Spatial Microsimulation and Activity Allocation in Python: An Update on the Likeness Toolkit

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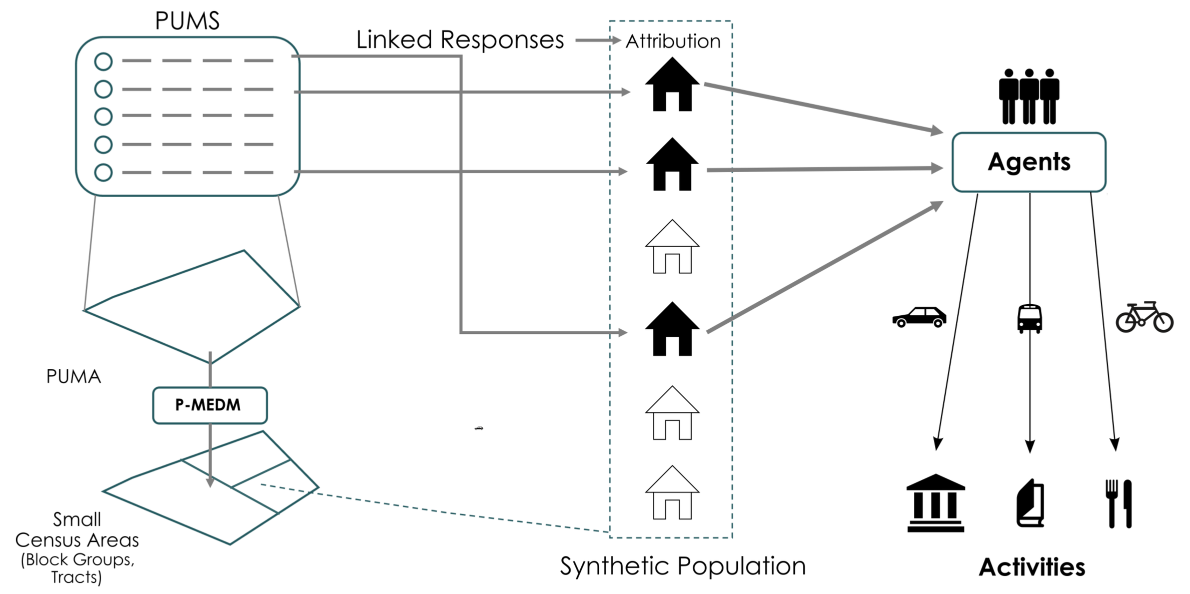
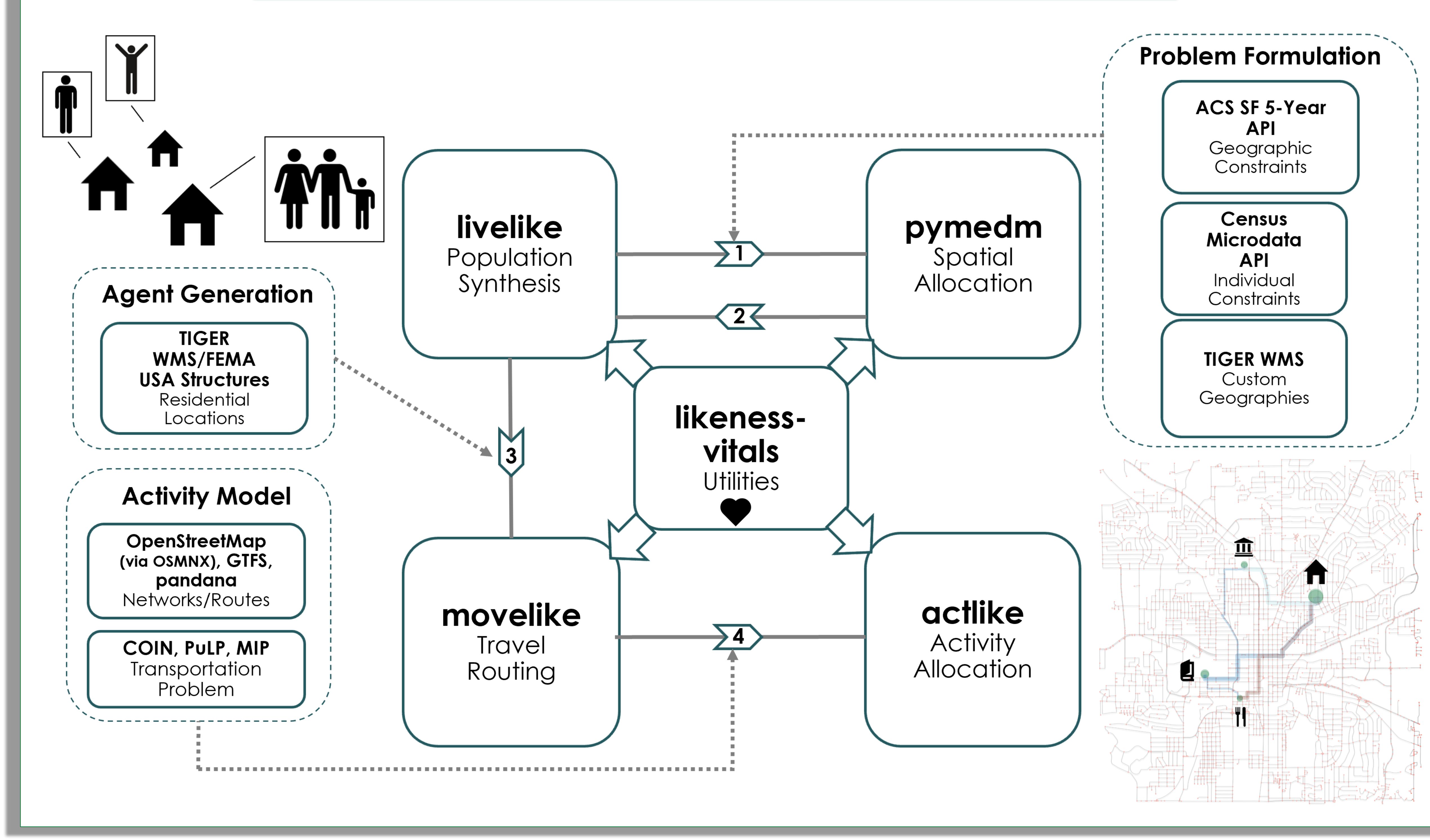
Vivid Synthetic Populations for Human Dynamics Models

- Security and social equity issues within human systems → human dynamics: *how people live, move, and interact*
- Likeness toolkit → human dynamics + vivid (attribute rich) synthetic populations from American Community Survey (ACS)
- Supports the creation of more dynamic agent-based models (ABMs) for topics from epidemiology to environmental hazards



- ***PUMS:*** *Public-Use Microdata Sample, an anonymized subsample of ACS longform responses.*
- ***PUMA:*** *Public-Use Microdata Area, a spatial unit of >=100k people at which PUMS is published.*

An Evolving Ecosystem



Key improvements

- Population synthesis workflow for any Metropolitan Statistical Area (MSA) in the US
- GPU-enabled spatial allocation modeling with `pymedm` (via `jaxopt`)
- Simulated residential locations for routing trips to essential activities (`livelike`)
- Dedicated support for transportation networks, incl. transit routes (`movelike`)
- Shared utilities for process management, data manipulation, post-processing (`likeness-vitals`)

Into the Future

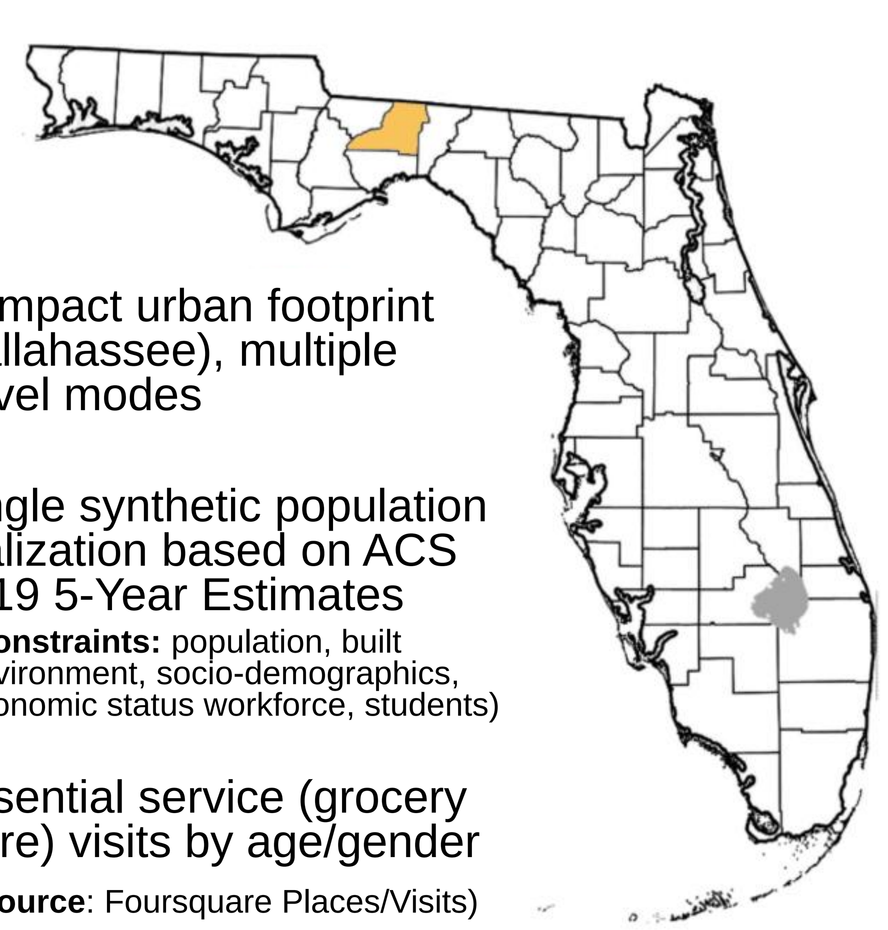
- **Open-sourcing** the software stack, beginning with `pymedm`
- **Packaging schema:** toward a monolithic Likeness package with submodules
- Creating a dedicated package for **visualization functionality**
- **Improving mobility modeling**, particularly realistically representing public transit networks
- **Solving the optimization bottleneck for large scale transportation problems** by profiling existing methodology or exploring high-efficiency solvers

Validation Exercise

How well does Likeness recreate demographic estimates:

- Based on neighborhood residential characteristics?
- For essential activities? (e.g., social, errands, health)

Case Study: Leon County, FL



- Compact urban footprint (Tallahassee), multiple travel modes
- Single synthetic population realization based on ACS 2019 5-Year Estimates
  (**Constraints:** population, built environment, socio-demographics, economic status workforce, students)
- Essential service (grocery store) visits by age/gender
  (**Source**: Foursquare Places/Visits)

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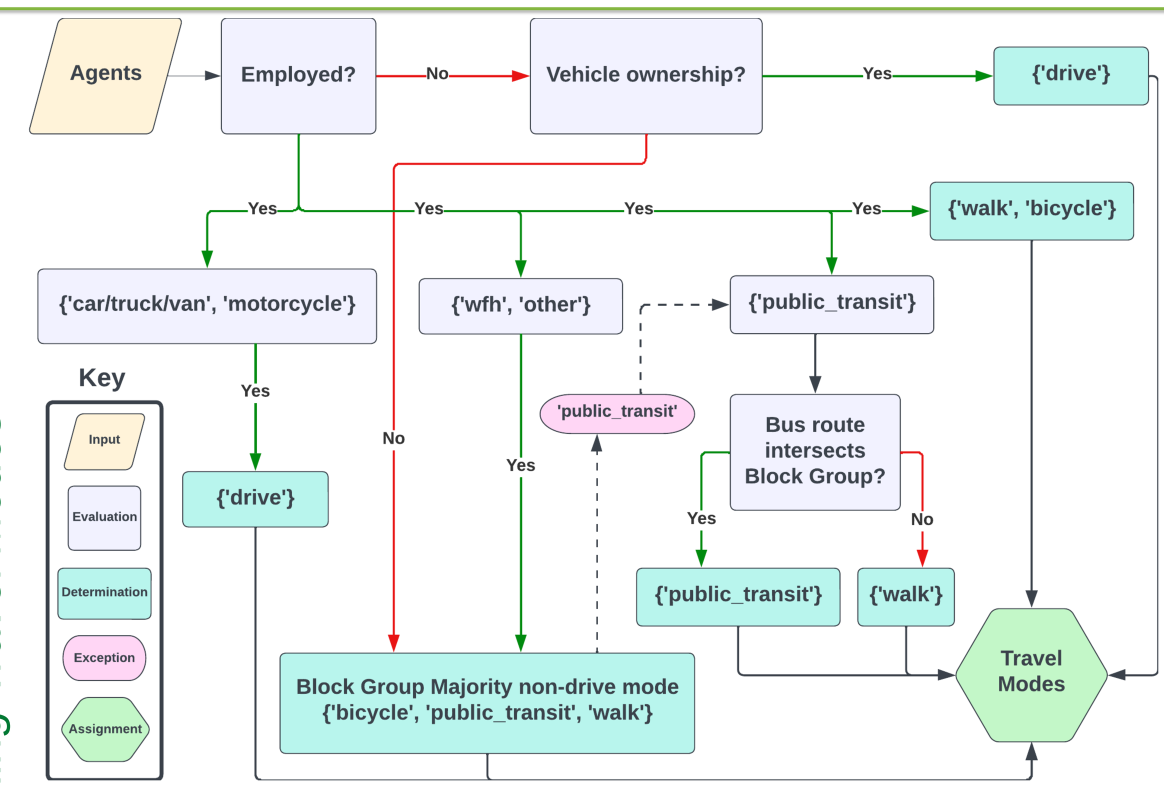
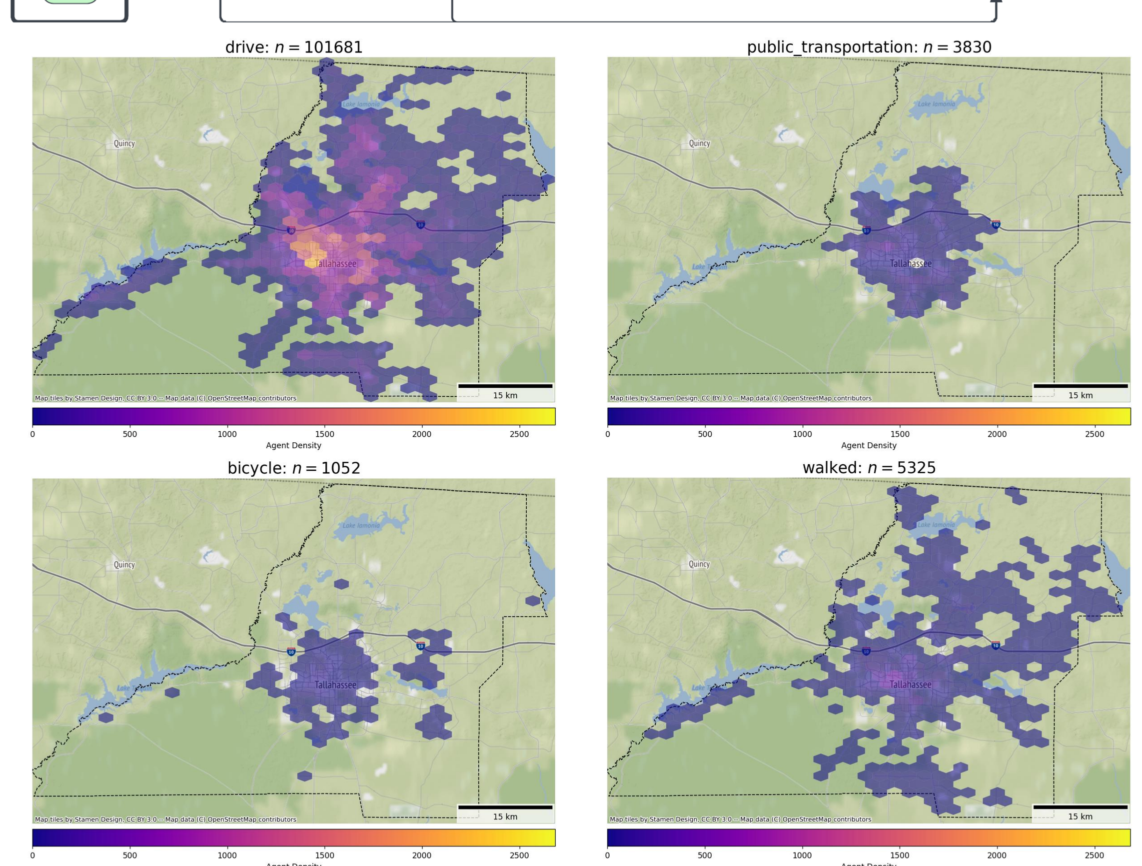
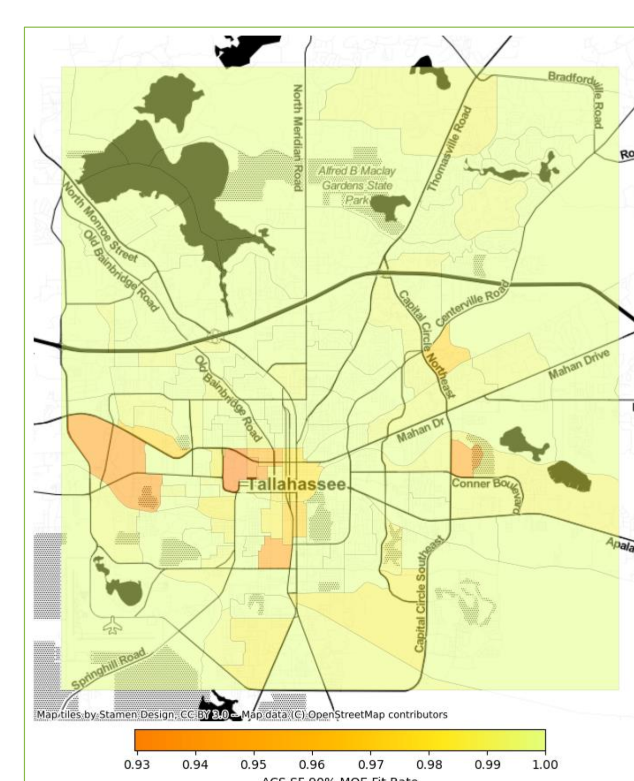
Locating Agents and Assigning Travel Modes





Results

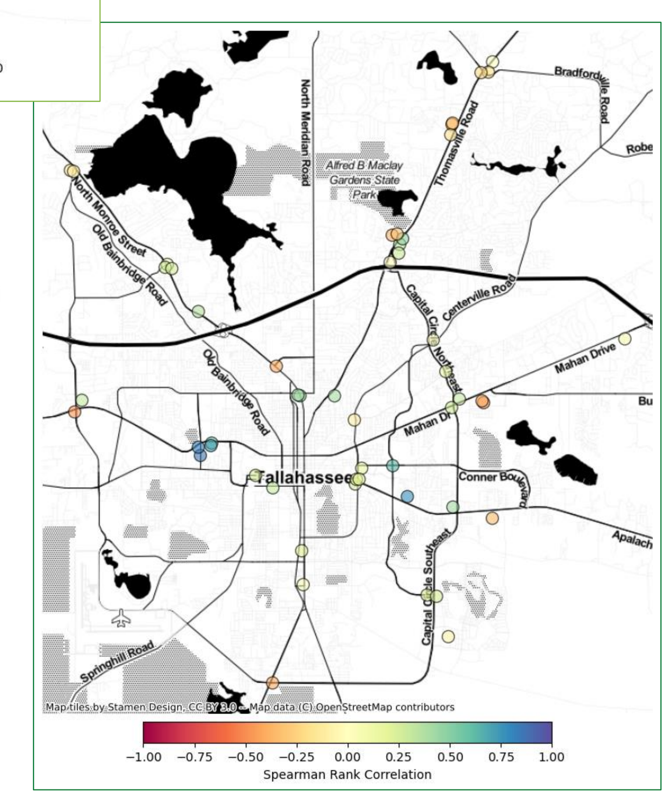
Neighborhood Demographics



- All synthetic block group estimates of model constraints preserved at least 90% of the ACS Summary File (SF) constraints.
- Performance weaker in areas with large group quarters populations (college dormitories, prisons), low density/rural areas.

Essential Activities

- Mixed performance for within-POI demographic composition (synthetic vs. observed).
- Performance generally improves in central areas of Tallahassee (pictured) and weakens along Leon County's urban fringe.
- Could spatial factors like activity density, diversity of travel modes influence this?



Recommended Resources

- Birkin, M. & Clarke, M. (2011). Spatial Microsimulation Models: A Review and a Glimpse into the Future. In: Stillwell, J., & Clarke, M. (eds) *Population Dynamics and Projection Methods. Understanding Population Trends and Processes*, vol 4. Springer, Dordrecht. DOI: 10.1007/978-90-481-8930-4_9.
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- Morton, A.M, J.O., Nagle, N.N., Aziz, H.M., Duchscherer, S., & Stewart, R.N. (2017b). A simulation approach for modeling high resolution daytime commuter travel flows and distributions of worker subpopulations. In *GeoComputation 2017*, pp. 1–5, Leeds, UK.
- Nagle, N.N., Buttenfield, B.P., Leyk, S., & Spielman, S.E. (2014). Dasymetric modeling and uncertainty. *Annals of the Association of American Geographers*, 104(1):80–95, DOI: 10.1080/00045608.2013.843439.
- Tuccillo, J.V. & Gaboardi, J.D. (2022, June). Likeness: a Python toolkit for connecting the social fabric of place to human dynamics. *GeoPython 2022*. DOI: 10.5281/zenodo.6685086.
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- Tuccillo, J.V., Stewart, R.N., Rose, A., Trombley, N., Moehl, J., Nagle, N.N., & Bhaduri, B. (2023) UrbanPop: A spatial microsimulation framework for exploring demographic influences on human dynamics. *Applied Geography*, 151, pp. 102844, DOI: 10.1016/j.apgeog.2022.102844.