Ben Wagner and Till Winkler

Comparing Travel Time Estimates of Routing Applications in Vienna.

Paper

COMPARING ROUTING PREDICTIONS: TRAVEL TIME ESTIMATES AND USER ACCOUNTABILITY IN NAVIGATION APPS

Research in Progress

Wagner, Ben, Vienna University of Economics, Austria, ben.wagner@wu.ac.at

Winkler, Till, Vienna University of Economics, Austria, till.winkler@wu.ac.at

Abstract

How are travel times displayed by different navigation apps? Do the way in which these work differ for different modes of transportation? We found unexpected divergence in the way travel time is displayed both between apps and within apps, when conducting testing on travel routing apps in Vienna. As a result, this paper will provide a brief overview of how travel times are displayed by commonly used apps in Vienna and how these differ. In conclusion, we will suggest different avenues for additional research based on these findings and illustrate the challenges of user accountability associated with these apps.

Keywords: Geographic Information Systems, Recommender Systems, App-based routing, Travel Time.

1 Introduction

Technology has a massive impact on the way we perceive the physical world around us. Not just in shaping how we see the world, but also in actively co-creating the structure by which we perceive the world Brey, 2005. These structures also have considerable effects on human behavior, defining ‘authoritative facts’ about our surrounding individual that appear to be neutral and objective Denardis, 2011. Technologies also have the ability to influence human perception of the world, even when they believe that they actually cognitively ‘know better’ Anderson, 2011; IJsselsteijn et al., 2006.

This is particularly the case with geographic environments, where human beings almost always need additional tools to be able to accurately perceive the geographic environment around them. Whether the astrolabe or the paper map, human beings have been using tools to understand their geographic environments for millennia. However the act of mapping has also always been a source of manipulation and an expression of power Harley, 2009. To create an authoritative map of geographic space involves countless subjective decisions which are not typically visible to users of the map and typically involves the expression of sovereign or corporate power Dalton, 2013. In this sense, the geographic space around us irreversibly intertwined with the tools we use to perceive it.

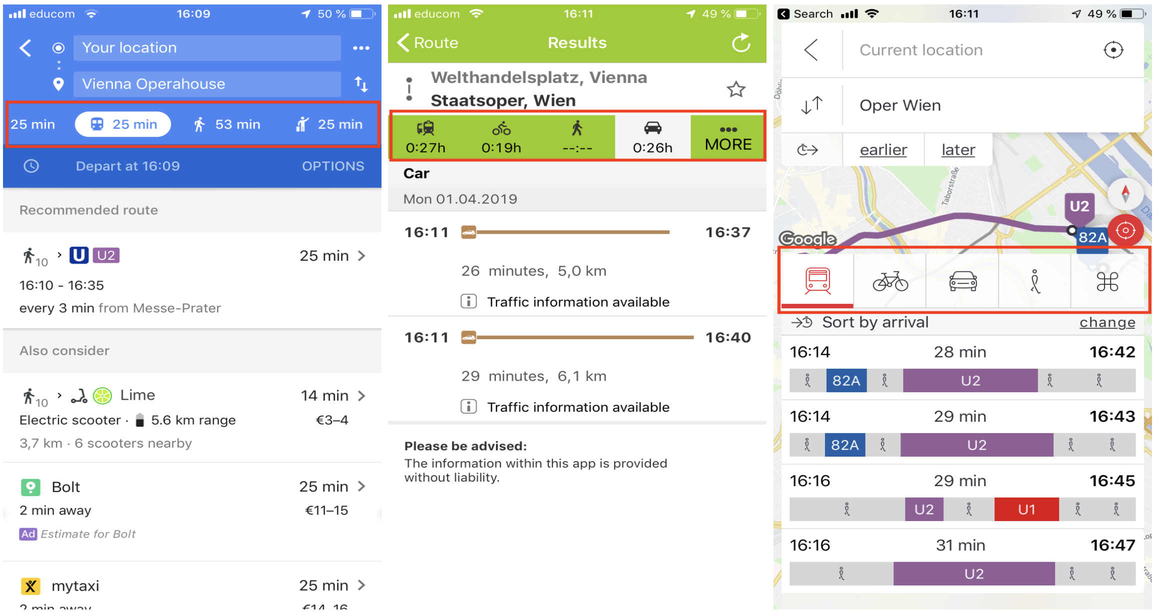
With the rise of computing, geographic maps have mostly transitioned to digital formats, to the point that for most individuals these are “virtual geographic spaces” Lin and Batty, 2009. In this context the rise of online universal mapping services like OpenStreetMap or Google Maps “threatens to change the nature of the way we handle abstract geographic space for ever” Lin and Batty, 2009. What was considered a threat little under a decade ago has swiftly become reality, with 41 per cent of all Internet users worldwide using Google Maps services in 2014 and around 1 Billion monthly users of Google Maps Privat, 2014. While Google Search has received considerable scrutiny for bias in its search results Diaz, 2008; Goldman, 2012; Hoboken, 2012; Lewandowski, 2018; Saurwein, Just, and Latzer, 2017 there has been much less scrutiny of the results produced by Google Maps Lao, 2013; Quattrone, Capra, and De Meo, 2015; Tufekci, 2015.

Aside from Google Maps, there is a broad ecosystem of geo-information systems that has been developed, with numerous different use cases in mind. For example, these apps providing specialised routing for specific types of transport like bicycles (Bike Citizen), driving (Waze) or public transport (Qando). There are however relatively few "general purpose" navigation apps, that allow for a comparison of different modes of transportation in one common app. Of the apps which allow this kind of comparison, all the data available to us suggests that Google Maps is the most commonly used product in this product category. To provide a broad comparison of presentation options, we compared the presentation style of the iOS versions of Google Maps (Version 5.14) to the WienMobil (Version 3.2.4) and VOR AnachB (Version 3.6.0). We chose a route from Vienna University of Economics and Business to the Vienna Opera House (Staatsoper) during the rush hour between 16:05 and 16:15 on 1 April 2019 to test the routing assumptions embedded in these apps.

2 Design choices around travel time

Within this group of geo-information apps that allow a comparison of different modes of transportation, the choice of who to present travel time to the user is particularly important. This is because the users are using the app to make a choice and typically make the decision based on the comparative information provided by these apps.

All the apps that we studied used travel time as the primary comparative metric for different modes of transportation. This is typically presented to users as part of a comparison bar. Both Google Maps and VOR AnachB conduct a comparison which includes estimated travel time, while WienMobil does not. To clarify this difference, we have marked screenshots of these three apps with an additional red box to show the area mentioned here.



It should be noted that even if WienMobil does not include time directly in the comparison bar, it still uses time as the central explanatory variable for different routing options. Thus the estimated travel time for different routing options represents an important component of the overall choice architecture that allows users to compare different modes of transportation.

In transportation science, the typical way to calculate travel time is based on the following measures. For example, Benenson et al. Benenson et al., 2011 calculate Bus travel time or more broadly public transport travel time as follows: "BTT = Walk time from origin to a stop of Bus 1 +Waiting time of Bus 1 + Travel time of Bus 1 + TransferwalktimetoBus2 + Waiting time of Bus 2 + Travel time of Bus 2] + [Transfer component related to additional buses] + Walk time from the final stop to destination." Benenson et al., 2011. In a similar fashion, car travel time is typically calculated as follows: "CTT = Walk time from origin to the parking place + Car trip time + Walk time from the final parking place to destination" Benenson et al., 2011.

When translated into a common travel time calculation framework that can be used to analyse both routing in public transport and driving, this leads to the following 6 key elements that need to be considered when predicting trip time:

1. **Walk to vehicle:** the time required for an individual to walk to the first vehicle that is part of their trip, whether it is a car, bus or train.

2. **Initial waiting time for vehicle(s):** the time required for an individual to wait for the first vehicle at their point of departure, whether it is a car, bus or train.

3. **Travel time of vehicle(s):** the actual travel time in one or several vehicles, whether these are cars, or buses or trains. This element also includes any waiting time required for changing modes of transportation during the trip.

4. **Delay in travel time of vehicle(s):** any delays that might occur in the travel time of vehicle(s) listed in option 3 above, which include include additional traffic or public transportation delays.

5. **Finding parking for vehicle:** taking time to find parking, which is likely to require for an individual driving their own car or a car-sharing car in most urban areas, but is not typically required for public transport options.

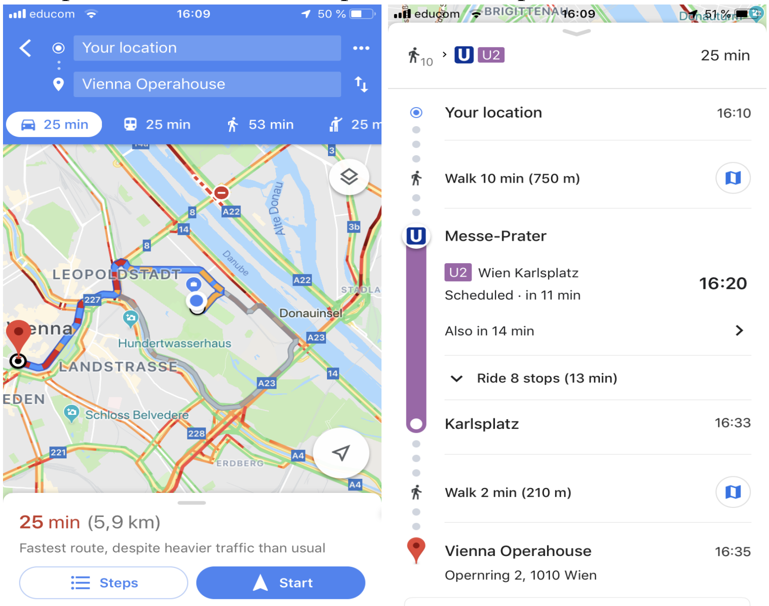
6. **Walking time from vehicle to destination:** The additional walking time required from point where the individual leaves their last vehicle, to get to their final destination.

3 Comparison of Apps

Given the importance of all of these factors in making an informed decision, we expected that the vast majority of them would be included in the calculation of travel time. As these apps are being used for a comparison, we also presumed that the foundations for the comparison made by the apps would be similar for different modes of transport, i.e. that the apps would compare different modes of transport in a fair manner. However contrary to our expectations this was not the case, and we found highly divergent elements of travel time calculation implemented within these apps.

3.1 Google Maps

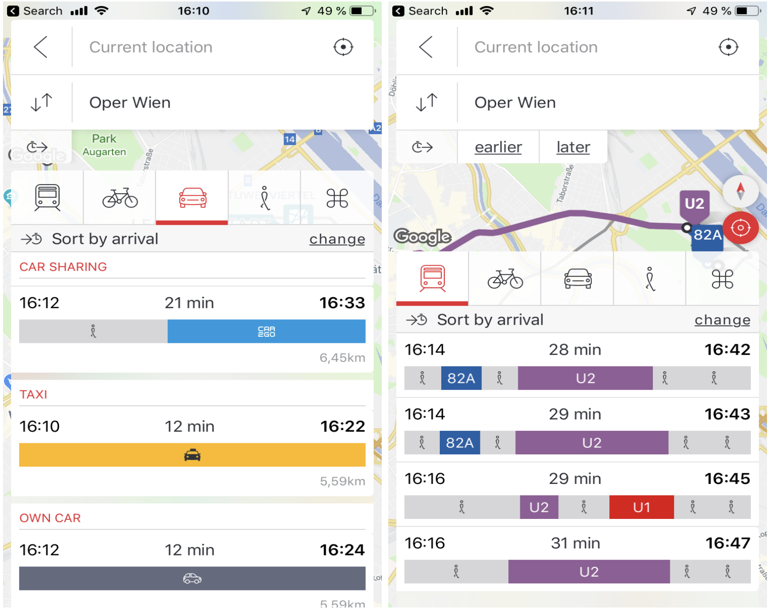
Google Maps provides an estimate for driving time that only includes two out of six potentially relevant variables: travel time of the vehicle as well as potential delays due to traffic. What is not considered is that users may not directly be sitting in the vehicle, but might first need to talk to it, or that they might need to wait for it to arrive, for example in the case of booking a Taxi or an Uber. While this information is presented to users within the Google Maps app, it is excluded from the overall estimate of travel time provided in the user interface. This is also the case for any time required for parking, or walking to a destination which cannot be reached by car, both of which are excluded from the overall estimate of travel time presented to the user as part of the comparison bar.



By contrast, Google Maps includes only three out of five possible dimensions for estimating public transportation travel time, only one of which overlaps with estimated driving time. While public transport travel time estimates also include time to walk to the vehicle, and walk from the vehicle to the final destination, these elements are not included in Google Maps estimates of driving journey time. However by contrast, Google Maps does not integrate data on public transport delays into its estimates, while it does integrate data on driving delays into its travel time estimates. The only thing that Google Maps estimates for public transport and driving have in common, are actual travel time.

3.2 Wien Mobil

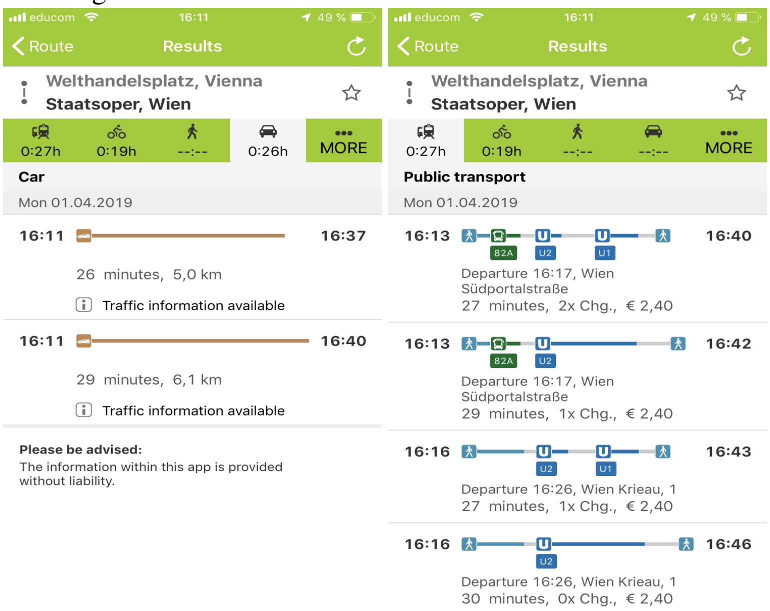
Moving from Google Maps to WienMobil, the WienMobil App provides one to two out of five potential elements of driving time within their analysis. That is to say that in predictions of car-sharing driving time, they acknowledge the time walking to a vehicle requires. However this additional time of walking to a vehicle is not includes in the analysis of driving your 'own car.'



It is in the analysis of public transport however where WienMobil shines, covering four out of five potential dimensions of the analysis. It's routing includes walking to vehicle, travel time of vehicle(s), potential delays in driving time as well as the walking distance from vehicle to the final destination. What is not included however is the potential initial waiting time for the vehicle, with WienMobil only calculating travel time from the optimal start point rather than making it immediate.

3.3 VOR AnachB

In comparison with Google Maps and WienMobile, VOR AnachB provides the most comprehensive routing decision-making input for both driving and public transport routing. The routing for VOR AnachB driving includes walking to vehicle, travel time of vehicle, finding parking and walking to final destination as potential variables. It only leaves out initial waiting time for the vehicle and potential delays related to traffic. However in the context of inner-city traffic, these delays can be considerable, leading to a potential doubling of travel time from 12 to 25 minutes on the route shown.



The variables included for public transport are similarly comprehensive, ensuring that walking to the vehicle, travel time of the vehicle, delays in public transport and walking time to the final destination are meaningfully considered. However similarly to WienMobil it does not consider the potential waiting time for a vehicle as a relevant variable.

3.4 Validity of comparison of travel time estimates

The following table provides an overview of which factors are included and which are not for driving and public transport in the three apps studied in greater detail:

Factors displayed as part of total estimate trip time	Google Maps		Wien Mobil		VOR AnachB	
	Driving	PubTrans	Driving	PubTrans	Driving	PubTrans
1. Walk to vehicle	✗	✓	✗✓	✓	✓	✓
2. Initial waiting time for vehicle	✗	✗	✗	✗	✗	✗
3. Travel time of vehicle(s)	✓	✓	✓	✓	✓	✓
4. Delays in travel time of vehicle(s)	✓	✗	✗	✓	✗	✓
5. Finding parking for vehicle	✗	n/a	✗	n/a	✓	n/a
6. Walking time from vehicle to destination	✗	✓	✗	✓	✓	✓

While including different factors, **none** of the three apps discussed here provides a valid, consistent comparison of public transport and driving options. Instead, all of them include different factors within their analysis. While Google Maps does not include time required to get to a vehicle for driving while it does for public transport, WienMobil and VOR AnachB do not consider delays such as heavy traffic for driving, while the do for public transport.
These 'apples and pears' comparisons are not meaningfully communicated to users, as a result of which it is difficult for users to interpret the results in a meaningful way. WienMobil provides for an interesting design choice here, in that it does not foreground the time estimate for different options in how it compares transport options, but instead reduces the comparison to a choice between different options. While this (legitimately) makes comparisons more difficult, it still does not resolve the question of how users should interpret the results.

4 Conclusion

The apps we studied here all provide a "best effort" estimate for each mode of transportation, rather than substantive comparisons of the different relevant elements of trip calculation. In doing so, they shift a considerable part of the cognitive load of how long a trip will actually take on to the users. As a result, it becomes very difficult for users to interpret the results of the comparisons, as none of them are fully able to reflect the relevant factors that influence travel time. Further research is required to better understand the cognitive models of how users interpret these types of comparisons and whether they are able to correct for missing information within the estimates provided to them.
There are several different ways in which app designers could meaningfully respond to this challenge:

1. **Present users with additional information as part of the travel time estimate:** all of the apps discussed here are highly likely to have access to vast amounts of data that goes beyond what they are presenting to users. There is no reason to suggest why they could or should not do this in the future.
2. **Ensure that comparisons between modes of transport are comparable:** another way would be to ensure that the information provided to users is meaningfully comparable, even if this means leaving out some data sources. Within the apps compared, VOR AnachB seems to do the best job at providing meaningful comparability between driving and public transport options. Without

meaningful comparability between different modes of transport, user are likely to confuse or misinterpret the information provided to the by the app.

3. **Further de-emphasise the role of time in relation to other metrics:** a third option is to de-emphasize the role of time in decision making, as the travel time estimates are themselves unlikely to be comparable. Wien Mobile already does this to a certain extent, by excluding travel time estimates from the comparison bar, while still including the biases in other elements of the apps.
4. **Ensure users are aware of limitations of app:** a fourth and last option is to ensure that users are aware of the different limitations of the app depending on the different modes of transport selected. This can be accomplished both by providing additional warnings to users about the limitations of data provided and reducing the importance of the design element comparison bar.

Regardless of which steps are taken, it is important that developers ensure that users are aware of relevant limitations of the apps they are using and able to take informed decisions based on the information provided to them. Should this not be the case, there is a considerable risk that users misinterpret the data provided to them and make bad decisions based on false or at best misleading information.
In this context it is particularly important to consider the structural effects of systematically providing false or misleading comparisons to users. Depending on whether comparisons make public transportation or driving seem more attractive, they are also likely to influence users travel decision making. While the extent to which this is the case obviously requires considerable further research, we believe that there is a considerable possibility that the nature of the choice architecture presented to users may be nudging them towards seeing driving as a more attractive option than it actually is.

References

Anderson, S. P. (2011). *Seductive interaction design: creating playful, fun, and effective user experiences*. English. OCLC: 851345286. Berkeley, CA: New Riders. ISBN: 978-0-321-72552-3.

Benenson, I., K. Martens, Y. Rofé, and A. Kwartler (2011). “Public transport versus private car GIS-based estimation of accessibility applied to the Tel Aviv metropolitan area.” en. *The Annals of Regional Science* 47 (3), 499–515. ISSN: 0570-1864, 1432-0592. DOI: 10.1007/s00168-010-0392-6. URL: http://link.springer.com/10.1007/s00168-010-0392-6.

Brey, P. (2005). “Artifacts as social agents.” In: *Inside the politics of technology: Agency and normativity in the co-production of technology and society*. Ed. by H. Harbers. Amsterdam University Press, pp. 61–84.

Dalton, C. M. (2013). “Sovereigns, Spooks, and Hackers: An Early History of Google Geo Services and Map Mashups.” en. *Cartographica: The International Journal for Geographic Information and Geovisualization* 48 (4), 261–274. ISSN: 0317-7173, 1911-9925. DOI: 10.3138/carto.48.4.1621. URL: https://utpjournals.press/doi/10.3138/carto.48.4.1621.

Denardis, L. (2011). “The Privatization of Internet Governance.”

Diaz, A. (2008). “Through the Google goggles: Sociopolitical bias in search engine design.” In: *Web search*. Springer, pp. 11–34.

Goldman, L. (2012). *How the New York Times Uses Citizen Media to Watch "Syria’s War"*. URL: http://techpresident.com/news/wegov/22573/interview-j-david-goodman-editor-new-york-times-interactive-media-project-watching-syrias.

Harley, J. B. (2009). “Maps, knowledge, and power.” *Geographic thought: a praxis perspective*, 129–148.

Hoboken, J. van (2012). “Search Engine Freedom: On the implications of the right to freedom of expression for the legal governance of Web search engines.” PhD thesis. University of Amsterdam (UvA). URL: http://dare.uva.nl/record/411972.

IJsselsteijn, W., Y. de Kort, C. Midden, B. Eggen, and E. van den Hoven (2006). "Persuasive Technology for Human Well-being: Setting the Scene." In: *Proceedings of the First International Conference on Persuasive Technology for Human Well-being*. PERSUASIVE'06. Berlin, Heidelberg: Springer-Verlag, pp. 1–5. ISBN: 978-3-540-34291-5. URL: http://dl.acm.org/citation.cfm?id=1986822.1986823.

Lao, M. (2013). "'Neutral'Search as a Basis for Antitrust Action?"

Lewandowski, D. (2018). "Suchmaschinen und ihre Rolle als Vermittler von Informationen." *Suchmaschinen verstehen*, 289–302.

Lin, H. and M. Batty (2009). "Virtual geographic environments: a primer." *Virtual Geographic Environments. Science Press, Beijing*, 1–10.

Privat, L. (2014). *Google Maps: 1 Billion Monthly Users*. us. URL: https://www.gpsbusinessnews.com/Google-Maps-1-Billion-Monthly-Users_a4964.html.

Quattrone, G., L. Capra, and P. De Meo (2015). "There's no such thing as the perfect map: Quantifying bias in spatial crowd-sourcing datasets." In: *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. ACM, pp. 1021–1032.

Saurwein, F., N. Just, and M. Latzer (2017). "Algorithmische Selektion im Internet: Risiken und Governance automatisierter Auswahlprozesse." *kommunikation@ gesellschaft* 18, 22.

Tufekci, Z. (2015). "Algorithms in our Midst: Information, Power and Choice when Software is Everywhere." In: *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. Vancouver, BC, Canada: Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing, pp. 1918–1918. URL: http://dl.acm.org/citation.cfm?id=2697079.