CityZoom

A Visualization Tool for the Assessment of Planning Regulations

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In the last twenty years, computer tools have progressively enabled the modeling of buildings and cities in lesser time and cost, along with an increase in the results quality. A city modeled according to planning regulations usually present a correlation between plots and buildings dimensions. The representation of such correlation for a large number of plots requires repetitive work, thus suggesting the use of a computational tool to perform the task. Existing CAD, GIS, and VR software can generate accurate representations of the reality, but have no capabilities to simulate the impact of alternative urban regulations for large number of plots in a short period of time.

CityZoom is a Decision Support System for urban planning, with a specific built-in city model, where data is represented in an object-oriented model representing the urban structure. CityZoom not only provide CAD tools, but a shell where different performance models can operate iteratively. It can simulate given urban regulations applied to a set of urban plots, as well as address environmental comfort issues such as shadow casting between buildings.

Results can be displayed as tables, graphs, and in a 3D preview of the whole city or part of it. It’s also possible to export them to commercial GIS tools, to perform different data analysis. The graphical outputs make for an easy understanding of the results by laymen, an important feature for participatory planning, while the display of the correspondent numerical data enable correlations with indicators and parameters of urban quality.

Keywords: CityZoom; urban planning; building simulation.

Introduction

In the last two decades cities and buildings have been represented in various ways with the support of computational tools. Aimed as a replacement for human skills, these tools do have reached capabilities far beyond these skills: in fact computer programs are able to shape buildings and cities in much faster and “realistic” ways than the human hand. As buildings and cities are edited with lines, planes,
points, volumes or other geometric features, computer programs have enabled another pathway for their representation: all these features can be “read” as data and hence able to feed performance models for the analysis of different attributes of these objects. Object oriented programming has achieved important results in linking the perceptual representation of buildings (what you can see with your eyes) as data with the production of information related to various aspects of buildings and cities performances such as environmental comfort, luminance, mobility and accessibility patterns; the correlation of these aspects within computational environments have helped architects and city planners to make important decisions concerning the shape of buildings and cities in the last years. On the other hand, the most expensive investment in such analytical environments is related to the construction of the built model. As a matter of fact it does take more much more time to edit a building or a city than to retrieve information from the edited representations.

Cities and buildings are, in general, shaped according to planning regulations. These are like “genetic” codes in that, planning regulations govern the basic volumetric aspects of the vast majority of buildings in most cities, relating the building shape and size to its plot shape and size. There exists therefore a proportion between these two elements. This is quite natural since large buildings require large plots and small buildings do not. Some regulations may well overemphasize this property and the volumetric result will be clearly dependent of a non three-dimensional variable, i.e. the plot size and shape. On the other hand, regulations may well emphasize the streetscape as its most important parameter. In this case the plot’s size and shape will not play a deterministic role. But in any of these two cases there exists a strong probability that the plot’s size and shape will vary, even if the block has had an initial homogeneous subdivision.

If all planning regulations correlate plot’s dimensions to building’s shapes, an enormous amount of work is necessary to simultaneously correlate these two variables for large quantities of plots and buildings in order to obtain a model or representation to assess the effect of planning rules. Existing software have not developed so far any tool to simultaneously represent the effect of planning regulations over large amounts of plots. This has lead to the use of city models just representing either existent or idealized form in that they do not take into account the precise correlation between building’s shapes and plot’s sizes. Simulations of future developments, lended by architects and planners, do cost a lot to be done and are constantly exchanged for a proxy or an idealized model of reality. The generation of a virtual city model and the simulation of possible future developments, is not only craved, but definitely needed specially when it is known that participatory planning do require heuristic tools (what if…) as to enable laymen audiences to have a better grip of the rules which will govern the growth of their districts and cities. Although CAD and GIS technologies have given important contributions to the visualization of would be scenarios an important gap between the real world and the idealized world still remained. This gap has led to the development of CityZoom, a software to be used both by laymen and planners as a visualization tool to level the discussion of themes such as privacy, solar radiation, luminance, environmental comfort, sky lines, view obstruction and other issues constantly raised in public enquires. This paper describes the main features of this software and it is divided in three parts. In the first part a short review of the available existing tools to represent urban space is made. The second part details CityZoom and its performance models. Finally, the third part presents the conclusions and future works.

**Existing tools**

Computer Aided Design (CAD) is defined as the use of computers for creating and editing drawings. In 1982 Autodesk introduced AutoCAD® (www.autodesk.com: May 2007) software, bringing CAD to the PC. It was initially file based and the drawings
organized in layers, with powerful tools for designing real-world objects and paying full attention to managing data without losing precision.

In the other hand, a Geographic Information System (GIS) is a computer software designed to efficiently capture, store, manipulate, analyze, display and link geographic information with descriptive information. Among GIS tools one of the leaders is ArcGIS, from ESRI (www.esri.com: May 2007). ArcGIS is an integrated collection of GIS software products that allow you to author, analyze, map, manage, share, and publish geographic information.

Historically, CAD tools have been much closer to “drawing” tools than actual “design” tools as their name imply, since they are not “smart” enough to correlate different parameters and user needs during the process, and don’t provide means to validate the results. GIS data is always more reliable when it has CAD precision. Therefore, it’s only natural that there’s an increasing demand for integrating CAD and GIS software.

ESRI has developed a solution to this integration problem: ArcGIS for AutoCAD that is a free application that installs on top of AutoCAD 2007 and provides access to the results of all of the GIS mapping and geoprocessing capabilities performed by ArcGIS in the form of map service images. This application accesses dynamic georeferenced ArcGIS Server map services and displays them in the AutoCAD drafting environment. The integration between CAD and GIS has also led to the correlation between plots and buildings but in a very shallow mode: buildings can vary their height from existing footprints but planning rules cannot be applied for each of the building floors.

Virtual reality (VR) solutions made easier to model and represent cities using 3D modeling based on the real or idealized cities. Cybercity (http://www.cybercity.tv: May 2007) developed the generation, distribution, analysis and visualization of reality-based virtual 3D city and facility models as well as photo-realistic 3D landmarks, using photos and images of the city to build its 3D model.

A faster method, Virtualised Reality, was proposed by Avideh Zakhor from Berkeley (http://www-video.eecs.berkeley.edu/~frueh/3d/index.html: May 2007), which scans the urban landscape using lasers and digital cameras mounted on a truck or plane enabling to model an existing city in a few hours.

It comes to attention that either using CAD and GIS tools, or virtual reality based models, it is possible to obtain an accurate representation of reality, but just a model based on real data. There’s no control on how changes in the data set would influence in the city. It is possible to explore and analyze existing scenarios, but the tools do not offer support to help the understanding of the city and what would it be if the urban plans were changed.

All the described tools are not active models in that they do not constitute an interactive model for what the city could be. In other words they are static models which allow planners and laymen to have a frozen picture for what a city could possibly be but without an assessment tool which could shed light on how it could be better.

**The CityZoom**

The idea behind CityZoom (www.cityzoom.net: May 2007) was originated from a challenge raised by Porto Alegre’s (Brazil) mayor Tarso Genro wanting to implement a bonus policy allowing the exchange of plot ratios between urban plots. In order to assess how much could be transferred, and how beneficial those transfers would actually be, a question needed to be answered, i.e. how much could one build in a particular urban plot.

To answer this question, the City Hall has asked the UFRGS (Federal University of Rio Grande do Sul) through different laboratories led by the SimmLab (Laboratory for the Simulation and Modeling in Architecture and Urbanism) to elaborate a study (Turkienicz, 1994) to show possible impacts of the existing and alternative Master Plan Rules over five different neighborhoods of Porto Alegre as to provide guidelines for the city’s development. The building
volumes for this report were manually edited, in a
time-consuming and labor-intensive process.

Departing from this experience, the SimmLab
decided to create its own software, capable of au-
tomatically generating buildings according to plan-
ning regulations. In 1996, the CityZoom research
project was incubated at the UFRGS` Institute of
Informatics. During over ten years of development,
many tools have been created to solve problems
raised by several different cities in Brazil and abroad
and by research partners in different Universities all
over the world.

At its current development stage, CityZoom is a
full Decision Support System for urban planning. It
provides a computational environment where dif-
ferent building performance models can operate
interactively, aiming to optimize the urban plan-
ning process. Each of these models corresponds to a
module that implements them in the computational
environment.

It has a specific built-in city model, where data
is represented in an object-oriented model repre-
senting the urban structure (city, blocks, roads, plots,
buildings etc.) so that information can be retrieved
at any required level. In CityZoom environment, each
performance model operates within its correspon-
dent part of the computational structure hence af-
f ecting all the related objects and models.

CityZoom's main tool is a graphical editor of ur-
ban features (figure 1). Data can be fed in different
ways, such as: freehand drawing, using a background
layer such as an aerial picture as reference, importing
neutral file types (AutoCAD DXF, ArcView SHP etc.), or by a direct connection to a spatial database. Once fed, data can then be used by CityZoom’s models, which are described in the following sections.

**BlockMagic**

BlockMagic (Turkienicz, 1999) is the CityZoom’s model for the simulation of given urban regulations applied to a set of urban plots. It can swiftly generate large sets of buildings in the most different urban scenarios, or validate designed or already built buildings. The regulations can be inserted and edited with the Urban Regulations Editor (figure 2), allowing the user to set the Master Plan parameters, such as maximum number of floors, maximum commercial and residential plot ratios, maximum slab area projection and minimum setbacks. Buildings are generated according to the regulations and using the user-input parameters which determine which of the building attributes are to be assessed or optimized, such as number of floors, front or size width, slab area, plot occupation and plot ratio.

BlockMagic also addresses environmental comfort issues, through the use of the Solar Envelope technique (Grazziotin, 2002). The Solar Envelope is a construct of space and time: the physical boundaries of surrounding properties and the period of their assured access to sunshine (Pereira, 2000). The way these measures are set decides the envelope’s final size and shape. Planning for insolation is essential in establishing the visual and thermal comfort, i.e., the benefits to be obtained from the

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**Figure 2**

Urban Regulation Editor and BlockMagic simulation window
sun in and around the buildings. The introduction of such parameters in the design process might substantially affect the land use, building density and urban land value. Using the Urban Regulations Editor, the user can set the obstruction angles for every possible plot orientation. These angles are then applied to the plot’s edges, generating a set of geometric boundaries. Any building restrained within this volume will not project shadows over the neighboring buildings during critical periods of the year.

**Visualization of results**
Results from the simulations can be visualized both in quantitative and qualitative ways, i.e., CityZoom can summarize numerical data generated by the performance models in tables and graphs as easily as it can show 3D graphical previews of the city (figure 3). These allow the user to quickly observe the desired results and to freely navigate through hypothetical scenarios.

Numerical data can be obtained from the geometric objects in the city (for instance, the area of a block) or explicitly associated to them (for instance, the population of a building). These data can then be extracted for the whole city, or specific regions, and visualized with the Numerical Results Viewer module. Land area, built area, plot ratio, average building height, and other important attributes can be easily summarized.

CityZoom’s 3D visualization tool, implemented using the OpenGL library, makes it possible to interactively navigate through the three-dimensional scenario which represents the city being modeled, with the blocks, plots, buildings and reconstruction of the 3D terrain. It also supports the generation

![Figure 3](image-url)
of realistic shadows in real time, based on the city location, date, and time input by the user, and can show the Solar Envelope superposed to the existing or simulated city objects. This allows the verification of the relations between the buildings, and the visualization of the impact of the shadow of a building over its neighborhood.

“Linking CAD to GIS”
CityZoom, with its built-in intelligent city model goes beyond the regular CAD, providing tools to assist on different levels of a city’s planning, as shown above. Besides the editing, importing, simulation and visualization tools, CityZoom also has its own data analysis tool, Mosaic.

Figure 4
Mosaic window

Mosaic (Scheidegger, 2002; figure 4) is a model correlation tool which allows visual access to the information generated by the performance models and/or entered manually by users. It works by applying a regular orthogonal grid over the urban area, effectively dividing it in square cells of the same size. Each of these cells is then assigned a numeric value, depending on the attribute that the grid is supposed to represent (for example, used area, or building height). This grid then works as a spatial representation, where each cell holds a value corresponding to the relative intensity of the attribute. In order to easily determine patterns and canters of density, an appropriate value to color mapping (a color scale) is used in each grid.
The information can be retrieved at any city region or required level (blocks, plots, streets, street segment or buildings). The information can be modularly aggregated or disaggregated in different and progressive steps. This allows a modular grid to be disaggregated into a 5x5 meter grid (almost the size of a small building projection) and to be aggregated up to a 200x200 meter grid (the size of a group of blocks).

From the original grid, called primitive map, it is possible to derive new ones, using map algebra (such as sum, multiplication etc) and image-processing filters, in a way very similar to the way raster GIS work with its maps. Mosaic’s ability to analyze and correlate different aspects of the city allows an urban planner to unveil the underlying structure and patterns that in most complex cities are hidden behind a significant amount of data.

However, with the advances in GIS tools, there are several great commercial packages for spatial analysis and mapping. With the increasing demand for integrated CAD and GIS analysis, a new laboratory joined the team. With expertise in GIS tools as Idrisi Developers, they have helped the SimmLab to implement CityZoom’s interface with shape files (.SHP), the ESRI geospatial vector data format. This interface allows both the importing and exporting of neutral GIS files to and from CityZoom.

CityZoom can feed data to commercial GIS software, enabling a whole new set of analysis to be done over CityZom generated data. Similarly, GIS files can be edited in CityzZoom, providing a very intuitive and desirable user interface, which is not a feature of every GIS package.

**Conclusions**

Beyond described applications, CityZoom and its modules constitute a powerful tool for the evaluation of the impact of urban regulations, showing clear advantages over existing GIS and Cad software. CityZoom also help planners to adjust urban regulations to performance targets as to anticipate the impact of different urban regulations in order to achieve desired environmental goals.

CityZoom is a powerful visualization tool when used in participatory planning processes. Its output allows an easy understanding of the likely effects of norms and numbers by people in general, who otherwise would have severe difficulties to understand complex numerical data. It has been used, in Brazil and abroad, in different ways as in technical sessions with planning officers, in decision sessions about planning regulations at municipal councils and in urban design exercises at Architecture and Urban Planning graduate and undergraduate courses.

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**References**


