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Analysis of the semantic quality of the topographic mapping of Porto Alegre

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Abstract:

Topographic mapping is a reference for urban planning, territorial management, engineering projects, and other activities. With the technological advances in geoinformation science, we notice a growing demand for geospatial information. As a result, new means of visualizing and using cartographic information have emerged, stimulating the generation of cartographic products and the dissemination of geospatial data. However, users and producers are not always experts.

Many countries and institutions developed norms and standards that encompass the assessment of positional and semantic accuracy of geospatial data. In Brazil, there are norms and technical specifications regarding geospatial data quality, such as Decree No 89,817, the Technical Specification for the Acquisition of Vector Geospatial Data (ET-ADGV), the Technical Specification for Geospatial Data Quality Control (ET-CQDG), and the Technical Specification for the Structuring of Vector Geospatial Data (ET-EDGV). However, the inclusion of large-scale topographic maps (1:1,000, 1:2,000, and 1:10,000) in national regulations was just in 2017 with the ET-EDGV version 3.0.

The International Organization for Standardization (ISO) created the ISO 19157:2013 standard, which updated and established parameters characterizing positional and semantic quality of the geospatial data. This set of parameters includes Completeness, Logical Consistency, Positional Accuracy, Thematic Accuracy, Temporal Accuracy, and Usability. ISO 19.157:2013 was the basis for elaborating the ET-CQDG (DSG, 2016) and the Technical Manual for Geospatial Data Quality Assessment (IBGE, 2017).

Completeness refers to the absence (Omission) or excess (Commission) of features in the map, according to the scale of cartographic representation. Omission occurs when a feature that should be represented is absent, while commission occurs when a feature that should not be represented is included in the map. Thematic Accuracy evaluates the correctness of the attributes of mapped features, and it is classified as the Accuracy of Non-quantitative Attributes, Accuracy of Quantitative Attributes, and Classification Accuracy (DSG, 2016).

Considering the importance of assessing semantic quality in topographic maps, this paper presents a methodology for the identification and quantification of Completeness and Classification Accuracy errors of a select subset of geographical information represented on the topographic maps of the municipality of Porto Alegre. We adopted the standards and criteria defined in the Planning Report for the Development of the Cartographic Base – Digital Topographic Mapping of Porto Alegre (PMPA, 2011). According to this document, the information displayed on the maps is organized into nine general categories: Transportation System, Energy, Hydrography, Vegetation, Mining, Urban Structure, Elevation, Reference Points, and Boundaries. For the analysis, we chose the categories Transportation System and Urban Structure. The classes of features of Transportation System are: Streets and Alleys; Curbs; Median Strips, Roundabouts, and Shoulders; Blocks; Railways; Bridges and Viaducts; Footbridges; Stairs and Ramps; Airport and Approach Cone; and Bus Stops and Bus Terminals. And for the Urban Structure category, we analyzed the classes: Buildings; Squares and Parks; Fences and Walls; Urban Lots; Sports Courts and Soccer Fields; and Interior Parks.

The methodology entails data selection, definition of the study area, definition of the cartographic language, identification of Completeness and Classification Accuracy errors, and quantification and mapping these errors. We used QGis software, version 3.8.1, Zürich. Identifying Completeness and Classification Accuracy errors was done through visual analysis, using orthophotos as reference data, and topographic mapping as test data. The orthophotos have a spatial resolution of 12.5 cm, and the topographic maps are at 1:1,000 scale. We also used the Statistical Grid of the Brazilian Institute of Geography and Statistics (IBGE, 2016) to minimize the occurrence of errors in the visual analysis. This statistical grid is 200 x 200 m in the East-West and the North-South directions. The grid system ensures

continuous visual analysis, independent of political-administrative boundaries, promoting the spatial-temporal stability of the data, adaptation to spatial divisions, versatility, hierarchy, and flexibility (IBGE, 2016). We verified the 16 feature classes in the Transportation System and Urban Structure categories, quantified the errors, and created thematic maps representing their spatial distribution.

We identified 1,653,673 features in the Transportation System and Urban Structure categories and found 1,936 Completeness errors, including 1,845 Omission errors and 91 Commission errors, as well as 144 Classification Accuracy errors, totaling 2,080 errors. These correspond, respectively, to 0.111%, 0.005%, and 0.009% of the occurrence of errors, considering the total number of features. This result indicates that the topographic mapping has an adequate semantic quality.

We found Omission errors distributed across almost all neighborhoods, mainly due to the absence of representation of the fences and walls class. Commission errors are predominant in the northern part of the study area caused by the representation of buildings that do not exist in the orthophotos. Classification Accuracy errors are mostly located in the Islands region and concentrated in the Bridges and Viaducts class. Figure 1 shows the maps representing the spatial distribution of Omission, Commission, and Classification Accuracy errors.

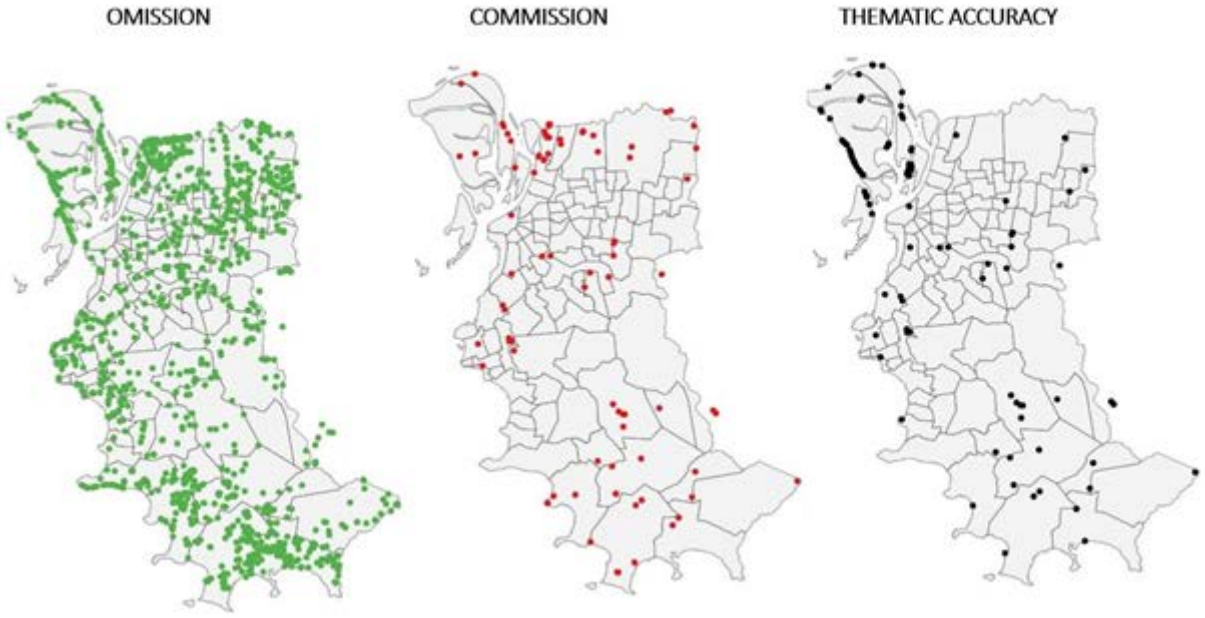

Figure 1. Distribution of Omission, Commission, and Classification Accuracy errors.

The methodology proved to be efficient for analyzing Completeness and Classification Accuracy in the topographic mapping of Porto Alegre. As a future direction, we intend to automate the identification of completeness errors, since the current methodology demands substantial manual effort. This advancement could improve the efficiency of semantic quality assessments in large-scale topographic mapping, and it may also be applied to other areas and adapted to different mapping scales.

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