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Examining the distribution of motion velocity during visual search towards designing effective dynamic point symbols for quantitative mapping

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Abstract:

Cartographic communication of quantitative data is based on the implementation of specific visual variables which can be scalable (e.g., size, color value, texture spacing) (Bertin, 1983). However, the development of animation in cartographic design allowed the utilization of dynamic point symbols as well (Lai & Yeh, 2004; Xiaofang et al., 2005). Dynamic point symbols are considered as traditional qualitative variables (Blok, 2005) with the additional use of animation technique (DiBiase et al., 1992). Thanks to continuous animated change of e.g., orientation of the cartographic symbol, it is possible to present quantitative data. It opened new possibilities for visual variables to become a factor in quantitative communication. Adding the motion to some qualitative variables (e.g., orientation, shape) enabled the development of so-called dynamic point symbols. Some of them have been the subject of empirical research in terms of their effectiveness during the execution of typical map tasks (Cybulski & Wielebski, 2019). Nevertheless, visual search is sensitive to the velocity of motion of dynamic point symbols. The differences in motion velocity between specific point symbols could be a potential factor for effective and efficient communication processes during map reading tasks. Additionally, the velocity of motion is a preattentive feature (Hohnsbein & Mateeff, 1998). It means that, during map reading, dynamic point symbol identification takes place rapidly, almost automatically, without focused attention (Treisman & Gelade, 1980). Therefore, the optimal distribution of motion velocity is significant for preattentive processing.

The presented results enhance visual variables set, which are immediately perceived. It is because continuous size, orientation, or transparency change leads to new variables such as pulsation, rotation, or “flashing point”. These dynamic symbols change, distributed on such a motion scale, could quantitatively present spatial data. Furthermore, this approach applies to the shape variable. Its continuous change leads to quantitative mapping methods. Visual variables, which could be dynamically animated according to one of the motion distribution methods and treated as new variables, are presented in Figure 1.

The presented study is an ongoing work and shows how motion distribution affects the preattentive processing of dynamic point symbols. We contribute to designing dynamic point symbols methodology based on specific visual variables and pictorial symbolization. The core of the methodological steps includes the definition of motion parameters that allow the preattentive processing of dynamic point symbols on the map. Designing these types of symbols require JavaScript scripting and implementation into HTML5 standard. Another important goal of the presented study is to determine the participants' accuracy in detecting extreme values on the map, referring to symbol detection in an eye tracking study.

The study consists of an empirical experiment with 100 participants in a top-down and bottom-up map reading task. It includes two types of symbols – geometrical and pictorial. Their motion velocity distribution relies on three scales: arithmetic, logarithmic, and exponential. During the experiment, we recorded eye movement with EyeLink 1000 Plus (2000 Hz, head stabilization). The recorded data will be analyzed using typical eye tracking metrics used in cartographic research (Cybulski & Krassanakis, 2022). Moreover, aggregated gaze visualizations will be utilized in order to indicate the participants’ cumulative behavior. This type of measurements can be found in recent cartographic studies such as examining information search in transit maps (Wang et al, 2021), evaluation of weather maps (Popelka et al., 2019), or examining the map legend position during cartographic memory tasks (Edler et al. 2020).

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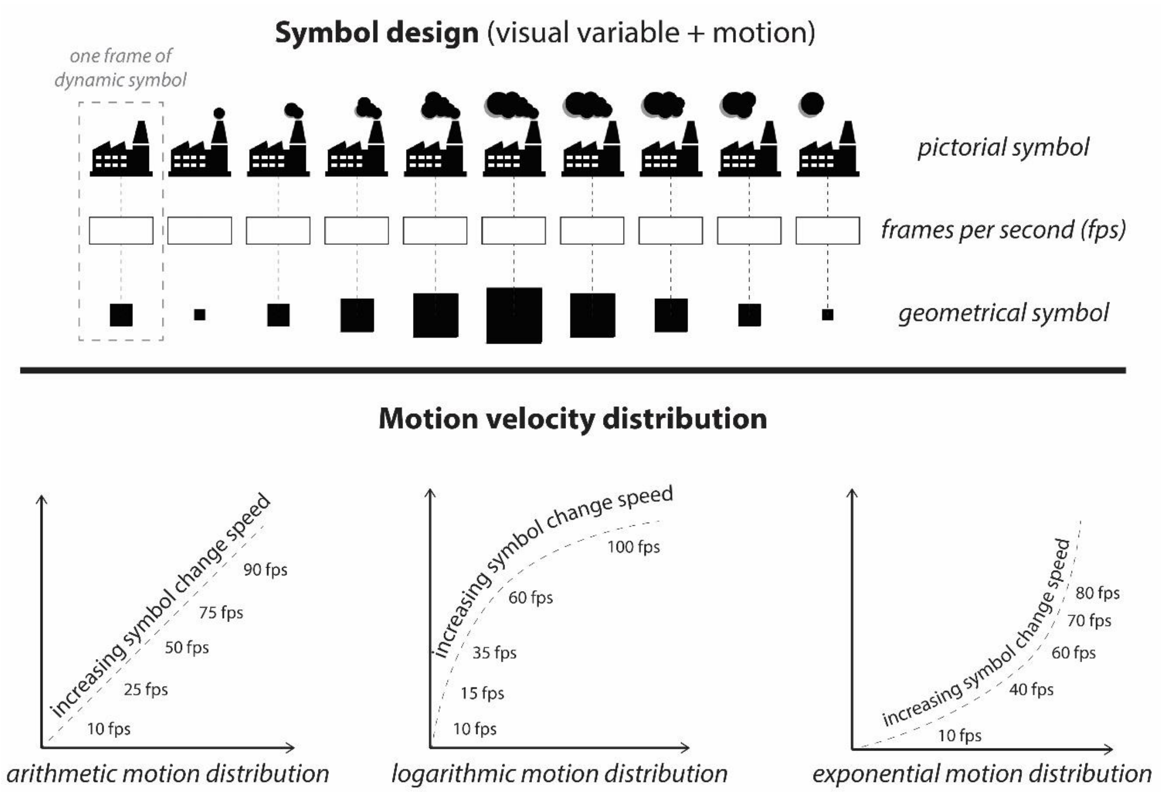

Figure 1. Example of symbol design using geometrical and pictorial features. Motion velocity distribution of symbol changes according to three types of scales: arithmetic, logarithmic, and exponential.

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