CITYZOOM – A TOOL FOR THE VISUALIZATION OF THE IMPACT OF URBAN REGULATIONS

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Abstract

Visualization has been used for many years as an important way of presenting architectural design and projects. However, beyond design, planning urban areas requires the analysis of different factors. Urban regulations are planning tools used to control and/or stimulate changes in the urban structure and to reproduce a certain level of quality of the urban milieu. Land area, built area, plot rate, average building height, and other important attributes can be easily obtained from the geometric objects in the city model or explicitly associated to them. This paper presents a system, CityZoom, which integrates several performance tools that allow the simulation of different attributes related to a planned or existing city. These attributes are shown in different ways either as tables of attribute values estimated from model evaluation, or 3D scenarios where the user can navigate and observe realistic shadows and daylighting estimation based on the concept of solar envelope.

1. Introduction

Urban regulations are planning tools enforced by municipalities in order to control and/or stimulate changes in the urban structure and to reproduce a certain level of quality of the urban milieu. They attempt to summarize different aspects of this quality. Building heights, plot ratios, building footprints and other elements are seen as determinants of some attributes such as visual obstruction, thermal comfort, availability of infrastructure, energy consumption, etc.

These regulations do not determine how the city will be, i. e. they do not constitute a matrix for the final shape of cities. They simply establish some constraints, thresholds and/or potentials to be followed by those who want to construct buildings.

If, at one hand, it is possible to simulate a desired city according to urban regulations, on the other hand this possible city is never built either because builders decide not to build in each plot according to the general constraints or because urban regulations changes over the years. The result of this process is a very idiosyncratic urban form, which is different from the idealized form. If urban regulations attempted to interpret these forms, new buildings would adapt better to the actual circumstances and a reciprocal profit be established between existing buildings and new buildings. This will require much more flexible urban regulations than the ones that exist at the moment.

The formulation of rigid urban regulations is a conventional practice for most urban planners. However, the assessment of the impact that may occur in cities every time that a new building is built put to these planners a far more difficult problem to be solved. It might be for this reason that the work of most urban planners do tend to stagnate at the formulation of the regulations. Planners tend do resign themselves to evaluate new buildings from the point of view of the established regulations conceived neither for the ideal city nor for the real one. The concept of building fitness is then related to an ideal city rather than to the existent structure.

Attributes such as visual obstruction, thermal comfort, energy consumption and urban drainage are intrinsic to any new building. At the same time, they do affect its immediate and more remote neighborhood. It is argued that the availability of adequate tools for the simulation of the reciprocal influence between these different attributes in the real city will help planners to intervene in the gap between the ideal city and the real city. The simultaneous correlation between the built form, urban regulations and different urban attributes could help urban regulations to be more flexible and therefore to approximate the real city from the main goals of the ideal city. The main challenge would therefore be how to assess aspects of the built form from different points of view so as to allow a different assessment each time that a building is built. The measure of building fitness will then be the result of the balance between the different intervening aspects in the existing urban fabric.

These aspects are independent, and also have independent evaluation criteria. They do not look like each other, but are correlated, which means that the improvement of one of them can cause unfavorable consequences to another. It follows that to observe how these aspects are related to each other, it would be necessary to use techniques to model cities that were sensible to the functional aspects being analyzed [1]. This complexity could be better understood only if the most important variables involved into a problem could be visualized in an integrated way.

However, there are no tools for the correlation of urban regulations to energetic, climatic, structural, and other attributes in the same computational environment. This will require the integration of different bodies of knowledge concerning urban performance. Urban regulations will then be seen as flexible tools, associated to this database and act as guide lines to reach environmental targets. The database could be visualized by a computational tool and used to take strategic decisions about city planning. A Decision Support System (DSS) operating over a database containing different aspects of a city would generate fast visualizations to different planning and urban growth options, considering the interrelations between these aspects.

This paper presents this tool – CityZoom – and it is organized in four sections. In the second section, a short review of the main computational tools associated to urban and building performance is presented. Section 3 shows CityZoom simulation modules and, in section 4, visualization tools are presented. Conclusions constitute the last section.

2. CityZoom

CityZoom [2] started as an urban planning research project and at its current development stage, is a Decision Support System for urban planning. It provides an environment where different building performance models can operate interactively, aiming to optimize the urban planning process. Each of these models corresponds to a module that implements them in the computational environment.

Its main difference and strength if compared to CAD or GIS is that a specific city model was designed. Data is represented in an object-oriented model representing the urban structure (city, blocks, roads, plots, buildings, etc. – see Figure 1) so that information can be obtained at any required level.

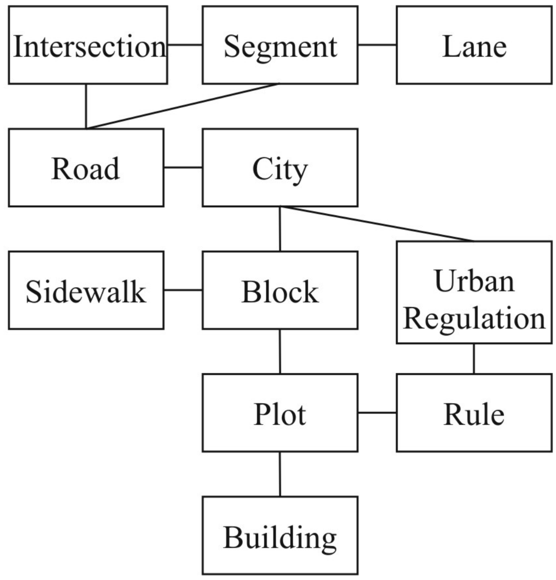

Figure 1: CityZoom city model

Each performance model in the CityZoom environment operates within its correspondent part of the computational structure, affecting all the related objects and models. Model integration is possible, since the correlation between any given parts is determined by the model (e.g., the building is contained by a plot, and a set of plots is contained in a block).

The main tool is a graphical editor (Figure 2) of urban structures. Data can be input in different ways, such as: freehand drawing of the urban structure, using a background aerial picture as reference, importing neutral file types (AutoCAD DXF, ArcView SHP, etc.), or by a direct connection to a spatial database. The data can then be used by the CityZoom's models, which are described in the next sections.

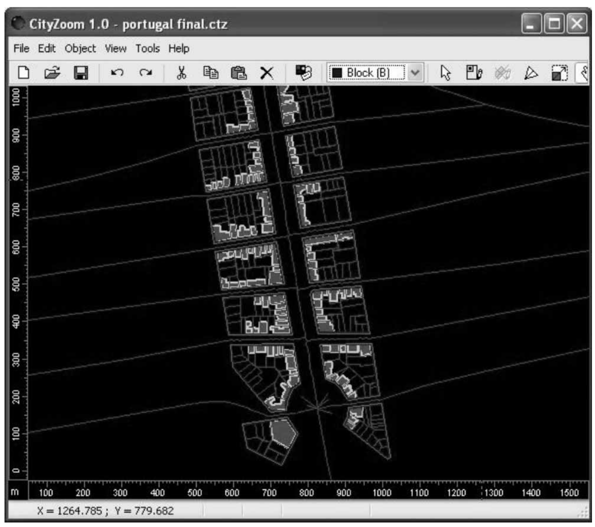

Figure 2: CityZoom main interface

2.1. BlockMagic

BlockMagic [3] is the model for simulation of the building potential of urban plots, based on urban regulations. It can swiftly generate large sets of buildings in the most different urban scenarios, or validate user-built edifications.

Buildings are generated by applying urban regulations on the plot geometry according to input parameters which determine which of the building characteristics are to be assessed or optimized, such as number of floors, front or size width, slab area, plot occupation and plot ratio. It is also possible to fit the building shape to the plot size and shape, or to use a designed building shape.

Urban regulations are fully customizable, using the Urban Regulation Editor (Figure 3), allowing the input of arbitrary rules and the immediate evaluation of the impact resulting from these rules in a single plot, set of plots, or whole blocks.

BlockMagic also addresses environmental comfort issues, through the use of the Solar Envelope [4] technique. 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. The way these measures are set decides the envelope's final size and shape [5, 6].

Planning for insolation is essential in establishing the visual and thermal comfort, i.e., the benefits to be obtained from the 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.

The Solar Envelope is represented by a set of obstruction angles. Applying these angles to a plot, it is possible to obtain the maximum volume a building can occupy without casting undesired shadows over the immediate neighborhood.

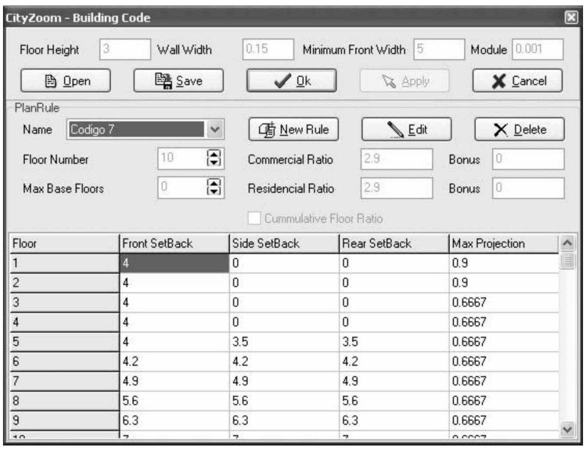

Figure 3: Urban Regulations Editor

The integration of the Solar Envelope into BlockMagic is obtained by converting the obstruction angles into setbacks, verifying the plot orientation, and then applying these setbacks along with the urban regulations during the simulations. It is then possible to maximize the plots building potential and solar radiation access and its benefits.

3. Visualization of simulation results

Simulation of the building potential of urban plots generates buildings by applying urban regulations on the plot geometry. The input parameters mentioned in section 2.1 determine which of the building characteristics are to be assessed or optimized.

Results 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. 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 (Figure 4). Land area, built area, plot rate, average building height, and other important attributes can be easily summarized.

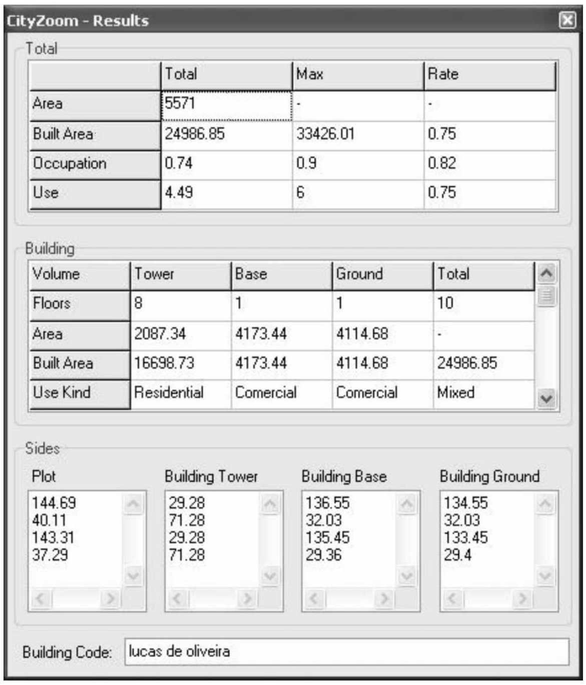

Figure 4: Numerical Results Viewer

3.1. Mosaic

Mosaic [7] (Figure 5) is a model correlation tool, built inside CityZoom, which converts data from the model evaluation of any city object attribute applied to its shape (in a polygon as opposed to a bitmap) to a regular grid of cells. The obtained grid is a regular mesh over the city geometric model, and data values associated to the grid are mapped to different colors. The grid itself becomes an image that can have a pixel resolution of arbitrary size. Thus, data obtained from different models, applied to different city objects can be compared.

A subset of the functionalities of a raster GIS was implemented. The obtained images are called *primitive maps*, and the user can employ map algebra to operate and compare these maps. Simple operations, such as sum and multiplication can be applied to generate *derived maps*. This tool is essential to allow city planners to obtain new information by combining data from different models.

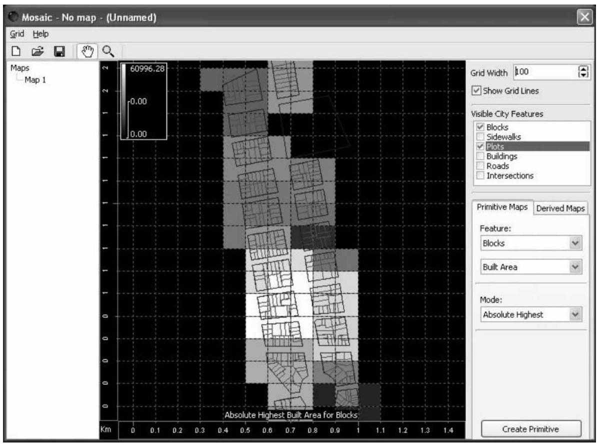

Figure 5: Mosaic

3.2. 3D Viewing Tool

CityZoom also provides a 3D visualization tool (Figure 6), implemented using the OpenGL library. It is 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.

The 3D viewing tool also supports generation of realistic shadows in real time, based on the date and time input by the user. Moreover, the Solar Envelope can be shown (Figure 7) superposed to the existing or simulated city objects. This allows the verification of the relations between the buildings, allowing observing the impact of one building in the lighting of the others. This impact varies depending on the location of the city, date and time, and the simulation of the solar path during the say can be dynamically shown along the 3D view of the buildings, with changing shadows and solar envelopes (Figure 8).

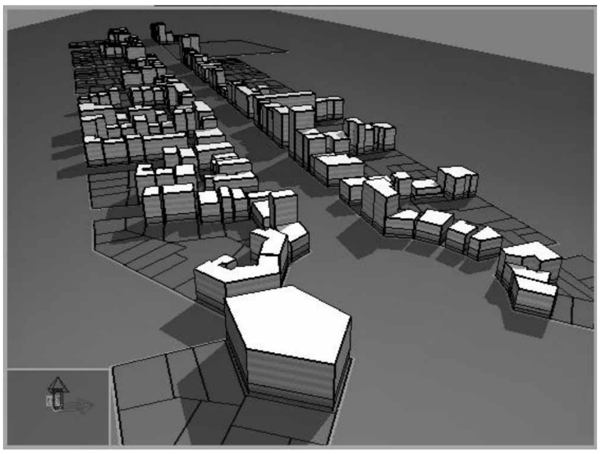

Figure 6: 3D Visualization tool

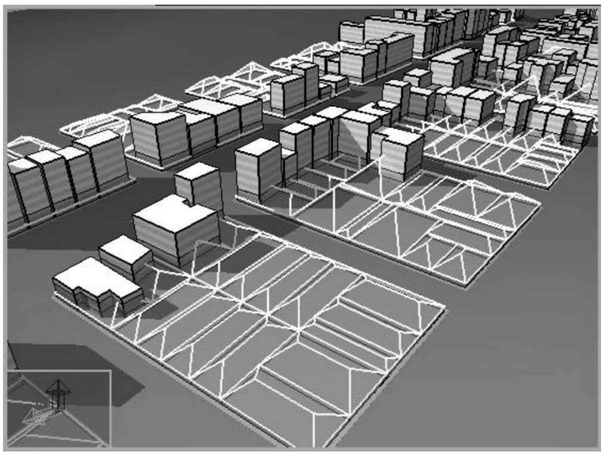

Figure 7: 3D view with superposed Solar Envelope

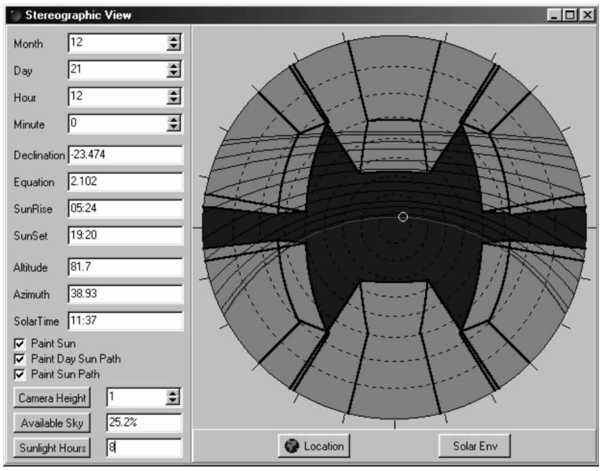

Figure 8: Solar path depending on the time of the day.

4. Conclusions

Beyond the described applications, CityZoom and its modules constitute a powerful tool for the evaluation of the impact of urban regulations. It helps to reduce the difference between targets of performance models to the real city in that it apply the parameters of ideal performance to the existent streets, blocks, plots and buildings. CityZoom also help planners to adjust urban regulations to the targets of performance models. This way it is possible to anticipate the probable result of different urban regulations and therefore to choose the best set of rules and parameters in order to achieve desired environmental goals.

CityZoom constitute, as well, a powerful aid in processes involving community participation in planning decisions. Its visualization capabilities are easily understandable by people in general, which otherwise would have to analyze intricate data. It has been used, in Brazil, in different situations such as technical sessions with planning officers, in decision sessions at municipal councils and in design projects at Architecture and Urban Planning courses.

Acknowledgments

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