Playground in Hannover, Germany

The Impact of Demographic Change on the Accessibility to Public Services for the Elderly and Children of Hannover, Germany

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Late in 2009, the German government conducted an exercise to determine population trends for the next 50 years. This study indicated that the German population, which is approximately 82 million, is expected to decrease by 12 to 17 million people as well as experience a significant shift in its demographic profile (Statitistisches Bundesamt, 2009). The most significant finding from this exercise is the projection for a shift in the share of senior citizens and children with respect to the economically active population; children and seniors are expected to account for half of the entire population of Germany, whereas they currently only represent 40%. Additionally, the ratio of senior citizens to children is expected to increase to 2:1 by the year 2040, indicating a trend towards an ageing population. With this expected declining population and changes in the age pyramid, a renewed focus on planning for future investments has been initiated with an eye on effective and efficient resource allocation of social services.

Improving the method for forecasting likely choices of location, migration patterns, and land development scenarios by using state-of-the-art urban simulation systems, such as UrbanSim, can foster improved planning for public services. This article presents the results of an urban simulation system developed to forecast the impact demographic change will have on the accessibility to public services for the elderly and children residing in Hannover, Germany.[1]

Demographic change and urban development

Hannover, a city of about 0.5 million people located in Niedersachsen, a region comprised of nearly 1.5 million, is attracting new inhabitants every day through increased urbanization. This trend of increased immigration from the rural environs is having a counterbalancing effect upon its existing declining and ageing population. In the long-term though, the phenomenon of rural to urban migration can only counterbalance the expected demographic change for ten to 15 years at most (Bertelsmann Stiftung, 2006). The impact from demographic change is expected to affect nearly every aspect of daily life, including labor and housing markets, social security, infrastructure, urban and regional planning, and education. A decrease in population will reduce the demand for goods and services, as well as disrupt general economic stability in the private sector. In the public sector a declining population can subsequently lead to reduced tax revenue for infrastructure maintenance, as well as capital improvements. As a result, the per capita burden will increase whenever services that continue to serve the public interest cannot be dissolved (CEMR & DIFU, 2006).

Demographic changes can have pervasive, substantial and widespread consequences for urban development. In regions where the population is in decline, the "growth allocation" planning paradigm[2] serves as the foundation for developing spatial reconfiguration strategies for maximum resource allocation and efficiency (CEMR and DIFU, 2006). In order to achieve this goal, Integrated Urban Models (IUMs) are becoming important tools for planners, as they have the capability to estimate the future locations of agents such as people and households as well as of employers (job locations), industries and real estate developments in a highly detailed, disaggregated manner. IUMs have been in use by urban planners for 50 years, but only in recent years have they begun to be considered as part of the planning process, moving away from a more singular focus on model development itself (Timmermans, 2003). These models involve accessibility, demographics, economics, regulations, global macroeconomic variables and others, in order to forecast the most probable agent location choices. UrbanSim is an IUM developed at the Center for Urban Simulation and Policy Analysis (CUSPA) in the University of Washington with the objective of providing a scalable, modular, robust, open source modeling platform (CUSPA, 2009). One advantage of UrbanSim is its ability to enable academics and programmers to collaborate and modify the core application, while at the same time users can process data, develop model scenarios, and generate forecast outputs which can be used in support of their land use planning processes.

Model development

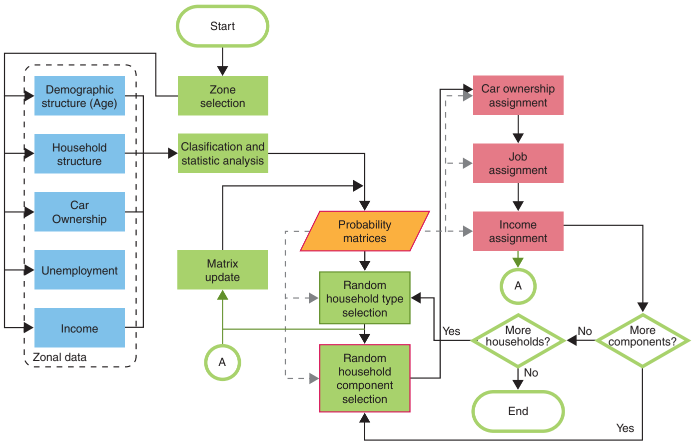
Configuring an urban simulation can be very challenging for most cities, as data is generally not standardized. There are no universal models or 'one size fits all' approaches, but instead each individual case must develop its own uniquely tailored approach. The Hannover Region transport planning department provided data for the transport model at the scale of the traffic analysis zone, which included a georeferenced job database and estimation of land value per area. Data processing was also an important first step in developing the base data for the urban simulation, which included writing a household synthesizer consistent with the available data structure at a higher level of aggregation. This synthetic households table was generated from the transport data which contained the age distribution and the statistic information about the specific household structure of each county. With this information a synthetic household generator was programmed in Visual Basic to randomly select one type of household within a given zone and then assign representative household data for each individual member. Once these synthetic households were generated, each one was assigned to one building, taking into account relationships such as income vs. rent/m^2 or household size vs. habitable area. Statistics calculated for the resulting households and the original data show almost identical results, with only minor differences which are attributed to inherent characteristics from the two sources (see Figure1).

Increased services for the elderly may become necessary due to an ageing population in Hannover, Germany

1 This is part of original work prepared for the Technische Universität München with the collaboration of the planning department of the Hannover Region.

2 When the general belief is that available resources are endless or that the limit of the given consumption rate would be difficult to reach, policies are created assuming that the preceding growth will prevail in the future. Analysis of the complex behavior of systems where planning has some relevance, has challenged those assumptions.

Figure 1 I Flowchart of the household synthesizer written to generate individual households from statistical data



A series of household forecasting models were developed which used the synthetic households table as their primary data input. The Household Transition Model (HTM) was programmed and specified to forecast the number and size of new households moving to the region, while the Household Relocation Model (HRM) used applicable variables to determine the probability that an existing household would chose to relocate within a given simulation year. Finally, the Household Location Choice Model (HLCM) aggregated new households moving to the region as well as existing households which had decided to relocate and employed several variables in order to predict the actual location where each household would move. Four sceneries were designed to predict potential regional development within the context of demographic change during the period between 2010 and 2040. The first two sceneries (1-W1 and 1-W2) represented the most likely limits to development in Niedersachsen and provide an illustration of what could potentially happen if the city fails to stem the impact from demographic change. The third scenario (BS-1-W2) was designed in accordance with the Bertelsmann Foundation estimations to 2025 (which exhibit a relatively stable population) and then slowly adapts to the general trend of Niedersachsen after 2025 until 2040. The fourth scenario (named FLAT after its horizontal shape when it is plotted) used a constant population to simulate stable conditions and was used as a reference case in order to evaluate the real impact of the long term mobility rate within the dynamics of the city.

Results

The results of the performed simulations provide a snapshot with clear tendencies of potential household preferences over the next 30 years. The first identified forecasted trend is the remarkable population decline in the more sparsely populated areas, with decreases of at least 22%. Another trend is the population increase in most urban cores, which is particularly noticeable in the second tier, smaller cities found throughout the region. Simulation runs for the city of Hannover were relatively consistent with the central boroughs revealing small positive variations, while some places in the outskirts exhibited moderate declines in population. On average, the urban simulation for Hannover predicts that the city will most likely maintain its population during the next 30 years, while other smaller urban centers in the region may witness a population increase through the in-migration of rural inhabitants. Nevertheless, this rural-to-urban migration will only dramatize the effect of demographic change outside of the urban cores. The Hannover urban simulation also reveals further concentration of households in the existing urban centers which is consistent with historical trends and concurs with previous estimations. Overall, migration to the cities will likely compensate for a deficit of newborns and increased deaths in the urban areas, but will accentuate the effect of the demographic changes within the rural fringe (see Figure 2).

Simulation results generated new household tables which revealed relocation patterns. The resulting distribution of new households was then processed using the projected demographic structure, in order to determine the future location of senior citizens and children. The scenario BS-1-W2 forecasted the smallest differences from other estimations and was selected to be used as part of the accessibility analysis. While scenario

Figure 2 I Long-term household mobilizations in the Hannover Region (color intensity represents the relative increase or decline of population, represented by green and orange colors respectively)

BS-1-W2 was considered to be the most realistic, in fact all of the simulation scenarios identified probable patterns of long-term household mobility as well as other trends. The model consistently predicts household concentrations centering on and around the consolidated urban centers. However, in comparison with previous projections made by the planning department of Hannover, the urban simulation predicts a more substantial and pervasive mobilization than had previously been considered. Simulation results indicate a significant number of households are likely to relocate closer to existing schools and hospitals, and that access to services will likely increase for the majority of inhabitants throughout the region. For this reason, a decrease in potential demand for medical and educational services is not expected in the urban centers; however, it may become necessary to increase capacity at some facilities. Accessibility to education and health services for people in rural locations will be more difficult since current facilities in those areas are likely to become even more underutilized. Additional public services implicit to educational and health care add an additional burden in the more rural environs as well, as public transportation systems in these areas often have low ridership and generate less revenue (see Figure 3a & b).

Future work

This work provides an advanced starting point towards building a comprehensive and complete model of the region. The next

Abandoned settlement in Hannover, Germany

step in the improvement of the urban simulation will be to implement a real estate model which evaluates new prices and balances them with the possibility of excessive migration. Since job market dynamics in the region have not changed significantly in recent years, nor are they expected to in the near future (Fuchs & Zika, 2010), it would be useful as a next step to implement the Employment Relocation Choice Model (ERCM) in support of the real estate model and an updated HRCM. Finally, coupled with detailed multimodal networks that enable isochrone-based catchment area estimations[3], a more detailed urban model fosters more precise accessibility

Figure 3a | Spatial distribution of children and elderly in the Hannover Region

Figure 3b | Coverage of schools and hospitals in the Hannover Region

calculations and the implementation of refined indicators, such as the Land Use and Public Transport Accessibility Indicator (LUPTAI). This indicator seeks to measure how easy it is to access common destinations (e.g. health and education) by walking and/or public transport. This is in contrast to the traditional method of measuring accessibility only by road or Euclidean distance (Pitot et. al., 2006).

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3 Since access to any location is enabled by transportation networks, "closeness" is better assessed by measuring the travel time across the network (including delays, waiting and transfer times), than measuring the distance between origin and destination. In this way catchment areas are better estimated by defining acceptable travel times to a given facility, than defining traditional buffer zones.