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Towards assessing generalization quality with visual complexity measures

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Abstract

This paper presents preliminary results on a visual complexity study with maps where we attempt quantifying generalization quality using algorithmic visual complexity measures.

Keywords: map complexity, visual complexity, clutter, generalization

Introduction

Generalization is perhaps the most persistent challenge in cartography, and with the advent of digital maps, its relevance has only increased. As we zoom in and out, some objects are removed; others are enlarged, aggregated or displaced, and all objects are simplified (Ruas, 2008). Traditionally, generalization has been manually performed and visually assessed (Bard, 2004). Visual assessment of the generalization results by experienced cartographers is still probably the best mechanism for detecting errors. Only a trained eye can detect whether important features are missing, whether shapes retained their characteristics, or if an unwanted fusion of two distinct objects occurred. However, with the automatization and on-the-fly generalization of big spatial databases, visually assessing every map has simply become unrealistic due to the amount of materials to be evaluated. Thus, there is a need for an efficient, computer based, approach for quality assessment. In this study, we assess the suitability of two algorithmic approaches in determining some aspects of generalization quality, specifically to measure the preserved information after generalization.

Methods

The metrics we feature in this paper, similarly as Schnur et al. (2010), are Feature Congestion (FC) and Subband Entropy (SE), proposed by Rozenholtz et al. (2007). Both the FC and SE are based on psycho-physiological principles of visual attention, thus we hypothesized that they would overall correspond with cartographers' visual assessment of generalization quality. To test our hypothesis, we first conducted a computational experiment to measure the visual complexity of 12 online maps in 16 zoom levels (5 to 20) from various map providers (Bing Maps[1], Bing Hybrid[2],

[1] https://www.bing.com/maps/

[2] http://www.arcgis.com/home/item.html?id=71d6d656cb2a4ded8fce35982ebdff25

ESRI Topo[3], HERE WeGo[4], Google maps[5], Google Terrain[6], Google Hybrid, OSM Hike and Bike[7], OSM Road[8], OSM Topo, Google satellite and ESRI satellite). Then, we conducted a user experiment, in which we asked cartographers to evaluate the amount of information on subset of the studied maps (zoom levels 6, 10, 14, 16 and 18).

Preliminary results and outlook

Overall, we found a moderate positive correlation between the cartographers' ratings and visual complexity metrics (cartographers-FC: $rs= 0.33$, $p < .001$; $r = 0.33$, $p < .001$; cartographers-SE: $rs= 0.38$, $p < .001$; $r = 0.41$, $p < .001$). These results suggest that the cartographers' judgment can be substituted with the FC and SE metrics only to a small degree. Surprisingly, cartographers and algorithms have agreed the most in the assessment of Bing Maps (cartographers-FC: $rs= 0.61$, $p < .001$; $r = 0.62$, $p < .001$; cartographers-SE: $rs= 0.58$, $p < .001$; $r = 0.53$, $p < .001$), while the weakest agreement was for Google Road maps, which was also most preferred by cartographers (cartographers-FC: $rs= 0.20$, $p < .001$; $r = 0.21$, $p < .001$; cartographers-SE: $rs= 0.21$, $p < .001$; $r = 0.23$, $p < .001$). These results open another question: Do the FC/SE work better for certain maps, or do cartographers overlook some issues on their favorite maps? Furthermore, we studied the interactions between zoom levels, cartographers' assessment and algorithmic visual complexity. At zoom levels 14, 16 and 18, cartographers' assessment corresponds to the algorithmic visual complexity: Stimuli with the lowest FC/SE were rated 1 (too little information), while those with the highest FC/SE were rated 5 (too much information). Importantly, cartographers' assessments constantly increased as the FC/SE increased.

There are still some unanswered questions about the suitability of FC or SE to assess the quality of cartographic generalization, and more studies are needed. However**,** we believe that our research contributes to an overall understanding of how visual complexity measures can reflect the quality of geographical data generalization and visualization (further analysis and details will be published in a follow-up paper).

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