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PÔSTER

3D SURFACE MODELS FOR URBAN PLANNING AND LAND VALUE CAPTURE: A CASE STUDY OF RIO DE JANEIRO'S CADASTRAL SYSTEM

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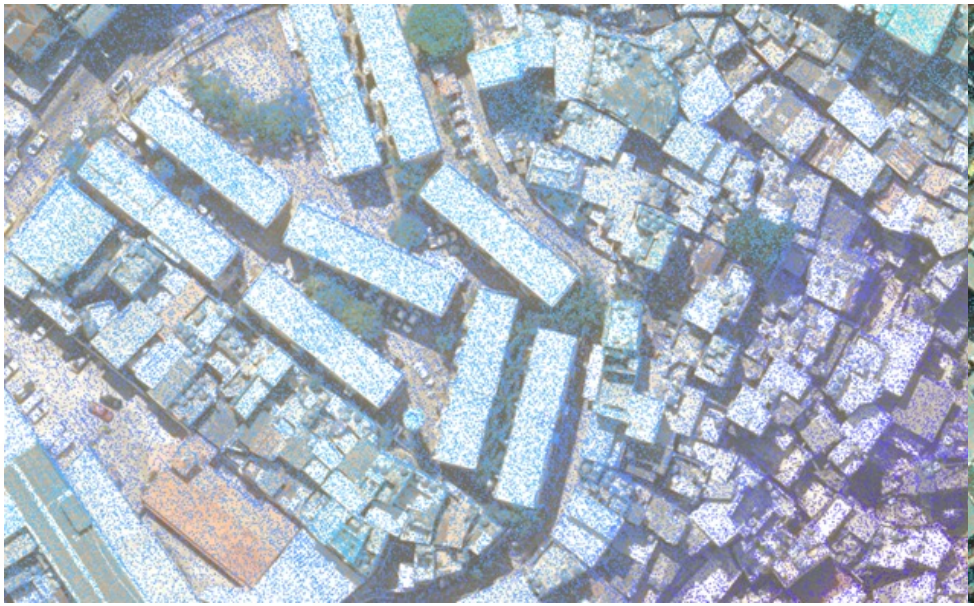
INTRODUCTION

The city of Rio de Janeiro is characterized by a highly complex dynamic in its formal and informal real estate markets.
In recent years, this dynamic has become even more complex, as limitations on the horizontal expansion of favelas, subdivisions, and occupations have led to more pronounced verticalization—either through the addition of floors to existing buildings or through the irregular construction of multi-family buildings.
It is of essential importance for the management of the city of Rio de Janeiro to understand how and where this verticalization is occurring

Example of informal construction in Rio de Janeiro (source: O Globo)

MATERIALS

Digital Elevation Model from LiDAR - referenced to the 2019 flight;
Digital Elevation Model from LiDAR - referenced to the 2024 flight;
Building Footprints - Originally digitized from a 2013 aerial survey, the layer was updated against the 2019 data and comprises 2D polygons, each with a height attribute.

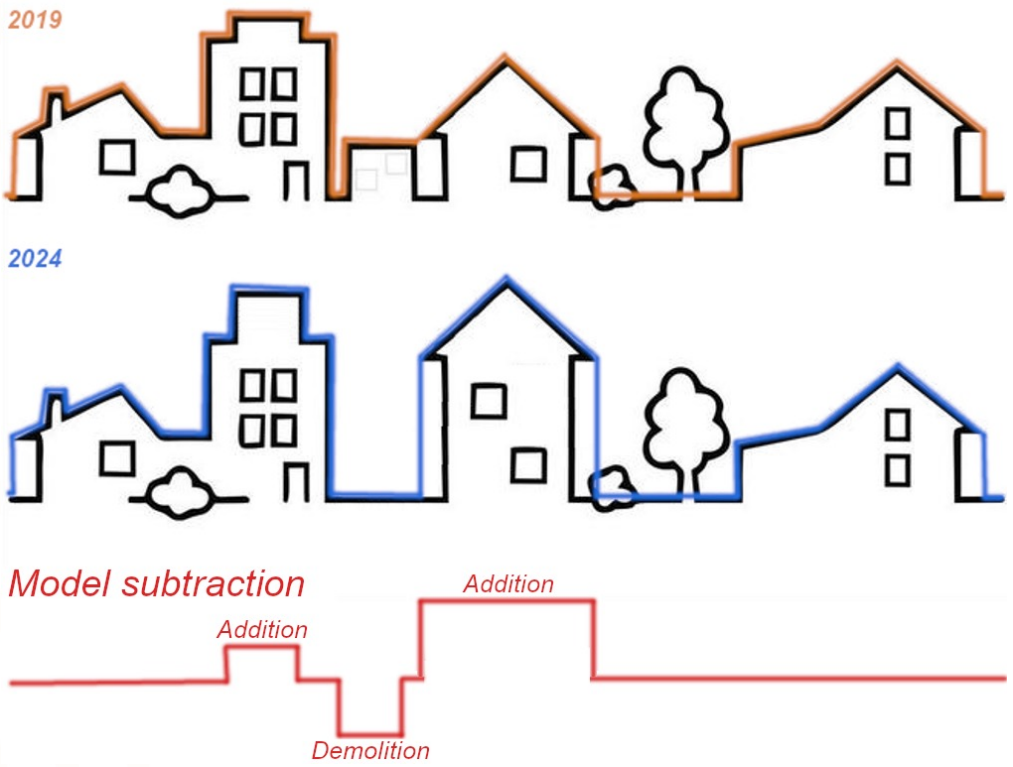


LiDAR point cloud (8 points/m²) over an orthomosaic – both from the 2019 flight and covering an area of Rocinha, Rio de Janeiro

LiDAR point cloud (8 points/m²) over an orthomosaic – both from the 2024 flight and covering an area of Rocinha, Rio de Janeiro

METHODS

1) The LiDAR point clouds were filtered to include only returns classified as ground (1), low vegetation (2), and building (6).This ensures the resulting models represented exposed ground and buildings, excluding trees and other features irrelevant to analyzing vertical construction growth.
2) The filtered point clouds were then converted into raster files with a 0.5-meter spatial resolution. The elevation value for each pixel was rounded to the nearest integer.
3) A pixel-by-pixel subtraction of the 2019 model from the 2024 model was performed. This operation generates a synthetic raster image (a Digital Difference Model) where positive values indicate vertical addition (new floors/structures), a value of zero indicates no change and negative values indicate demolition.
4) Zonal statistics to summarize the mean per building (using the 2019 vector building footprint dataset).



RESULTS

The initial datasets underwent a reclassification process using 3-meter intervals as thresholds.
-3: Altitude differences below -3m (Demolition) – represented by the color purple.
no color: Absolute altitude differences less than 3m (Inconclusive whether addition or demolition occurred).
3: Altitude differences above 3m and below 6m (Addition of 1 floor) – represented by the color yellow.
6: Altitude differences above 6m and below 9m (Addition of 2 floors) – represented by the color orange.
9: Altitude differences above 9m and below 12m (Addition of 3 floors) – represented by the color coral.
12: Altitude differences above 12m and below 15m (Addition of 4 floors) – represented by the color red.
15: Altitude differences above 15m (Addition of 5 or more floors) – represented by the color crimson.

Vertical growth in the Muzema region 2019-2024 over 2024 orthoimagery (raster and vector datasets)

RESULTS

Nevertheless, these raster datasets contain several artifacts, which look like minor demolitions among the edges of buildings. These stem from minor planimetric differences between the two models and, while not necessarily difficult to understand for trained personnel, may be hard to guess for regular users not fully acquainted with geotechnologies. On the other hand, when summarized per building, the same model is clearer and easier to read. Notice that this procedure does not capture new constructions - only changes in buildings already extant in 2019.

From the comparison between the two products, it is possible to identify areas of significant expansion from bare ground or through deforestation, as in this example from Rocinha Favela (2019-2024 over 2024 orthoimagery), alongside expansion by adding floors to extant buildings.

RESULTS

Another important application of this building model is to compatibilize permits and actual construction, as can be inferred from the figure, which shows a large condominium entirely built from scratch, whose altitude was properly captured by the procedure.

Finally, when summarized through zonal statistics, the dataset could also be used as a virtual 3D model, which easily helps identify notable changes in building height, and significantly enhancing the dataset's utility for both analytical purposes and visualization.

ACKNOWLEDGEMENTS

The authors acknowledge the support of the Pereira Passos Municipal Urban Planning Institute and of the Rio de Janeiro City Hall.

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