superblockify: A Python Package for Automated Generation, Visualization, and Analysis of Potential Superblocks in Cities

Carlson M. Büth [1,2], **Anastassia Vybornova** [1], **and Michael Szell** [1,3,4]

1 NEtwoRks, Data, and Society (NERDS), Computer Science Department, IT University of Copenhagen, 2300 Copenhagen, Denmark **2** Institute for Cross-Disciplinary Physics and Complex Systems (IFISC), University of the Balearic Islands (UIB) and Spanish National Research Council (CSIC), 07122 Palma de Mallorca, Spain **3** ISI Foundation, 10126 Turin, Italy **4** Complexity Science Hub Vienna, 1080 Vienna, Austria

DOI: 10.21105/joss.06798

Software

- Review
- Repository
- Archive

Editor: Chris Vernon

Reviewers:

- @erexer
- @caimeng2

Submitted: 23 April 2024
Published: 14 August 2024

Summary

`superblockify` is a Python package designed to assist in planning future Superblock implementations by partitioning an urban street network into Superblock-like neighborhoods and providing tools for visualizing and analyzing these partition results. A Superblock is a set of adjacent urban blocks where vehicular through traffic is prevented or pacified, giving priority to people walking and cycling (Nieuwenhuijsen et al., 2024). The potential Superblock blueprints and descriptive statistics generated by `superblockify` can be used by urban planners as a first step in a data-driven planning pipeline for future urban transformations, or by urban data scientists as an efficient computational method to evaluate potential Superblock partitions. The software is licensed under AGPLv3 and is available at https://superblockify.city.

Statement of need

The Superblock model is an urban planning intervention with massive public health benefits that creates more liveable and sustainable cities (Laverty et al., 2021; Mueller et al., 2020; WHO, 2022). Superblocks form human-centric neighborhoods with reduced vehicular traffic. They are safer, quieter, and more environmentally friendly (Agència d'Ecologia Urbana de Barcelona et al., 2021; Martin, 2021; Mueller et al., 2020) than car-centric urban landscapes which fully expose citizens to car harm (Miner et al., 2024). The scientific study of Superblocks has expanded quickly in recent years, summarized in a review by Nieuwenhuijsen et al. (2024). The planning and implementation of Superblocks is an intricate process, requiring extensive stakeholder involvement and careful consideration of trade-offs (Nieuwenhuijsen et al., 2019; Stadt Wien, 2021; Transport for London, 2020). New computational tools and data sets, such as the `osmnx` Python library (Boeing, 2017) and OpenStreetMap (OpenStreetMap contributors, 2023), provide the opportunity to simplify this process by allowing to easily analyze and visualize urban street networks computationally. Recent quantitative studies on Superblocks have seized this opportunity with different focuses, such as potential Superblock detection via network flow on the abstract level (Eggimann, 2022a) or in the local context of Vienna (Frey et al., 2020); development of interactive micro-level planning tools (Carlino et al., 2024; *TuneOurBlock*, 2024); green space (Eggimann, 2022b), social factors (Yan & Dennett, 2023), health benefit modeling (Li & Wilson, 2023), or an algorithmic taxonomy of designs (Feng & Peponis, 2022). However, to our knowledge, none of these emerging research efforts have led to an open, general-use, extendable software package for Superblock delineation, visualization, and analysis. `superblockify` fills this gap.

The software offers benefits for at least two use cases. First, for urban planning, it provides a quick way to generate Superblock blueprints for a city, together with descriptive statistics informing the planning process. These blueprints can serve as a vision or first draft for potential future city development. In a planning pipeline, `superblockify` stands at the beginning, broadly delineating the potential areas of study first. Then, exported Superblocks can feed into an open geographic information system like QGIS (QGIS Development Team, 2024) or into tools like A/B Street (Carlino et al., 2024) or TuneOurBlock (*TuneOurBlock*, 2024) that allow finetuned modifications or traffic simulations. This quick feedback can reduce the time and resources required to manually plan Superblocks, which in turn can accelerate sustainable urban development. Second, `superblockify` enables researchers to conduct large-scale studies across multiple cities or regions, providing valuable insights into the potential impacts of Superblocks at a broader scale, e.g. travel time changes. In both cases, `superblockify` can help to identify best practices, algorithmic approaches, and strategies for Superblock implementation.

The software has served in a preliminary analysis of potential Superblocks in 180 cities worldwide (Büth, 2023) and will be used in subsequent studies within the EU Horizon Project JUST STREETS (https://just-streets.eu). With increased urbanization, impacts of climate change, and focus on reducing car-dependence (Mattioli et al., 2020; Ritchie & Roser, 2018; Satterthwaite, 2009), the need for sustainable urban planning tools like `superblockify` will only increase (Nieuwenhuijsen et al., 2024).

Features

`superblockify` has three main features: Data access and partitioning, Visualization, and Analysis.

Data access and partitioning

`superblockify` leverages OpenStreetMap data (OpenStreetMap contributors, 2023) and population data GHS-POP R2023A (Pesaresi & Politis, 2023). From a user-given search query, e.g., a city name, `superblockify` retrieves the street network data of a city, the necessary GHS-POP tile(s), and distributes the population data onto a tesselation of the street network.

After the street network and optional metadata are loaded in, the package partitions the street network into Superblocks. In its current version 1.0.0, `superblockify` comes with two partitioners:

1. The residential approach uses the given residential street tag to decompose the street network into Superblocks.
2. The betweenness approach uses the streets with high betweenness centrality for the decomposition.

The choice between these two approaches depends on the data quality and the desired outcome. The residential approach is appropriate for using residential data, if available and accurate. The betweenness approach is an alternative based on traffic flow approximation. The resulting Superblocks can be exported in GeoPackage (`.gpkg`) format for further use.

Visualization

After the partitioning, factors relevant for analysis and planning of Superblocks can be calculated and visualized, e.g., area, population, population density, or demand change by betweenness centrality. Example Superblock configurations for two cities are shown in Fig. 1.

The Journal of Open Source Software

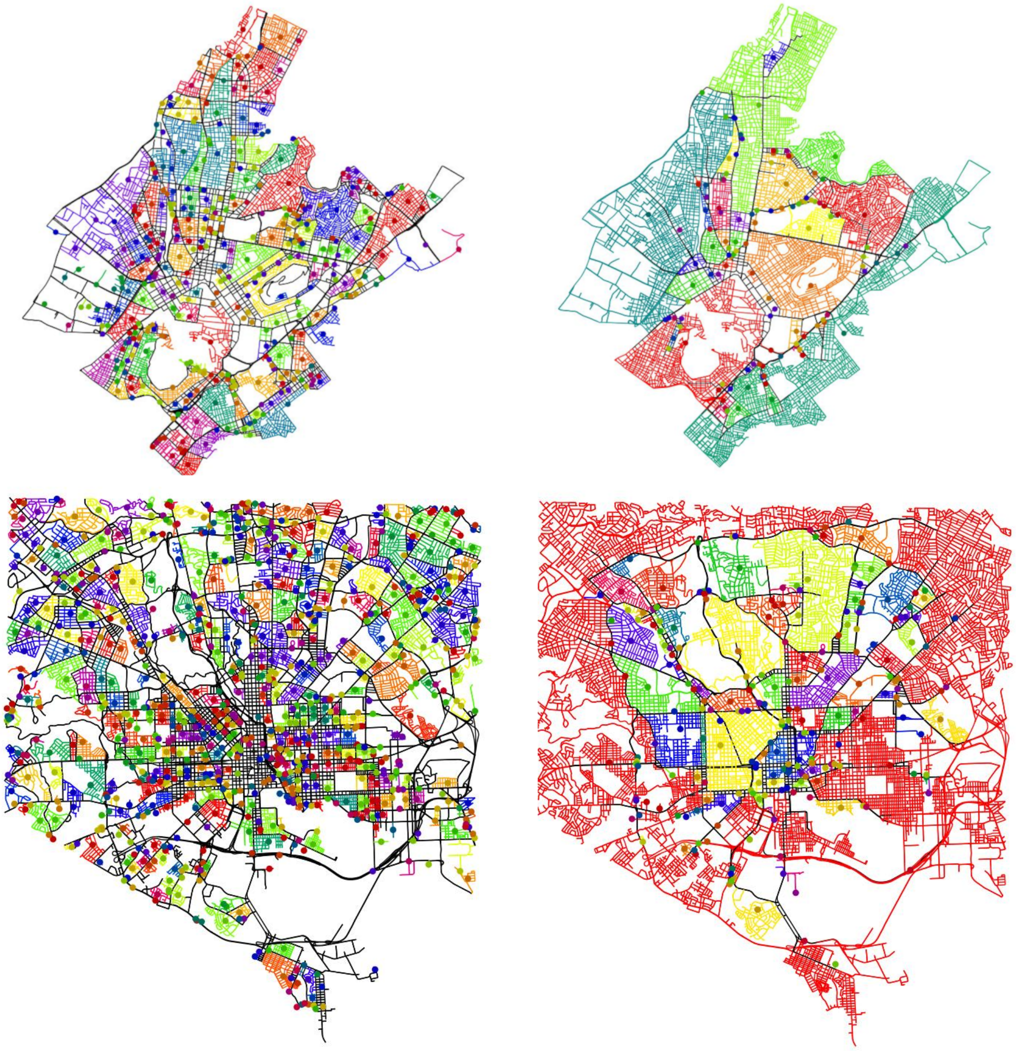

Figure 1: Automated generation of Superblocks. Athens, GR (top row) and Baltimore, MD, USA (bottom row) Superblocks generated using the residential partitioner (left column) and the betweenness partitioner (right column). Each Superblock is plotted in a different color, the rest of the streets are black. For easier visual recognition, each Superblock is also highlighted by a representative node of the same color. Map data from OpenStreetMap.

Analysis

For analysis, the package calculates various graph metrics of the street network, including:

- Global efficiency (Latora & Marchiori, 2001): In the context of Superblocks, this measures how the overall ease of vehicular movement across the city might change after implementation.
- Directness (Szell et al., 2022): This indicates how Superblock implementation might affect the directness of routes, potentially increasing or decreasing detours.
- Betweenness centrality (Brandes, 2008): Identifies which streets might bear increased traffic load after Superblock implementation.
- Spatial clustering and anisotropy of high betweenness centrality nodes (Kirkley et al., 2018): Describes how clustered and non-uniformly distributed the expected traffic bottlenecks are.
- Street orientation-order (Boeing, 2019b): Quantifies how grid-like each Superblock is.

- Average circuity (Boeing, 2019a): Measures the length increase of routes on the street network compared to straight-line distances.

These metrics are calculated for the entire street network and for each Superblock individually, providing insights into how the Superblock implementation might affect the overall city structure and local neighborhood characteristics. To facilitate further analysis, all of these metrics are included in the exportable GeoPackage file.

Design

`superblockify`'s design is object-oriented with a focus on modularity and extensibility. An abstract partitioner base class is provided to facilitate implementing new custom approaches for Superblock generation. At the core of the package, `superblockify` extends Dijkstra's efficient distance calculation approach with Fibonacci heaps on reduced graphs, ensuring optimal performance when iterating various Superblock configurations while respecting the Superblock restriction of no through traffic. This restriction is checked via just-in-time (JIT) compilation through `numba` (Lam et al., 2023) to speed up the calculation of betweenness centrality on directed, large-scale street networks. Central code dependencies are the `osmnx` (Boeing, 2017) and `networkx` (Hagberg et al., 2008) packages for data acquisition, preprocessing, and network analysis, and the `geopandas` (Bossche et al., 2023) package for spatial analysis.

Acknowledgements

Michael Szell acknowledges funding from the EU Horizon Project JUST STREETS (Grant agreement ID: 101104240). All authors gratefully acknowledge all open source libraries on which `superblockify` builds, and the open source data that this software makes use of: Global Human Settlement Layer, and map data copyrighted by OpenStreetMap contributors available from https://www.openstreetmap.org.

Authors contributions with CRediT

- Carlson M. Büth: Conceptualization, Software, Investigation, Methodology, Writing – original draft, Validation
- Anastassia Vybornova: Conceptualization, Supervision, Writing – review & editing, Validation
- Michael Szell: Conceptualization, Project administration, Writing – review & editing, Validation, Funding acquisition

References

Agència d'Ecologia Urbana de Barcelona, Barcelona Regional Agència de Desenvolupament Urbà, S.A., & Àrea Metropolitana de Barcelona. (2021). *BCNecologia: 20 años de la Agencia de Ecología Urbana de Barcelona*. Ajuntament de Barcelona. ISBN: 978-84-9156-349-5

Boeing, G. (2017). OSMnx: New methods for acquiring, constructing, analyzing, and visualizing complex street networks. *Computers, Environment and Urban Systems*, *65*, 126–139. https://doi.org/10.1016/j.compenvurbsys.2017.05.004

Boeing, G. (2019a). The Morphology and Circuity of Walkable and Drivable Street Networks. In L. D'Acci (Ed.), *The Mathematics of Urban Morphology* (pp. 271–287). Springer International Publishing. https://doi.org/10.1007/978-3-030-12381-9_12

Boeing, G. (2019b). Urban spatial order: Street network orientation, configuration, and entropy. *Applied Network Science*, *4*(1), 67. https://doi.org/10.1007/s41109-019-0189-1

Bossche, J. V. den, Jordahl, K., Fleischmann, M., McBride, J., Wasserman, J., Richards, M., Badaracco, A. G., Snow, A. D., Tratner, J., Gerard, J., Ward, B., Perry, M., Farmer, C., Hjelle, G. A., Taves, M., ter Hoeven, E., Cochran, M., Gillies, S., Caria, G., … Ren, C. (2023). *Geopandas/geopandas: V0.13.2* (Version v0.13.2). Zenodo. https://doi.org/10.5281/zenodo.8009629

Brandes, U. (2008). On variants of shortest-path betweenness centrality and their generic computation. *Social Networks*, *30*(2), 136–145. https://doi.org/10.1016/j.socnet.2007.11.001

Büth, C. M. (2023). *From gridlocks to greenways: Analyzing the network effects of computationally generated low traffic neighborhoods* [Master's thesis, University of Münster]. https://doi.org/10.13140/RG.2.2.26204.36481

Carlino, D., Kirk, M., Smith, A., dcarlino, Konieczny, M., Kott, G., Bruce, Nissar, J., Nederlof, T., Steinberg, V., Lovelace, R., Ilias, Nebeker, J., Sam, Orestis, Dejean, M., Shenfield, M., Schimek, N., Foucault, M., … Huston, K. (2024). *A-b-street/abstreet: Night markets at -15C* (Version v0.3.49). Zenodo. https://doi.org/10.5281/zenodo.10476253

Eggimann, S. (2022a). The potential of implementing superblocks for multifunctional street use in cities. *Nature Sustainability*, *5*(5), 406–414. https://doi.org/10.1038/s41893-022-00855-2

Eggimann, S. (2022b). Expanding urban green space with superblocks. *Land Use Policy*, *117*, 106111. https://doi.org/10.1016/j.landusepol.2022.106111

Feng, C., & Peponis, J. (2022). Algorithmic definitions of street network centrality sub-shapes: The case of superblocks. *Environment and Planning B: Urban Analytics and City Science*, 239980832210987. https://doi.org/10.1177/23998083221098739

Frey, H., Leth, U., & Sandholzer, F. J. (2020). *Potenziale von superblock-konzepten als beitrag zur planung energieeffizienter stadtquartiere-SUPERBE*. https://nachhaltigwirtschaften.at/en/sdz/projects/superbe.php

Hagberg, A. A., Schult, D. A., & Swart, P. J. (2008). Exploring Network Structure, Dynamics, and Function using NetworkX. In G. Varoquaux, T. Vaught, & J. Millman (Eds.), *Proceedings of the 7th Python in Science Conference* (pp. 11–15).

Kirkley, A., Barbosa, H., Barthelemy, M., & Ghoshal, G. (2018). From the betweenness centrality in street networks to structural invariants in random planar graphs. *Nature Communications*, *9*(1), 2501. https://doi.org/10.1038/s41467-018-04978-z

Lam, S. K., Pitrou, A., Florisson, M., Seibert, S., Markall, G., Anderson, T. A., Leobas, G., Collison, M., Bourque, J., Meurer, A., Oliphant, T. E., Riasanovsky, N., Wang, M., Pronovost, E., Totoni, E., Wieser, E., Seefeld, S., Grecco, H., Masella, A., … Turner-Trauring, I. (2023). *Numba/numba: Version 0.57.1* (Version 0.57.1). Zenodo. https://doi.org/10.5281/zenodo.8087361

Latora, V., & Marchiori, M. (2001). Efficient Behavior of Small-World Networks. *Physical Review Letters*, *87*(19), 198701. https://doi.org/10.1103/PhysRevLett.87.198701

Laverty, A. A., Goodman, A., & Aldred, R. (2021). Low traffic neighbourhoods and population health. In *bmj* (Vol. 372). British Medical Journal Publishing Group. https://doi.org/10.1136/bmj.n443

Li, K., & Wilson, J. (2023). Modeling the Health Benefits of Superblocks across the City of Los Angeles. *Applied Sciences*, *13*(4), 2095. https://doi.org/10.3390/app13042095

Martin, R. J. (2021). *Points of Exchange: Spatial Strategies for the Transition Towards*

Sustainable Urban Mobilities. Aalborg Universitetsforlag. https://doi.org/10.54337/aau451017237

Mattioli, G., Roberts, C., Steinberger, J. K., & Brown, A. (2020). The political economy of car dependence: A systems of provision approach. *Energy Research & Social Science*, *66*, 101486. https://doi.org/10.1016/j.erss.2020.101486

Miner, P., Smith, B. M., Jani, A., McNeill, G., & Gathorne-Hardy, A. (2024). Car harm: A global review of automobility's harm to people and the environment. *Journal of Transport Geography*, *115*, 103817. https://doi.org/10.1016/j.jtrangeo.2024.103817

Mueller, N., Rojas-Rueda, D., Khreis, H., Cirach, M., Andrés, D., Ballester, J., Bartoll, X., Daher, C., Deluca, A., Echave, C., Milà, C., Márquez, S., Palou, J., Pérez, K., Tonne, C., Stevenson, M., Rueda, S., & Nieuwenhuijsen, M. (2020). Changing the urban design of cities for health: The superblock model. *Environment International*, *134*, 105132. https://doi.org/10.1016/j.envint.2019.105132

Nieuwenhuijsen, M., Bastiaanssen, J., Sersli, S., Waygood, E. O. D., & Khreis, H. (2019). Implementing Car-Free Cities: Rationale, Requirements, Barriers and Facilitators. In M. Nieuwenhuijsen & H. Khreis (Eds.), *Integrating Human Health into Urban and Transport Planning* (pp. 199–219). Springer International Publishing. https://doi.org/10.1007/978-3-319-74983-9_11

Nieuwenhuijsen, M., De Nazelle, A., Pradas, M. C., Daher, C., Dzhambov, A. M., Echave, C., Gössling, S., Iungman, T., Khreis, H., Kirby, N., Khomenko, S., Leth, U., Lorenz, F., Matkovic, V., Müller, J., Palència, L., Pereira Barboza, E., Pérez, K., Tatah, L., … Mueller, N. (2024). The Superblock model: A review of an innovative urban model for sustainability, liveability, health and well-being. *Environmental Research*, *251*, 118550. https://doi.org/10.1016/j.envres.2024.118550

OpenStreetMap contributors. (2023). *OpenStreetMap*. https://www.openstreetmap.org

Pesaresi, M., & Politis, P. (2023). *GHS-BUILT-S R2023A - GHS built-up surface grid, derived from Sentinel2 composite and Landsat, multitemporal (1975-2030)* [Data set]. European Commission, Joint Research Centre (JRC). https://doi.org/10.2905/9F06F36F-4B11-47EC-ABB0-4F8B7B1D72EA

QGIS Development Team. (2024). *QGIS geographic information system*. QGIS Association. https://www.qgis.org

Ritchie, H., & Roser, M. (2018). Urbanization. *Our World in Data*. https://ourworldindata.org/urbanization

Satterthwaite, D. (2009). The implications of population growth and urbanization for climate change. *Environment and Urbanization*, *21*(2), 545–567. https://doi.org/10.1177/0956247809344361

Stadt Wien. (2021). *Pilotstudie Supergrätzl - Ergebnisbericht am Beispiel Volkertviertel* (GZ 367568; p. 58). Stadt Wien - Stadtentwicklung und Stadtplanung.

Szell, M., Mimar, S., Perlman, T., Ghoshal, G., & Sinatra, R. (2022). Growing urban bicycle networks. *Scientific Reports*, *12*(1, 1), 6765. https://doi.org/10.1038/s41598-022-10783-y

Transport for London. (2020). *Streetspace guidance: Appendix Six (a): Supplementary guidance on Low Traffic Neighbourhoods*. https://tfl.gov.uk/info-for/boroughs-and-communities/streetspace-funding

TuneOurBlock. (2024). https://jpi-urbaneurope.eu/project/tuneourblock.

WHO. (2022). *Walking and cycling: Latest evidence to support policy-making and practice*. https://apps.who.int/iris/handle/10665/354589

Yan, X., & Dennett, A. (2023). Re-defining Transport for London's strategic neighbourhoods from spatial and social perspectives. *Applied Geography*, *161*, 103116. https://doi.org/10.1016/j.apgeog.2023.103116