ; Physical approaches [Barthélemy and Flammini, 2008] ; Biological self-organizing network [Tero et al., 2010].
- Hybrid dynamic approaches : few works propose dynamic coupled models, always toy-models. [Caruso et al., 2011, Moreno et al., 2009][Schmitt, 2014][Raimbault et al., 2014] [Le Néchet and Raimbault, 2015]

Research questions

Primal research question :

Why so few contributions on modeling this crucial problem ? What could be the role of the well-known disciplinar compartmentalization on that issue ?

Dual research question :

How does lack of pluridisciplinarity influences scientific outcomes ? Can this be understood through quantitative epistemology analyses ?

Work hypothesis

Possible Explanations :

- Too difficult problem ? (Fear of negative results [Ioannidis, 2005])
  "*A tale of complex coupling of spatio-temporal socio-technical processes at the good scales*" : Good luck !
- Tried before (a long time ago) and forget ?
  [Rey-Coyrehourcq, 2015]
- Compartmentalization of disciplines having different ontological frameworks, research objectives, etc.
  [Commenges, 2013]

→ Work on testing quantitatively the last hypothesis.

Proposed approach

Bibliometric quantitative analysis

- Bibliometry and Systematic Reviews (SR) play nowadays a significant role in many disciplines (see SR/Meta-Analyses in therapeutic evaluation [Rucker, 2012]) ; 11 SR.day^{-1} [Bastian et al., 2010] !
- SR may even be considered as mandatory as missing a reference is more a mistake given new ressources [Lissack, 2013].
- Interesting results such as models predicting success of a paper and scientific success [Wang et al., 2013]
- Current bibliometric network study do rely on citation networks [Newman, 2013] or co-autorship networks [Sarigöl et al., 20

Proposed approach

$\rightarrow$ *Iterative construction of semantic neighborhoods in scientific reference network.*

- Extension of the method proposed in [Chavalarias and Cointet, 20 where a dynamic cartography of scientific disciplines is built through text-mining (*phylomemy*).
- Based on generalized keywords extraction from titles and abstracts of references, we propose to iteratively explore the keyword co-occurence network.
- If disciplines are indeed "closed", we should converge towards communities.

Algorithm formalization

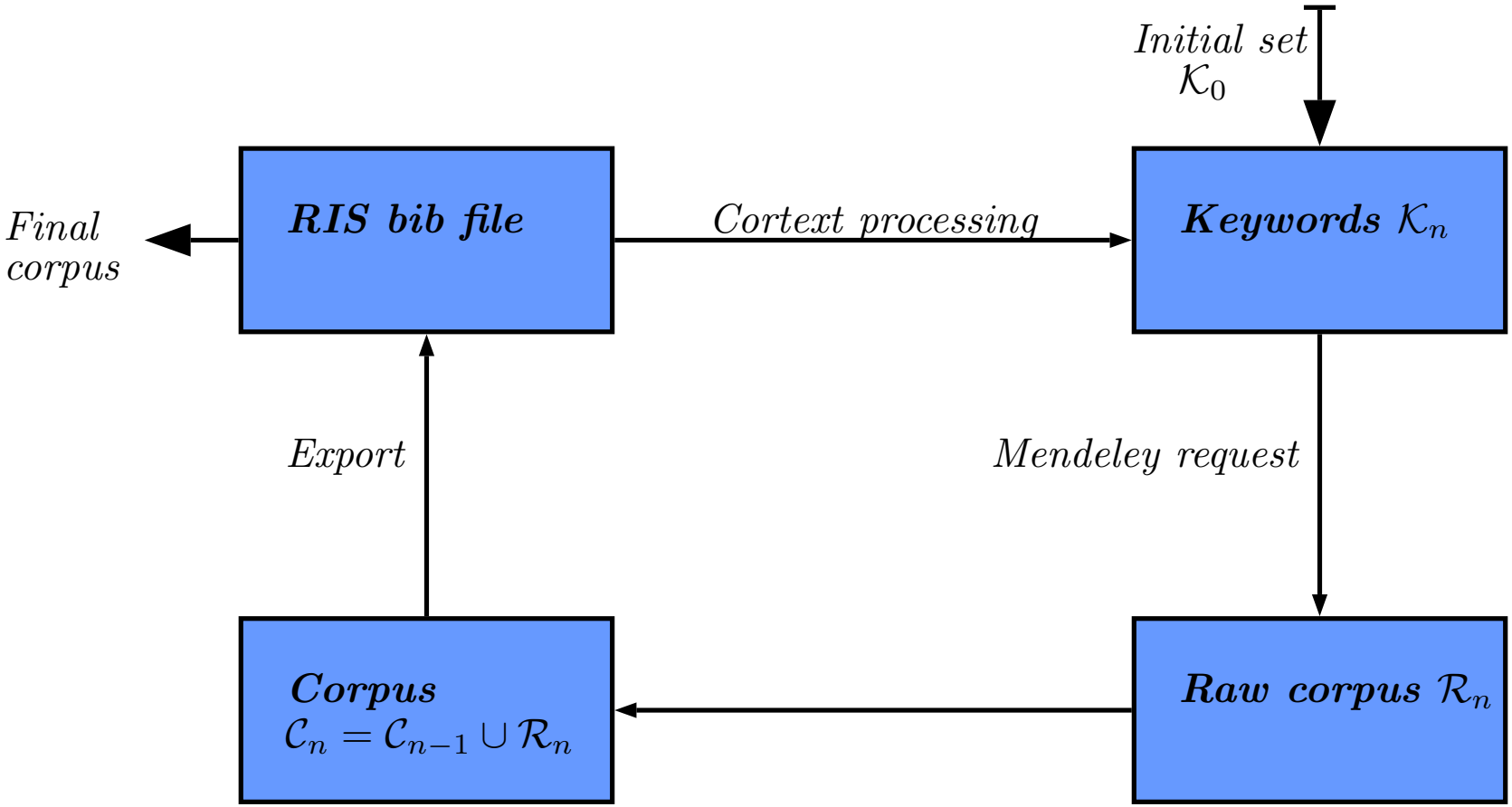
Let $\mathscr{A}$ an alphabet, $\mathscr{A}^*$ words and $\mathscr{T} = \cup_{k \in \mathbb{N}} \mathscr{A}^{*k}$ finite texts on it ; set of references at iteration n denoted $\mathscr{C}_n \in \mathscr{T}^3$. Set of keywords $\mathscr{K}_n$, initial keywords $\mathscr{K}_0$

Iteration of the algorithm

- Intermediate corpus $\mathscr{R}_n$ is obtained through a catalog request from previous keywords $\mathscr{K}_{n-1}$.
- New corpus : $\mathscr{C}_n = \mathscr{C}_{n-1} \cup \mathscr{R}_n$.
- New keywords $\mathscr{K}_n$ extracted from corpus through Natural Language Processing, with N_k fixed number of keywords.

Stopping criteria : converged corpus size or fixed max iteration

Algorithm architecture



Convergence : sketch of proof

1st attempt : we have obviously, with K, C keyword extraction and catalog request functions, $|\mathscr{C}_n| \leq |\mathscr{C}_{n+1}| \leq |\mathscr{C}_n| + |C[K(\mathscr{C}_n)]|$, what gives $|C[K(\mathscr{C}_n)]| \to 0 \iff |\mathscr{C}_n|$ bounded $\iff \mathscr{C}_n$ converges. *But assumptions difficultly interpretable*

2nd attempt :

- Assumption 1 : existence of *communities* $\mathscr{S}$ in network, on which K is stable.
- Assumption 2 : *random* steering behavior of the corpus (if not, converges as it growths)
- Then $T = \inf_n \mathscr{C}_n \in \mathscr{S}$ is a Stopping Time and thus convergence by stability of any $S \in \mathscr{S}$.

Implementation

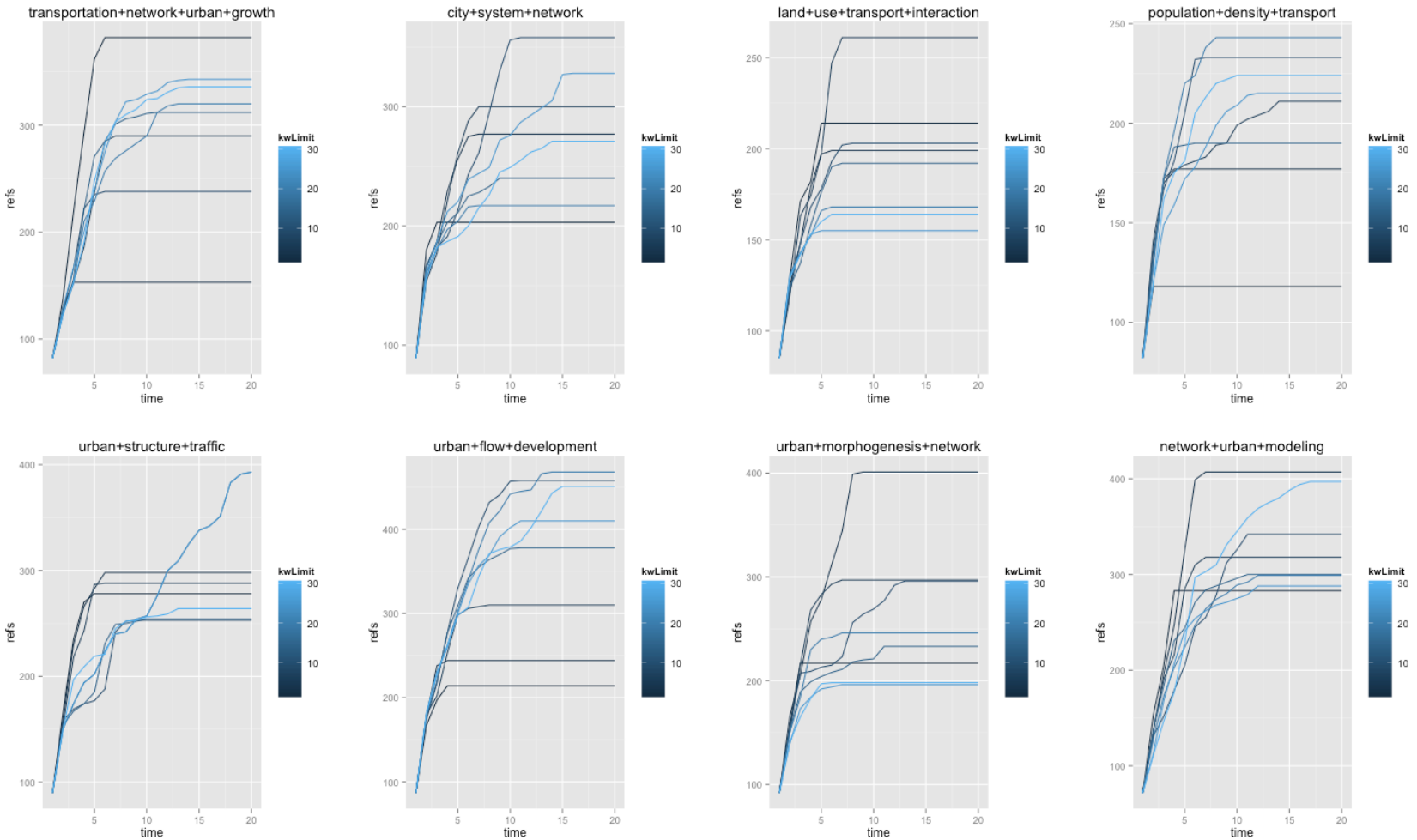
$\rightarrow$*Heterogeneity of functional specifications suggest an hybrid architecture (applied language agnosticity !) :*

- Core implemented in java ; experiment module in R
- Catalog request done to Mendeley open catalog [Mendeley, 2015] through REST API.
- Natural Language Processing through an hacked API of the web platform provided openly by [Chavalarias and Cointet, 2013] in the frame of the *Cortext* project.

Openly available at
https://github.com/JusteRaimbault/CityNetwork/tree/master/Models/Biblio/AlgoSR/AlgoSRJavaApp

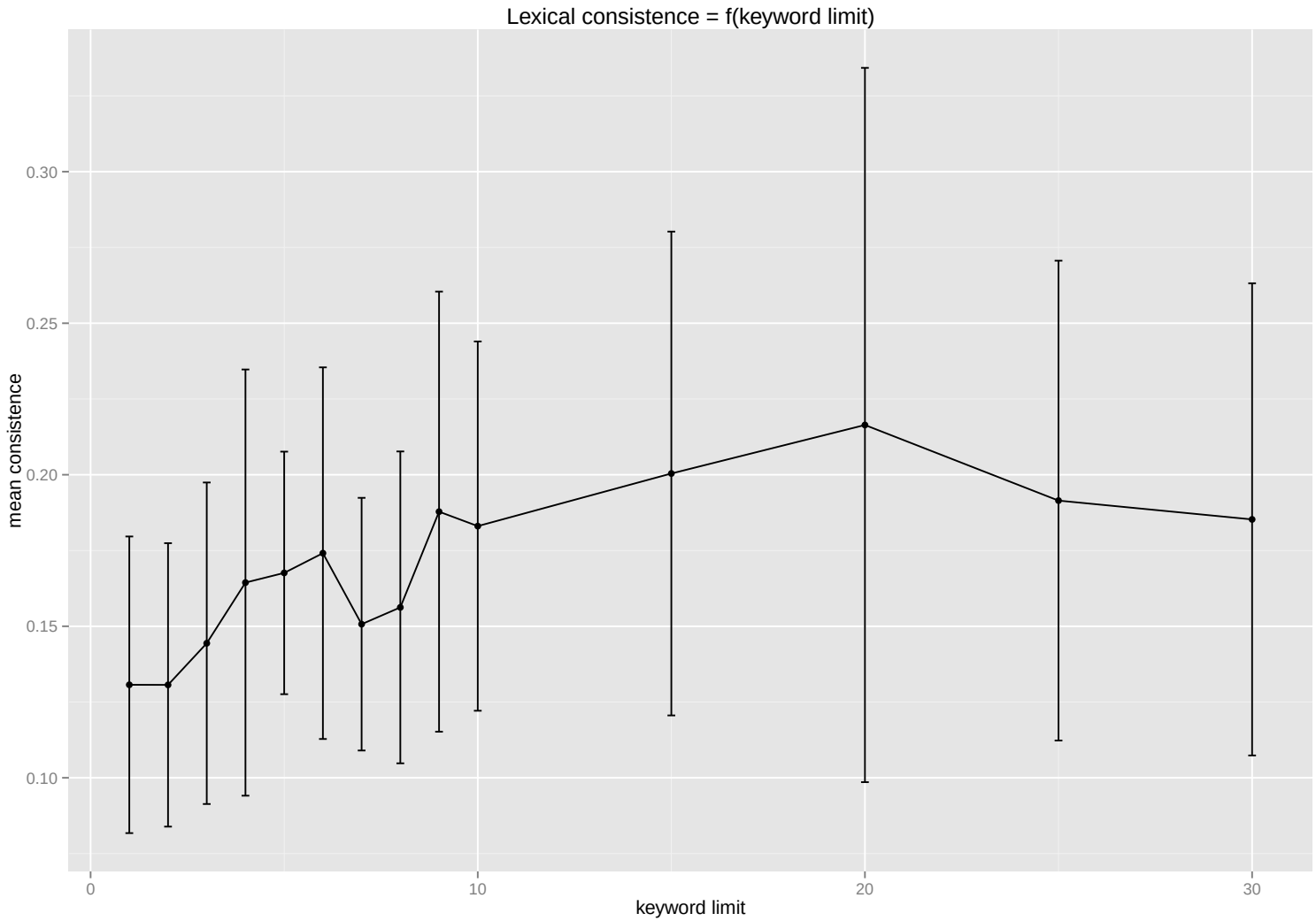
Algorithm convergence

Influence of parameters on convergence behavior



Algorithm consistence

Corpus lexical consistence



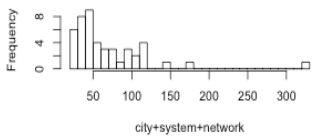
Application : experimental design

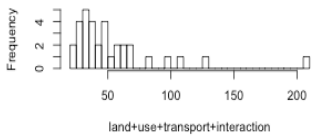
→ **Initial entries :** `city+system+network`, `land+use+transport+interaction`, `network+urban+modeling`, `population+density+transport`, `transportation+network+urban+growth`

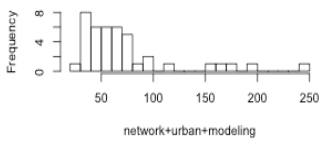
→ **Not restraining propagation parameter :** $N_k = 30$

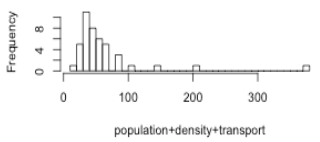
→ **Large convergence time** (obtained convergence steps : 16, 8, 17, 14,14)

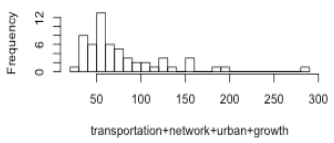
Application : corpuses distances











Corpuses	1	2	3	4	5
1 (W=3789)	1	0	0.0719	0.0078	0.0724
2 (W=5180)	0	1	0.0338	0	0.0125
3 (W=3757)	0.0719	0.0338	1	0.0100	0.1729
4 (W=3551)	0.0078	0	0.0100	1	0.0333
5 (W=8338)	0.0724	0.0125	0.1729	0.0333	1

Application : ongoing extensions

1. Method of construction of controlled random synthetic corpuses, to construct a kind of *null model* to have objective benchmark on intercluster rates.

2. Comparison of results obtained by semantic analysis with results from citation network or co-authorship network ; should find similar patterns.
   Problem : Construction of citation network from **Open Data** is tricky ; elaboration of a scholar API avoiding google blocking using a TOR threads pool.

Discussion

- Quality of / robustness to catalog [Bohannon, 2014] has to be more investigated.
- "Subjective" initial review and corpuses choices should be more systematically based on expert knowledge.
- More systematic analysis and exploration of behavior, as for a computationnal model (concept of proof in Social Sciences ? [Banos, 2013][Laughlin, 2006]
- Need to use/implement analysis and visualization tools such as in [Cuyala and Commenges, 2015]

Perspectives

- Project of a qualitative work (interviews of "old" experts, archives, grey litterature investigation) following the methodology of [Commenges, 2013].
- Algorithm as an Open source software available, easy to use by anybody $\Longrightarrow$ perspective of data collection on algorithm behavior ; collaborative building of local science maps from expert knowledge.
- Transposition of the methodology in other bibliometrical projects.

Conclusion : Proposition and implementation of an iterative semantic discipline mapping algorithm ; first results suggest a positive answer to the compartmentalization hypothesis.

Reserve slides

Reserve Slides

Lexical consistence

Lexical consistence is defined though co-occurrences of keywords by, with N final number of keywords, f final step, and $c(i)$ co-occurrences in references,

$$\kappa = \frac{2}{N(N-1)} \sum_{i,j \in \mathscr{K}_f} |c(i) - c(j)|$$

Corpuses Distances

Corpus distances defined as

$$d(i,j) = \frac{\sum_{k,l} \mathbb{1}_{w_{ki}=w_{lj}} \cdot (c_{ki} + c_{lj})}{\sum_k (c_{ki} + c_{kj})}$$

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