# M2 Erasmus Mundus Complex Systems "Open problems" project description

Juste Raimbault
Département HSS, Ecole Polytechnique ParisTech
LVMT, Ecole Nationale des Ponts et Chaussées

October 9, 2013

*Investigating bottom-up solutions to optimization of rental Bikes repartition*

## 1 Presentation of the context

City rental bikes systems have been recently installed in many big European cities. The flexibility offered to users, the decongestion of car traffic and the contribution to a more "clean" urban mobility have been for example presented as arguments in favor of such kind of system, as it is argued in an unformal way in [1]. According to [10], at least 16 countries have adopted it, although majority of implemented systems are still in France (26 systems in France out of 78 in the world).

Planning of stations distribution stays a keypoint in a particular implementation and studies have been conducted to understand planning features, adaptability and reproductability of a configuration, as it is done in [6] on Paris in order to evaluate possible implantation in a Chinese city, or in a more transversal and general view in [7] where different factors of success or fail of city rental bikes are investigated.

After the system is installed, some problems often appears through its use: depending on time of day and landuse (residential or work area), stations can be totally empty or full on a all district, what strongly decrease the quality of the service and does not encourage the users to go on using it. Field survey or eye overview on data can simply confirm that fact. Therefore, companies use trucks to redistribute the bikes and avoid such problems. That need a precise knowledge of flows or even hypothetical trajectories of bikes, what have

been done on the Velo'v system in Lyon: construction of a fine statistical cyclic model in [3, 4], extrapolation of spatial distribution of bikes in [5], deduction of probabilities of trajectories in [8] and refinment of the statistical estimators in [9].

## 2 Work proposal and expected results

**Project description** Most of existing litterature on the subject seems to be centered on statistical analysis and prediction, i. e. top-down optimization methods from a complex systems point of view, as the statistical analysis presented before. Through these flow predictions, it is obvious to proceed to operationnal research optimisation, e. g. to a weighted Trade-Saleman-Problem algorithm for optimization of the trajectory of the redistribution truck. However, the results of such mehods can be complicated or costly to implement.

We would like to investigate how could be useful bottom-up simple and cheap measures for a better repartition of bikes, or at least for a better experience of the user. Since such measures can only be taken at the local scale of stations or bike, or on isolated users, it appears to be necessary to create an agent-based model of simulation for movements of users and bikes, in which local measures can be integrated. For example, we could first try to evaluate the consequences of the free-time reward when a user let his bike on a high station (solution that has already been implemented, but that could need a better evaluation of the optimal reward time). Then local solution can be faster information screens on stations that give available bikes or parking places on other station around, or the effect of better general knowledge of the system by users.

Since high bonus stations can be a minority of the system, we may concentrate more on the propensity of user to drop or take their bikes at a certain distance of their objective point (which will be of course a function of the distance and possibly of the type of user if we define heterogeneous users) and on the associated possible knowledge that the user can have of the current situation of the bike distribution. Given distribution of stations and spatial tendancies of flows, it is not obvious that increasing these parameters will directly impact the homogeneity of bikes repartition (a simple argument going that way can be the case were a user can't go over a certain walking distance, but all network is congestioned on a greater radius around his objective point; in that case increasing his knowledge will have no effect). We can work in a first time with these parameters staying abstract, and then try to determine possible corresponding real measures, but also by reviewing possible measures and translating with these parameters as proxies.

To sum up abstractly, our aim is to explore bottom-up measures through directly associated bottom-up means (the agent-based model).

**Collect and treatment of data** The model will have to be usable on real situations, we have therefore to use GIS data of a real city, that will be arbitrary Paris. The collection of GIS data can be done through OpenStreetMap (see [2]) and associated tools for data extraction and treatment.

Concerning temporal data of bike repartition, no time-series are publically available on the API of the company exploiting renting bikes in Paris, so we wrote a script which is constantly running on a web server, collecting all 5 minutes all data of all stations in Paris. Simple treatment will give us exploitable time-series for the calibration of the model. Statistical analysis of these data will be done in the frame of an other project and could be useful in our case for a better parametrization.

**Expected results** We expect to obtain a running ABM, integrating real GIS data and that could be calibrated on the real time-series or on statistical extrapolation from these data. The model will include parameters translating possible local measures (that could be e. g. propensy of users to climb the hill, general radius of knowledge of user around fixed points, etc. ) on which we will be able to explore different scenarii corresponding to different real measures.

We expect also to proceed to sensitivity analysis (on parameters but also on spatial configurations) and exploration of some parts of the parameter space of the model before drawing conclusions from the investigations on possible measures.

# 3 Detailed schedule

**General preparation**

- General bibliography: 2h
- General reflexion: already done
- Temporal data collection: already done
- Temporal data statistical analysis: done in the frame of an other project (2h per week). Needs to be done before first explorations, i. e. before 01/12.

Total: 2h, before the 13/10

**Theoretical construction of the Agent-based model (2 weeks)**

- Study on agents, scale and environment: 2h
- Determination of interactions, properties and evolution rules: 2h

- Formal description of the model: 4h

Total: 8h, before the 27/10

**Implementation and coding (3 weeks)**

- Intermediate script for temporal data integration into NetLogo: 2h
- GIS data collection and integration: 2h
- Core model coding (NetLogo): 12h
- Possible feedbacks on theoretical construction: undefined

Total: 16h, before the 17/11

**Model exploration and calibration (2 weeks)**

- Tests and "hand" exploration, sensitivity analysis: 4h
- Automatic exploration: 0h (functions coding counted in coding part, does not represent work here, only launch calculations during nights)
- Calibration (on MSE on temporal data): 4h (idem as previous point, unless we include for this part exploration of results obtained thanks to calibration)

Total: 8h, before the 01/12

**Analysis of results, discussion, finalisation of reports and presentation (2 weeks)**

- Results analysis: 3h
- Discussions, possible feedback on explorations: 3h
- Redaction of documents and oral presentation: 4h (should have logically strongly been begun inside some other parts)

Total: 10h, before the 15/12

# References


[1] John Ward Anderson. Paris embraces plan to become city of bikes. *Washington Post Foreign Service*, 2007.

[2] Jonathan Bennett. *OpenStreetMap*. Packt Publishing, 2010.

[3] Pierre Borgnat, Patrice Abry, and Patrick Flandrin. Modélisation statistique cyclique des locations de vélo'v à lyon. In *XXIIe colloque GRETSI (traitement du signal et des images), Dijon (FRA), 8-11 septembre 2009*. GRETSI, Groupe d'Etudes du Traitement du Signal et des Images, 2009.

[4] Pierre Borgnat, Patrice Abry, Patrick Flandrin, Jean-Baptiste Rouquier, et al. Studying lyon's vélo'v: a statistical cyclic model. In *European Conference on Complex Systems 2009*, 2009.

[5] Pierre Borgnat, Eric Fleury, Céline Robardet, Antoine Scherrer, et al. Spatial analysis of dynamic movements of vélo'v, lyon's shared bicycle program. In *European Conference on Complex Systems 2009*, 2009.

[6] Xue Geng, Kai TIAN, Yu ZHANG, and Qing LI. Bike rental station planning and design in paris [j]. *Urban Transport of China*, 4:008, 2009.

[7] Jonathan Gifford and Arlington Campus. Will smart bikes succeed as public transportation in the united states? *Center for Urban Transportation Research*, 7(2):1, 2004.

[8] Pablo Jensen, Jean-Baptiste Rouquier, Nicolas Ovtracht, and Céline Robardet. Characterizing the speed and paths of shared bicycle use in lyon. *Transportation research part D: transport and environment*, 15(8):522–524, 2010.

[9] Gabriel Michau, Céline Robardet, Luc Merchez, Pablo Jensen, Patrice Abry, Patrick Flandrin, and Pierre Borgnat. Peut-on attraper les utilisateurs de vélo'v au lasso. In *Proceedings of the 23e Colloque sur le Traitement du Signal et des Images. GRETSI-201*, pages 46–50, 2011.

[10] Peter Midgley. The role of smart bike-sharing systems in urban mobility. *JOURNEYS*, 2:23–31, 2009.