Kinematic Isochrones: An Early Look

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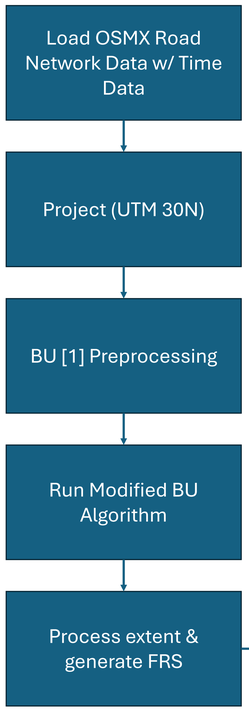
Introduction

- Standard isochrones estimate reachability under a given resource constraint
- Real-world vehicles have physical restrictions that determine the turns they can make
- Implementing vehicle turn restrictions into isochrone models may improve model accuracy

Methodology



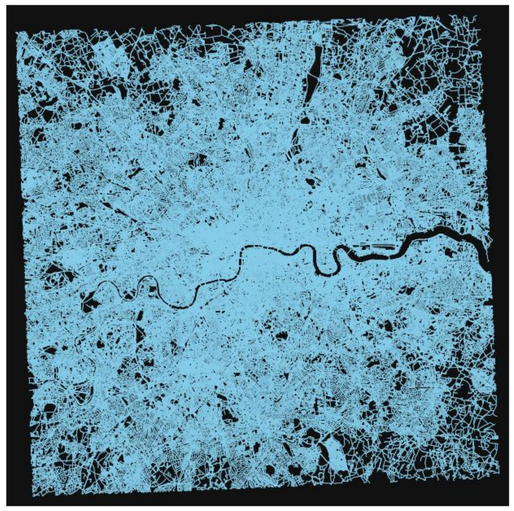


Figure 1: Projected OSMX road network

Limitations & Future Work

- The BU [2] turn-angle restriction exhibits a failure mode at higher resolutions
- OSX network segmentation limits angle checks to intersections - limiting scope
- Incorporating more network information will improve accuracy
- Restrictions were arbitrarily chosen
- Off-network applications may prove more relevant

Conclusion

- Incorporating a vehicle's turning restrictions reduces the reachable area in road networks
- Though the angle-only method has flaws, it demonstrate the potential of this line of research
- The reliability and necessity on road networks is unknown
- More work is needed to create a true "kinematic isochrone", but this presents a strong foundation

Results

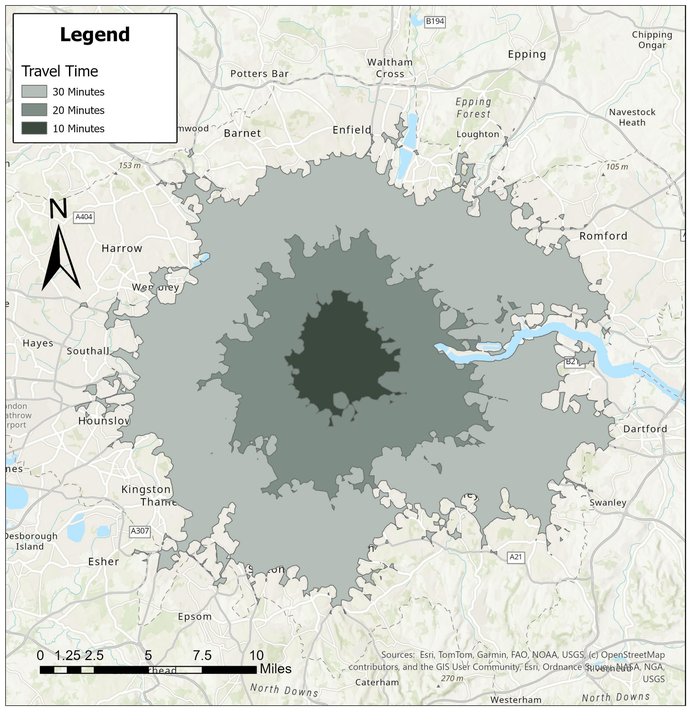


Figure 2: Multi-band isochrone centered about London, UK with angular restrictions.

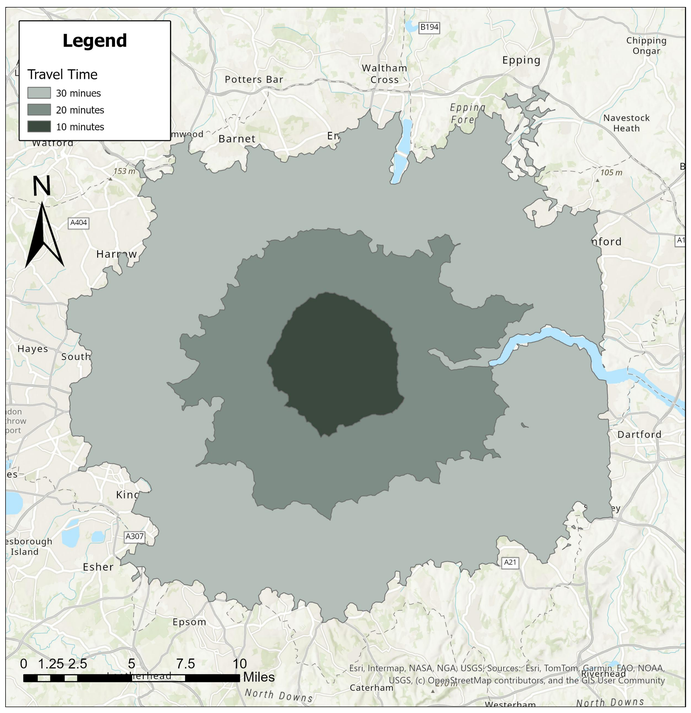


Figure 3: Multi-band isochrone centered about London, UK with traditional RC-BU Algorithm.

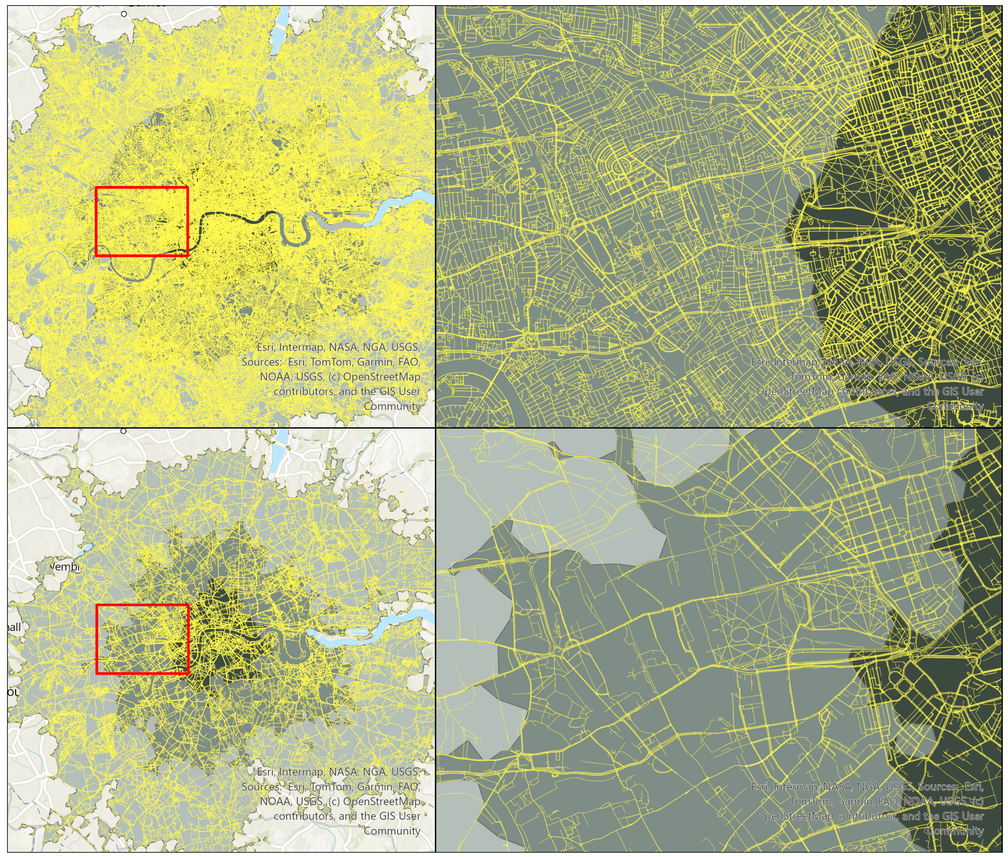


Figure 4: Side street access is severely limited in the angle-restricted map (bottom) compared to the unrestricted map (top).

- The angle-restricted isochrone presented a smaller reachable area than its unrestricted counterpart
- Major differences likely stem from side-street access (Figure 4) restricting paths to main throughfares

References

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[2] A. Boroujerdi and J. K. Uhlmann, "Empirical analysis of new methods for computing minimum cost paths with turn constraints," presented at the Aerospace/Defense Sensing and Controls, G. R. Gerhart and B. A. Abbott, Eds., Orlando, FL, Aug. 1998, pp. 262–272. doi: 10.1117/12.317554.

[3] M. Baum, V. Buchhold, and J. Dibbelt, "Fast Computation of Isochrones in Road Networks".

[4] K. Jun, W. Zihao, and W. Qianqian, "Time-constrained shortest path search algorithm for urban road network," in *2023 7th International Conference on Transportation Information and Safety (ICTIS)*, Xi'an, China: IEEE, Aug. 2023, pp. 1798–1803. doi: 10.1109/ICTIS60134.2023.10243896.

[5] M. Gendreau, G. Ghiani, and E. Guerriero, "Time-dependent routing problems: A review," *Computers & Operations Research*, vol. 64, pp. 189–197, Dec. 2015, doi: 10.1016/j.cor.2015.06.001.