Eurographics Conference on Visualization (EuroVis) (2015)
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Visualizing Accessibility of Chicago Metropolitan Area

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Abstract

Accessibility analysis is an important element in urban transportation planning. Accessibility measures combine mobility as well as land use measures to provide a more complete picture of the transportation-land use nexus than either of these measures alone. They provide insights into the varying degrees to which different areas of a region are connected to opportunities by the transportation system. Accessibility analysis helps urban planners to understand the relationship between transportation and land use and provides reference for them to improve the equality of the residents. In this paper we present a web-based tool that visualizes multi-modal accessibility to multiple land uses in the Chicago metropolitan area as the first step of an effort to build an integrated platform that automatically builds visualizations of accessibility.

Categories and Subject Descriptors (according to ACM CCS): I.3.8 [Computer Graphics]: Applications—Visual Analytics

1. Introduction and Backgrounds

Accessibility is an important element in urban transportation planning. It is a measure of the ease of reaching valuable destinations. Unlike other measures such as *mobility*, which measures the ease of traveling along the traffic network [Han94], accessibility also take into account whether a resident can reach an opportunity or an activity. For example, a high accessibility level can be achieved even if the traffic is with a high level of congestion, as long as there are a lot of opportunities or activities nearby.

Accessibility is not only useful in evaluating existing traffic network and transportation system, but also helps in identifying gaps and informing future directions for land use and transportation system changes. Since the groundbreaking work of [Han59], accessibility has been used as an indicator of the performance of transportation system in serving residents of an urban area and received substantial attention.

Accessibility analysis is a comprehensive process consisting of three steps. The first step is to develop or choose one or more appropriate accessibility measures based on the purpose of the study. Over the past four decades, different accessibility measures have been developed for a variety of analytical and evaluative purposes [Bre78] [LZ04] [EGLC06] [Jon81].

The second step is to specify parameters and calculate the accessibility measures. The parameters include the *spatial unit* (census tract, building block, block group, etc), the *type of opportunity* (jobs, hospitals, schools, etc), the *travel mode* (car, transit, walking, etc) and *travel impedance* (e.g. distance, time, cost) [LZ04]. The third step is to present, analyze and interpret the results.

Traditionally, GIS-based software is used for accessibility calculation (half of the 2nd step) and analysis (the 3rd step). GIS is powerful, but usually costs a lot of money. In most cases, only a small fraction of GIS functionality is used in accessibility analysis. Also, its built-in functionality is not sufficient for accessibility analysis [GRVE95]. Therefore, if one wants to use GIS for accessibility analysis, customized plug-ins or extension modules need to be written. After the accessibility is calculated, GIS is used to support on-screen visualization and export of high quality static maps [MW00].

Our accessibility visualization system allows automated building of visualizations for accessibility by multiple modes, to multiple regional amenities, within multiple impedance thresholds, and at the scale of whole Chicago metropolitan area, thus allows people who work in transportation and who work in economic development or related fields to easily identify places with transportation access problems. Also, it uses open-source software and libraries and has web-based interface, making it accessible to a wide range of audiences.

2. Accessibility Building System

Our web-based accessibility visualization system consists of three stages, graph build stage, travel time calculation stage, accessibility calculation stage and visualization stage.

Firstly, The system feeds OpenStreetMap (OTP) [HW08] data of Chicago area (for street network) and GTFS [Goo15] data of three transit agnecies of Chicago (for transit network) into OpenTripPlanner (OTP), an open source platform for multi-modal and multi-agency trip planning written in Java [Ope15], to build an integrated traffic network.

Then Travel Time Matrices (TTM) are calculated by issuing customized batch analysis command to OTP. Opentripplanner-jython library by Matthew Conway [Con15] was used to write Python scripts to do batch processing via Java-written OTP. The input of this phase is the list of centroids of all block groups of Chicago area. Also specified are parameters such as travel modes and corresponding departure time. We calculated accessibility by driving, by public transit and by walking. For public transit, accessibility varies a lot at different time in a day, so we calculated accessibility for each hour.

Accessibility calculation stage is where accessibility values are calculated. Job count data and land use data used in this stage came from the United States Census BureauâĂŹ s Longitudinal Employer-Household Dynamics (LEHD) program. Job count data contains the number of jobs in different industrial categories in each block group, and land use data contains the number of land uses in block groups. Parameters specified for this phase is impedance thresholds. We calculated accessibility for 12 thresholds, from 5 minutes to 60 minutes, with 5-minute increase between each. Following formulas are used to calculate accessibility:

$$Acc_{i,opp} = \sum_{TTM_{i,j} \leq threshold} Opp_j / \sum_j Opp_j$$

where $Acc_{i,opp}$ is the accessibility to opportunity opp from block group i, $TTM_{i,j}$ is travel time from block group i to j, and Opp_j is the number of opportunities in block group j.

The complete set of parameters we calculated is in Table 1).

Table 1: *Accessibility measure parameters used*

Parameter	Value
spatial unit	census block group
type of opportunity	jobs in different categories park areas, park counts schools, public schools, private shools fire stations, hospitals grocery stores, libraries
travel modes	car, transit, walk
origins and destinations	from each block group to every block group
travel impedance	$5min, 10min, \ldots, 60min$

3. Visualization Design

The purpose of our visualization is to provide a way to allow users to investigate accessibility from different perspectives as they see fit.

To customize what data set to look into, the first parameter that users can set is which land use to show. Then users are able to select a transportation mode they are interested in. If transit is selected, then a new drop down menu will appear to allow the user to select travel departure time, because transit accessibility varies significantly by time of a day. Users can choose from any of the 24 hours in a day to investigate. Then the user should specify a travel time threshold that interests him or her. They can choosed from any of the 12 thresholds we calculated. If job is selected as the type of opportunity to show, the user needs to specify a category (or all jobs) to show. Figure 1 shows a snapshot showing accessibility to Professional and Scientific jobs within 45 minutes of driving.

We used Jenks optimization method to cluster block groups into 7 classes, and rendered them using a monochromatic green color scheme. Hovering the mouse over any block group will show detailed accessibility value as well as the total number of opportunities in currently selected data set.

Users are also able to bring up CTA subway lines onto the map for reference, as well as Metra railway lines.

4. Conclustion and Future Work

In this paper, we present our recent work on visualizing multi-modal accessibility of Chicago. It creates a platform for researchers and urban planners to better understand accessibility in the Chicago metropolitan area by providing an easy-to-use user interface with well-designed customization options to investigate data from multiple perspectives.

We are currently working on adding a second travel time view where users can see isochrone travel time map as reference when they investigate accessibility values. The ultimate goal of the project is to make the system a fully automated platform that allows users to provide input data and returns calculated accessibility and visualizations.

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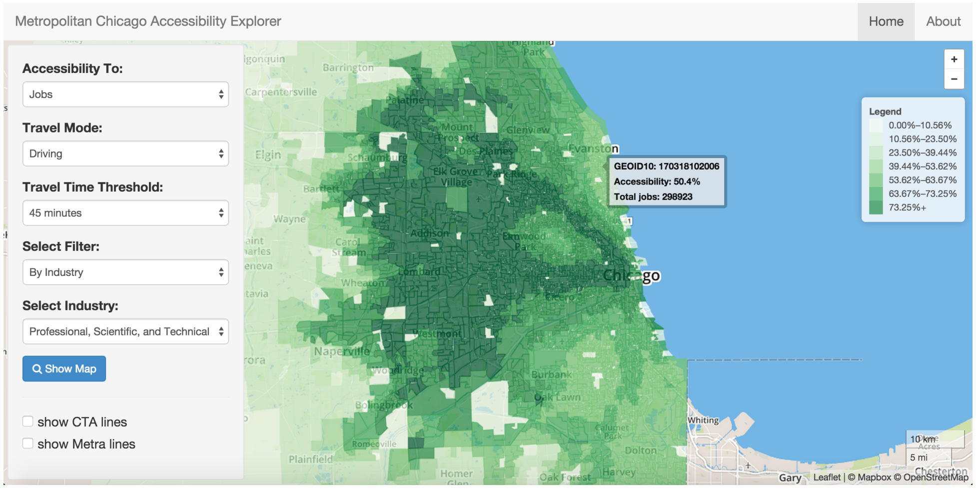

Figure 1: *Snapshot of our prototype web interface and visualization*

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