Accessibility measures for cycling: Catchment-areas in Amsterdam

I.M. Galama[1,], W. Daamen[1], S. C. van der Spek[2], S.P. Hoogendoorn[1]*
[1]Delft University of Technology, Civil Engineering and Geosciences, Transport & Planning | [2]Delft University of Technology, Architecture and the Built Environment, Urbanism | [*]Corresponding author: i.m.galama@tudelft.nl

1. Introduction

Walking and cycling – or active modes – have a well-known positive effect on cities and their citizens (Gehl, 2010). Many cities throughout the world encourage their inhabitants to use active modes, and as previous studies have shown, larger accessibility for active modes, is an important factor to increase their use (Buehler & Dill, 2015).

Measuring accessibility, however, is not straightforward and can be done in various ways, as Vale et al. (2016) state in their review. They found four categories of accessibility measures: distance-based, gravity-based, infrastructure-based, and walk score-type (combination of the previous) measures. Each category uses different characteristics to quantify accessibility: some include built environment characteristics (e.g. street network), others include weights for "opportunities" (e.g. schools, work), and there are measures that include various types origins and destinations. As Vale et al. (2016) stress in their review, the most important issue might not be what to measure, but how to measure accessibility.

Understanding bicycle accessibility is important for encouraging modal shift towards cycling. There is relatively little research on accessibility using bicycles as travel mode. The few studies that have been carried out did mainly focus on infrastructure-based measures (Vale et al., 2016). Besides the studies in Northern America (e.g. Winters et al., 2016), to the knowledge of the authors, no studies on bicycle accessibility have been carried out in countries with relatively high shares of cyclists such as Denmark or The Netherlands.

This paper compares existing methods to determine catchment areas for cyclists – often used in accessibility measures – with a new data-driven method. We use Amsterdam as a case to compare these methods. Amsterdam is the capital of The Netherlands, it has 834,713 inhabitants and its area is 219sq kilometers (OIS, 2016b). The city has a good network of cycle paths, many low-speed residential streets, a flat surface, and is known for its cycling culture: having cycling shares up to 43% (Municipality of Amsterdam, 2015). The main contribution of this work is to gain insight into new methods to determine accessibility of the cycle network in Amsterdam.

2. Methods and data used

To determine the bicycle catchment areas from multiple origins in Amsterdam, we used different methods: 1) "as the crow flies" distance; 2) network-based distance; 3) and cycling time. For the first and second method, we used a Geographical Information System, ArcGIS 10.5, to analyze the catchment areas. For second method, we used Open Street Map data (OSM) to specify the cycle network of Amsterdam. This network exists of different types of roads, of which we selected all cycle paths, and other roads that are accessible for cyclists (i.e. residential roads, less than 30 km/h).

For the third method, the data-driven cycling time method, we used experimental data of a cycling experiment in Amsterdam, where bicycles were equipped with GPS-trackers to track their routes. We used data of 10 days (1-10 July, 2017), including 94 cycling trips (of mainly tourists). All trips started at one home-location in Amsterdam (see Figure 4). We analyzed the trips, using Matlab. We explored this new catchment area method, based on the travel times, for multiple origins in Amsterdam (e.g. train stations).

3. Results

First, we analyze catchment areas for the train stations in Amsterdam, based on the network for cyclists, as cycling is a common access- or egress-mode in The Netherlands. Catchment areas are calculated for travel distances of 500, 1000, and 2000 meters, using different methods: 1) "as the crow flies" catchment area (circles around the train stations), and 2) network-based catchment area (following existing roads). Figure 1 shows a map of Amsterdam with these calculated catchment areas.

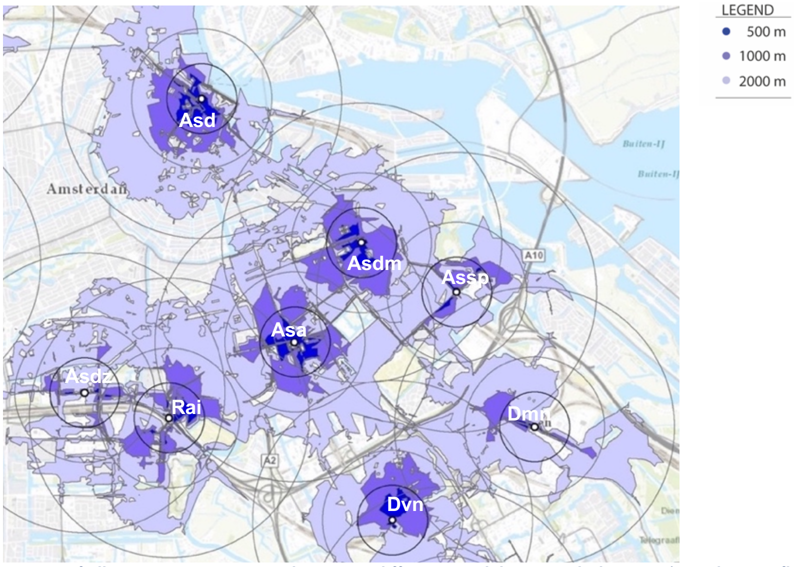

Figure 1. Catchment areas of all train stations in Amsterdam, using different travel distance calculations: 1) "as the crow flies" and 2) network-based. The circles or colors represent different cycling distances: 500, 1000, and 2000 meters.

The figure clearly shows that the, purple colored, network-based catchment areas are smaller than the "as the crow flies" catchment areas. In Figure 2, we propose a measure that entails the proportion of the network-based catchment area to the "as the crow flies" catchment area. This measure is an indicator for network quality. We see that not all stations have the same proportion, and differences are found in the travel impedance from 500, to 1000 or 2000 meters. This is as expected, because although the Netherlands is flat, we have certain restriction due to barriers such as water ways (bridges) and main infrastructure (train lines, highways).

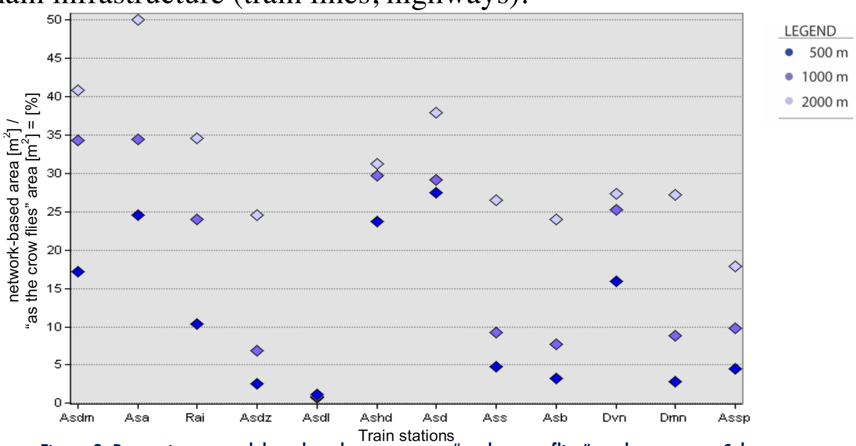

Figure 2. Proportion network-based catchment area to "as the crow flies" catchment area. Colors (representing 500, 1000 and 2000 meters) and train stations match with the catchment areas in Figure 1.

Second, we explore a data-driven method to determine catchment areas, where the travel impedance is based on cycling time (instead of distance), using the GPS tracker data on bicycles. This new method includes delays in the network (e.g. traffic lights, cycle congestion). Catchment areas are calculated for travel times of 5, 10, 15 and 20 minutes. Figure 3 and 4 show the travel times from two origins: the central station (Asd) and the home-location of all bicycles.

Both figures show, that directions are faster (e.g. the Wibautstraat), than others, as people travel much further in a shorter time-period. Partly, this can be explained by the small data sample, which especially holds for trips from the central station (Asd). However, Figure 4 has a lager sample, and still shows some “gabs” in the network. It shows that moving from the home-location towards the canal district (in Northeastern direction) takes relatively much time, if compared to moving from the home-location towards the central station (via the Wibautstraat).

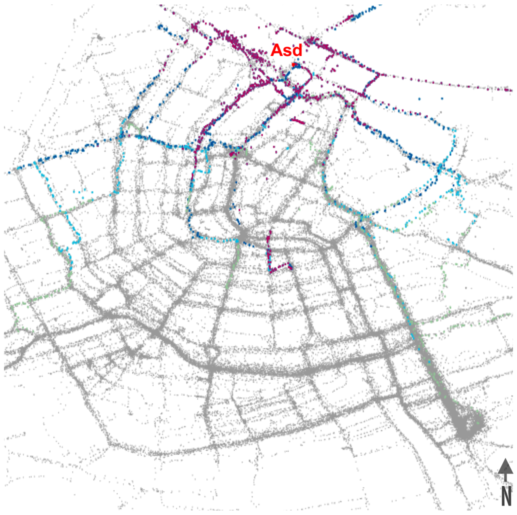

Figure 3. Bicycle trajectories based on time from the central station (Asd)

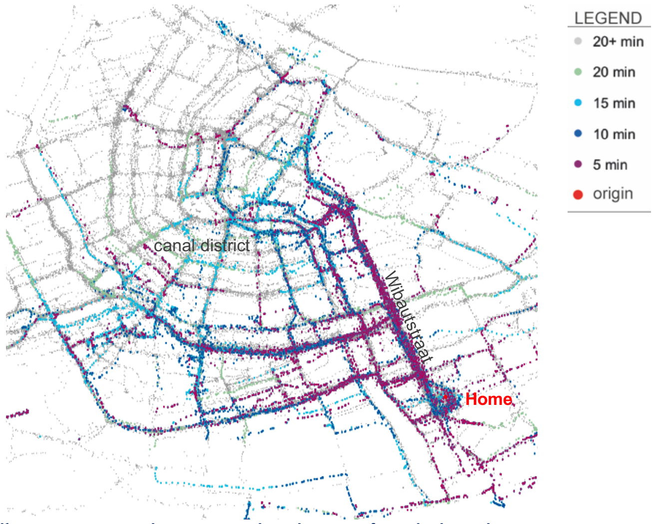

Figure 4. Bicycle trajectories based on time from the home-location

4. Conclusions

Our results show, that the comparison of different ways to measuring catchment areas for cyclists, provides useful information about the accessibility of an area. We compared both the “as the crow flies” distance with the network-based distance, as well as the cycle time measure with the network-distance measure. We found that, although on the network-level an area might look very connected, the real use of a cycling network might be different. We see in Amsterdam, that some streets can be considered as “fast cycling streets”, while other, seemingly well connected streets, have lower speeds. Our hypothesis is, that reasons for this are found at a more detailed level of the infrastructure and network. For example: a smooth surface, thus higher speeds, are more attractive to cyclists; and many crossings on the road or many traffic lights cause delays, thus, decrease speeds too.

The contribution of this paper is the comparison of both existing and new catchment area measures for cycling, applied on the network of Amsterdam. For this case study, we analyzed the accessibility measures in a unique way, due to the availability of bicycle trajectory data. Based on the growing availability of GPS data, we perceive that creating such a new method, using GPS data, will add value to the existing accessibility measures.

5. References

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