Generative coupled model for urban configuration optimisation

J. Raimbault

Département Humanités et Sciences Sociales, Ecole Polytechnique
LVMT, Ecole Nationale des Ponts et Chaussées

Complex System Made Simple
Project Presentation
October 14, 2013

Outline

1. Introduction
2. Description of the project

General context

- Cellular Automata model well studied in quantitative geography ([Iltanen, 2012])
- Application in Urban design and planning
- In our case: particular model of CA coupled with an evolving network ([Moreno et al., 2007, Moreno et al., 2009])

General context

- Cellular Automata model well studied in quantitative geography ([Iltanen, 2012])
- Application in Urban design and planning
- In our case: particular model of CA coupled with an evolving network ([Moreno et al., 2007, Moreno et al., 2009])

General context

- Cellular Automata model well studied in quantitative geography ([Iltanen, 2012])
- Application in Urban design and planning
- In our case: particular model of CA coupled with an evolving network ([Moreno et al., 2007, Moreno et al., 2009])

Previous work: Theoric model

Rules of the automaton

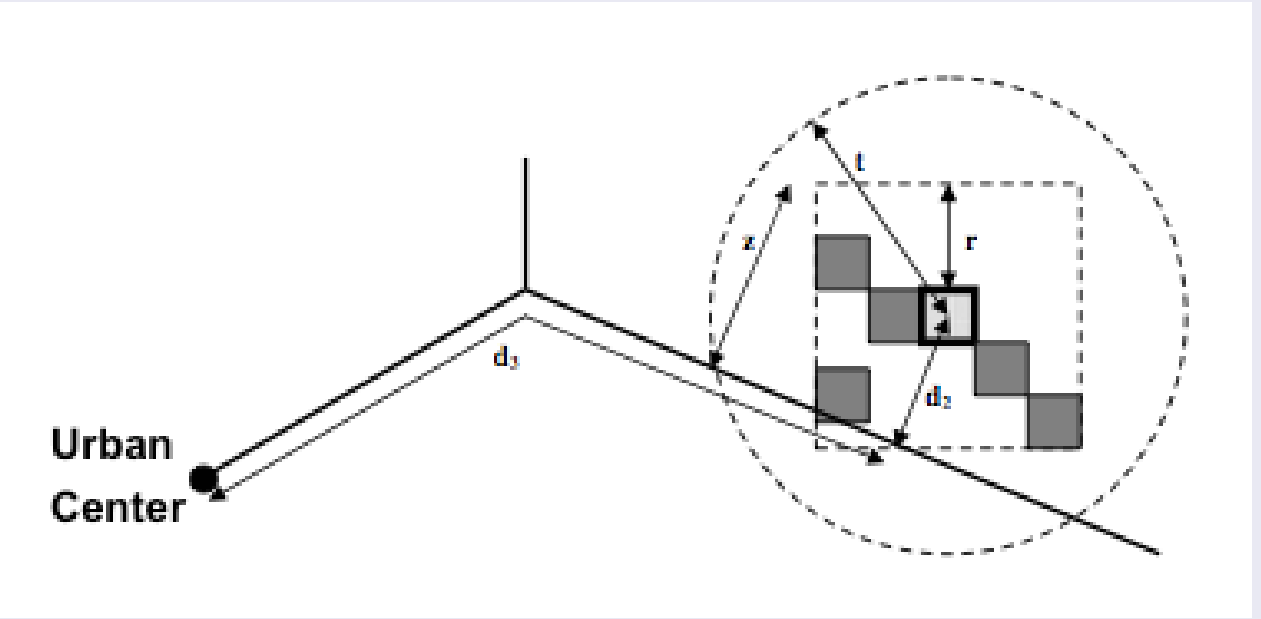
- World : rectangular subset of $\mathbb{R}^2$, decomposed by a regular grid of size $N \times N$
- Let $(d_i)_{1 \leq i \leq K}$ the explicatives variables, $(c_k)_{1 \leq k \leq K}$ corresponding weights
- At each step, occupy n (fixed) new cells, chosen by preference on the value

$$v(i,j,t) = \frac{\sum_{k=1}^{K} c_k \cdot \frac{(d_k^{max} - d_k)}{(d_k^{max} - d_k^{min})}}{\sum_{k=1}^{K} c_k}$$

Previous work: Network evolution

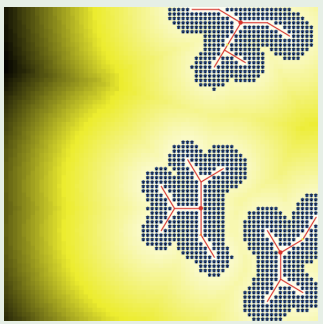
Network evolution rules

- When a new cell is built, if it is over a fixed step d_s of the network, buit a new road to connect it to the network, along the shortest path (perpendiculary in our euclidian space)

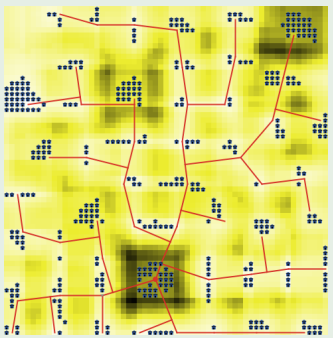


Previous work: Results

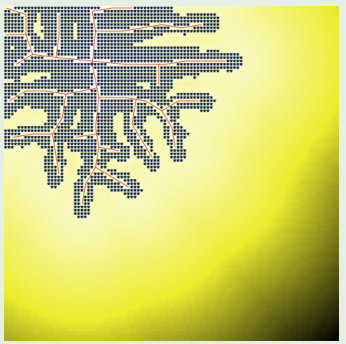
Examples of results



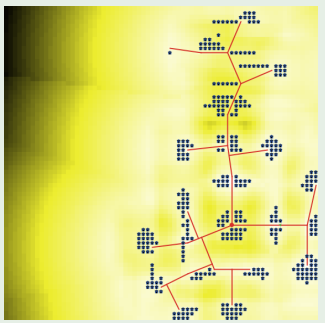
(a) Three centers, no influence of density



(b) Only density, no distances



(c) One center, no density



(d) Equal influence of variables

Figure: Characteristic urban shapes

General objective of the project

- Extension of the model by addition of dynamic agents (inhabitants): coupling with an Agent-based Model
- Better definition of evaluation functions
- Better exploration, sensitivity analysis and concrete application

General objective of the project

- Extension of the model by addition of dynamic agents (inhabitants): coupling with an Agent-based Model
- Better definition of evaluation functions
- Better exploration, sensitivity analysis and concrete application

General objective of the project

- Extension of the model by addition of dynamic agents (inhabitants): coupling with an Agent-based Model
- Better definition of evaluation functions
- Better exploration, sensitivity analysis and concrete application

Dynamic agent-based model

- Based on microeconomic model of sprawl ([Caruso et al., 2011]) and ABM for residential dynamics in the city ([Benenson, 1998])
- Patches have now value (rent), agents have wealth and want to move in in the "better place". Feedback on rents values (natural segregation effect, [Schelling, 1969])
- Coupling could be simple or complex (still need to figure out)

Dynamic agent-based model

- Based on microeconomic model of sprawl ([Caruso et al., 2011]) and ABM for residential dynamics in the city ([Benenson, 1998])
- Patches have now value (rent), agents have wealth and want to move in in the "better place". Feedback on rents values (natural segregation effect, [Schelling, 1969])
- Coupling could be simple or complex (still need to figure out)

Dynamic agent-based model

- Based on microeconomic model of sprawl ([Caruso et al., 2011]) and ABM for residential dynamics in the city ([Benenson, 1998])
- Patches have now value (rent), agents have wealth and want to move in in the "better place". Feedback on rents values (natural segregation effect, [Schelling, 1969])
- Coupling could be simple or complex (still need to figure out)

Evaluation functions

- Need of determination of the morphological enveloppe ([Tannier et al., 2008, Frankhauser and Tannier, 2005]) and implementation of morphological function more effective than simple density (ex Moran index, [Tsai, 2005])
- Network measures adapted to urban mobility ([Banos and Genre-Grandpierre, 2012])
- Economic measures linked to the ABM ?

Evaluation functions

- Need of determination of the morphological enveloppe ([Tannier et al., 2008, Frankhauser and Tannier, 2005]) and implementation of morphological function more effective than simple density (ex Moran index, [Tsai, 2005])
- Network measures adapted to urban mobility ([Banos and Genre-Grandpierre, 2012])
- Economic measures linked to the ABM ?

Evaluation functions

- Need of determination of the morphological enveloppe ([Tannier et al., 2008, Frankhauser and Tannier, 2005]) and implementation of morphological function more effective than simple density (ex Moran index, [Tsai, 2005])
- Network measures adapted to urban mobility ([Banos and Genre-Grandpierre, 2012])
- Economic measures linked to the ABM ?

Epistemological frame

- Use of quantitative models of simulation for urban system have lead to a loss of their sense ([Portugali, 2012])
- We must reconsider the model and results from this point of view
- Level of complexity for the coupling: what is the best choice ? ([Varenne et al., 2013])

Epistemological frame

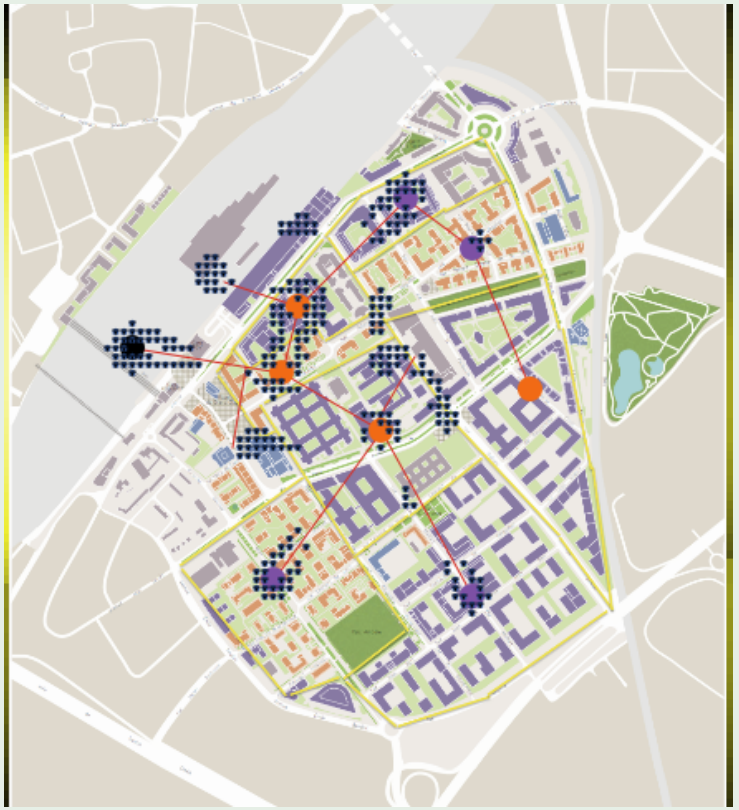
- Use of quantitative models of simulation for urban system have lead to a loss of their sense ([Portugali, 2012])
- We must reconsider the model and results from this point of view
- Level of complexity for the coupling: what is the best choice ? ([Varenne et al., 2013])

Epistemological frame

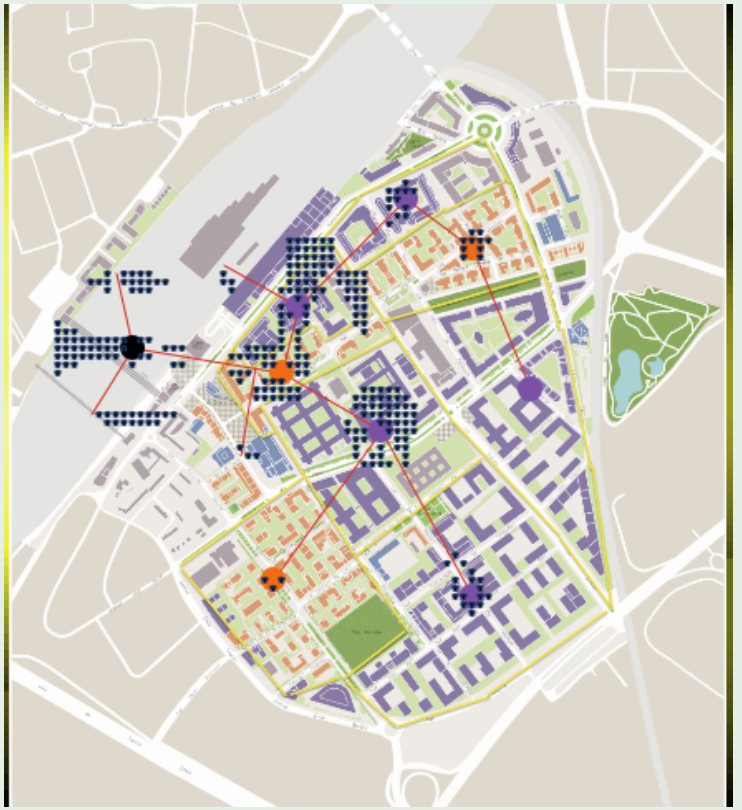
- Use of quantitative models of simulation for urban system have lead to a loss of their sense ([Portugali, 2012])
- We must reconsider the model and results from this point of view
- Level of complexity for the coupling: what is the best choice ? ([Varenne et al., 2013])

Concrete application: expected results

Comparison of configurations



(a) Configuration of a good compromise



(b) Real configuration

Figure: Optimal configurations

References I

Banos, A. and Genre-Grandpierre, C. (2012).
Towards new metrics for urban road networks: Some preliminary evidence from agent-based simulations.
In *Agent-based models of geographical systems*, pages 627–641. Springer.

Benenson, I. (1998).
Multi-agent simulations of residential dynamics in the city.
Computers, Environment and Urban Systems, 22(1):25–42.

Caruso, G., Vuidel, G., Cavailhes, J., Frankhauser, P., Peeters, D., and Thomas, I. (2011).
Morphological similarities between dbm and a microeconomic model of sprawl.
Journal of Geographical Systems, 13:31–48.

References II


Frankhauser, P. and Tannier, C. (2005).
A multi-scale morphological approach for delimiting urban areas.
In *9th Computers in Urban Planning and Urban Management conference (CUPUM'05), University College London*.


Iltanen, S. (2012).
Cellular automata in urban spatial modelling.
In *Agent-based models of geographical systems*, pages 69–84. Springer.


Moreno, D., Badariotti, D., and Banos, A. (2009).
Un automate cellulaire pour expérimenter les effets de la proximité dans le processus d'étalement urbain : le modèle raumulus.
Cybergeo : European Journal of Geography.

References III

Moreno, D., Banos, A., and Badariotti, D. (2007).
Conception d'un automate cellulaire non stationnaire à base de graphe pour modéliser la structure spatiale urbaine: le modèle remus.
Cybergeo: European Journal of Geography.

Portugali, J. (2012).
Complexity theories of cities: Achievements, criticism and potentials.
In *Complexity Theories of Cities Have Come of Age*, pages 47–62. Springer.

Schelling, T. C. (1969).
Models of segregation.
The American Economic Review, 59(2):488–493.

References IV


Tannier, C., Vuidel, G., and Frankhauser, P. (2008).
Délimitation d'ensembles morphologiques par une approche multi-échelle.
In Foltête, J.-C., editor, *Actes des huitièmes Rencontres de Théo Quant*, page 14, Besançon, France.
http://thema.univ-fcomte.fr/theoq/.


Tsai, Y.-H. (2005).
Quantifying urban form: compactness versus' sprawl'.
Urban Studies, 42(1):141–161.


Varenne, F., Silberstein, M., et al. (2013).
Modéliser & simuler. Epistémologies et pratiques de la modélisation et de la simulation, tome 1.

Questions

?