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A flexible accessibility analysis tool for enhanced urban analytics

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Abstract[1]

Most existing accessibility analysis tools are ad-hoc systems with predetermined geographic coverage, spatial resolution, methodology and indicators, which are difficult to change without involving the original developers. This might partially explain why accessibility largely remains in the hands of academics and there is low uptake among transport and planning practitioners. The Urban Analytics Data Infrastructure (UADI) Accessibility Tool was designed as the first step to fill in this gap by empowering users. The goal is to provide a generic tool, by which agencies can insert their available data and geography to map accessibility without requiring GIS background. Using an opportunity-based metric, UADI lets the users select their own analysis areas, at their chosen resolution, for any given indicator, e.g. residents' access to jobs, education and services; and businesses' access to the labour pool or potential clients/customers.

1. Introduction

Accessibility is a *'measure of spatial separation of human activities'* (Morris et al. 1979, p.91). As a function of the interplay between land-use and transport, it measures the ease of reaching destinations which enable individuals and firms to conduct their activities ((Handy & Niemeier 1997; Geurs & van Wee 2004; Dong et al. 2006; Scott & Horner 2008). Substantial research has shown its importance in improving urban structures and quality of life for citizens (Kwan & Weber 2003; Scott & Horner 2008; Curtis & Scheurer, 2016).

While the importance of accessibility has been acknowledged, its exact meaning remains abstract and ambiguous in the literature (Tillema et al. 2003). Different interpretations and classifications of accessibility and their associated metrics have limited a wide-spread use of accessibility tools among transport and planning practitioners and made them subject of scientific debate across disciplines and geographies (Kwan & Weber 2003; Geurs & van Wee 2004; Páez et al., 2012; Curtis & Scheurer, 2016; Albacete et al., 2017). This paper aims to discuss the challenges of traditional accessibility tools and present our partial solution as part of an urban analytics infrastructure. The paper presents a location-based measure, considered by Curl et al. (2011) as the most commonly used, given the ease to assess and communicate the results and fewer data requirements.

[1] This is an abridged version of the paper originally submitted for ATRF 2017. For further information about this research please contact the authors.

2. Accessibility analysis in Australia

Given the context of this conference, this section focuses on briefly reviewing accessibility measures developed in Australia. It is by no means a complete list and we acknowledge this may not cover all projects.

The Spatial Network Analysis for Multimodal Urban Transport Systems (SNAMUTS) (Curtis & Scheurer 2010; Curtis & Scheurer 2016) is a GIS application to assess interaction between activities and services by public transport (PT). It calculates a composite indicator based on a range of indicators, many of which are topological concepts such as degree centrality, nodal betweenness. SNAMUTS has been applied to most Australian capital cities, as well as in many European and Asian cities (Curtis & Scheurer 2016).

Austroads used ARRB Accessibility Metric (AAM) to calculate accessibility in their report on 'Application of Accessibility Measures' (Austroads 2011), which examined relationships between how accessibility is linked to travel distance, transport mode share and property price in the areas of Perth and Melbourne. AAM requires two key inputs: number of opportunities and a transport impedance matrix. Number of jobs, students, or workers was used as proxies to opportunities. Door-to-door travel time derived from transport models was used to produce the transport impedance matrix.

Other Australian accessibility tools including Land Use and Public Transport Accessibility Indexing (LUPTAI) (Yigitcanlar et al. 2007) which was developed to calculate accessibility by walking and/or public transport with two pilot studies applied in the Gold Coast. Another, the Metropolitan Accessibility/Remoteness Index of Australia (Metro ARIA) measures access to basic services within metropolitan areas with six indices and has been applied to all Australian Capital Cities. It is based on the Accessibility/Remoteness Index of Australia (ARIA) methodology applied by the Australian Bureau of Statistics since 2001 (The Australian Population and Migration Research Centre n.d.). Finally, the study by Grattan Institute (Kelly et al. 2013) used multivariate analysis and isochrone measures to model accessibility across Australia's four largest cities, namely – Sydney, Melbourne, Brisbane and Perth.

3. Current challenges

3.1 Data and model interoperability

Besides the confusion caused by multiple definitions of accessibility, challenges in data and model interoperability also hinder its wide adoption across different domains and jurisdictions. One major issue is the lack of harmonised data. For example, while the demographic data are available in the statistical geographic boundaries, the commercial land-use and transport data might be available in transport analysis zones, so incorporating them poses significant difficulties.

Other challenges include context sensitivity of many tools - because they are highly place-specific - and incompatibility between different computing platforms.

3.2 Fragmentation and the lack of user empowerment

Despite the excellence of the existing accessibility tools, users often have to adapt to the particular methodologies that are embedded in them, with no adequate choices given. The UADI Accessibility Tool addresses this by letting users chose their own geographic coverage, spatial resolution and socio-economic indices etc. The aim is to make accessibility analysis available to the wider community of practitioners and researchers, with limited resources or expertise in GIS. The long-term goal is to integrate and harmonise data from multiple sources and provide some metadata to help the interpretation of the outputs.

4. Next generation of urban analytics infrastructure

The UADI Project was a collaborative effort between a consortium of urban research centres across Australia and is funded by the Australian Research Council (ARC). The consortium comprises the Centre for SDIs and Land Administration (CSDILA) at the University of Melbourne (UNIMELB); the Planning and Transport Research Centre (PATREC) at the University of Western Australia (UWA); the National Centre for Social and Economic Modelling (NCSEM) and Canberra Urban and Regional Futures (CURF), both at the University of Canberra; City Futures Research Centre (CFRC) at the University of New South Wales (UNSW); the eResearch Lab at the School of ITEE, and the Centre for Population Research (CPR), both at the University of Queensland (UQ); and the SMART Infrastructure Facility at the University of Wollongong (UOW). Collectively, these research centres represent expertise in the domains of land and property, transport, economy, environment, housing, population mobility, and urban infrastructures.

The project aspired to develop the next generation of urban analytics infrastructure digital infrastructure. It strived to capitalise and add value to the Australian Research Infrastructure Network (AURIN) platform, creating a positive impact to the fragmented data landscape that persists in Australia, and enabling new capabilities in urban analytics.

4.1 The UADI Accessibility Tool

UWA in collaboration with UNIMELB developed the UADI Accessibility Tool.

4.1.1 Data access and integration

One of the aims of the UADI Infrastructure is to enable integration, harmonisation, connectivity and scalability of multi-source urban datasets. A data management component has been developed for data publication and registration. All data layers are enriched by metadata, to provide additional information for users to effectively understand and use the data.

4.1.2 Accessibility ontology development and semantic mapping

Ontologies are used to provide a semantic structure for terms and concepts, as well as their relationship to represent a domain of knowledge. Therefore, the mapping between any dataset or web resource to any concept within the ontology can be used to describe the dataset for discovery, and also data integration purposes.

The UADI infrastructure provides an embedded sophisticated tool for semantically enriching the datasets. The semantic enrichment process maps datasets (fully or in-part) and their attributes to one or more concepts of one or more registered ontologies. The main purpose of semantic enrichment is to improve discoverability of datasets and also to prepare datasets to be consumed by the tools developed within this infrastructure.

4.1.3 Inputs, outputs and workflow

UADI encapsulates and registers each indicator tool as a Web Processing Service (OGC 2017) endpoint, which then can be executed by users with various parameters as inputs for the accessibility indicator:

zone_profiles_wfsurl provides information such as number of labour force, total population etc. for the indicator calculation.

traveltimes_matrix_pt defines the public transport travel time matrix for a given region.

traveltimes_matrix_car is similar to **traveltimes_matrix_pt** but defines the private car travel time matrix for a given region.

threshold caps the maximum travel time (in minute) for the accessibility calculation. This parameter controls the geographical scope of the outputs.

mode_of_transport determines whether the calculation will be performed on PT or Car, or a combination of both.

Other modes of transport can also be used once data becomes available.

Outputs include downloadable spatial distribution maps, descriptive graphs, and tables.

5. Sample outputs of the UADI Accessibility Tool

This section provides some sample outputs based on the Perth data. Information was extracted from the Strategic Transport Evaluation Model (STEM) from the Western Australian Department of Transport (WA DoT).

Figures 6 to 9 show a substantial disparity between job accessibility by car and by PT in Perth. The highest public transport accessibility forms gradients around the railway lines. By contrast, car accessibility forms isochrones that are centred around the CBD, probably due to its high employment numbers.

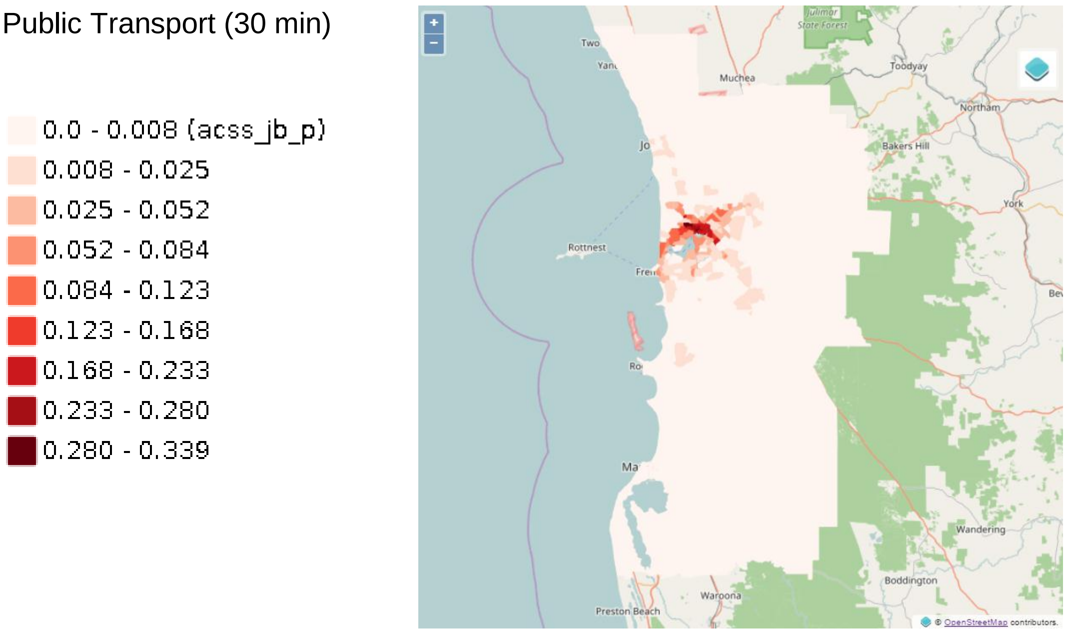

Figure 1 Access to jobs by PT within 30min (Perth, WA)

Note: The legend indicates the proportion of jobs that can be accessed by residents in 30 min.

As expected, Figure 7 shows a substantially higher accessibility to jobs in 60 min, yet areas of the metropolitan region North and South of the city, as well as East have low PT access.

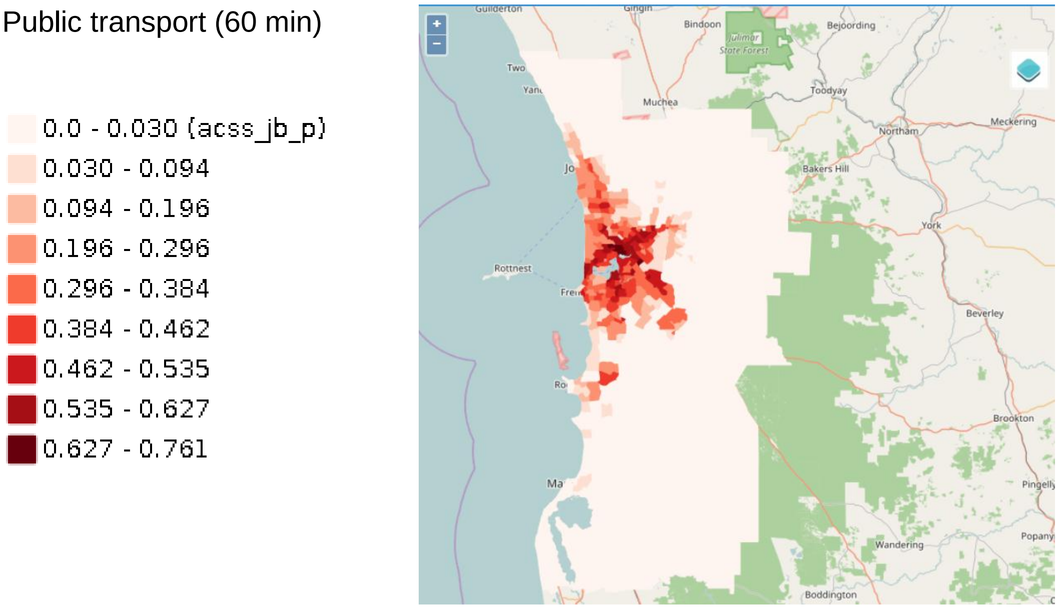

Figure 2 Access to jobs by PT within 60min (Perth, WA)

Figure 8 is illustrative for the traditional car-oriented development of the city, with 30 min access by car higher than 60 min by PT.

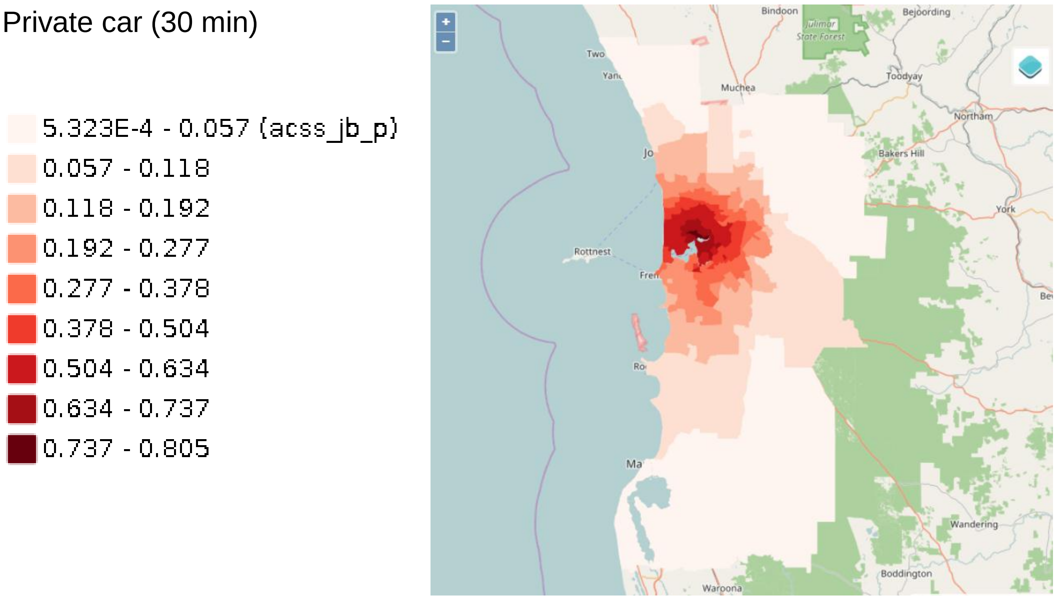

Figure 3 Access to jobs by car within 30min (Perth, WA)

Figure 9 indicates that most metropolitan area has good access to jobs in 60 min travel by car.

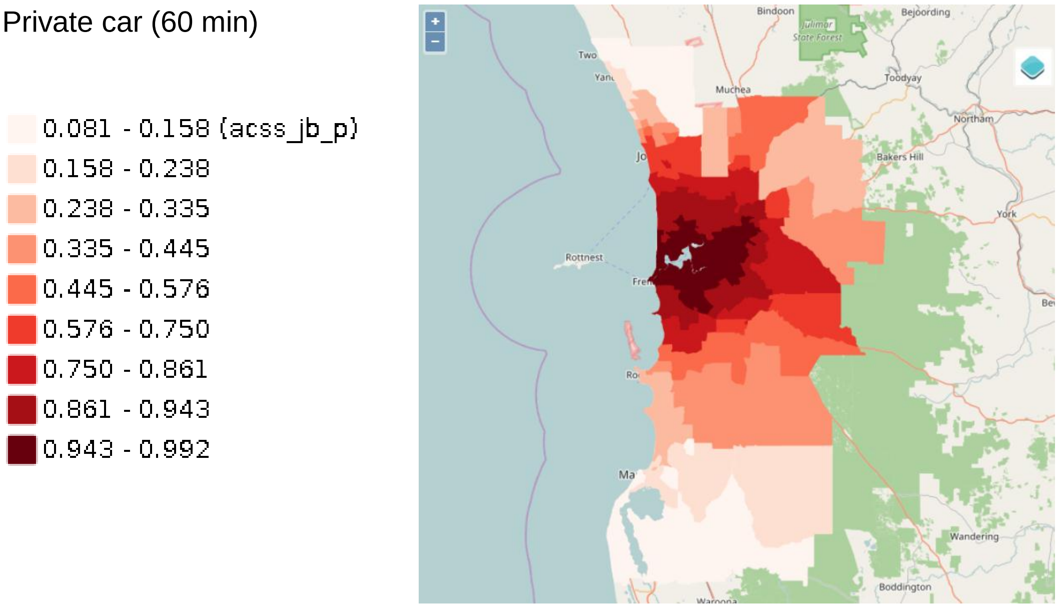

Figure 4 Access to jobs by car within 60min (Perth, WA)

6. Discussion

The UADI Accessibility Tool addresses challenges in data access, integration and semantic enrichment. It brings together different datasets in a unified format using ontology.

The tool aims at empowering users by offering flexibility and lowering technological barriers. For flexibility, it allows users to select their own zone boundaries and different social, economic and demographic indicators for analysis, as well as multiple travel time thresholds. However, currently, it does not allow users to change the definition of accessibility (calculated as an opportunity measure based on isochrones). A possible extension could be the introduction of more flexibility in terms of accessibility calculations.

Regarding the second goal of lowering technical barriers, the tool does so by automating certain procedures such as PT travel time matrix calculation based on GTFS schedules. However, it has been observed that some users still had difficulties in finding and using the right files. More automation is possible, but it depends on data availability, and the possibility to automatically retrieve and update the data sets.

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7. References

Austroads, 2011. *Application of accessibility measures, report AP-R397/11*, Sydney, NSW.

Curl, A., Nelson, J.D., & Anable, J. 2011. Does accessibility planning address what matters? a review of current practice and practitioner perspectives. *Research in Transportation Business & Management*, 2, pp. 3–11.

Curtis, C. & Scheurer, J., 2010. Planning for sustainable accessibility: Developing tools to aid discussion and decision-making. *Progress in Planning*, 74(2), pp.53–106.

Curtis, C. & Scheurer, J., 2016. Planning for Public Transport Accessibility: An International Sourcebook, Routledge, London, UK.

Dong, X. et al., 2006. Moving from trip-based to activity-based measures of accessibility.

Transportation Research Part A: Policy and Practice, 40(2), pp.163–180.

Geurs, K.T. & van Wee, B., 2004. Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography*, 12(2), pp.127–140.

Kelly, J.-F. et al., 2013. *Productive Cities: Opportunity in a changing economy*, Melbourne.

Kwan, M.-P. & Weber, J., 2003. Individual Accessibility Revisited: Implications for Geographical Analysis in the Twenty-first Century. *Geographical Analysis*, 35(4), pp.341–353.

Morris, J.M., Dumble, P.L. & Wigan, M.R., 1979. Accessibility indicators for transport planning. *Transportation Research Part A: General*, 13(2), pp.91–109.

OGC, 2017. Web Processing Service. Available at: http://www.opengeospatial.org/standards/wps [Accessed June 30, 2017].

Scott, D. & Horner, M., 2008. Examining The Role of Urban Form In Shaping People's Accessibility to Opportunities: An Exploratory Spatial Data Analysis. *Journal of Transport and Land Use*, 1(2), pp.89–119.

The Australian Population and Migration Research Centre, *Metropolitan Accessibility / Remoteness Index of Australia (Metro ARIA)*, AURIN. Available at: https://www.adelaide.edu.au/apmrc/research/MetroARIA_InfoSheet.pdf.

Tillema, T., van Wee, B. & De Jong, T., 2003. Road pricing from a geographical perspective: a literature review and implications for research into accessibility. In *the 43rd European Regional Science Association (ERSA) Congress*. Jyväskylä, Finland.

Yigitcanlar, T. et al., 2007. A GIS based land use and public transport accessibility indexing model. *Australian Planner*, 44(3), pp.30–37.