Crowdsourcing ground-truth datasets for building change detection

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ÉCOLE NATIONALE DES SCIENCES GÉOGRAPHIQUES

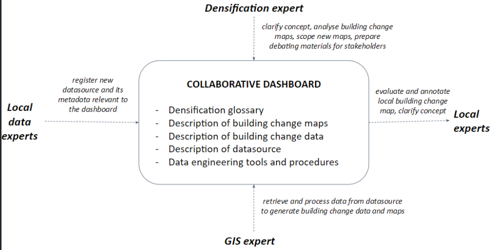
Dynamics of urban densification

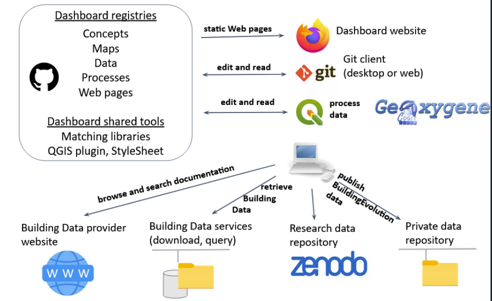
→ Understand urban densification dynamics for sustainable planning [Batty, 2018], with an integrated assessment of trade-offs between Sustainable Development Goals [Raimbault and Pumain, 2022] (linked to densification: increased access and limiteed sprawl vs UHI and less green space [Evers et al., 2024]).

→ In the suburban case, processes at multiple scales with diverse stakeholders; difficult to control through policy [Jehling et al., 2020]; the SUBDENSE European project to understand qualitatively and quantitatively these polyrationalities.

→ Need for a consistent, despite various GIS data qualities across compared countries (FR, UK, DE), quantification of urban change **at the building scale**.

A collaborative dashboard for mediation



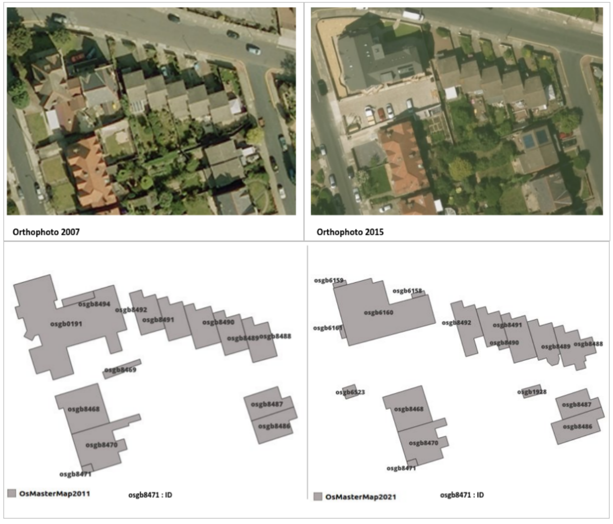


Preliminary work aimed at harmonising operationnal concepts and data sources qualification across the different countries:

→ git-based dashboard to share knowledge and resources between different types of experts [Bucher et al., 2024]

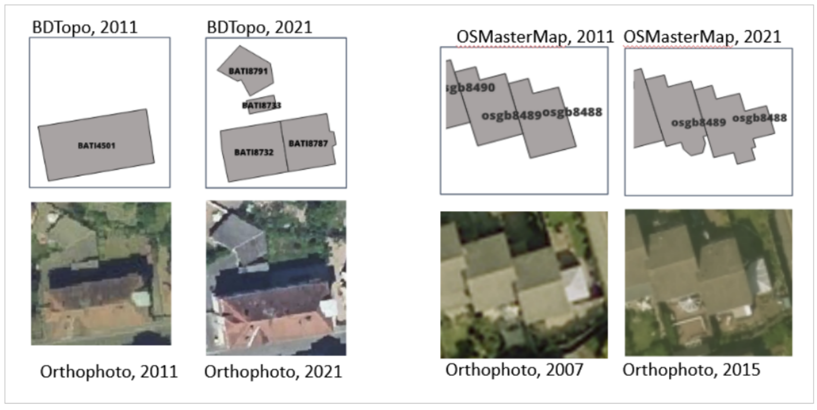
→ reproducible tools and methods, including **building change detection scripts**

Difficulties with data for building change



Example in the UK where changes in OSMasterMap building data includes both real changes and data changes. Source: [Bucher et al., 2025]

Difficulties with data for building change



Example of data specification changes only, for France (BDTopo) and the UK (OSMasterMap). Source: [Bucher et al., 2025]

Quantifying building change

$\rightarrow$ Geospatial vector data matching algorithms as a method for change detection [Xavier et al., 2016], applied to linear data [Costes et al., 2015] and polygonal data [Gregory and Healey, 2007].

→ Several algorithms which have been developed and tested for different application (change detection, data quality) and different contexts, with meta-parameters for each.

Research objective:

Which algorithm and parametrisation are optimal to detect true building changes, across the three case study countries and the various urban contexts within the study areas?

Functionalities of the annotation web-application

Two stage annotation process

Dashboard and maps to monitor progress

Architecture

Deployment

Work in progress: application to algorithm optimisation

Perspectives

Batty, M. (2018).
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Bucher, B., Brasebin, M., Buard, E., Grosso, E., Mustière, S., and Perret, J. (2012).
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- Bucher, B., Raimbault, J., Ndim, M., Raimond, A.-M., Perret, J., Dembski, S., and Jehling, M. (2025).
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  Under review for IJGI.
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  In *The 18th AGILE International Conference on Geographic Information Science*.

Evers, D., Katurić, I., and van der Wouden, R. (2024).
Urbanization in Europe: Past Developments and Pathways to a Sustainable Future.
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  In *Proceedings of the French Regional Conference on Complex Systems*, pages 277–280.
- Guardiola, P., Raimbault, J., Olteanu-Raimond, A.-M., and Perret, J. (2024b).
  Optimising geospatial vector data matching algorithms for change detection with synthetic data.
  In *Conference on Complex Systems 2024*.

Harvey, F., Vauglin, F., and Bel Hadj Ali, A. (1998).
Geometric matching of areas, comparison measures and association links.
In *Proceedings of the 8th International Symposium On Spatial Data Handling*, pages 557–568.

Jehling, M., Schorcht, M., and Hartmann, T. (2020).
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Town Planning Review, 91(3):217–237.

- Mustière, S. (2002).
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  Technical report, IGN.
- Olteanu-Raimond, A.-M., Mustiere, S., and Ruas, A. (2015).
  Knowledge formalization for vector data matching using belief theory.
  Journal of Spatial Information Science, (10):21–46.
- Raimbault, J. and Pumain, D. (2022).
  Trade-offs between sustainable development goals in systems of cities.
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Xavier, E. M., Ariza-López, F. J., and Urena-Camara, M. A. (2016).
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ACM Computing Surveys (CSUR), 49(2):1–34.

Reserve slides

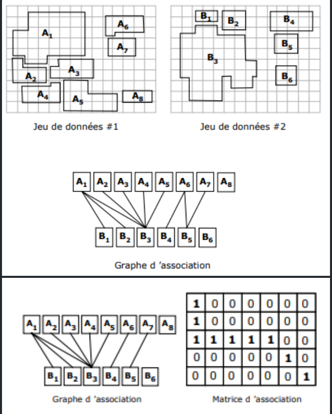
The SUBDENSE project

The SubDense European project studies the dynamics of suburban densification by:

Understanding polyrationalities of space, actors and policies on suburban densification

- exploring how diverse strategies of land policy interact with landowners' and local stakeholders' interest and agency to shape suburban densification and their impact on suburbia across different planning systems (France, Germany, UK);
- combining quantitative approaches (geodata analysis and geosimulation) with qualitative approaches (social and policy science and planning).

Geometric Matching of Areas (GMoA) algorithm

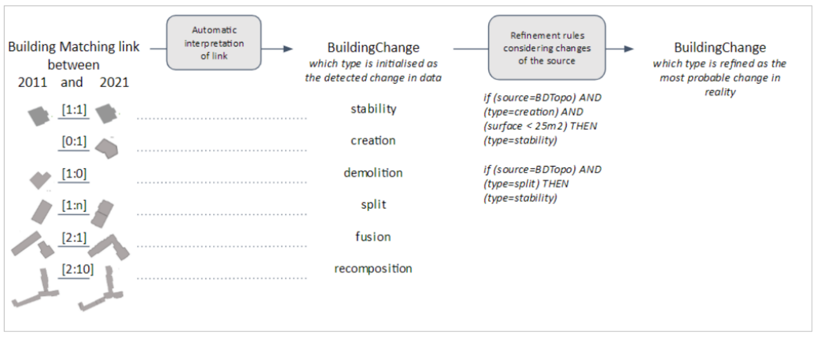


Algorithm to produce m-n links based only on geometries [Harvey et al., 1998] [Bel Hadj Ali, 2001]:

1. Construct all possible association links as surfaces with a non-empty intersection (top left Fig.)
2. Filter links with an intersection surface below a threshold parameter
3. Filter links with an intersection surface too small relatively to matched surfaces (rate parameter)
4. Construct all m-n links as connected clusters in the remaining bipartite graph (bottom left Fig.)

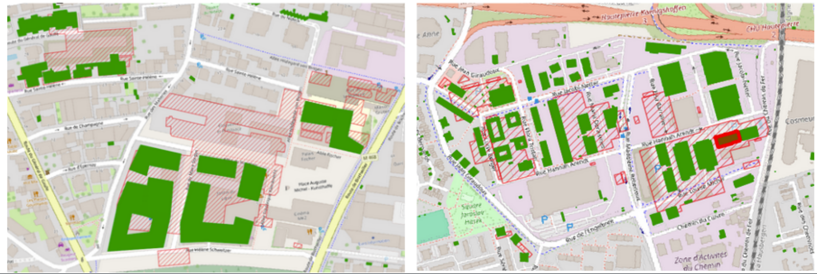
→ implemented in the geoxygene java library [Bucher et al., 2012] by [Mustière, 2002]

Application of the GMoA to change detection



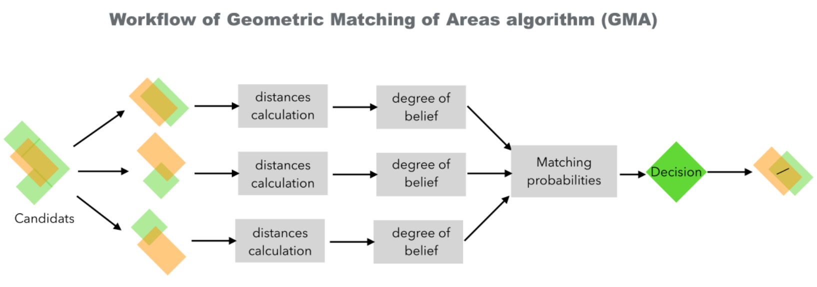
Automatic interpretation of matching links into building change, with specific adjustements for BDTopo [Bucher et al., 2025], by a python script available at `https://github.com/subdense/matching`

Example



Building evolution for two examples in the urban area of Strasbourg [Bucher et al., 2025]

Multi-criteria matching algorithm (MCA)



Implementation of the Multi-criteria matching algorithm [Olteanu-Raimond et al., 2015] in python by [Guardiola et al., 2024a], with euclidian, surface, radial and Hausdorff distances, and run twice to obtain m-n links.

Benchmarking of algorithms

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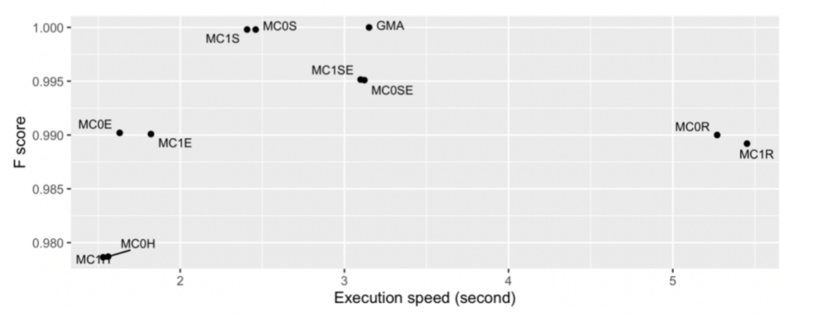


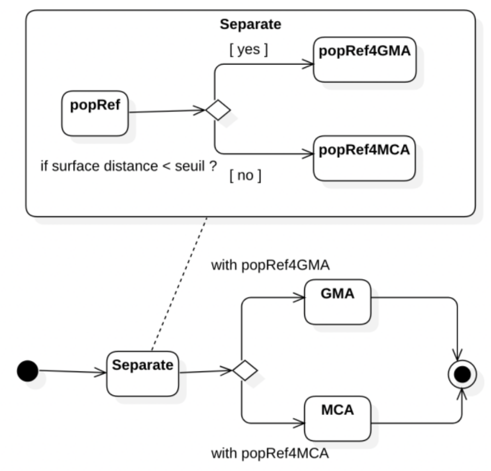
Bi-objective benchmark optimising for performance (F-score on a $\simeq$ 2k buildings ground truth dataset) and runtime, for different parametrisations of the two algorithms, by [Guardiola et al., 2024a]

$\rightarrow$ various algorithm performances

$\rightarrow$ under-detection of change by GMoA and over-detection by MCA

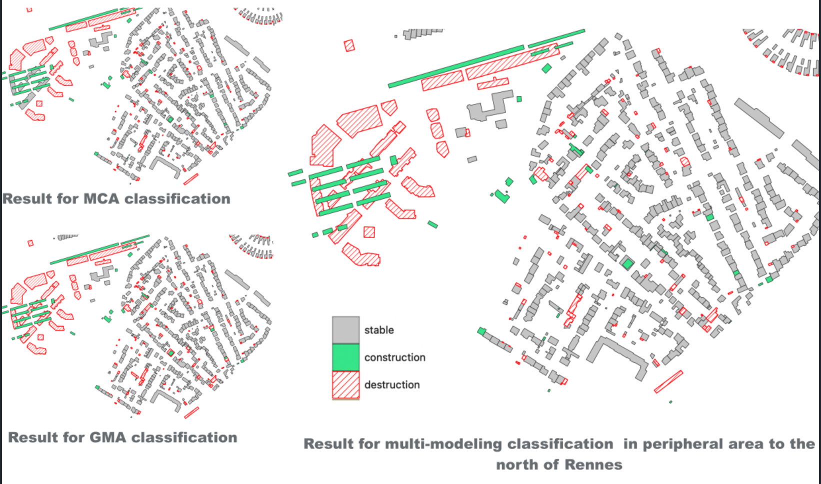
$\rightarrow$ GMA better for m-n links, MCA better for 1-1 links

A new algorithm using multi-modeling



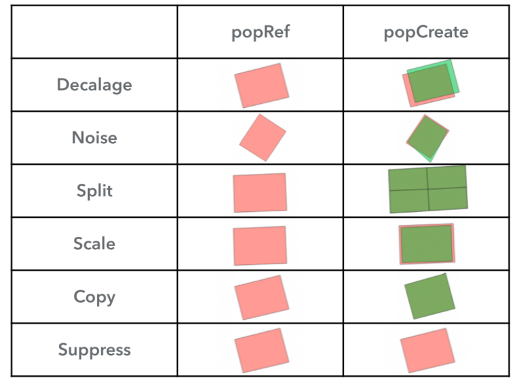
Proposition of a new algorithm combining GMoA and MCA, with the choice made through thresholding surface distance [Guardiola et al., 2024b]

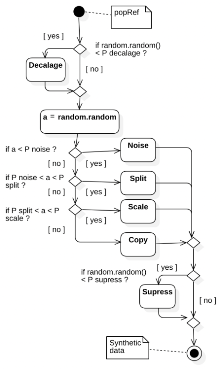
Example



Results obtained on an example in the suburbs of Rennes [Guardiola et al., 2024b]

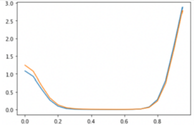
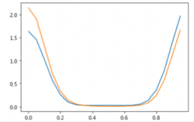
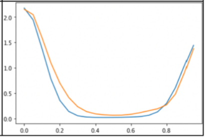
Validating the algorithm with synthetic data





Synthetic data generator introduced by [Guardiola et al., 2024b] to generate datasets on which to validate and optimise the algorithm

First results on synthetic data

Lieu Géographique	Valeur des paramètres optimisés	Courbes des densité des distances surfacique de popRef et popCreee
Centre Urbain	Decallage= 0.05 Brouilleur = 0.45 Echelle = 0.20 Spliteur = 0.25 Copieur = 0.10 Suppression = 0.10	
Banlieue	Decallage= 0.10 Brouilleur = 0.75 Echelle = 0.10 Spliteur = 0.05 Copieur = 0.10 Suppression = 0.10	
Ville périphérique	Decallage= 0.10 Brouilleur = 0.25 Echelle = 0.40 Spliteur = 0.15 Copieur = 0.15 Suppression = 0.10	

Integration into the OpenMOLE software and calibration of the generator for different urban typologies (single fitness: distance between surface distance densities) [Guardiola et al., 2024b]