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Data Flow

a GIS based interactive planning tool for educational facilities

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This paper describes the development of a Grasshopper-based planning support tool for urban planning. The tool aims at the analysis of demand in educational facilities and the optimization of their location and capacities. It was developed for the use case of Berlin using only publicly available resources and data sets. Through preprocessed GIS- and statistical data plus an easy-access interface, the tool encourages people from different backgrounds and even those with no professional knowledge in planning, to engage in urban decision making. Although being initially aimed at contributing to a moderated participation process, the tool's simple GUI (graphical user interface) and open source backend, make it usable in any setup - without a briefed advisor or the need for later professional evaluation by another party.

Keywords: *urban planning, data visualization, gamification, education, GIS*

INTRODUCTION

Gamification and Planning Games

In Psychology it is argued, that play takes an important part in a person's thinking, exploring and creating. (Rice 2009; Bateson 2015) That involves both iteration and interaction. For the former it means exploration and experimentation; exaggerating ideas and setting boundary conditions, help to deepen one's understanding of a certain problem. For the latter in means passing arguments and ideas back and forth to extend the scope on a situation using the expertise and experience of the people involved. Thus explorative gaming (gamification) forms a core concept behind planning or participation games, the purpose of which is to make decision making more effective and reliable.

Geographic Information Systems (GIS) and their role in contemporary urban planning

Although the principles of GIS have their origins already in the early 20th century with the manual overlay of mapped-out data and GIS evolved into a scientific tool in the 1960s, it has undergone a significant shift or rather extension of scope with the emergence of digital communication (Malczewski 2004)(see figure 2). Web-based platforms, open databases and real-time visualization lift GIS from a professional tool, limited to experts, to an instrument of communication: Conveying accessible knowledge about spatial conditions, empowering the public to engage in the planning process (both as stakeholders and as researchers) and providing them with a platform to exchange on the issue (Malczewski 2004, Pettit et.

Figure 1
Negotiaton process on the interactive table

al. 2004). Malczewski (2004) refers to this as web-based multimedia-GIS.The authors would argue that here GIS functions less as a means to pursue objectivity than as an interface between subjective perspectives and interests. The accessibility and visualization of data can help form the stakeholders understanding (ibid., p.32) and dynamic responsiveness enables them to make their perspective visually accessible to others.

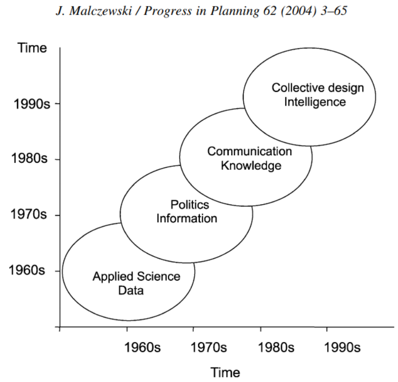
The objectivity trap

The authors view this understanding as crucial aspect of the technological approach, since urban planning is a far too complex and multidimensional field to claim scientific, numerical objectivity. (Malczewski 2004, p.37 et sqq.). Malczewski cites Openshaw (1999): "Decision making is seldom (if ever) a Science." The evaluation and interpretation of any analysis trying to grasp an as dynamic and complex system as a society or city relies on normative assumptions and is heavily dependent on prevalent paradigms. The goal of a comprehensive planning can only be "'that the decisions should be fair, reflect community choice, be based on evidence and facts that are correct, and be subject to post hoc scrutiny with penalties attached to those who deliberately abuse people's rights" (Openshaw, cited in Malczewski 2004, p. 58).

Participation in Urban Planning

Urban planning is a complex issue, with many dimensions, factors, players and needs. To negotiate in between those within the planning process, has become a vital part of contemporary urban planning to ensure acceptance within the public, to reduce friction between stakeholders and make the outcome more reliable (Brody et. al. 2003). Thus the obligation for participatory processes was also included in the "Agreement for new housing in Berlin" (Bündnis für Wohnungsneubau in Berlin 2014)[1], concluded between the City of Berlin and both the private and the public housing companies' associations.

Figure 2
Evolution of planning paradigms (Malczewski 2004)



Thus developing methods and standards to organize such processes can definitely be named as a key challenge the planning discipline is currently presented with. As of today there is no commonly accepted definition of what participation in the urban realm actually involves: Who participates? To what extend? At which point of the planning process? In what format? A wide variety of methods and concepts, rooted in different backgrounds (ranging from corporate consultancy to sociological science to political activism) is currently applied and tested under also various circumstances. For community participation Van Empel (2008) in general identifies four indicators for its effectiveness:

1. Identification of the interested parties and their motivations for participation.
2. Identification of the conflicts of interests of the various participants in the process.
3. Evaluation of the participants' satisfaction levels in relation to their objectives.
4. Evaluation of the conditions set for the community involvement process.

Still, since those concepts have not really been institutionalized in a broad scale yet, there are little to no sound studies to evaluate success and problems in different methods when it comes to the long-term effects of the planning concerned. Since this paper's scope is a specific tool and not the broad topic of participation and planning theory the authors will not go into detail here.

Urban Gallery and the Conscious City Lab

The CHORA Chair for Sustainable Planning and Urban Design at Technische Universität Berlin, where the authors are located, and its head, Prof. Raoul Bunschoten, position themselves within the spectrum of methods sketched above with their "Urban Gallery" methodology, developed from 1995 on. "It is a tool and an instrument for management and curation of dynamic master plans. Urban Gallery is a new approach to urban planning that can address [...][its] complexity and dynamic character" [2]. Although the concept was extended and adapted over time to address a broader audience and be used in a public participation process, it was originally directed directly at the decision making level. "The Urban Gallery is a public arena that enables the stakeholders related to prototype projects to act jointly or collaborate over longer periods of time in order to develop, monitor and evaluate prototypes as pilot projects within an overall plan." [3] The methodology aims to formalize the steps of the planning process, giving planners a defined set of rules to follow when approaching a problem in a curated process (Bunschoten 2001). Thus rendering it a "planning support tool". Tomaz Pipan describes the workflow in detail in the Chora white paper on the methodology, published in 2012 [3].

Hereby one of its cornerstones is the so-called "Data Base"-Layer, providing the participants with data sets of the preconditions their cooperative planning process is based on, whereas the data is either provided by the stakeholders themselves or acquired during the preparation process. Originally, the Urban Gallery method was applied in an analogue scenario game (see figure 3), requiring the collection and assessment of the relevant data and their preparation for the game, i.e. converting it into an easily readable format and locating/visualizing it on a map. That process understandably consumes a lot of time and resources. Though, in the course of the digitalization, the emerging concept of GIS (geographical information system) provided evermore standardized formats to exchange spatial information saturated with all sorts of datasets.

In 2013 the concept of Urban Gallery was integrated in the Conscious City Lab (CCL) at TU Berlin, a EU-funded research project, which introduced it 2014 as part of the spatial installation "BrainBox" to a larger audience, shifting it's scope from professionals to an educational application. Based on the methodology the CCL-Team developed a digital application for a interactive table which could track objects and movement with a camera underneath (Due to this paper's extend the technology will no be described in detail here). The app allowed to visualize various georeferenced data sets on a map and enabled the users to draw on the screen and to switch features and elements on and off by playing cards with TUIO-trackers on their backs. The data therefore was prepared in beforehand and stored on a geoserver in a standardized GIS-format (CityGML).

Figure 3
Scenario Game - analog urban planning game - Chora Tu Berlin

Standardization and Open Data

The tool described in this paper has its roots in this very concept. Its goal is to provide an interactive environment to visualize statistical data on a map and allow the user to iterate scenarios upon this information. The standardization of GIS data exchange formats enables researchers to easily apply similar solutions to different contexts and problems. Such standards make it possible to overlay and correlate information collected from different sources without much manual conversion. Also digital interfaces allow for a posteriori inclusion of new data. The authors argue that this kind of accessibility is important to conduct comprehensive and responsible urban planning in a continuously changing society and environment.

In general public accessibility of empirical data is increasingly regarded as a key factor for democratic decision making and urban innovation. The hoped-for effect is that, where stakeholders throughout different sectors can openly access and use empirical data, "new knowledge can be generated through new ideas and combinations of analyses". They also make government actions more transparent and add to the democratic control mechanisms. It the last decade that approach has led to a growing number of governments and authorities making their databases publicly available and implementing data standards. Germany institutionalized this line of policy through several federal laws (e.g. "E-Government-Gesetz", "Informationsfreiheitsgesetz Bund", etc.). The city of Berlin pioneered amongst others by establishing its "Berlin Open Data" hub in 2011 and its "FIS-Broker" (geo data platform), specifically for maps and GIS data, in 2013, which are continuously updated and extended. Those provide researchers with a rich source for their work and facilitate a large number of research papers and urban planning proposals.

USE CASE BERLIN

Along with the growth of urban areas, their demands are also constantly developing. In the course of ongoing urbanization some cities cannot satisfy the demand for educational facilities any longer, such as the area of Berlin. As dynamic and thriving as the German capital is rendered in the media, there are undeniable challenges the city has to face due to its growth. School places have been increasingly hard to find for first graders for years now. Some children have to commute far through the city to reach their school and the expected population growth in the next years will intensify that problem. Until 2026 there are 30,000 additional primary school students predicted (see figure 4). In some districts the demand will increase up to 40% (Blickpunkt Schule Berlin 2018)[4] But not only the increasing demands have to be dealt with. Additionally many of the existing school buildings are in such a bad shape that it has become a widely discussed topic in Berlin in recent years [5][6]. While the number of students in private education has increased by 100% over the last 15 years, the tuition costs, long travel distances and the often specializied curricula make the only 60 private primary schools not an option for many families in Berlin.

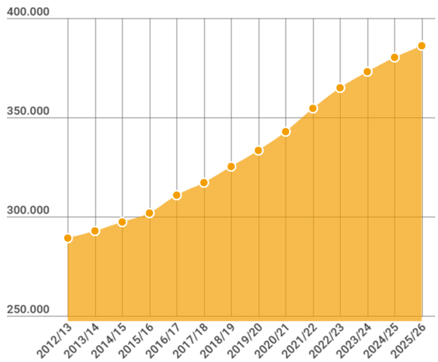


Figure 4
Predicted growth in student numbers until 2025 (SenFin/SenBJF Berlin)

The senate of Berlin has been trying to face this issue during the current legislative period. Large scale projects have confirmed funding in the government budget 2018/19, including the construction of around 30 new primary schools. (Senatsverwaltung Berlin 2017)[7]. Until 2026 a consortium consisting of the federal state of Berlin, the local districts and state-owned housing and real estate companies commited to spend 5.5 billion Euro on new schools, refurbishments and maintenance. To be able to keep up with this urgent topic, stakeholders have to be able to act fast and efficient. Therefore planning support tools are needed, which help analyzing the problems and can be used to compare multiple scenarios. That is what *Data Flow* is targeting at. It offers a surface to visualizes data and planning decisions in an understandable way, which makes it easy to negotiate between stakeholders of multiple backgrounds.

THE TOOL

Target Audience

The tool targets especially on three different groups of users. First it addresses the actual stakeholders of education in the urban context such as the municipality, other providers of educational facilities, teachers, students and the public. It this context DataFlow can increase a common understanding of the related parameters and the development of a common language, on which to negotiate particular interests. Secondly it is also directed at professional planners, such as architects and urban planners. Here the tool provides a fast and broad overview of relevant empirical information, thus allows for rational decision making and functions as an interface between them and the stakeholders mentioned above. In the third instance it can work as a learning tool itself, giving students and laypeople a playful access to the contemporary dynamics and problems in urban development.

Functionality

The tool is displaying and correlating data on geometrical, numerical and text-level, directly inside its environment, to allow for real-time responsiveness and thus fast understanding of otherwise abstract information. It overlays a multidimensional set of data (e.g. demographics, population density, distances, etc.) to facilitate conclusions about their interdependence and the negotiation of their individual weight.

The tool's real time feedback enables the users to immediately comprehend advantages and weaknesses of their interactions with data. It visualizes the impact of the users' actions graphically to further comparability between different decisions. Without much foreknowledge the users are allowed to quickly iterate the scenarios in playful manner and simultaneously negotiate and discuss the results amongst each other.

Technical Workflow

The tool is programmed as a grasshopper patch in Rhinoceros 3D. To use it the additional free plugins "meerkat" - to read GIS files, "Human UI" - to create statistical graphs, and "GHowl" - to communicate through the TUIO protocol are required. Additionally an interactive TUIO tracking device (i.e. an interactive table) is needed for the current state of development.

The following will describe the workflow of the tool in seven steps:

1. The meerkat plugin reads out the fed-in GIS data which is visualized in the Rhino environment on the interactive table. (locations of schools, the amount of space for first grade pupils per school, how many requests each school has per year, the number of children in the age of 6 to 12 per housingblock, and the number of inhabitants for each housingblock)
2. Those datasets are overlayed and partially correlated, to interpolate deeper information e.g. a total demand and supply number for school places of first graders in the studied area, which are not immediately apparent from the data sheets.
3. Based on the thought that primary schools are mostly picked by distance to home, and not like high schools, by specification or reputation, the maximum walking distance due to demand and capacity, can now be calculated.This happens in an iterative process, visualized in the figure 6.
4. The capacity, the utilization rate and the maximum walking distance per school are displayed in a statistic graph (see figure 5).
5. Until this point the tool was reading and correlating data on a static level. Now the users have the option to place TUIO trackers on the interactive table. Their location and rotation on the table represent the planned actual location and the capacity of a new educational facility (see figure 8).
6. This information is fed back into the calculation of the steps 3 and 4.
7. The changed behaviour of pupil distribution and maximum walking distances is visualized immediately

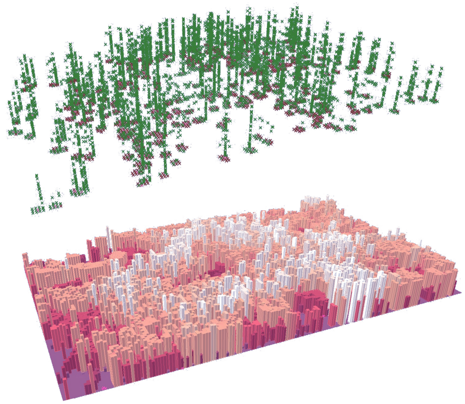


Figure 5
Capacity usage of facitlities and maximum length of schoolway for all Berlin

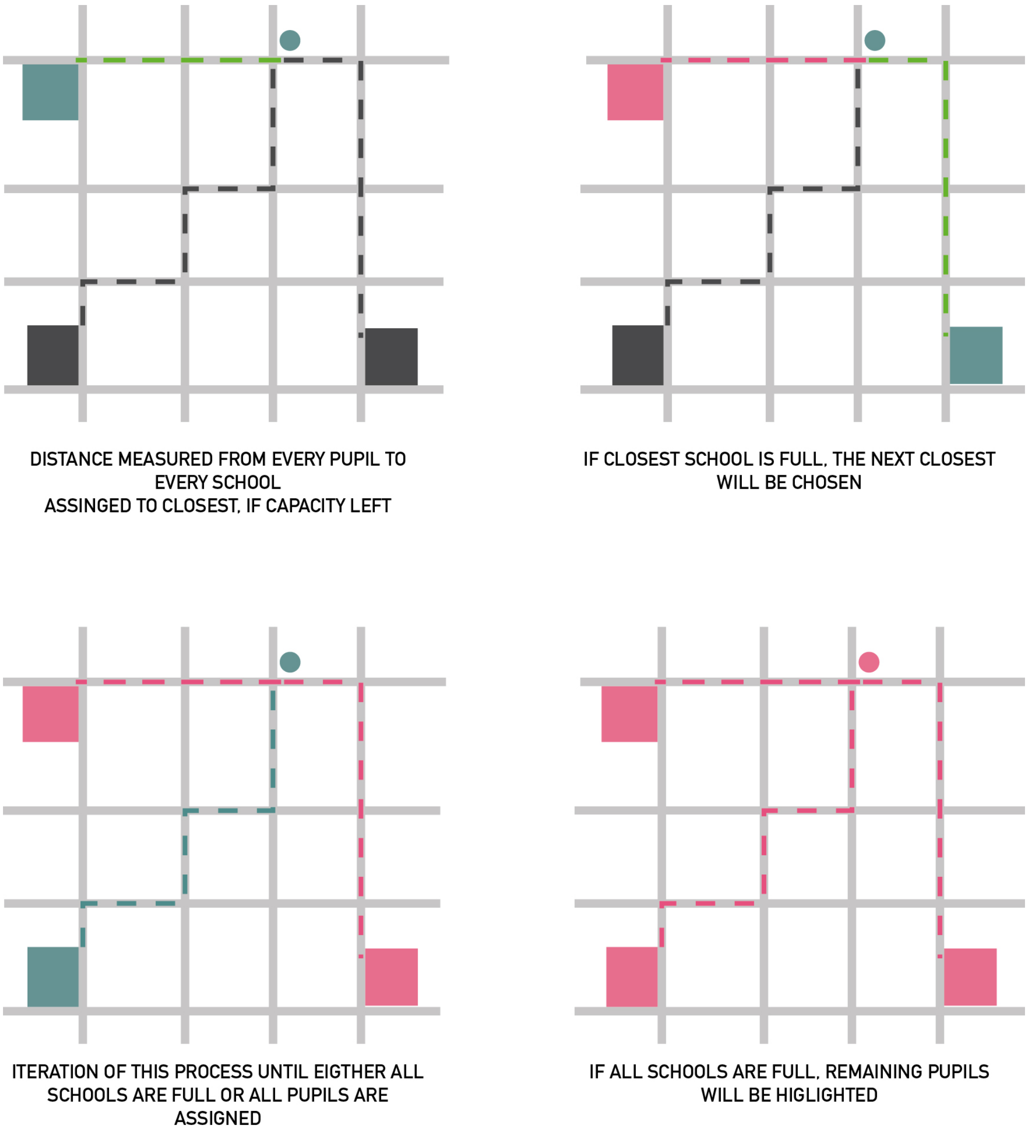
All data for the exemplary use-case was collected from the publicly accessible digital archives of the Berlin senate mentioned above. Since those datasets did not include high resolution data on each parameter, multiple correlations were needed to estimate the lacking numbers. For example, information on population density was provided on building-block-scale, whereas the age-distribution was only provided on so-called "Lebensweltlich orientierte Planungsräume" (planning areas) of around 10 blocks.

The following figure (6) shows an extract of the Grasshopper patch.

Interactive Table

By presenting the tool on an interactive table, users have the option to place physical markers on the screen. These are tracked by sensors and give direct data feedback to the code, which immediately adapts to the added input parameters. In case of the tool's current version, a placed marker represents for a possible new educational facility, i.e. an elementary

Figure 6
Iteration diagram
green: assigned
red: not assigned
black: not iterated



school, which the user can relocate and scale in terms of capacity in real-time. The adaptive code then returns information about the efficiency of the current scenario. It analyzes the resulting coverage and integrates the proposed scenario with the preexisting data, displaying its commuting area, overlaps with existing facilities and again spatial proximity for students in those areas.

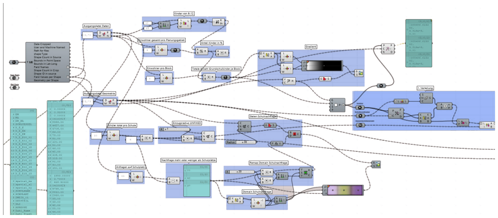


Figure 7
First part of the Grasshopper patch - reading GIS, correalation of data, and estimated distribution of students (see figure 6)

The setup on the interactive table can have helpful advantages for the negotiation process in terms of understatement of the visualization and the haptic process of locating a tracker inside the negotiated. But not in many circumstances those table infrastructures can be accessible for the users. Still, as mentioned above, the project aims both at a more advanced audience (such as a moderated participation process) and more individual users (such as planners or schools) at the same time. Therefore, *Data Flow*'s code is designed to be also functional as a software only solution which serves its open source philosophy.

Development Environment
Being developed entirely in the grasshopper environment for rhinoceros 3D it offers third party developers to modify the code to their specific needs. A major emphasis was put on keeping the tool open source to allow for community driven expansion and including other domains of interest. Therefore, the code, documentation and user manual in text and video will be provided as a GitHub repository. Still, at its current state the requirement of Rhinoceros 3D still could be seen as a drawback regarding accessibility. To address that there are ambitions to migrate the code to a python runtime environment to serve the goal of a standalone application.

PROSPECT
Features
Since the tool is still work in progress as of the publishing date and needs to undergo further testing and refinement there are several features that still need to be implemented and integrated into the workflow. As prospect for an applicable build it is intended to test for the viability of additional parameters such as empty building lots, no-build areas and the potential of densification on or in between buildings on the one hand, and a more dynamic simulation model on the other. That means the possibility to project a scenario into the future by utilizing data on demographic development and an automated detection of areas of special concern. Furthermore, it is attempted to integrate the geographical proximity with the coverage of public transportation throughout the city, which could especially be a crucial asset when dealing with more remote or rural areas.

Data Story
Based on the considerations above the authors conceived a setup to make the tool core of a publication aimed at a larger public audience. Oriented at the *Transport Gaps* interactive online publication (data story, figure 9)[8], developed by Chora together with the Berlin newspaper *Tagesspiegel*, the underlying hypothesis of the Berlin use case was phrased as the subject of a journalistic piece.

Following the analytical logics described throughout this article a web application will be developed visualizing the overall coverage of the demand for primary schools in Berlin in an interactive online map. The aim is to capture possible sites for new facilities and rate them along different parameters - feeding into a certain *location score* value.

Special emphasis will be put on localizing the areas of special concern: Those with especially high population growth rates, extremely large class sizes and a high number of students who do not find a school place in the vicinity. Also qualitative fac-

Figure 8
closeup on the tools interface

tors, such as the supply of cultural and public institutions (e.g. libraries, theatres, public swimming pools, sports clubs) and the distance to parks, main streets, public transport, etc., will be taken into account for the *location score*.

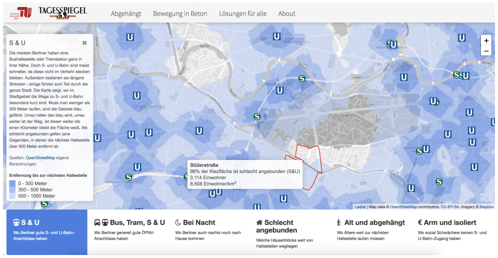


Figure 9
Arm und Abgehängt - Online Data Story of Chora TU Berlin and Tagesspiegel Berlin

Hereby, it is crucial not to present a fixed score, i.e. a definitive statement, but to allow for interactivity: Enabling the user to weight the parameters and adjust variables such as the acceptable walking distance themselves. Letting them "play around" with different scenarios and see how adjustments affect the results in realtime can be regarded a core aspect of the methodology, facilitating understanding and educating the recipient's awareness of the problem.

As mentioned above the author's position is that urban planning is not a science that in which one can expect objective answers. Thus the goal of a web-based multimedia-GIS application should rather work as an educational instrument contributing to the public debate. This is even more valid as the proposed publication does not intend to be a scientific study and cannot take into account the latest findings in educational and sociological research as it would be therefore necessary.

Context Transfer

Finally, the perspective is to transfer the main code to other use-cases, like retirement homes or children daycare, using the existing data interfaces, computations, the UI and the physical interactive environment. We expect to be able to achieve this with only minor adjustments within the code itself to allow for fast adaptability.

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