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Visualizing the Effects of Public Transportation Growth on Urban Demographics

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Abstract

We present Tidebanan (Time Way), an interactive visualization of the history of the metro system of Stockholm from 1949 to 2014 that includes a projection to 2025. The analytics tool visually correlates the growth of the metro system with the changing demographic density of Stockholm. Interestingly, we discover patterns of density decrease in central Stockholm as new metro lines open, in particular the southern red and northern blue lines in the 1970s. In fact, central Stockholm has never been as dense as it was in 1949, a surprising fact that is visually salient in our application. This paper presents the design process, architecture, data models and sources, interactive visual structures, and visual analytic trails discovered through Tidebanan.

Categories and Subject Descriptors (according to ACM CCS): H.5.2 [INFORMATION INTERFACES AND PRESENTATION]: User Interfaces—Graphical user interfaces (GUI)

1. Introduction

Since its inauguration, the first subway line has molded the availability of different living areas around Stockholm. Tidebanan is a web-based visualization tool that shows the expansion of Stockholm's subway system from the year 1950 to 2025 in relation to the population growth of Stockholm's parishes (see Figure 1). At the moment, there are three filters. One filter allows the user to toggle the geographical map of Stockholm. The next one "Befolkning" shows the change in population in Stockholm's parishes as well as its bordering municipalities compared to 1950. The legend shows the values of the interval. The final filter shows population density of the these parishes and municipalities. By sliding the button on the timeline, one can move through time and see how the subway system as well as Stockholm's population has changed. One can also press on the "Play" button and the visualization automatically transitions through each year.

The motivation to create transport system visualizations is not new. Hughes provides a substantial review of the work in visualizing transport systems in geographic information systems and virtual environments that users can navigate in first person perspective and in real time [CVKA11, H04, H08, RMC04]. Tidebanan is similar to many of the systems presented there, with significant technical advancements. Primarily, it is a complete web-based application that runs on the browser, allowing for seamless cross platform operation. Furthermore, the interactive visual structure of Tidebanan are a general framework onto which the data layers can be readily plugged in.

2. System Architecture

Tidebanan is a web-based application created in HTML and CSS frameworks. We used D3.js for subway animations, legends, and the choropleth map [BOH11]. We used JQuery for computational operations. Finally, we constructed the framework coupling the modules through javascript. We imported population data from Sweco, both present and future projections. We did not employ data query APIs for the current version of the project. Everything is done by hand, with the help of some libraries such as D3.js and jquery. The data for geographical area of the municipalities is from Wikipedia. For the computation of density, we only account for land area, not water, giving a more accurate people per livable space measurement. We map subway real-world coordinates into the visualization's coordinates. The visual structures of Tidebanan include a geographical map, a political map, a network structure accurately located on top of the geographical map, meta-layers of information represented through the colors of a choropleth map, and meta-layer information currently displaying details on demand for the individual metro stations, including history and past and present images. The view transformations include: spatial and semantic zooming,

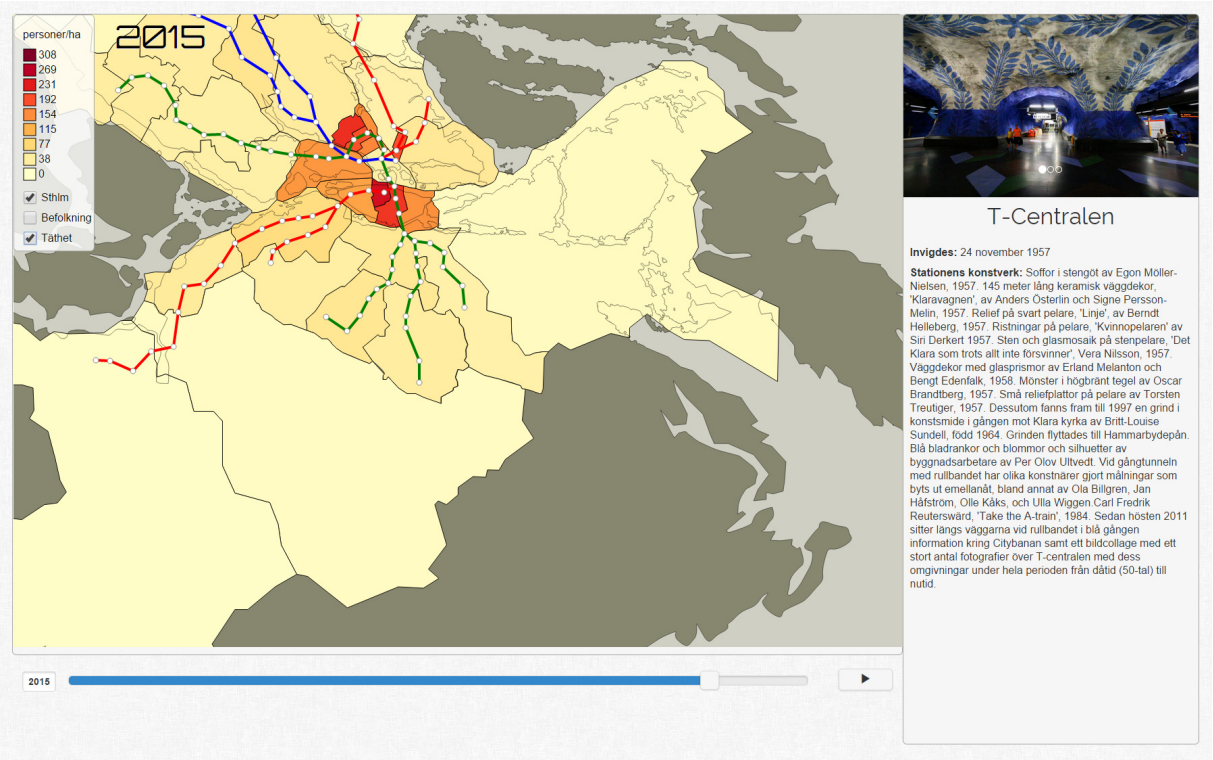

Figure 1: *Tidebanan: an interactive visualization of the history of the metro system of Stockholm from 1949 to 2014 that includes a projection to 2025. The upper left corner of the main window shows the legend, next to it the year 2015. The blue timeline at the bottom also shows the year 2015. The choropleth mal shows the population density of the parishes in Stockholm for the year 2015. The geographical location and identifying color of the metro lines are overlaid on the map. A gray geographical map of the city is underlaid beneath the map, highlighting the bodies of water around Stockholm. To the right of the map there is an information box where metadata about filtered objects in the map can be presented to the user. In this case, it is presenting information about the central station of Stockholm, T-Centralen. The user can zoom spatially and semantically over the map, translate, toggle information layers on and off, selected the temporal window of view, and index to details on demand regarding the individual metro stations. For a video figure of the Tidebanan, please follow the link* https://youtu.be/XMetDQAYuX4.

panning, time travel, filtering, details on demand (clicking, hovering), real-world mapping, and selective fading.

3. Visual Analytics

Figure 2 visualizes a visual analytic trail of the evolution of Stockholm's demographics as a function of the growing metro system. Surprisingly, the population density in the center of the city is highest in 1949. When analyzed together with the growing transportation networks of the metro system, it is apparent that mobility allowed people to live further away from downtown. Interestingly, the migration pattern continues to increase dramatically farther away from the center, including the projection to 2025 on the far right.

While these insights are significant, they are limited by the layers of information the model contains. Tidebanan presents an infrastructure that is flexible for the importing of other data types and the creation of multiple layers. Currently, the application includes historical images and information about each metro station. The metalayer information of the visualization can grow to include real-time information of traffic patterns that incorporate the bus, train, and tram systems, allowing the command and control of the transportation of a major metropolitan area in managing crises as they occur, for example.

4. Evaluation

We collected hands-on feedback from the director of the Transportation Museum in Stockholm who praised the tool for its existing affordances in opening windows of historical exploration. For him, the future of the application should include more data layers, more opportunities for commu-

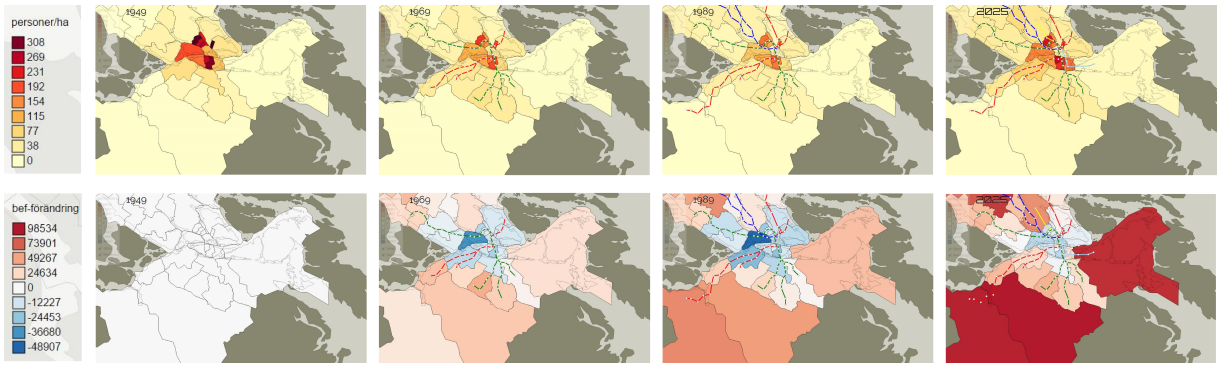

Figure 2: *Analytic trail of the relationship between new metro lines and migration patterns. The first row visualizes population density with darker colors representing higher densities. The second row visualizes population migration in number of individuals. Blue represent emigration and red represents immigration in the city regions with darker shades representing higher migration numbers . The columns visualize the years 1949, 1969, 1989, and the projection to 2025. In each column we see the effects of new metro lines opening to the public. The fourth column shows the projected effects of two lines that will open before 2025. Interestingly, the highest density the center of Stockholm registered is in 1949.*

nication and instruction through the tool to groups of high school students, for example, and greater hypothetical testing abilities to execute simulation scenarios. The goal for the museum is to convey the complexities of the modern urban transportation system as a fun and didactic experience for the different group ages of visitors.

5. Conclusion and Future Work

We have presented Tidebanan, a visualization of the history of the metro system of Stockholm visually correlated to the population density of the city. Tidebanan has the potential to show more layers of analysis. With the use of data query APIs, we can readily import other data types. We can build filters of income, education centers, job opportunities, prices per square meter of housing, as well as additional transportation lines such as buses and commuter trains. These filters would provide an even richer source of insight. It would be instrumental for city planners, researchers and people searching for where to make a good investment in housing. It also has the potential to be an educational tool for students and history enthusiasts.

6. Acknowledgements

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