Implementing Geospatial Data in Parametric Environment

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Abstract

This paper demonstrates the benefits of incorporating geo data into parametric modeling environments in order to help architects and planners leverage spatial data in an immersive way.

Architects, engineers and planners are increasingly using mapping applications to interpret the complex nature of cityscapes, and to provide innovative buildable solutions. In recent years, Open Data and GIS have become more accessible, but they are still not fully accessible to designers and decision makers in architectural practices. Most mapping and data visualization tools are web-based, and strictly represented in 2-D. The integration of GIS spatial data within the parametric model allows for a highly sophisticated design interface. The approach discussed in this paper uses the Grasshopper plugin "@it" to visualize historical GIS data and future developments with proposed design solutions in a parametric design platform.

'@it', is a spatial analysis plugin for Grasshopper that enables quick 2-D and 3-D data visualization within the 3-D modeling program Rhinoceros. It allows architects and planners to integrate spatial cityscape data into new designs. The ability to query the attributes of spatial data allows designers to reveal invisible dimensions, relationships, patterns and trends and eases the process of decision making.

The paper illustrates examples of integrated workflows by using '@it' to demonstrate the benefits of incorporating GIS into parametric modeling environments.

Keywords: GIS, Geospatial Data, Open Data, Architecture, Urban Planning, Parametric Modeling, Grasshopper3D, @it [atit].

1. Introduction

The paper aims to demonstrate the benefits of incorporating Geographic Information System (GIS) data into parametric modeling environments in order to assist architects, engineers and planners in leveraging geospatial data in an immersive way.

Architects, engineers and planners are increasingly using mapping applications to interpret the complex nature of cityscapes, and to provide innovative buildable solutions. In recent years, Open Data and GIS data have become more available, but they are still not fully utilized by the designers and decision makers in architectural practices. Most mapping and data visualization tools are web-based, and strictly represented in 2-D. There is a lack of spatial analysis tools for parametric modeling environments.

AEC professionals encounter larger and more complex design challenges every day. There is an abundance of data collected and processed concerning built environments and urban infrastructure. Professionals are expected to deliver innovative solutions not only at the structural or building level but also regarding the cross-relational impact within the urban contexts.

The amount of resources for geospatial data has been growing exponentially in recent years. Many local and state officials have been committed to engaging with the public and making their operations and data more open and transparent. [See Figure 1] Open data portals for cities have been sharing a large variety of public information such as climate data, the air quality of city neighborhoods, building footprints and demographic data. Every citizen has a right to read, search and reproduce all of the documents provided, but they are so large and complex that it can be difficult to grasp and scrutinize them using traditional data processing methods. Visualization and mapping tools become crucial to advance the unfolding of the data.

Figure 1: Lists of some examples of Open Data Portals

2. Integrated Parametric Modeling and GIS

2.1. Why integration of GIS is important for the design process?

GIS is widely known as a system designed to capture, store, query, manipulate and manage various formats of spatial data. Geospatial data consists of two main parts; the geometry with geolocation information i.e. the map and its attributes i.e. tabular data. Spatial analysis tools allow AEC professionals to conduct spatial analyses and overlay, query and visualize data. Architects, engineers and planners utilize geospatial data to analyze the physical environment more readily by unveiling the less straightforward dynamic relational patterns. They increasingly use mapping applications to interpret the complex nature of cityscapes in order to provide innovative buildable solutions. In recent years, GIS has been playing a more important role in AEC where there is a diverse range of geospatial data provided by local and state institutions. The data sets serve as rich resources for architects, engineers and planners. Data such as topography, weather, zoning, land cover; land use etc. can be accessed in regional or urban scales and or in a building scale such as use, occupancy classification, building type and construction type etc. The integration of this GIS data within the parametric platform enables a highly sophisticated design interface.

2.2. Why parametric modeling environments are the correct platforms?

Parametric modeling environments enhance the exploration of multiple design options simultaneously and the integration of more complex design, analyses and simulation techniques. Parametric design has started to be widely implemented by AEC professionals in the design of almost everything in the built environment from building skins to large-scale urban developments. The notion of 'parameter' is defined as a variable that sets a condition within a system where its change affects other variables or conditions of the system. Parametric approach for analyzing urban data might help us uncover new relationships between building form, building performance and the urban fabric.

The most powerful aspects of visual programming languages are to generate, manage and manipulate an immense amount of data. The visual scripting editors such as Grasshopper3D [9] for Rhinoceros or DynamoBIM [2] for Autodesk Revit provide exceptional platforms for AEC professionals to compute and generate their designs while managing large amounts of quantitative data. Grasshopper3D provides a highly intuitive visual graphical interface that allows users to compute, manipulate large data and visualize spatial characteristics within a Rhino 3-D modeling interface.

2.3. @it: Spatial Analysis Tool for Grasshopper

@it reads 'atit', is a parametric spatial analysis tool that allows the user to interact with geospatial data in Grasshopper / Rhino. It enables quick 2-D and 3-D data visualizations within the 3D modeling program Rhinoceros. It allows architects and planners to integrate spatial cityscape data into new designs. The plug-in @it was developed to leverage Open Data, GIS and geospatial data into a parametric environment. The ability to query the attributes of spatial data allows designers to reveal invisible dimensions, relationships, patterns and trends and eases the process of decision making.

@it enables the importation of GIS data from various sources and allows quick 2-D and 3-D visualizations using look-up, parse and query components. Sources of GIS data include Shape files (ESRI), Google Maps Geocoder [6] and Open Street Map API REST services. [8]

Figure 2: @it custom component palettes appears on Grasshopper3D

Next illustrates examples of integrated workflows by using '@it' to demonstrate the benefits of incorporating GIS into parametric modeling environments.

2.3.1. Exploring and Visualization of Data
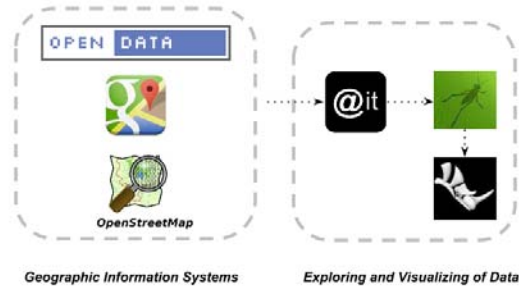
Figure 3: Flow chart of '@it' plug-in

@it has components to parse 2-D and 3-D spatial data that pulled Google Maps and Open Street Map with using HTTP web services. The main feature is the parser of the ESRI shape files, allowing the user to obtain GIS data from a wide variety of online sources of Open Data. The parsers trace GIS data into Rhino's view with Grasshopper native elements such as point, line, polygon and 3-D closed objects.

Besides importing spatial data and tracing the geometry into Rhino/Grasshopper, @it has also a very powerful algorithm of query engine of non-spatial data of data sets. The attributes are like the attribute-value pairs. They compose the tabular information of GIS but they are also associated with geographic features such as a location (point), road (line) or boundary (polygon).

Here are the some examples of how to filter a specific attribute and visualize its values in a specific data set. The visualization seen in Figure 4 is the overlay of two data sets. The traffic infrastructure of the City of Amsterdam [1] is used for the background. The data set of Architecture and Urban Values

of Buildings is filtered by the attribute name 'gebouwtypo', building type. The building geometries that have the same building type are grouped with the 'create set' component of Grasshopper and baked into Rhino in respective layers named as their values. The next visualization uses the same workflow; NYC buildings' footprint data set was imported and filtered by the attribute of the ground elevation of the buildings. Visualization data ranges from 6 feet to 406 feet from the sea level. The blue color represents lower and red represents higher elevations. The visualization confirms that the highest point of NYC is Todt Hill in Staten Island.
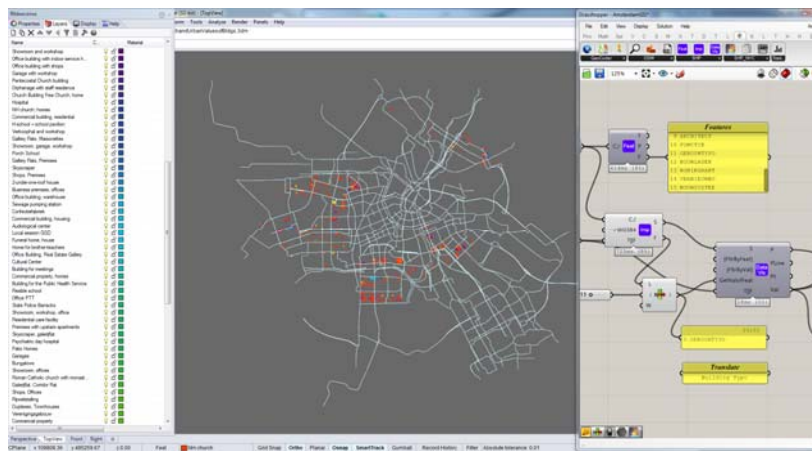
Figure 4: Architecture and Urban heritage of the City of Amsterdam, filtered by Building Types

Figure 5: NYC Digital Elevation Map. Source NYC Building Footprints

The Mexico City Terrain Topography study is a good example of handling immense amounts of data in Grasshopper. Just a few days after @it was first released dated back to 2014, Joe Miranda, one of the first adopters of @it, posted his Mexico City Topography study into a Grasshopper group page.[5] He was able to import all the contour lines of Mexico City into Rhino through Grasshopper creating a highly accurate topography of the entire city. [Figure 5] The imported data was used for further flow analyses and urban form studies.
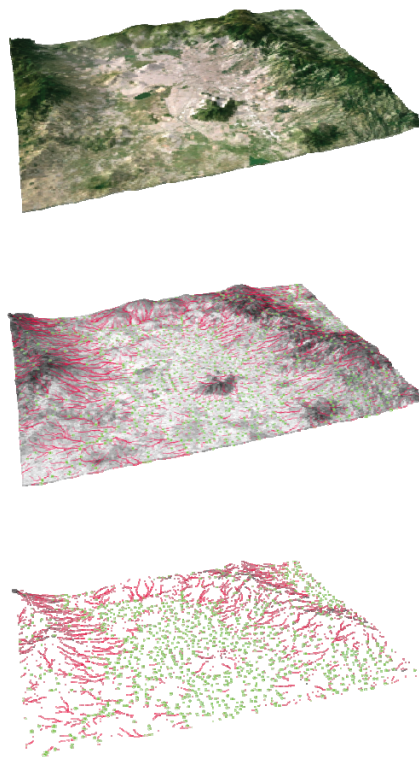
Figure 6: Mexico City Terrain Topography by Joseph Miranda

The next example is filtering the data set by a specific value of an attribute. [Figure 7] The dataset of existing buildings in Chicago [4] is filtered by the year the building was built. The left frame emphasizes the buildings in red were built in 1852; it found only one in the dataset. On the other hand, the right frame emphasizes the ones in red were built in 1889; there are 9326 buildings that still existed in the year filtered.
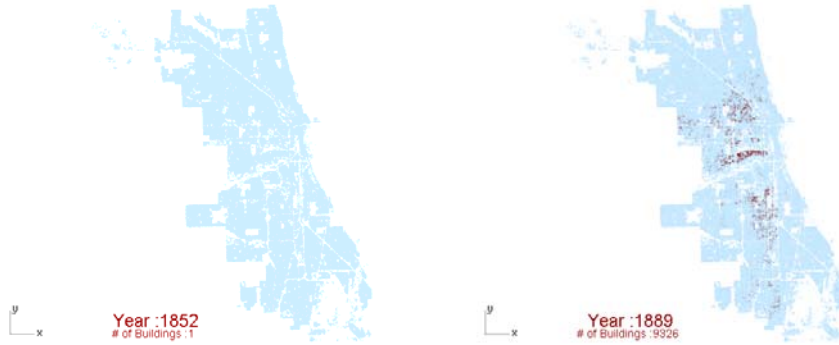
Figure 7: Time Series Animation created in Grasshopper:

Existing Buildings of Chicago animated by year of built

OSM buildings have more detailed geometries and importing 3-D building geometry would be very useful for design analyses. @it has an OSM buildings parser using a web service and only needs an address input.
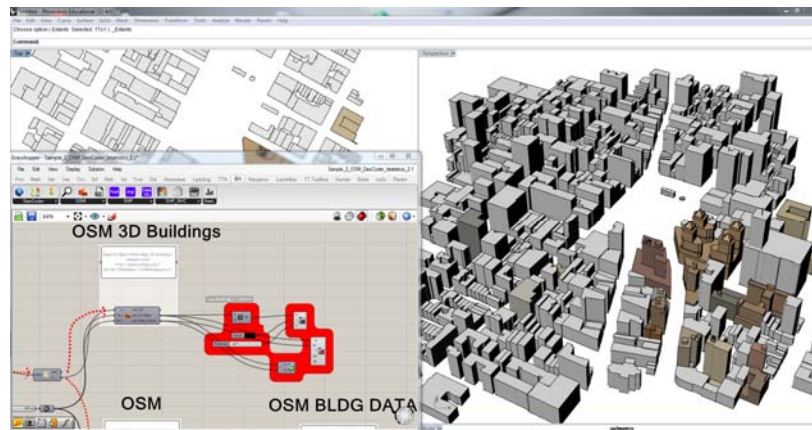

Figure 8: Open Street Map 3-D buildings parser: Union Square, NYC

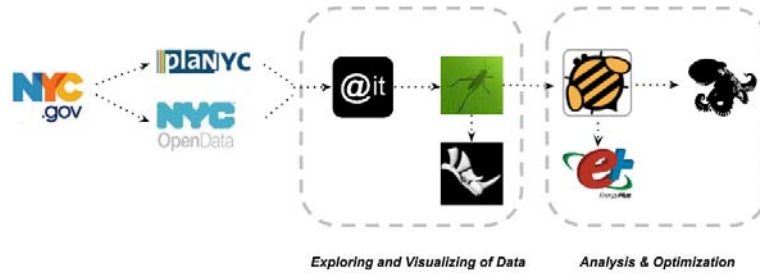*2.3.2. Computational Analysis and Optimization*

Figure 9: @it workflow for analysis and optimization

Beyond the spatial exploration and visualization with parametric tools, Grasshopper enables us to integrate a multi-objective analysis and optimization. With environmental plug-ins such as Ladybug and Honeybee, it is possible to examine energy saving potentials for existing building stocks in an urban fabric in terms of sustainability and passive house criteria. [Figure10] The study shows what happens if the zoning districts and buildings forms are regulated by solar envelopes in NYC. The other study explores the retrofitting of an existing building to make it more energy efficient. Parametric city energy audit tool [Figure 11] utilizes the data sets from NYC Open data.[7]
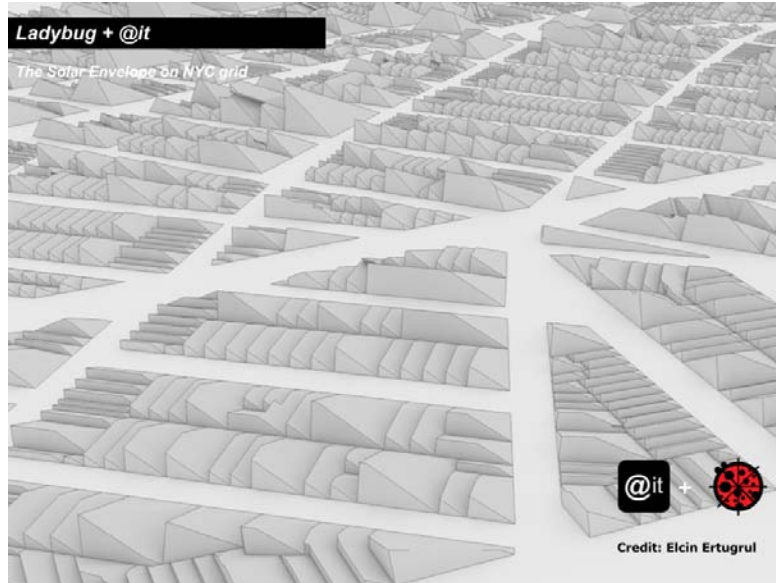
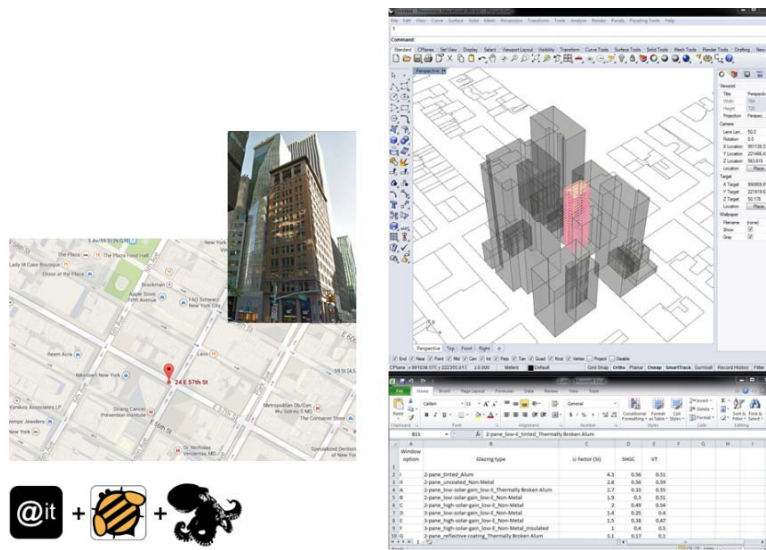Figure 10: Solar Oriented Buildings to Solar Oriented Cities: The solar envelope on NYC grid

Figure 11: Energy Simulation and Retrofit Study in Grasshopper.
Design Science Final project. Elcin Ertugrul and Naciem Nowrouzi. 2013

3. Conclusion

AEC professionals need a platform and parametric tools to analyze, capture, visualize the large complex and dynamic geo data parametrically and integrate the quantitative analyses into their holistic design processes. The ability to query the attributes of spatial data allows designers, planners and engineers to reveal invisible dimensions, relationships, patterns and trends and eases the process of decision making.

It might be possible to design and build more resilient and sustainable cities if we put the urban analyses into the equation and look at environmental problems not in micro i.e. building-centric fashion but in macro fashion i.e. urban scale.

Urban data analyses within a parametric environment could help us reveal multiple design options and create a new urban morphology.

Acknowledgement

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