Quantifying Magnitude of Change for Animated Maps

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Abstract

The development of multimedia technologies has resulted in production and distribution of various types of animated maps, in which users can easily recognize movements or changes of map components over time and space. Animated maps are fundamentally different from static maps not only in terms of the characteristics of phenomena represented, but also the perceptual-cognitive aspects of visual stimuli. For example, animated maps are based on a one of the core principles of the vision mechanism for processing visual stimuli, *retinal persistence*, based upon which animated maps can be effective in emphasizing changes between map scenes (Cauvin et al. 2010). Owing to these traits, cognitive and usability research has evaluated effectiveness of animated maps. They have revealed that although animated maps represent time-dependent phenomena well, animated maps sometimes fail to satisfy the Apprehension Principle (Tversky et al. 2002), by which "the structure and content of the external representation should be readily and accurately perceived and comprehended." Some empirical studies imply that too complex and dynamic animated maps lead to difficulties in conveying information (Bétrancourt & Tversky 2000, Morrison & Tversky 2001, Fabrikant et al. 2008, Goldsberry & Battersby 2009).

Therefore, to make well-designed animated maps, it is fundamental to address the question of how dynamic visual variables including magnitude of change (MOC), duration, order, display date, frequency, and synchronization (DiBiase et al. 1992, MacEachren 1995) influence users' performance in map reading. This study focuses on MOC because representing changes between map scenes is a main advantage of animated maps. Some research has discussed the cognitive aspects of transition behaviors of animated maps. Specifically, Goldsberry and Battersby (2009) dealt with the cognitive issues of animated choropleth maps, in particular, focusing on change detection; the authors proposed that change-characterization arrays

can efficiently quantify the magnitude of changes in each enumeration unit's fill appearances in animated choropleth maps. Battersby and Goldsberry (2010) associated transition behaviors with the level of measurement, visual variables, and data classification methods. From a map usability evaluation perspective, quantifying MOC is useful to evaluate effectiveness of animated maps in the way that quantitative indicators for MOC allow researchers to control the amount of changes in scene transitions, one of experimental conditions, when generating experiment materials operationally; accordingly, researcher can conduct the experiments, in order to answer the question of what amount of changes would significantly influence users' performance in detecting changes.

In this research, we develop the way of quantifying MOC for various types of animated maps by using change-characterization arrays in the way similar to Goldsberry and Battersby (2009), in which while they focused on the method of quantifying MOC for animated choropleth maps, this study suggests more universal ways of quantifying MOC, with suggesting different methods of quantifying MOC for different types of animated maps. To develop suitable quantifying methods, we classify the types of animated maps first. There are existing classifications of animated maps; Lobben (2003) and Cauvin et al. (2010) classified depending on whether characteristics of the phenomenon represented including time, space, and attributes are static or variable. However, because map users' perceptual-cognitive performance is more linked to how to measure the phenomena and how to represent map elements visually than the phenomena itself, we classify animated maps in terms of the level of measurement (nominal, ordinal, and numeric), dimension (point, line, area, and volume), and visual variables (color, size, orientation, texture, spacing, and so forth), and finally, we suggest methods of quantifying MOC to fit each type of animated maps according to our classification.

Keywords: animated maps, change detection, classification of animated maps, magnitude of change, transition behaviors

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