Quantifying the co-evolution of economic activities locations with geo-historical data: Paris, 19th century

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SoDUCo (Social Dynamics in Urban Context) ANR project

Social Dynamics in Urban Context

Open tools, models and data - Paris and its suburbs, 1789-1950

Welcome to the SODUCO project

SODUCO is a 4 years pluridisciplinary project funded by the French National Research Agency, it has started in march 2019 and will end in 2023. SODUCO brings together people from the geographical sciences, from urban history, specialists of network morphogenesis and computer scientists to study the evolution of Paris over time, both in terms of its morphological transformations and its social evolutions.

Project partner institutions

L'ÉCOLE DES HAUTES ÉTUDES EN SCIENCES SOCIALES

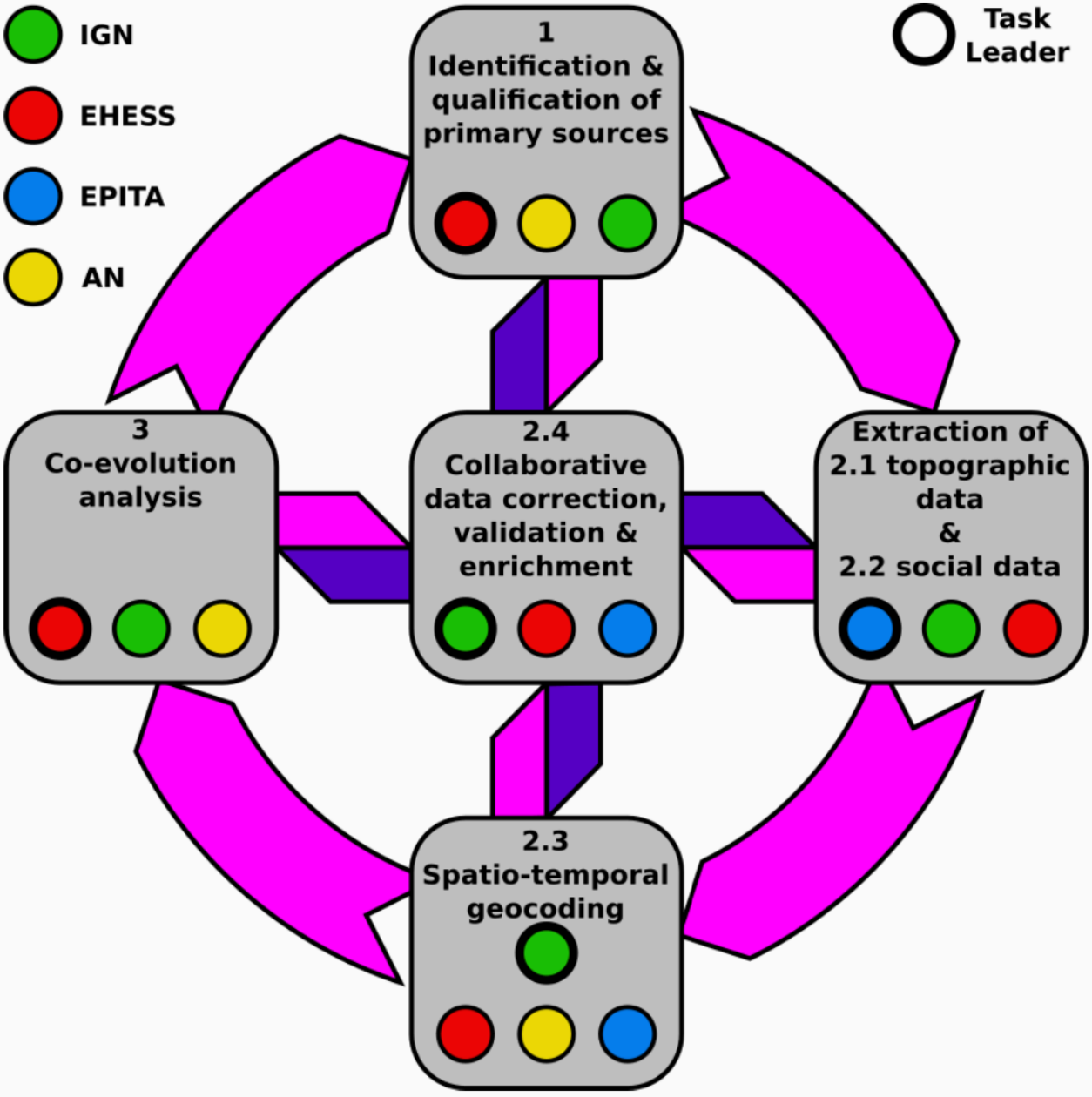
IGN INSTITUT NATIONAL DE L'INFORMATION GÉOGRAPHIQUE ET FORESTIÈRE

EPITA ÉCOLE D'INGÉNIEURS EN INFORMATIQUE

ARCHIVES NATIONALES

https://soduco.github.io/

Structure of the SODUCO project



Project research objectives

WP 1: Identification and qualification of relevant sources

→ Catalog of primary sources; qualification of sources and metadata construction; online publication as Linked Open Data; modeling of uncertainties.

WP 2: Digitalisation of sources

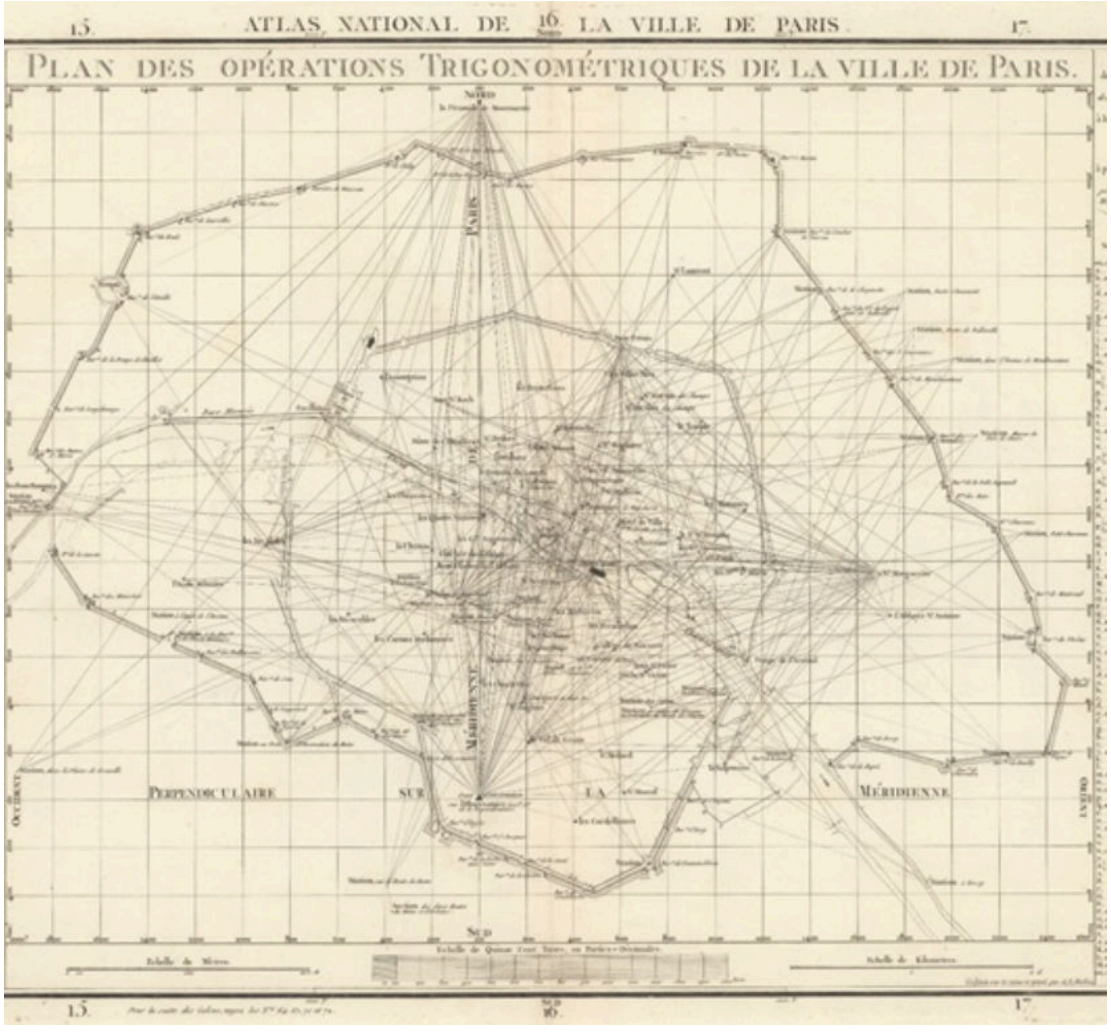
→ Extraction of topographic data (2.1); extraction of socio-economic data (2.2); spatio-temporal geocoding (2.3); collaborative data correction, validation and enrichment (2.4).

WP 3: Co-evolution analysis

→ geovisualisation of data and associated dynamics.

Tools: collaborative open platform to ensure reproducibility and traceability of data and processes.

Verniquet atlas accuracy

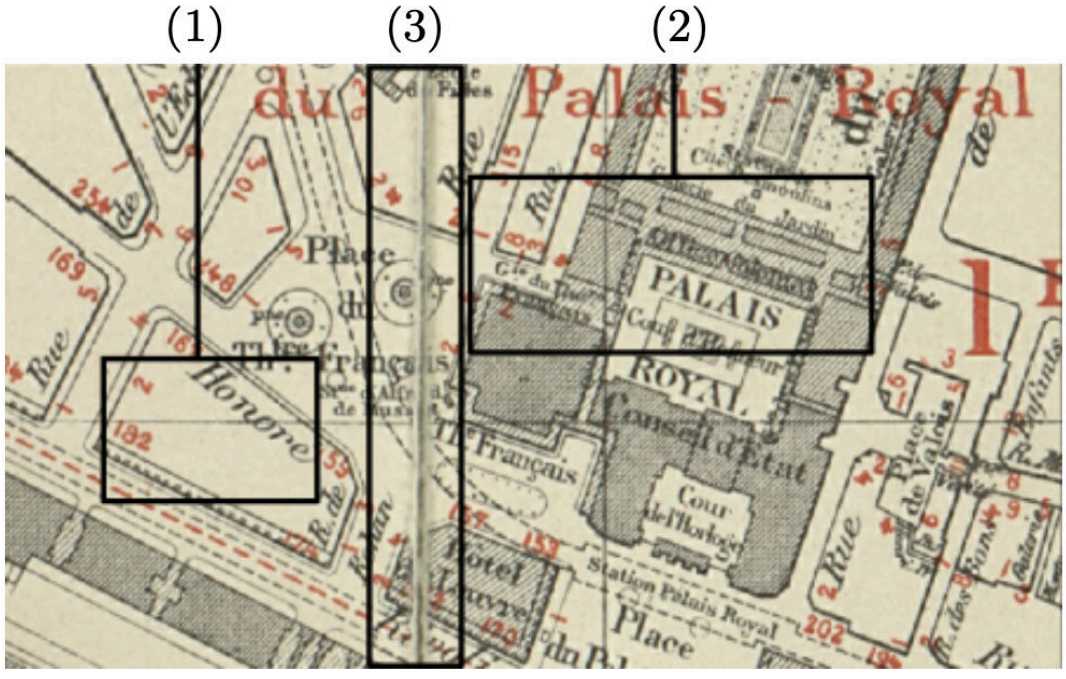


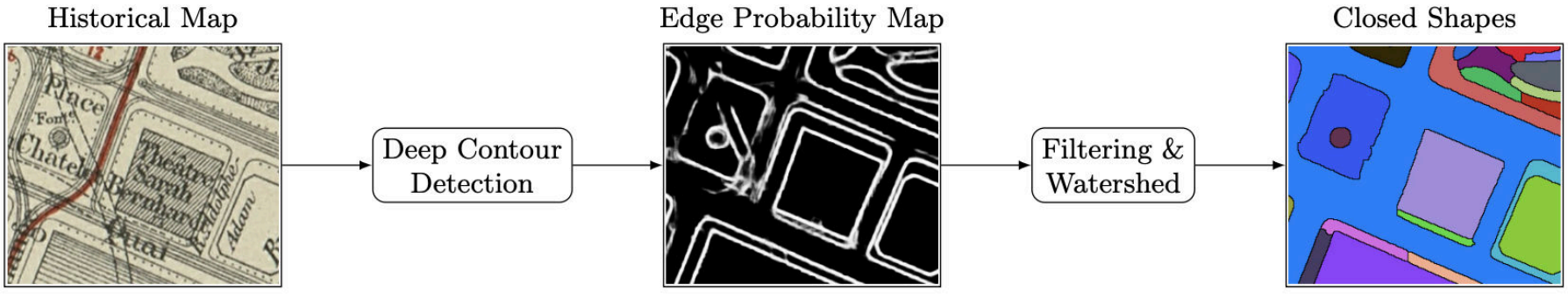
Fieldwork survey with modern instruments to verify the planimetric accuracy of Verniquet atlas (claimed at 1/10 of a toise $\simeq$ 19cm)

$\rightarrow$ Claimed uncertainties were correct

$\rightarrow$ CRS parameters for the historical coordinate system (reused as reference in many historical plans)

Vectorisation of historical maps





PhD thesis by Yizi Chen soon finished: vectorisation combining deep learning and mathemaatical morphology [Chen et al., 2021b] [Chen et al., 2021a]

Quantification of intra-urban co-evolutionary dynamics

$\rightarrow$ Multi-dimensionality of urban systems is one aspect of their complexity, strongly present in the co-evolution of economic activities locations.

$\rightarrow$ Understanding past processes better inform urban theories and models for future sustainable planning.

Research objective of this contribution (partly WP3):

Use geo-historical data to quantify the co-evolution of economic activities in Paris during the 19th century; methodological aspects on the issues linked to the exploitation of such data.

Urban systems and geo-historical data

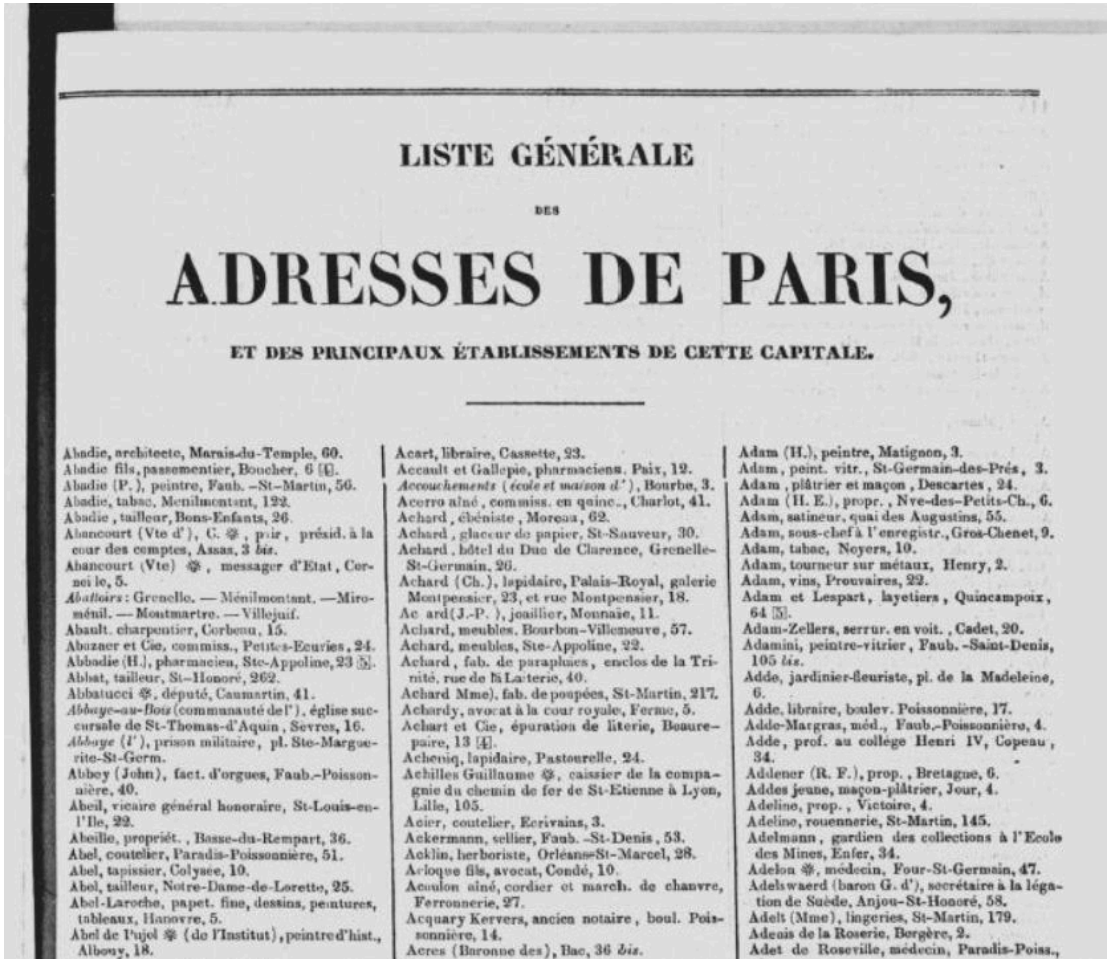
→ Contemporary intra-urban dynamics are better and better characterised through the emergence of urban data and urban analytics [Kandt and Batty, 2021]; more difficult with past dynamics.

→ Interdisciplinary approaches to the modeling of settlement systems transitions: qualitative or very sparse data, stylised models (Transmondyn project) [Sanders, 2018]

→ Stylised models for systems of cities on long time scales [Pumain and Reuillon, 2017]

→ Difficulty to build geo-historical data: geocoding [Cura et al., 2018], vectorisation [El Gouj et al., 2022]

Data extraction



LISTE GÉNÉRALE

DES

ADRESSES DE PARIS,

ET DES PRINCIPAUX ÉTABLISSEMENTS DE CETTE CAPITALE.

Abadie, architecte, Marais-du-Temple, 60.
Abadie fils, passementier, Boucher, 6 [1].
Abadie (P.), peintre, Faub.-St-Martin, 56.
Abadie, tabac, Menilmontant, 122.
Abadie, tailleur, Bons-Enfants, 26.
Abancourt (Vte d'), C. ✻, pair, présid. à la cour des comptes, Assas, 3 *bis*.
Abancourt (Vte) ✻, messager d'Etat, Cornei le, 5.
Abattoirs: Grenelle. — Ménilmontant. —Miroménil. — Montmartre. — Villejuif.
Abault, charpentier, Corbeau, 15.
Abazner et Cie, commiss., Petites-Ecuries, 24.
Abbadie (H.), pharmacien, Ste-Appoline, 23 [5].
Ablat, tailleur, St-Honoré, 262.
Abbatucci ✻, député, Caumartin, 41.
Abbaye-au-bois (communauté de l'), église succursale de St-Thomas-d'Aquin, Sevres, 16.
Abbaye (l'), prison militaire, pl. Ste-Marguerite-St-Germ.
Abbey (John), fact. d'orgues, Faub.-Poissonnière, 40.
Abeil, vicaire général honoraire, St-Louis-en-l'Ile, 22.
Abeille, propriét., Basse-du-Rempart, 36.
Abel, coutelier, Paradis-Poissonnière, 51.
Abel, tapissier, Colysée, 10.
Abel, tailleur, Notre-Dame-de-Loretto, 25.
Abel-Laroche, papet. fine, dessins, peintures, tableaux, Hanovre, 5.
Abel de l'ujol ✻ (de l'Institut), peintre d'hist., Abbouy, 18.
Acart, libraire, Cassette, 23.
Accault et Gallepie, pharmaciens, Paix, 12.
Accouchements (*école et maison d'*), Bourbe, 3.
Acerro aîné, commiss. en quinc., Charlot, 41.
Achard, ébéniste, Moreau, 62.
Achard, glaceur de papier, St-Sauveur, 30.
Achard, hôtel du Duc de Clarence, Grenelle-St-Germain, 26.
Achard (Ch.), lapidaire, Palais-Royal, galerie Montpensier, 23, et rue Montpensier, 18.
Ac ard (J.-P.), joaillier, Monnaie, 11.
Achard, meubles, Bourbon-Villeneuve, 57.
Achard, meubles, Ste-Appoline, 22.
Achard, fab. de parapluies, enclos de la Trinité, rue de la Laiterie, 40.
Achard Mme), fab. de poupées, St-Martin, 217.
Achardy, avocat à la cour royale, Ferme, 5.
Achart et Cie, épuration de literie, Bourepaire, 13 [4].
Achenig, lapidaire, Pastourelle, 24.
Achilles Guillaume ✻, caissier de la compagnie du chemin de fer de St-Etienne à Lyon, Lille, 105.
Acier, coutelier, Ecrivains, 3.
Ackermann, sellier, Faub.-St-Denis, 53.
Acklin, herboriste, Orléans-St-Marcel, 28.
Acloque fils, avocat, Condé, 10.
Acoulon aîné, cordier et march. de chanvre, Ferronnerie, 27.
Acquary Kervers, ancien notaire, boul. Poissonnière, 14.
Acres (Baronne des), Bac, 36 *bis*.
Adam (H.), peintre, Matignon, 3.
Adam, peint. vitr., St-Germain-des-Prés, 3.
Adam, plâtrier et maçon, Descartes, 24.
Adam (H. E.), propr., Nve-des-Petits-Ch., 6.
Adam, satineur, quai des Augustins, 55.
Adam, sous-chef à l'enregistr., Gros-Chenet, 9.
Adam, tabac, Noyers, 10.
Adam, tourneur sur métaux, Henry, 2.
Adam, vins, Prouvaires, 22.
Adam et Lespart, layetiers, Quincampoix, 64 [5].
Adam-Zellers, serrur. en voit., Cadet, 20.
Adamini, peintre-vitrier, Faub.-Saint-Denis, 105 *bis*.
Adde, jardinier-fleuriste, pl. de la Madeleine, 6.
Adde, libraire, boulev. Poissonnière, 17.
Adde-Margras, méd., Faub.-Poissonnière, 4.
Adde, prof. au collège Henri IV, Copeau, 34.
Addener (R. F.), prop., Bretagne, 6.
Addes jeune, maçon-plâtrier, Jour, 4.
Adeline, prop., Victoire, 4.
Adeline, rouennerie, St-Martin, 145.
Adelmann, gardien des collections à l'Ecole des Mines, Enfer, 34.
Adelon ✻, médecin, Four-St-Germain, 47.
Adelswaerd (baron G. d'), secrétaire à la légation de Suède, Anjou-St-Honoré, 58.
Adelt (Mme), lingeries, St-Martin, 179.
Adenis de la Roserie, Bergère, 2.
Adet de Roseville, médecin, Paradis-Poiss.,

Several commercial economic activities repertoires, archived and digitalised.

→ Work on *Didot-Bottin*, covering most of 19th century (to avoid multi-source bias for now)

→ Document segmentation, OCR

→ Named Entity Recognition to extract names, adresses, activities

→ Historical geocoding

Data pre-processing

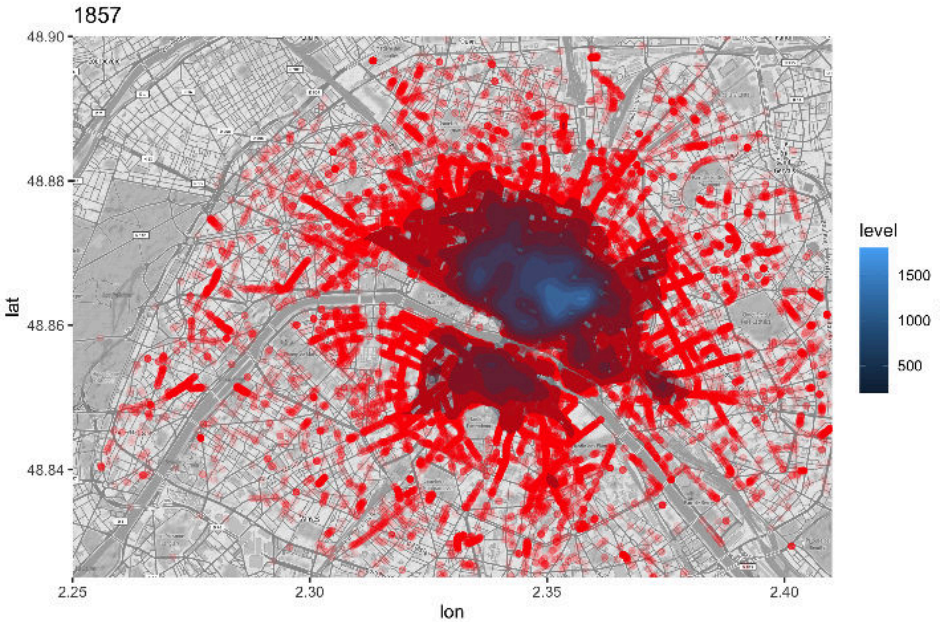
→ Data covering 1857-1908: 4,218,048 entries, 80.32% with coordinates and a defined activity.

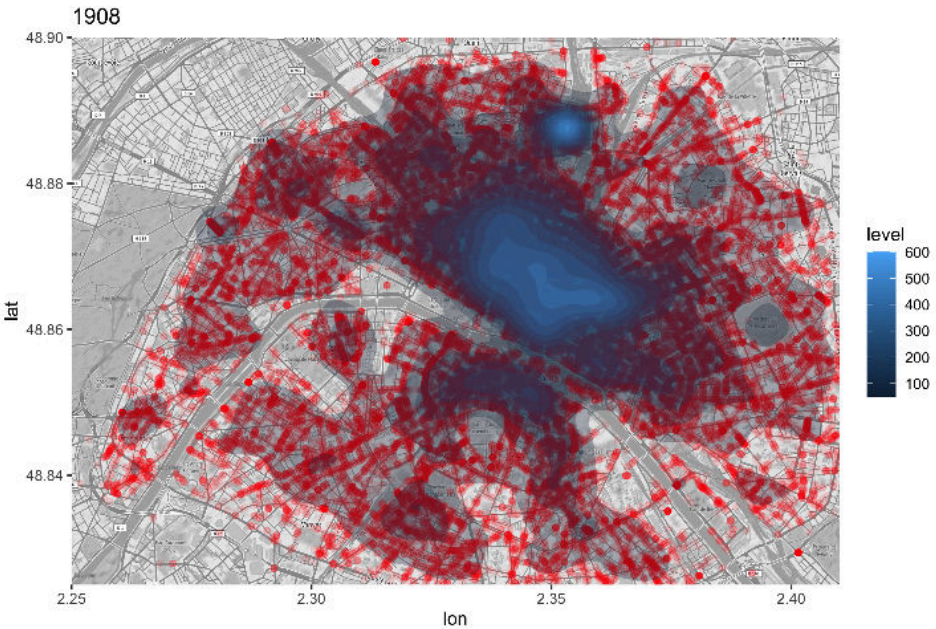
→ Natural Language Processing: stop-words removal and stemming to descriptions of activities.

→ Stems with more than 100 occurrences (996) coded for broad activities (food, craftsmanship, art and literature, health, law and governance, service, teaching)

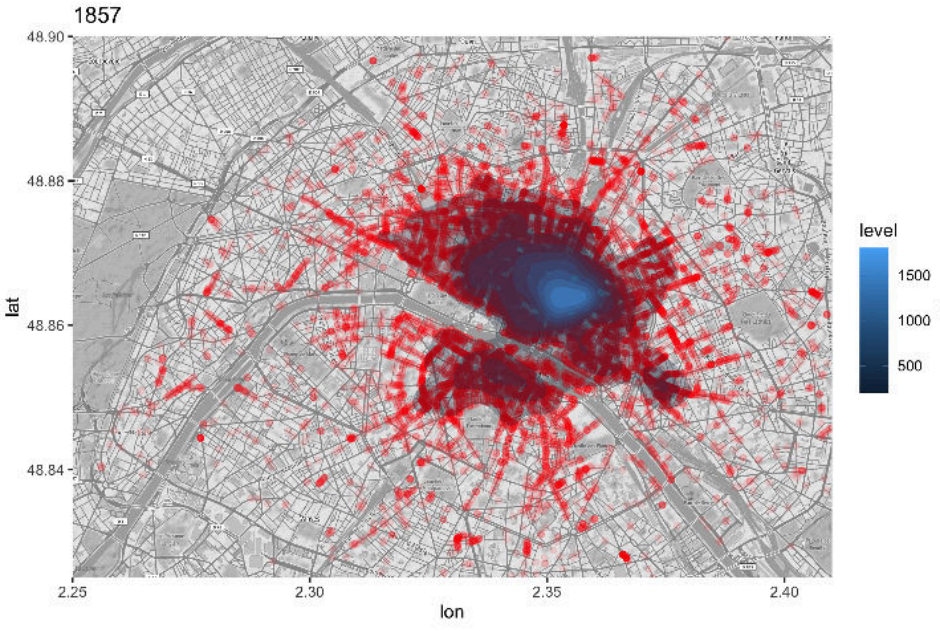
→ 1,990,222 entries with coordinates and classified activities

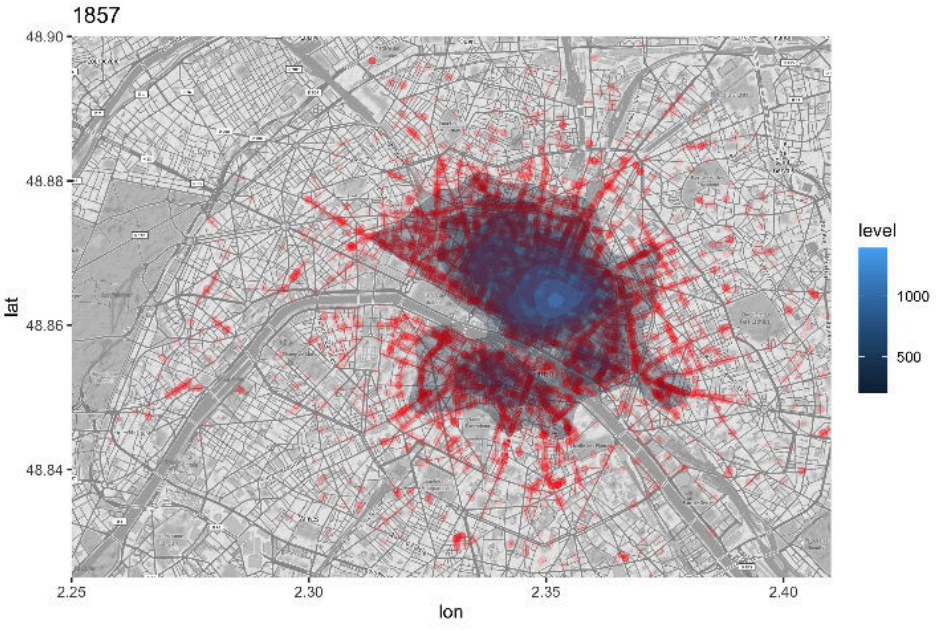
Location of activities





Location of activities





Left: craftsmanship; Right: food.

Defining co-evolution

Objects: Cities and territories (*Evolutionary Urban Theory* [Pumain, 2018]) co-evolving with transport networks (*Territorial Theory of Networks* [Dupuy, 1987])

Processes:

A multi-level definition of co-evolution:

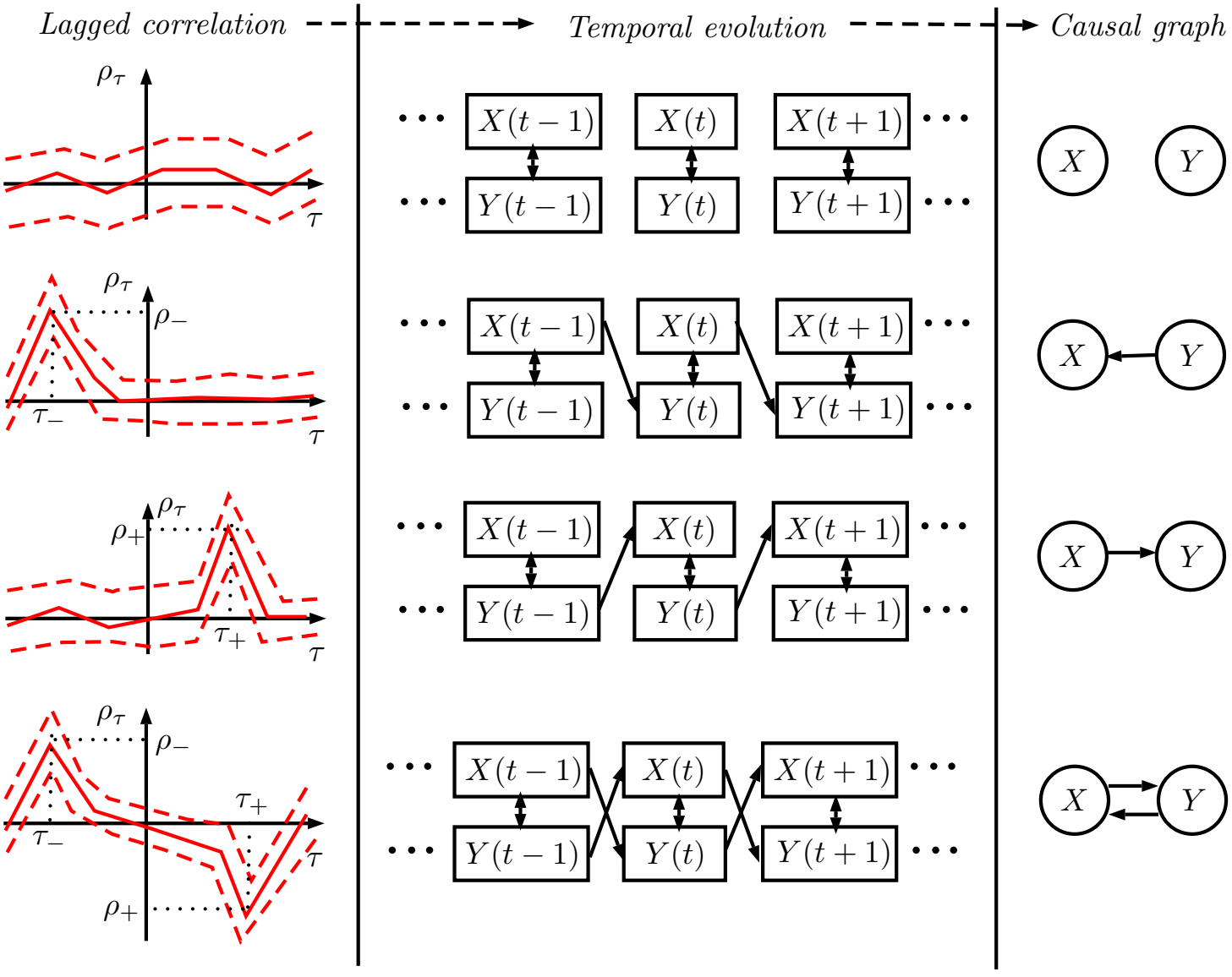
1. agents level
2. agent populations level (niches)
3. global system level

Corresponding approaches:

1. Empirical approach (microscopic level)
2. Morphogenesis approach (niche level)
3. Evolutionary theory approach (global level)

Raimbault, J. (2019). Modeling interactions between transportation networks and territories: a co-evolution approach. arXiv preprint arXiv:1902.04802.

Method to characterise co-evolution



Raimbault, J. (2017). Identification de causalités dans des données spatio-temporelles. In Spatial Analysis and GEOmatics 2017.

Application to this dataset

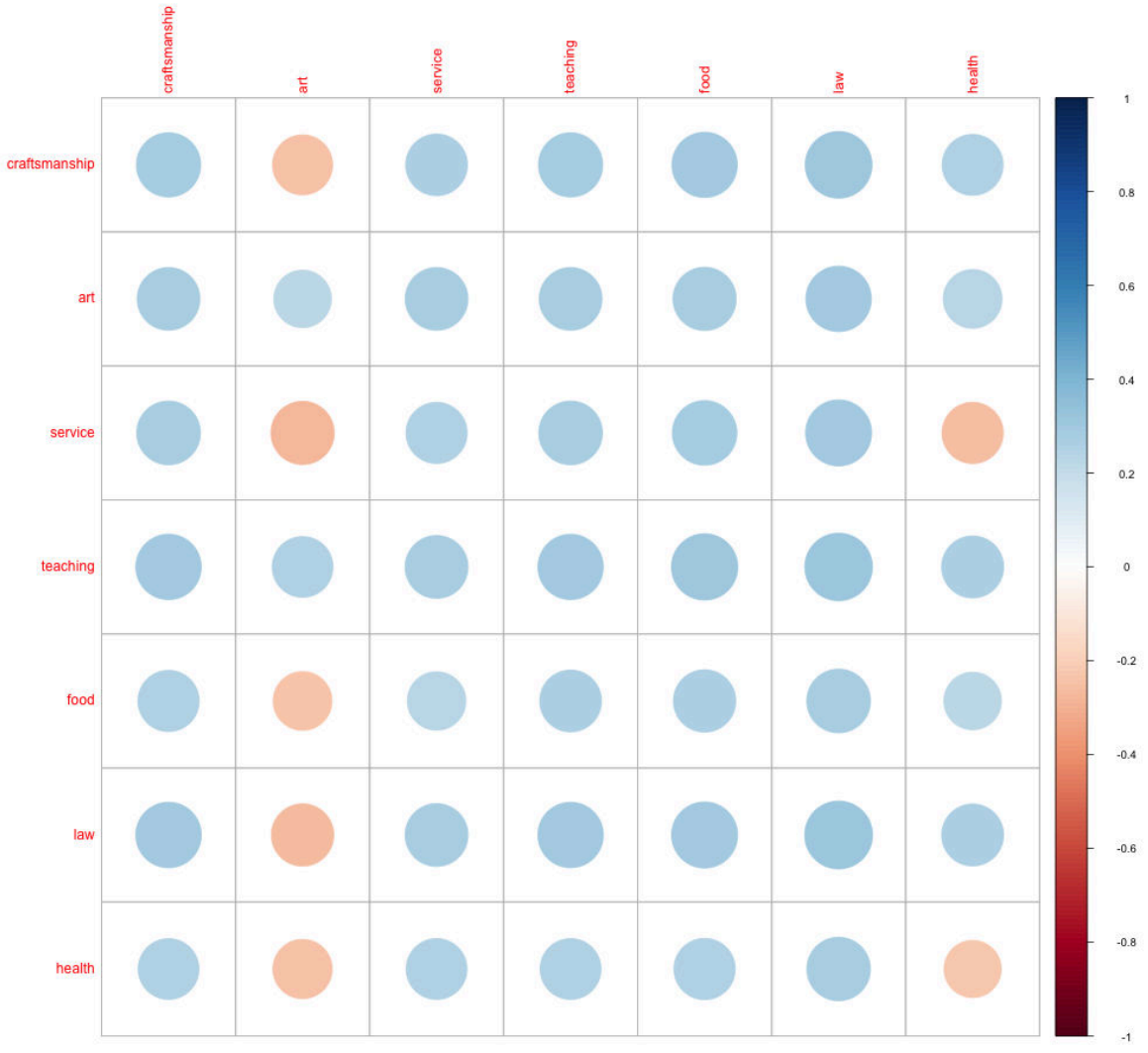
$\rightarrow$ Activity counts $N_{a,r}$ within raster cells: 10x10 grid to split the covered area into zones.

$\rightarrow$ Variation of activity counts in time $\Delta N_{a,r}(t) = N_{a,r}(t + \Delta t) - N_{a,r}(t)$

$\rightarrow$ Lagged correlations in time between activities

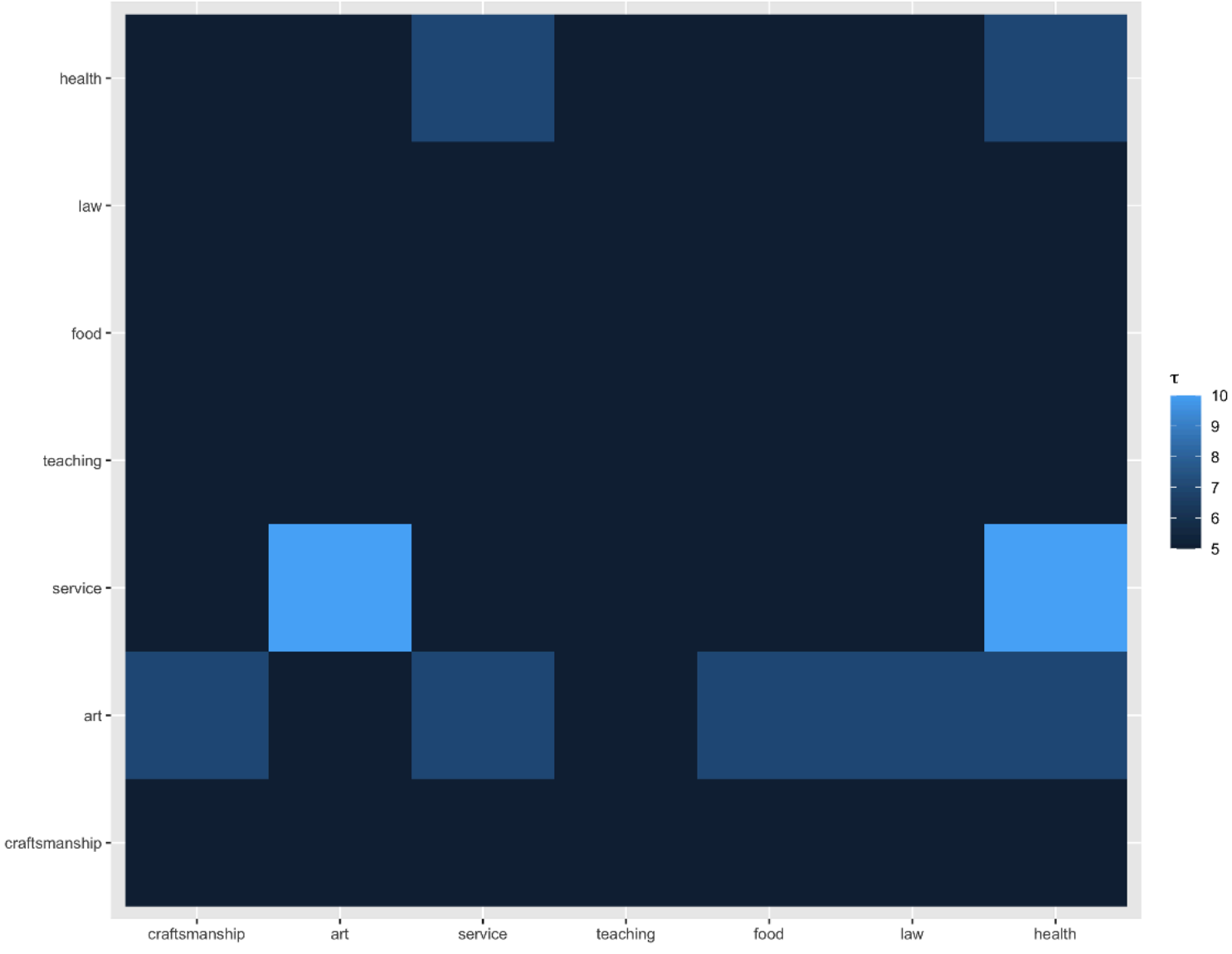
$$\rho_{a_1,a_2}(\tau) = \rho\left[\Delta N_{a_1,r}(t), \Delta N_{a_2,r}(t-\tau)\right]$$

Results: lagged correlations



Optimal lagged correlations between variations of activity counts

Results



Corresponding delays

Discussion

→ Micro insights into historical intra-urban economic processes.

→ Existence of a co-evolution between some activities (circular causality in location dynamics).

→ In discussion with historians in the project: capture qualitative knowledge (e.g. "*fabrique urbaine*")?

Current and future work:

→ Sensitivity analysis to classification, meta-parameters; null model with random activities.

→ Endogenous spatial neighbourhoods to estimate correlations, using a GWR-like approach [Brunsdon et al., 1998]; temporal moving-window.

→ Benchmark of methods to measure co-evolution (instrumental variables, causal machine learning).

Conclusion

→ Geo-historical data is new data; quantification of past intra-urban processes; many consistence and processing issues.

→ Opening for interdisciplinary discussions and collaborations: actual new knowledge and its validation depends on disciplines.

Soduco website and repository:
`https://soduco.github.io/`
`https://github.com/soduco`

Models and results open at
`https://github.com/JusteRaimbault/HistoricalData`

References I

Brunsdon, C., Fotheringham, S., and Charlton, M. (1998).
Geographically weighted regression.
Journal of the Royal Statistical Society: Series D (The Statistician), 47(3):431–443.

Chen, Y., Carlinet, E., Chazalon, J., Mallet, C., Duménieu, B., and Perret, J. (2021a).
Combining deep learning and mathematical morphology for historical map segmentation.
In *International Conference on Discrete Geometry and Mathematical Morphology*, pages 79–92. Springer.

References II


Chen, Y., Carlinet, E., Chazalon, J., Mallet, C., Dumenieu, B., and Perret, J. (2021b).
Vectorization of historical maps using deep edge filtering and closed shape extraction.
In *International conference on document analysis and recognition*, pages 510–525. Springer.


Cura, R., Dumenieu, B., Abadie, N., Costes, B., Perret, J., and Gribaudi, M. (2018).
Historical collaborative geocoding.
ISPRS International Journal of Geo-Information, 7(7):262.


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

References III

El Gouj, H., Rincón-Acosta, C., and Lagesse, C. (2022).
Urban morphogenesis analysis based on geohistorical road data.
Applied Network Science, 7(1):1–26.

Kandt, J. and Batty, M. (2021).
Smart cities, big data and urban policy: Towards urban analytics for the long run.
Cities, 109:102992.

Pumain, D. (2018).
An evolutionary theory of urban systems.
In *International and transnational perspectives on urban systems*, pages 3–18. Springer.

Pumain, D. and Reuillon, R. (2017).
Urban dynamics and simulation models.
Springer.

References IV


Raimbault, J. (2017).
Identification de causalités dans des données spatio-temporelles.
In *Spatial Analysis and GEOmatics 2017*.


Raimbault, J. (2019).
Modeling interactions between transportation networks and territories: a co-evolution approach.
arXiv preprint arXiv:1902.04802.


Sanders, L. (2018).
Peupler la terre: De la préhistoire à l'ère des métropoles.
Presses universitaires François-Rabelais.