Brownian Bridge Activity Spaces

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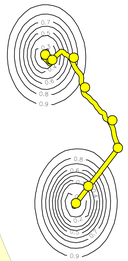
Activity Space: The set of locations with which a person comes into contact while doing about daily activities.

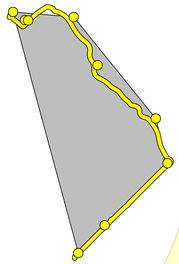
Traditional Approaches

Minimum convex polygons and **Standard deviation ellipses** give crude, atemporal estimates of activity space and tell nothing about space-use intensity.

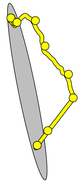
Traditional **kernel density methods** capture space-use intensity but fail to incorporate temporal information.



Utilization distribution based on bivariate normal kernel density. Contour lines show probability of presence.

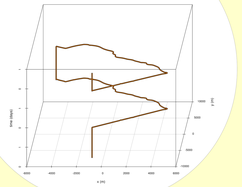


Minimum convex polygon encompassing 95% of sampled locations.

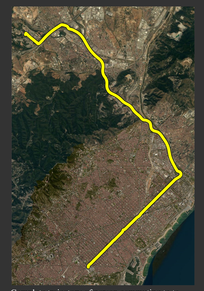


Standard deviation ellipse from sampled locations.

Space-time path



Challenge



Complete trajectory of person commuting to to and from work in Barcelona, Spain, over 24 hours. Synthetic data.

Observed locations of commuter in left figure, using 10 minute sampling interval.

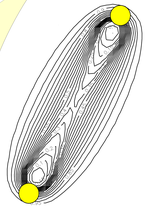
How to reconstruct activity spaces from sampled locations?

Relevance: Estimating activity space helps us understand things like mobility, access to resources, exposure to hazards, social interaction, and segregation.

Brownian Bridges

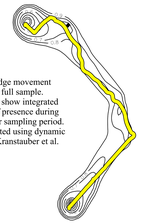
The Brownian bridge movement model (Bullard 1999) is based on the probability distribution of a particle following a Brownian random walk between two known locations.

Advantages:
- Better predicts actual locations.
- Captures variation in space-use intensity.
- Incorporates temporal and spatial information.
- Accounts for measurement error.



Brownian bridge between two sampled locations. Contour lines show probability of presence during the sampled time interval.

Individual Brownian bridges between all sampled locations. Contour lines show probability of presence during each time interval between the observed points.

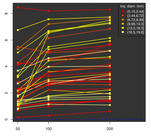


Brownian bridge movement model for the full sample. Contour lines show integrated probability of presence during entire 24-hour sampling period. Model estimated using dynamic approach of Kranstauber et al. (2012).

BBMM vs. MCP

How do dynamic Brownian bridges compare to minimum convex polygons in terms of predicting actual locations? We compare "full trajectory" expectations calculated by summing utilization densities at each point of full trajectory.

The expectation index (EI) is the geometric mean of the ratio of BBMM expectations to MCP expectations.



For this analysis, we used high resolution trajectories recorded by volunteers using the *Space Mapper* mobile phone application.

BBMMs outperform MCPs (higher EI) at all sample sizes, with the difference tending to increase with sample size.

Selected References

Bullard, F. 1999. "Estimating the Home Range of an Animal: A Brownian Bridge Approach." Chapel Hill, North Carolina, USA: The University of North Carolina.

Horne, Jon S., Edward O. Garton, Stephen M. Krone, and Jesse S. Lewis. 2007. "Analyzing Animal Movements Using Brownian Bridges." Ecology 88 (9): 2354–63.

Kranstauber, Bart, Roland Kays, Scott D. LaPoint, Martin Wikelski, and Kamran Safi. 2012. "A Dynamic Brownian Bridge Movement Model to Estimate Utilization Distributions for Heterogeneous Animal Movement." Journal of Animal Ecology 81 (4): 738–46.

More Information:

http://johnrbpalmer.com/brownian_bridges/

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 657956.