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VR-visualization of High-dimensional Urban Data

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The project aims to investigate the possibility of VR in a combination of visualizing high-dimensional urban data. Our study proposes a data-based tool for urban planners, architects, and researchers to 3D visualize and experience an urban quarter. Users have a possibility to choose a specific part of a city according to urban data input like ``buildings, streets, and landscapes''. This data-based tool is based on an algorithm to translate data from Shapefiles (.sh) in a form of a virtual cube model. The tool can be scaled and hence applied globally. The goal of the study is to improve understanding of the connection and analysis of high-dimensional urban data beyond a two-dimensional static graph or three-dimensional image. Professionals may find an optimized condition between urban data through abstract simulation. By implementing this tool in the early design process, researchers have an opportunity to develop a new vision for extending and optimizing urban materials.

Keywords: *Abstract Urban Data Visualization, Virtual Reality, Geographical Information System*

INTRODUCTION

The origin of data visualization is found in the origins of mapping. Connecting geographical information with statistical data was one of the first steps to graphical practice. It was only in the 18th century that statistical graphics as the first way of data graphics were introduced by scientists as an instrument for the communication and analysis of high dimensional data. As the set of information got more and more complex and visualization technologies and softwares improved, visualizations as medium to represent a state of complexity turned more abstract. In our research we define graphics as an abstraction of (real) data. Generally accepted ways to visualize data efficiently are statistical graphs, plots, and infographics. (Friendly, 2006; Tufte, 2004; Schroeder, Martin and Lorensen, 1998)

Accessibility of data and increasing digitization and connectivity of dynamic behavior with static spatial conditions makes data a sought after good. In the current period of the 4th industrial revolution, data is continuously collected and analyzed, which gives us access to large quantities of complex data, that can be applied in different domains (e.g. GIS, medical imaging). The visualization process of such data, therefore, is getting more challenging. (Tory & Moller, 2004)

Two-dimensional graphics are limited by two

axes to show its information and in this way limited in the amount of shown quantities and their relation. Three-dimensional graphics, on the other hand, lose readability because one is never able to view all perspectives at once. (Ertöz and Kumar, 2004). Our tool aims to visualize data separately in a hybrid of 2D and 3D graphs but overlaps the relevant variables.

THEORY

Location analysis is an important, and time-consuming topic for architects and planners, so the questions are how can we use existing location-based open source data to help make the analysis easier. Location analysis is an important, and time-consuming topic for architects and planners, so the questions are how can we use existing location-based open source data to help make the analysis easier.

An axle system shows the relationship between two or more elements that are linked to each other by a mathematical relationship. Filtering and comparing factors that are not related to each other directly is useful in order to compare the ratio of different urban parameters. To assure comprehension the tool offers the possibility to overlap different diagrams. A cube is a three-dimensional solid object bounded by six square faces, facets or sides, with three meeting at each vertex. With its six sides, a cube can visualize six different contents. A transparent cube never shows only one of its sides (Figure 1).

Our tool contains information regarding public buildings, private buildings, land-uses, streets, and population. Each category is represented as a two-dimensional diagram by one side of the cube (Figure 2). The user views the visualized data not separated but in context of the other shown urban data.

Figure 1
First prototype

WORKFLOW

In our tool, we split Berlin into 8 equal parts (Figures 4 and 5). The user chooses the part of the city they want to analyze. All parts of the map are linked to their specific data sets (Figure 6). After choosing the part of the city, the linked data runs through our grasshopper algorithm in order to get a result. The open source data our tool uses is found in two different data tables, buildings, and land-uses. It is organized as “code”, “class”, “name” and “type”. These elements are what we used to create a redistribution. The algorithm reorganizes the original dataset into categories (private buildings, public buildings, land-uses, streets, and population) and subcategories, that are relevant to the architectural analysis.

Figure 2
Conceptual workflow

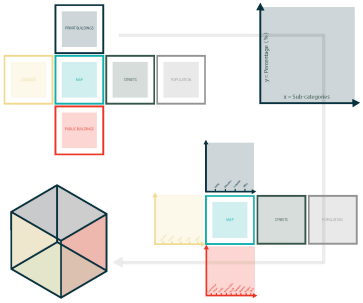
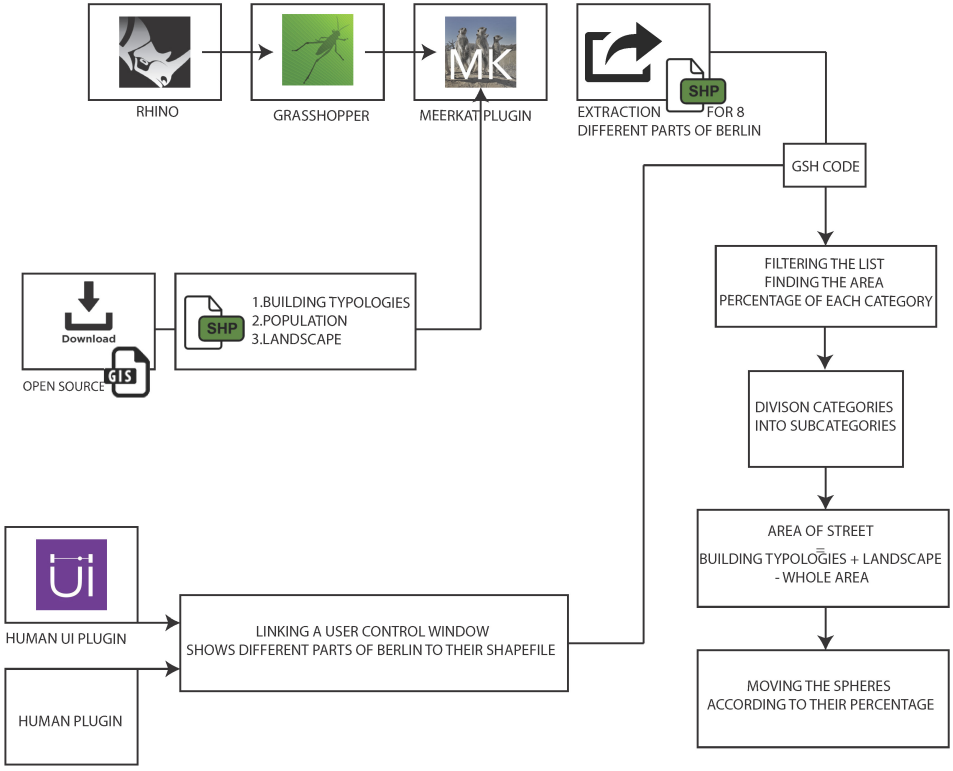


Figure 3
Workflow



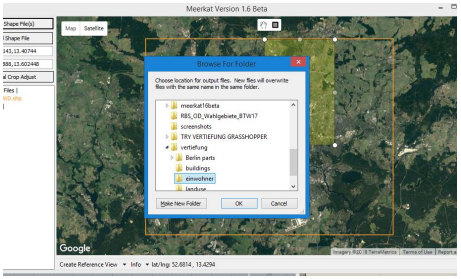


Figure 4
Cropping Shapefiles using Meerkat

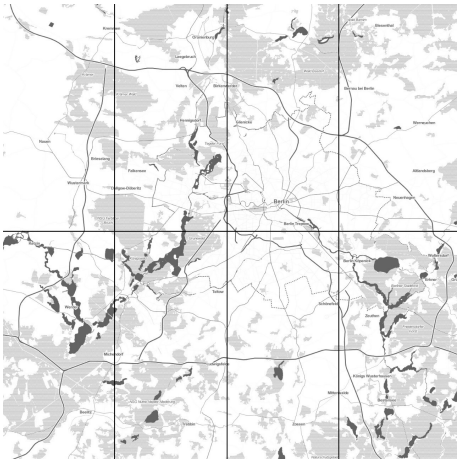


Figure 5
Segments of Berlin

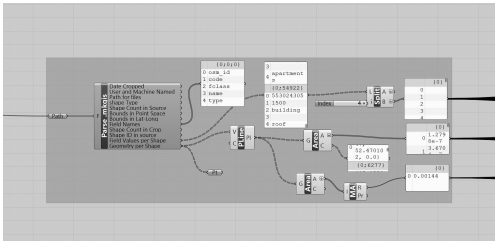


Figure 6
Connecting the path to meerkat and extracting lists from the shapefile

All "types" of the buildings-data-table (gis_osm_-buildings_a_free_1.shp) are feed into the algorithm (Figure 7) and converted into subcategories defined by us:

1. living 2. education 3. industrial 4. office 5. commercial 6. retail 7. hotel 8. service building 9. health 10. transport 11. museum 12. religion 13. sport

These subcategories are divided into "private buildings" (1-4) and "public buildings" (5-13).

For "land-uses" the "typologies" of the land-use-data-table (gis_osm_landuse_a_free_1.shp) are converted into the subcategories (Figure 8):

1. cemetery 2. forest 3. grass 4. park 5. others

By combining the building- and land-use-data-table the algorithm processes the "streets"-data (Figure 9).

The shapefile for "population" is organized as "EW = population" "HA = area" "EW_HA". Our algorithm extracts the population in relation to the specific area (Figure 10).

The tool compares the areas related to the categories/subcategories (Figure 11). In this way, the algorithm calculates the important percentages, for the visualization, of each category in relation to each other (Figure 12). Each side of the cube visualizes the percentages of each category (Figure 13).

We linked the result from our Grasshopper algorithm with Prospect One-Click VR (by IrisVR) to translate the visualized cube into Virtual reality (Figure 14).

Our code works with the Oculus Rift, recommended requirements for a compatible computer are NVIDIA GTX 1060/AMD Radeon RX 480 graphic card, an Intel i5-4590/AMD Ryzen 5 1500X processor, an 8 GB+ RAM memory, an HDMI 1.3-video output, 3 x USB 3.0-ports plus 1 x USB 2.0-port and at least Windows 7 SP1 (64 Bit).

Figure 7
Private and public

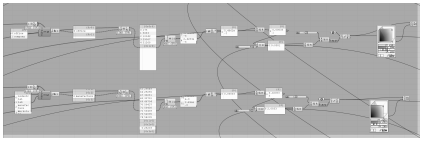


Figure 8
Land-uses

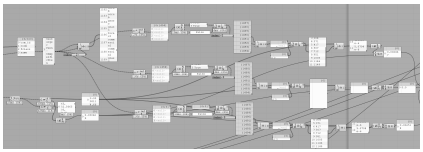


Figure 9
Streets

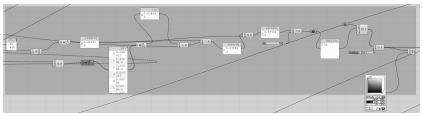


Figure 10
Population density

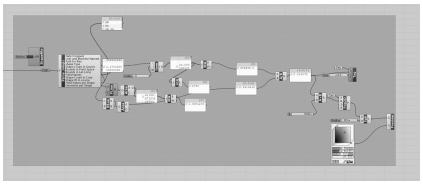


Figure 11
Area percentage

Figure 12
Using the biggest number we got as the highest value

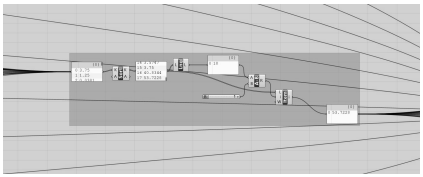


Figure 13
Moving the spheres in the cube according to their percentage

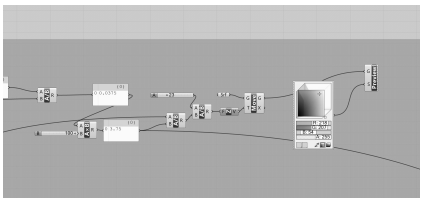
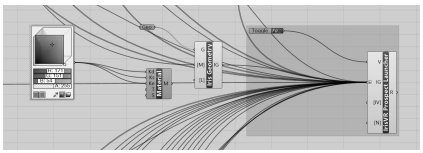


Figure 14
Prospect code



MANUAL FOR USER

1. The user has to have Rhino and Grasshopper downloaded.
2. The user next will have to download the Grasshopper plugins (Human-Ui, Human, gh-python-remote, Prospect One-Click VR (by IrisVR), and Meerkat GIS) which are all to find on the www.food4rhino.com/website
3. Link the plug-ins to Grasshopper
4. Open the script file
5. Open 'Data-Cube.3dm' (in Rhino) and 'Data-Cube.gh (in Grasshopper)' files
6. Refresh all data links by inserting new file locations of Links-folder (SCRIPTS > Links) in Grasshopper: Red > images, Blue > einwohner, Green > buildings, Pink > landuse
7. Connect the VR-glasses with your PC
8. Set the code 'true' (light blue) in Grasshopper

Our tool can also be used to visualize data for all parts of the world:

1. Obtaining the Shapefile for the City or Urban district that the user wants to analyze (We use OpenStreetMap Data Extracts by geofabrik for the shapefiles).
2. After unzipping the file the user will find various types of files. The relevant file are (gis_osm_buildings_a_free_1.shp, gis_osm_-landuse_a_free_1.shp)
3. Then the user crops the relevant urban district shapefile using Meerkat GIS. (The size of the chosen district is freely selectable.)
4. The user should then link the Path to the cropped shapefile to our code.
5. Plug in the VR glasses.
6. Run the Code and get the results.

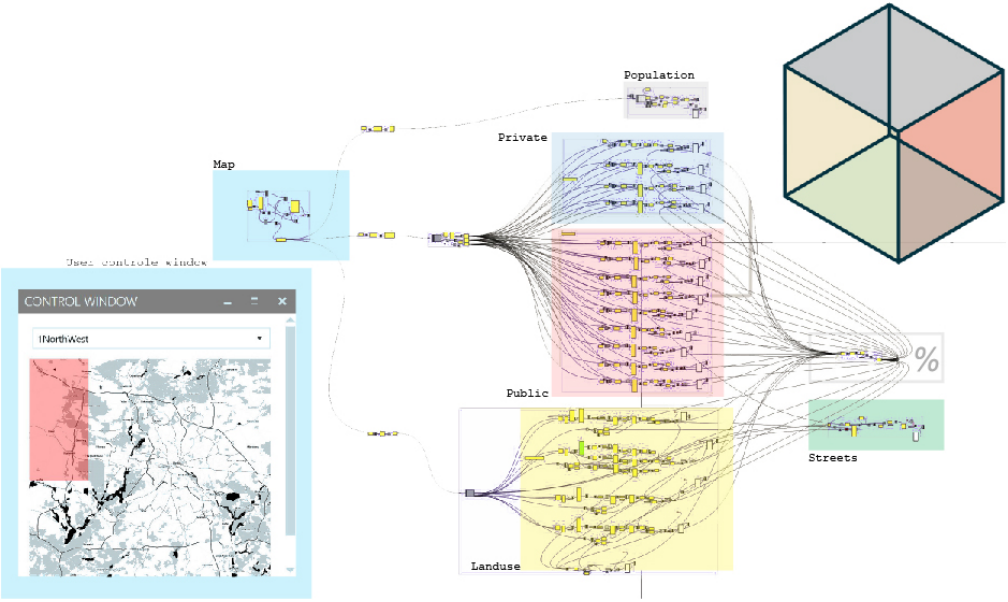


Figure 15
Code

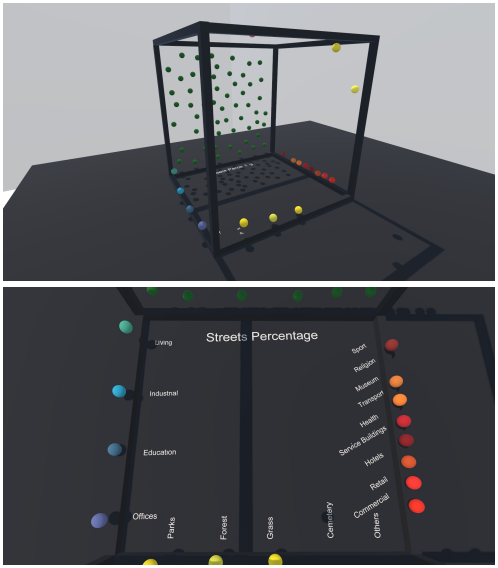


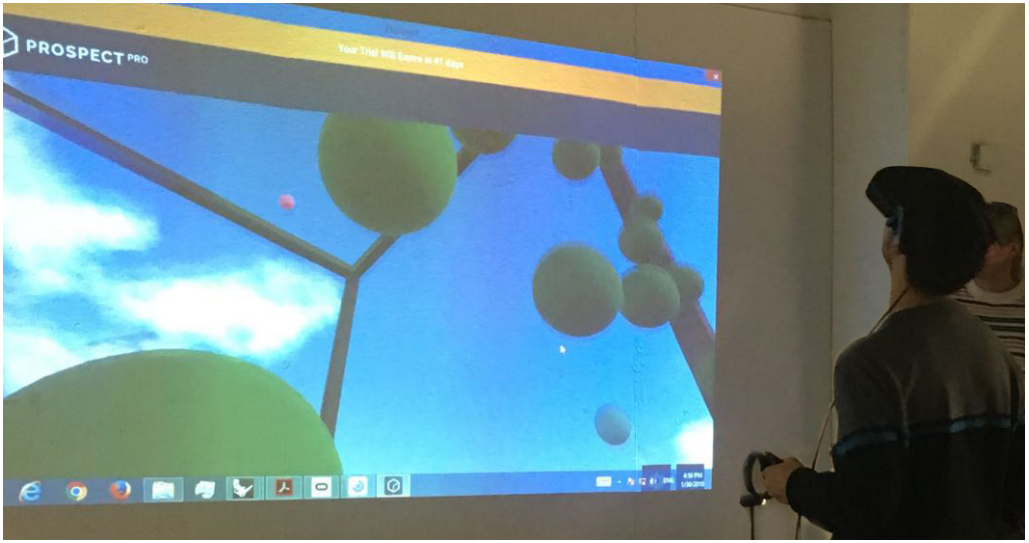
Figure 16
The Grasshopper algorithm in Prospect

Figure 17
Categories

CRITIQUES

Grasshopper is a graphical algorithm editor tightly integrated with Rhino's 3D modeling tools. While developing the algorithm with Grasshopper we expereinced some limitations. The most important one was due to the huge amount of data which was used for the program, that resulted in the constant crash of the Rhino and Grasshopper during our attempts to write the algorithm. The solution was to balance the amount of information that our tool can work with. That is why the biggest urban area our tool can analyze is a city. Another limitation is that our tool can only visualize one urban district at a time (Figure 18). As the tool is primarily aimed at architects and planners it seems not as a disadvantage considering that architects and planners mainly deal with only one urban situation for each project. An implication of VR Glasses is to provide the possibility that the user can experience different perspectives (inside, and outside the cube) for the data-sets, which helps them to

Figure 18
Oculus Rift view of the tool



understand and analyze data deeply. Our tool only can be modified and viewed by one user in the VR-environment.

FUTURE PROSPECT AND POSSIBILITIES

A feature that could be added to our tool is to save the results of an urban district and linking them with google earth to make them available for users that do not have access to our tool. VR visualization of urban data could have a possibility of evolution gradually in consequence of using it.

Another way to use the saved results is to show the development of an urban district over a period of time (data storage).

A further important futuristic implication is that our method could probably be usefully employed in HYVE 3D.Hybrid Virtual Environment 3D (Hyve-3D) is a system that allows architectural co-design inside Virtual Reality by a new model of interaction through a 3D cursor without using VR Glasses (headset). The Idea is to have better interaction with three-dimensional virtual spaces, rethinking it as a drawing/control plane and viewpoints inside the virtual world. In Hyve-3D all users can edit and manipulate the three-dimensional-environment with tablets. Participating parties can be located all over the world while working at the same project. In this way, users are able to try changes in urban parameters. Changing one parameter in the cube it would affect the ratio of all other parameters. It enables the interaction of various participants at the same time. (Dorta and Beaudry Marchand, 2017)

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