Studies of Volumetric Potential in Pampulha, Brazil

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Introduction

The visualisation is a key support in an urban environment analysis. Whether representing real physical aspects of the city or abstract information, the visualization has a great potential of both improving the general understanding of urban related aspects and supporting the decision making process in urban planning activities. This work intends to contribute with a methodology process for the simulation and visualisation of volumetric potential studies in urban analysis using Lidar (light detection and ranging) data for Pampulha Region in Belo Horizonte, Brazil for the years of 2007 and 2015.

Maps are primarily informative. Therefore, when one goes from 2D to 3D representation is necessary to analyse if there is a gain in information. One great contribution of 3D representation is the possibility of visualizing abstract information such as the urban regulations that shape the city. Amoroso (2010, xi) defends the abstraction of urban data from the textual format to a visualization. Among others forces, she mentions criminal activities, population densities and air-quality as examples of these abstract forces that also shape the city and she argues that the visualization can provide deeper insights as it enables to take those aspects into account.

Between the benefits from the visualization, there are the faster and easier understanding of urban aspects, and the possibility of supporting the decision making process. A relevant problem in the decision process in urban planning is the complexity of the urban regulations. In general, the most frequent format to present the rules for urban occupation in Brazil is through texts and tables which are of difficult decoding. This can become an obstacle for the community participation on the planning process in general, and can also increase the informal city areas where the urban regulations are not applied because people tend to consider it a difficult process (Zyngier, 2012).

The main goal of this work is to present a methodology approach for the simulation and visualisation while developing a study of envelops and volume stocks in Pampulha, Brazil. The selection of the study area was a result from the Geodesign Pampulha Workshop – Third Iteration developed by the Geoprocessing Lab/EA/UFMG, Belo Horizonte, in March 2016. As a result from the Workshop, five priority areas were chosen for residential densification. However, only one of those areas was used for this analysis in order to simplify the processing time.

The process of analysis was based on three main steps: first, it was necessary to update the cadastral polygons from 2007 which were provides by PBH-Prodabel, in order to have the Lidar dataset matching the polygons of buildings' projections; then, the heights were extracted from the Lidar dataset; and last, the occupation was simulated in CityEngine software using only the existing buildings at first, and then, calculating the possible volume stocks.

As a final product, the work presents both a visual and a textual analysis of the relation between the existing volumes and the volume stock available for area analysed. The intention is to reach a gain in visualization in relation to 2D maps that could also show the same information even if only in a binary format (yes or no for volume stock).

Methodology

The first step during the simulation process was to update the cadastral information of lots and buildings projections. The initial cadastral data provided by PBH-Prodabel was for 2007 so that an update work was necessary to have the 2015 Lidar dataset matching the actual polygons. This process was executed by visual control using a high resolution image of the area also from 2015 provided by PBH-Prodabel. The new and altered polygons (lots and buildings' projections) were vectorised and properly identified as non-official data in the ArcMap software.
Secondly, the Lidar dataset was transformed in height information for each one of the existing buildings. Lidar is a remote-sensing technique that collects surface elevation information from points in the surface through the use of laser light (ESRI 2016). The Lidar dataset needed to be converted first from LAS to Multipoint, and then, from Multipoint to Singlepoint in order to extract the "Z" value of the points and interpolate a raster surface from them. As the point cloud dataset from Lidar covers a continuous surface without distinguishing the elements, the additional information such as elevation from cars, vegetation and so one were excluded using the buildings' projections as a delimitation layer. Also, to avoid variations in the heights of the same element, the majority elevation value for each element was extracted generating only one elevation value for each buildings in the study area. Last, to reach the height information for buildings, the terrain elevation from the central point of the building projection was subtracted from the elevation information generated from Lidar dataset.
After reaching a height information for each one of the buildings' projections, the some steps were developed in CityEngine. For the simulation in CityEngine, it was important to have both the buildings and the lots cadastral polygons in shapefile (shp) formats associated with parameters that define the volumetric potential, or maximum occupation for each lot. Although there are great variations in the land use regulations among the cities in Brazil, in general, the maximum occupation is defined by a coefficient of utilization called *CA* (*Coeficiente de Aproveitamento*) that is applied to the total area of the lot, and the resulting area is assigned to the possible area of occupation (*TO – Taxa de Ocupação*), which is the lot's area reduced by the applicable setbacks, and find out the maximum height. Thus, the first CityEngine's procedure was to simulate the existing conditions applying a simple extrusion of the heights on the buildings' projections shape. Then, volumetric stocks for the existing buildings were simulated for each building according to its applicable *CA*. Last, volumetric stocks for vacant lots were simulated creating a *TO* area, according to the setbacks, and extruding a volume up to the maximum allowed by the *CA*. This was the only case where the simulation actually represents a maximum envelope.

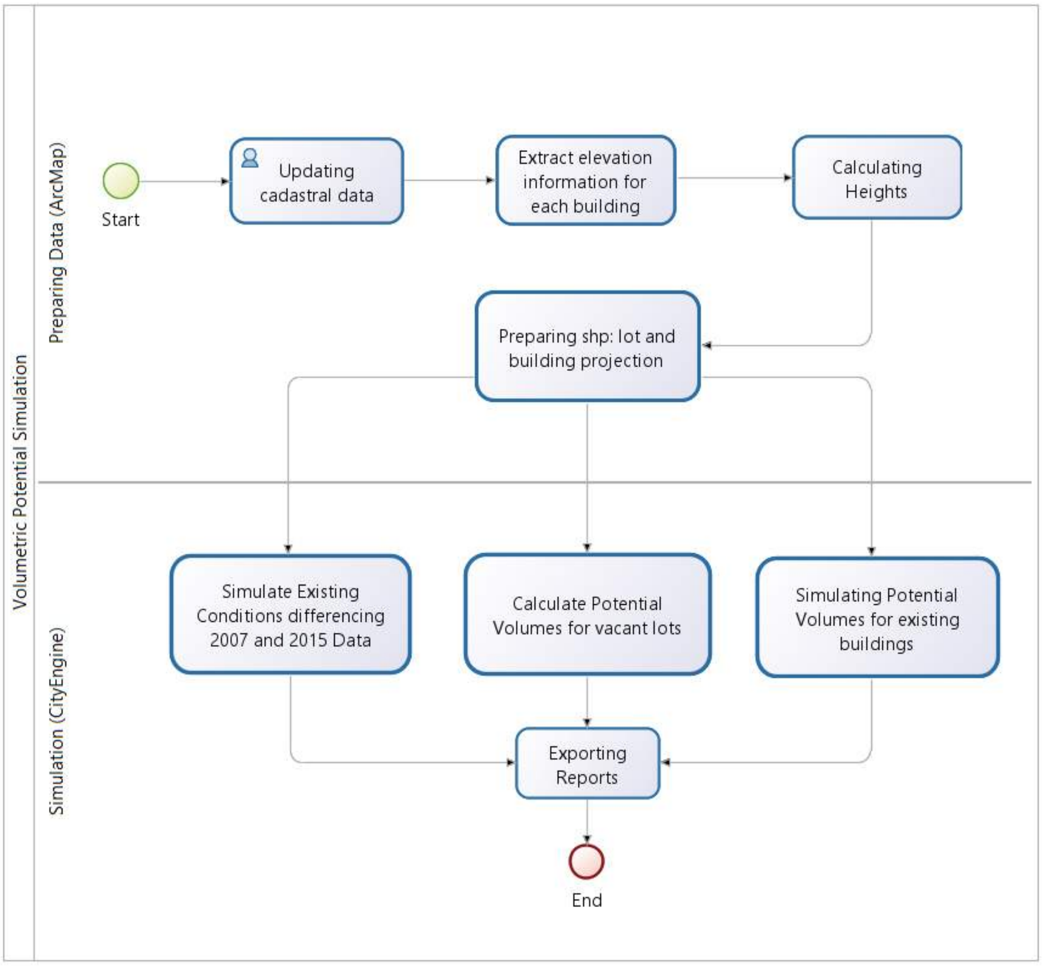

Fig. 1. Methodology process diagram.

CityEngine also offers the possibility of reporting information from the model. The access to this reported information enables the analysis of the alterations occurred. For instance, it is possible to analyse the relations between the occupation in the two periods, and the volumetric relations between existing buildings and stocks.

Results

The simulation of the existing conditions through the extrusion of the buildings' projections (figure 2) enables a temporal analysis of the occupation between 2007 and 2015. Most of the transformed areas in the region analysed are in a preferred densification zoning (*ZAP*). Around 70% of the total altered buildings are in the *ZAP* zoning area, while second most transformed areas are in *ZAR2,* a restricted densification zoning. The increase rate in the number of units for the *ZAP* area was 4,5%, while for *ZAR2* it was 3%. This shows the transformation potential of densification zonings for the analysed areas. From the volumetric aspect, the new buildings correspond to about 9% of the total existing volume in the area as shown in Table 1.

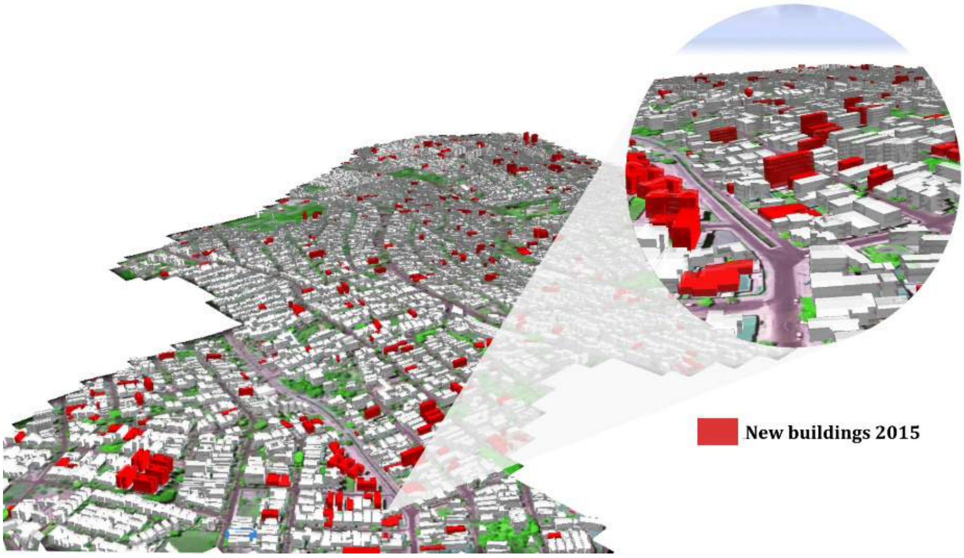

Fig. 2. Simulation of the existing conditions.

Tab. 1. Report from CityEngine's simulation of the existing conditions.

Report	Sum Vol	%	Avg/Vol
Updated Buildings	294,583.95	4.401546	1137.389774
Original Buildings	6,092,581.92	91.03272	941.6664485
Edited Buildings	305,572.76	4.565736	1608.277684

For the volumetric stocks of vacant lots, the simulation showed that there is still some availability for occupation. (Figure 3). The volume stocks of vacant lot represent about 2% of the total volume allowed by the zoning regulations for the total area.

Fig. 3. Simulation volume stocks.

Finally, comparing the existing buildings with the volume stocks for the study area, the simulation shows that most of the buildings still have great amount of stocks. It is important to highlight that although the existing conditions represent real physical information, the volume stocks simulations are abstract information. Therefore, the stocks does not necessarily represent envelopes, but instead they can represent a potential for construction. Figure 4 shows both abstract and physical information.

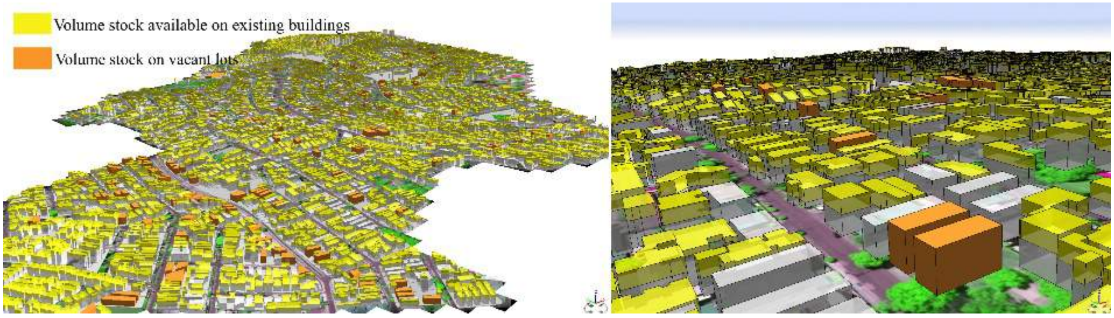

Fig. 4. Simulation volume stocks & existing volumes.

Conclusions

From the results presented, it is possible to observe a gain in the reached visualisation. The interpretation of the relation between the existing volumes and the volumetric stock available goes beyond the binary information (yes or no for volume stock), and offer a visual representation that enables the perception of the proportions and relations between the volumetric elements. Also, through the report possibility offered by CityEngine was possible to quantitatively analyse the transformations occurred in the area not only in a visual but also in a textual way.
Further studies which are already in process intend to explore the reached outputs such as the areas with great amount of volume stock, with a prognostic approach. The goal is to simulate and analyse scenarios for future occupations according to the present-day applicable urban regulations.

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