Visualizing Multi-Modal Metropolitan Job Accessibility

Shi Yin*° Moyin Li+ Nebiyou Tilahun+ Andrew Johnson°

° Department of Computer Science +Department of Urban Planning and Policy

University of Illinois at Chicago

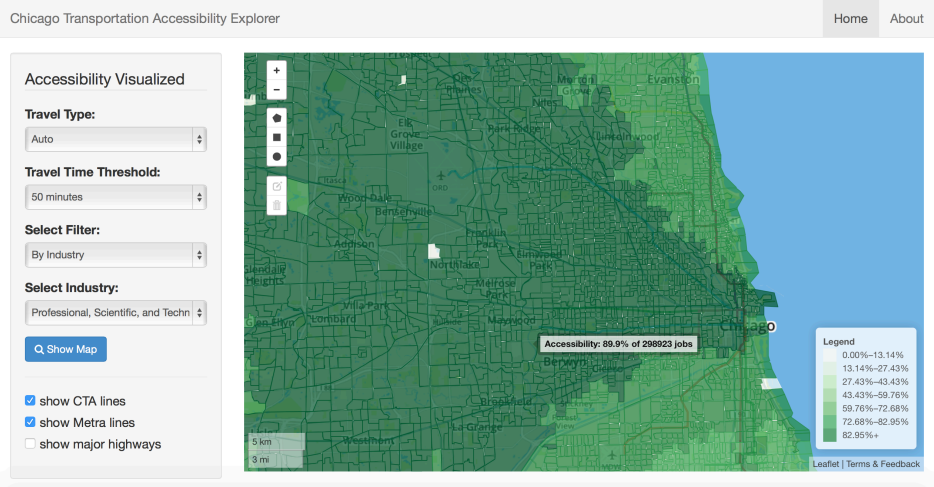

Figure 1: Snapshot of our prototype web interface and visualization

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. Accessibility measures also provide insights into the varying degrees to which different areas of a region are connected to opportunities by the transportation system. Calculating accurate accessibility data and visualizing it in an effective way is challenging. We designed and developed a web-based tool to visualize multi-modal job accessibility data in the Chicago metropolitan area as the first step of an effort to build an integrated platform for accessibility analysis and other urban planning tasks.

Keywords: job accessibility, geographic visualization, urban planning

Index Terms: Human-Centered Computing - Visualization - Visualization Application Domains - Geographic Visualization

1 INTRODUCTION

Accessibility is an important element in urban transportation planning. It 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. Substantial research effort has been put into this area, and large amounts of data have been collected. However, it is a very complicated task to analyze and discover patterns in this data. This is especially true for large cities as they have large populations and complex traffic networks.

Visualization has always been of significant importance in geographic related fields [1]. Good visualization makes analyzing and investigating collected geospatial data simpler and more efficiently thus enabling a deeper and more organized understanding and more effective application into practice.

Our prototype web-based visualization tool is developed with the goal of providing researchers and practitioners with an integrated environment to mine and analyze hidden patterns in the job accessibility data of Chicago.

2 DATA PROCESSING

2.1 Data collecting

Job count data for this work came from the United States Census Bureau's Longitudinal Employer-Household Dynamics (LEHD) program. For each block group, the data set contains the number of jobs in different industrial categories.

We used two tools to calculate a Travel Time Matrix (TTM), a customized data structure that behaves like a 2D array, but with customized functionality, in which travel time from each block group to all other block groups in the area is stored.

The first tool is the Open Source Routing Machine (OSRM) [2]. OSRM is a high-performance routing engine for shortest paths in road networks written in C++. We used it to calculate a TTM for automobile travel time.

The second tool we used is OpenTripPlanner (OTP) [3]. OTP is an open source platform for multi-modal and multi-agency trip planning written in Java. We used it to calculate TTM for transit.

* syin8@uic.edu

For both tools, we used open source map data from OpenStreetMap (OSM). For transit TTM calculation, we also used GTFS (General Transit Feed Specification) data made public by the Chicago Transit Authority (CTA), the bus and subway service provider of the city of Chicago, PACE, the suburban bus service provider of Chicago, and Metra, the commuter rail agency in the Chicago area, to obtain transit routes and schedule information.

2.2 Accessibility Calculation

In order to calculate job accessibility from job data and TTM, we wrote Python scripts to calculate how many jobs one can reach in a certain amount of time by summing up the number of jobs in all block groups that one can reach from one particular block group in that period of time:

$$Acc_{i,cat} = \sum_{TTM_{i,j}<threshold} Job_{j,cat} / \sum_{j} Job_{j,cat}$$

where $Acc_{i,cat}$ is the accessibility to jobs in category *cat* from block group *i*, $TTM_{i,j}$ is travel time from block group *i* to *j*, and $Job_{j,cat}$ is the number of jobs in category *cat* in block group *j*.

For traveling by automobile, we calculated accessibility under 12 different thresholds, from 5 minutes to 60 minutes, with a 5-minute increase between each level of threshold. For traveling by transit, we calculated accessibility under 12 thresholds for each hour in a day (i.e. 288 combinations).

The result for automobile was used directly in our visualization, while the result for transit was used to validate transit accessibility data calculated by Accessibility Observatory at the University of Minnesota [4], which is currently used by us in our visualization.

We then joined each set of data with a shapefile containing polygonal block groups in the Chicago metropolitan area, creating 300 shapefiles in total, followed by the last step, converting shapefiles to GeoJSON files using "ogr2ogr" command line tool.

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. We decided to use a relatively traditional way to present the data, while providing as many options to the user as possible.

The experimental website of this visualization tool can be found at http://urbanaccessibility.com/accessibility.

To customize what data set to look into, the first parameter that users can set is which **transportation mode** they would like to investigate, currently either automobile or transit. If transit is selected, then a new drop down menu will appear to allow the user to select for which **time of day** the transit accessibility should be shown, 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. We have 12 different thresholds available, from 5 minutes to 60 minutes, with a 5-minute difference between each threshold.

Also available to customize is a **job category** filter. Jobs are categorized using different classification methods, including age, earning, industry, race, ethnicity, education and gender. The fields corresponded to variables in the U.S. Census Bureau's LODES data format [5] and are listed in the table.

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 job 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. CTA and Metra lines are also GeoJSON files converted from shapefiles.

We used Leaflet and Mapbox API for map hosting and rendering GeoJSON files.

Category	Classes
Age	<=20; 30 - 54; >=55
Earning	<=$1250/month; $1251/month - $3333/month; >$3333/month
Industry	Agriculture, Forestry, Fishing and Hunting; Mining, Quarrying and Oil and Gas Extraction; Utilities; Construction; Manufacturing; Wholesale Trade; Retail Trade; Transportation and Warehousing; Information; Finance and Insurance; Real Estate and Rental and Leasing; Professional, Scientific, and Technical Service; Management of Companies and Enterprises; Administrative and Support and Waste Management and Remediation Services; Educational Services; Health Care and Social Assistance; Arts, Entertainment, and Recreation; Accommodation and Food Services; Other Services [except Public Administration]; Public Administration
Race	White, Alone; Black or African American; American Indian or Alaska Native Alone; Asian Alone; Native Hawaiian or Other Pacific Islander Alone; Two or More Race Groups
Ethnicity	Not Hispanic or Latino; Hispanic or Latino
Education	Less than high school; High school or equivalent, no college; Some college or Associate degree; Bachelor's degree or advanced degree
Gender	Male; Female

4 Conclusion and Future Work

In this paper, we present our recent work on visualizing multi-modal urban job accessibility data. It creates a platform for researchers from around the world to better understand job 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 visualizing walking accessibility data, as well as integrating accessibility for other types of land uses such as parks, grocery stores, hospitals, etc. An automated tool that calculates accessibility for any given urban facility counts is also under discussion.

References

[1] Kheir Al-Kodmany, Using visualization techniques for enhancing public participation in planning and design: process, implementation, and evaluation, *Landscape and Urban Planning 45*(1), pp. 37-45, 15 September 1999.

[2] Open Source Routing Machine, http://project-osrm.org

[3] OpenTripPlanner, http://www.opentripplanner.org

[4] Andrew Owen and David Levinson, *Access Across America: Transit 2014 Methodology*. No. CTS 14-12. 2014.

[5] LEHD Origin-Destination Employment Statistics (LODES) Dataset, http://lehd.ces.census.gov/data/lodes/LODES7/LODESTechDoc7.0.pdf