Measuring Urban Mobility and Accessibility Using OpenTripPlanner Analyst

Abstract

Measures of urban mobility and accessibility are useful in many situations, from real estate to urban planning. Some methods of measuring and visualizing mobility and accessibility include making travel-time isochrones, measuring travel time effects of network changes, measuring accessibility using opportunity data, and creating time-space prisms. Transit, walking and cycling are more important to mobility than driving in many urban areas. This poster examines how the open-source OpenTripPlanner Analyst software can be used in conjunction with open transit agency and street network data to create visualizations of multimodal mobility, accessibility and changes in travel time.

Introduction

Travel-time isochrones are very common and useful tools in network analysis, with diverse uses in many fields, including real estate and urban planning. A travel-time isochrone is a map showing the time to reach any point in a given area from a starting point. In the real-estate arena, such a map might be used to determine all locations within a given commute time of a work location, or they might be used to assess the number of potential customers within a given distance of a proposed retail outlet. Some example uses in the field of urban planning might be assessing where there are barriers in the transportation network, assessing potential transit stop locations to determine their pedestrian accessibility, or visualizing how service or network changes affect mobility.

In many urban areas, public transportation time is more important than driving time. Cycling and walking are also important, either individually or as components of a multimodal trip. This poster examines creating isochrones including one or more of these modes using the multimodal routing software OpenTripPlanner (OTP) and its analytics companion OpenTripPlanner Analyst.

OpenTripPlanner is an open-source, multimodal trip planner that can plan trips by public transportation, cycling and walking, or any combination of said (Fig. 5). It is developed by OpenPlans, a New York City-based non-profit, and a team of developers from around the world. The initial work on OpenTripPlanner has been funded by Portland, Oregon's TriMet as a replacement for their customer-facing trip planner. OTP Analyst is a relatively young project, also developed by OpenPlans, which uses the codebase of OpenTripPlanner to generate visualizations of transportation networks.

Purpose

In this project, I explored the use of OpenTripPlanner Analyst to visualize and analyze multimodal transportation systems. I generated maps using Analyst (Figs. 1-4) to show their applicability to various situations.

Results

One somewhat unique attribute of OpenTripPlanner Analyst is that, since it has a trip planner with full schedule information at its core, it accurately represents the time dimension, from varying levels of service at different times of day, to differing transfer times. This is not a technique that has been commonly used, although it was used by Lei and Church of UC Santa Barbara (286, 292). One concern with this approach is that so much information is produced that system operators may not be able to process it all; there are many possible origins and times of day for any urban area (298). Also, many people have flexible trip times and may structure their trips around the transit schedule (i.e., opt to leave when they can catch a bus more easily); taking the best-possible travel time at multiple times of day may yield more meaningful results (295-6).

One of the simplest and most useful visualizations that can be generated by Analyst is the travel-time raster. If one provides Analyst with a starting point and a time, it can generate a GeoTIFF with the travel time from the specified point to all other locations in the analysis area. Classing or contouring this data in a GIS produces an isochrone (Fig. 1).

Analyst-generated rasters provide a good measure of urban mobility, and combined with other spatial data they can also be used to generate measures of accessibility. An isochrone may show that one can go 10 miles from one's home in 45 minutes, which is mobility. However, it does not show if there is a grocery store within that area, which is accessibility (Walker). By combining the GeoTIFF data that Analyst produces with urban opportunity data, accessibility to urban opportunities (jobs, customers, grocery stores, theaters, &c.) can be calculated.

There are several possible ways to use Analyst output to assess the accessibility of a location. Two common methods of measuring accessibility are the isochrone method and the gravity method. The isochrone method defines the accessibility of a location as the sum of the destinations within a set time of that location (e.g., there are 181,000 people residing within 90 minutes). The gravity method is similar, but it weights opportunities using a declining function of their access costs (i.e., a faraway location will still be included in the calculation, but not at the same weight as a nearby one) (Busby 21-23). Accessibility measures of both types are possible using Analyst data as well as opportunity data in a GIS environment (Fig. 4).

Another visualization that Analyst can produce is the Hägerstrand or time-space prism (Fig. 3). A fundamental piece of time geography, the time-space prism shows the constraints on a individual's time and movement throughout an area. It starts with activities that are fixed in time-space, for instance an individual may leave work no earlier than 5:00pm and be required to arrive at school by 6:00pm. Within that, perhaps they need 20 minutes for dinner. The potential locations for dinner are all the locations where they have 20 minutes of remaining time while still leaving work at 5:00 and arriving at school by 6:00 (Miller 3).

Conceptually, this is often represented as a 3-dimensional prism, with space on the X and Y axes and time on the Z (or M) axis (3). Analyst generates a one-band raster with the values representing the remaining time at each location. Finding all of the potential locations from this raster is not difficult: one must simply take all the raster pixels with values greater than or equal to the time needed to complete the activity. If the activity can only take place at certain locations (e.g., restaurants), one can do further analysis in the GIS to find those locations.

Travel Time from UC Davis Campus, 8am Weekdays

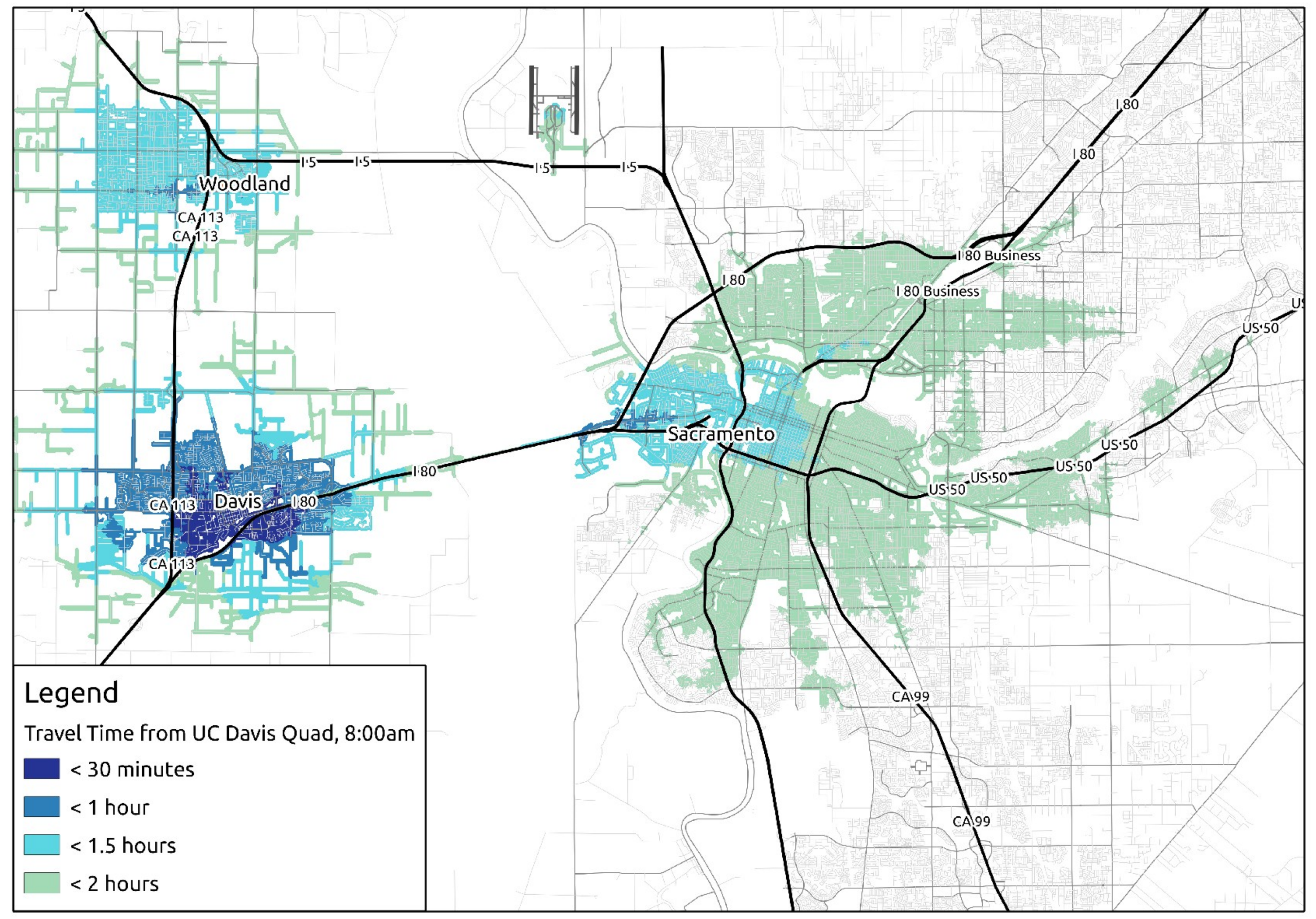

Fig. 1: Analyst Travel-Time Isochrone

Difference in Travel Times: Saturdays and Weekdays, 8am

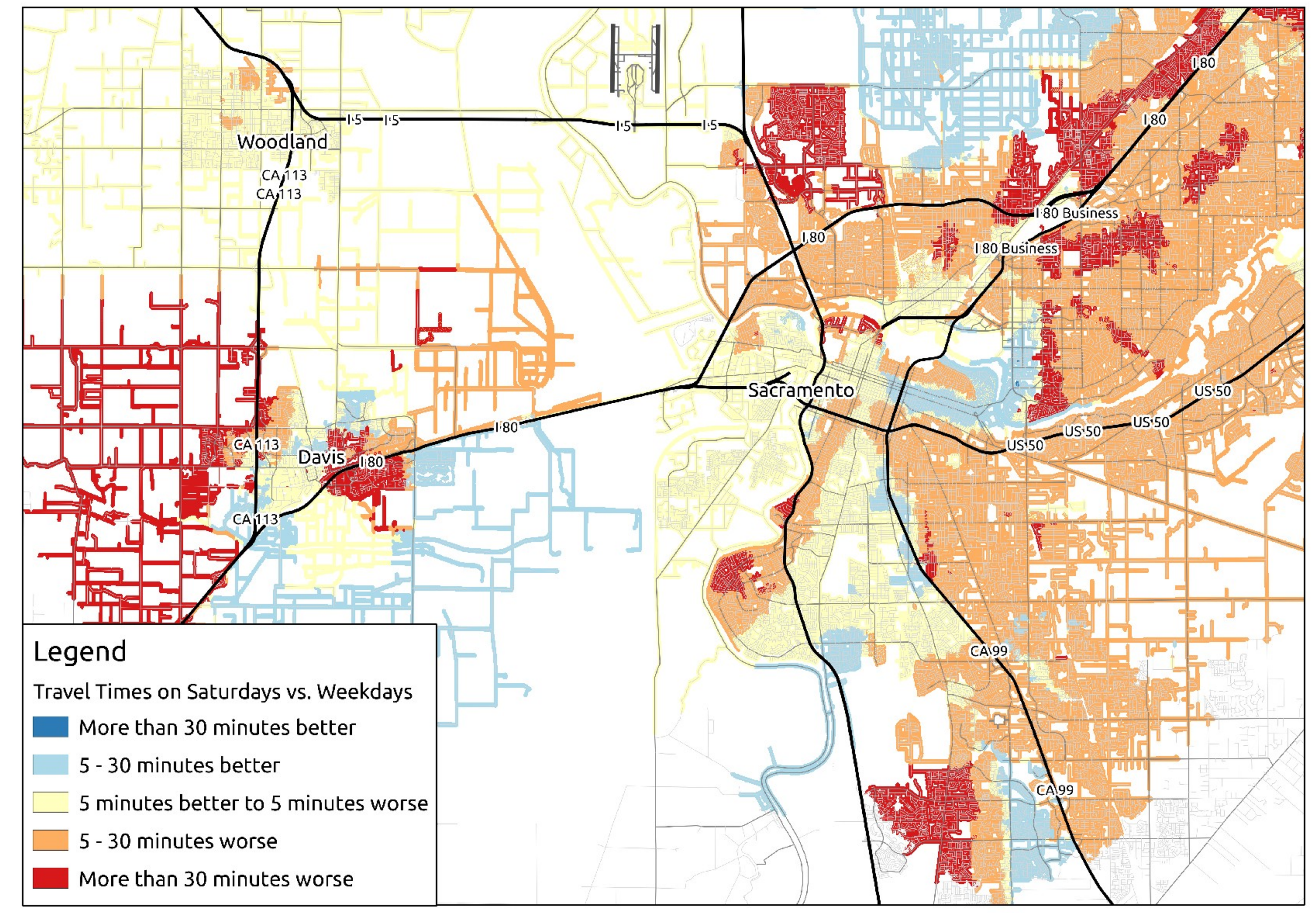

Fig. 2: Measuring the difference between two levels of service. The same technique could be applied to a change in service or in the street network.

Areas With 20 Minutes of Remaining Time,
UC Davis to California State Capitol, 8:00am to 10:30am
(Hägerstrand's Prism Visualization)

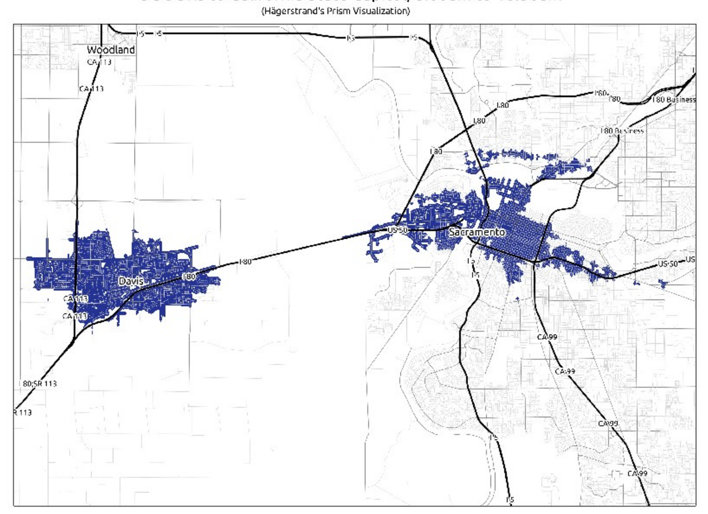

Fig. 3: Hägerstrand's Prism Visualization

Calculating Accessibility—Isochrone Method—5pm Weekdays

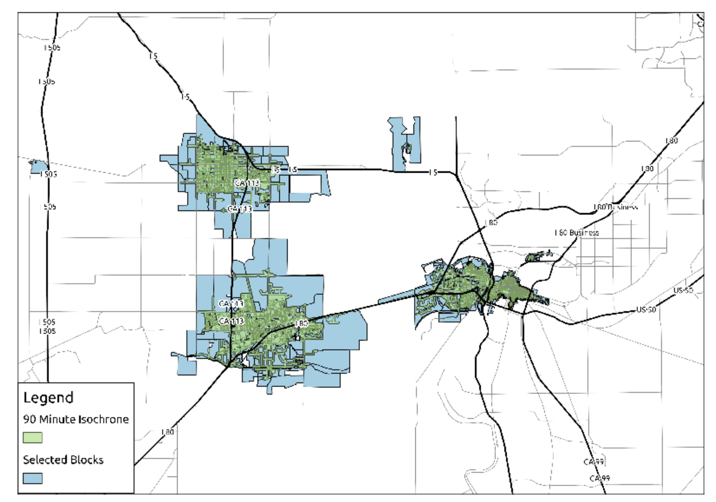

Fig. 4: Calculating accessibility using the isochrone method. Summing all blocks fully or partially within 90 minutes of the Quad indicates that 180,547 people live within 90 minutes (Census 2010 block-level data) at 5pm. Taking the best-possible trip time for several times of day would likely yield a larger value (Lei and Church 295-6).

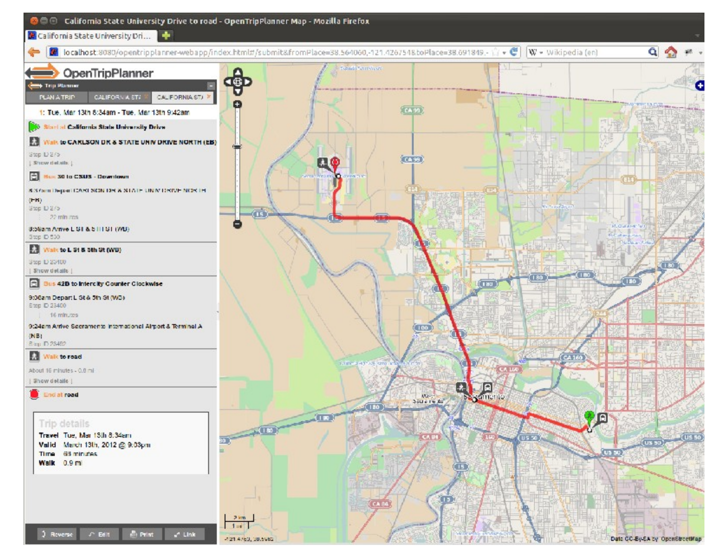

Fig. 5: Routing with OpenTripPlanner

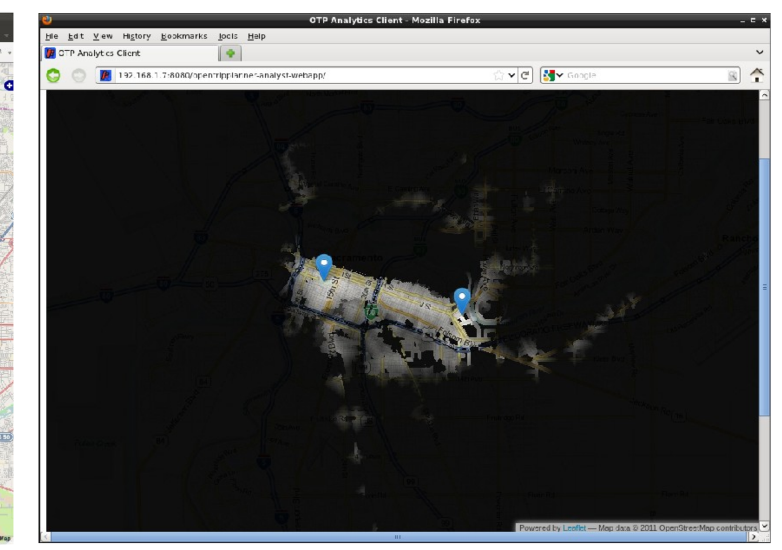

Fig. 6: Previewing an Analyst Hägerstrand Visualization

One more analysis that can be carried out with Analyst is a measurement of the change in travel times due to a change in the network (Fig. 2). By generating rasters of the same size and resolution, one can use raster algebra in a GIS to determine the change or difference between the travel times represented by the two rasters. This might represent changes in service level due to changes in schedules. Alternately, it might represent changes in the pedestrian and bicycle network, such as the opening of a new bridge. Soon, Analyst will be able to generate difference rasters directly.

OpenTripPlanner Analyst can be configured using transit agency data in GTFS format, the standard format that is also consumed by the Google Maps transit trip planner. A street network for off-vehicle routing is also needed, and can be provided in either Shapefile or OpenStreetMap format. Data may also be imported from the National Elevation Dataset to calculate path slopes for walking and cycling. Once data are acquired, a graph building step is performed. At this point, Analyst can be started.

Analyst is implemented as a client-server application. The server generates rasters with travel times, which are then rendered by the client. There is a webapp that can be used to preview Analyst results (Fig. 6). However, many analyses will warrant the use of a desktop GIS package for print output and for integration with other data (such as population data); GeoTIFFs for use in desktop GIS can be downloaded using the webapp. From there, maps and analyses can easily be created. Sampling and zonal statistics techniques may be used to calculate accessibility by assigning raster values to a dataset of opportunities.

There are several challenges to setting up Analyst and generating the first analyses. One problem is that there are often network connectivity issues in the data. Stop linking problems, where transit stops are not connected to the street network, or where they are connected to the wrong road, are also common and generally result from imperfect overlay of transit data and the street network. Finally, Analyst is still a young project, and as such does not yet provide a binary distribution; the user is required to build the software from source. However, since Analyst is implemented as a client-server application, it is possible to run the software on one server and permit access from many workstations.

Conclusion

OpenTripPlanner Analyst is a powerful tool for multimodal transportation network analysis, taking into account transit schedules as well as permitting walking. It runs as a client-server application, meaning one server can produce rasters and serve them to many workstations. It can be used to generate isochrone maps, measure accessibility, and analyze time-space prisms. Many analyses and combinations with other data are possible by using Analyst data in a desktop GIS.

Works Cited

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Lei, T. L. and R. L. Church. "Mapping Transit-Based Access: Integrating GIS, Routes and Schedules." *International Journal of Geographical Information Science* 24. 2 (2010): 283–304. Web. 12 Apr. 2012.

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Note: These maps are intended as proofs of concept, and should not be used for analysis. The graph they are built from has not been extensively debugged.

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