International Cartographic Association
Association Cartographique Internationale

Minimum Dimensions for Cartographic Symbology: Towards a Comprehensive Definition and Assessment Method

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Keywords: guidelines, minimum dimensions, map design, perception, definitions

Abstract:

Guidelines on minimum dimensions for cartographic symbology are often specified in cartographic publications and textbooks, and seem to have been commonly discussed in European schools of topographic cartography (Arnberger & Kretschmer, 1975; Neudeck, 2001; Hake et al., 2002; Schweizerische Gesellschaft für Kartografie, 2002). Such guidelines usually specify an absolute minimum value for the dimension of a class of symbols, such as the diameter of point symbols or the distance of separation between two parallel lines. With the increased ability of high-resolution displays to accurately reproduce fine graphical detail near the limit of human visual capabilities, guidance on the minimum size of cartographic symbology has recently become more relevant also in the context of digital cartography, which was previously limited by low-resolution screens (Ledermann, 2023).

Despite many authors proposing minimum dimensions for cartographic symbology, few have based their recommendations on empirical investigations (e.g. Chlupac, 1982), and none of the reviewed literature gives a definition of what the term "minimum dimension" refers to precisely. At first sight, the topic seems too trivial or self-explanatory to justify giving an elaborate definition. However, in the light of recent technological advancements, which facilitate a wider range of symbology designs and application scenarios and thus require a detailed understanding of the map reading process, the following comprehensive definition for a cartographic minimum dimension is proposed:

> *For a given **viewing situation, target demographics** and **map use task**, the smallest size out of a downwards **progression of sizes**, starting at a clearly legible size, for which the information conveyed by a symbol can be correctly picked up among other, **similar symbols** without a **significant drop** in performance as compared to larger sizes.*

The terms printed in bold in the above definition denote six aspects that should be specified in conjunction with assessing and/or stating a minimum dimension recommendation. The first three aspects refer to the context in which a map symbol is intended to be used. For historical guidelines on minimum symbology dimensions, it needs to be be assumed that authors referred to ideal conditions for each of these aspects – viewing under good lighting and contrast conditions, map users with good visual acuity, simple map use tasks (e.g. discriminating the class a symbol from other, sufficiently differentiated ones) et cetera. The latter three aspects refer to details of the assessment of the minimum dimension: which size levels were (or will be) tested, which other symbols are present in the test, and how is a drop in performance detected?

A method to identify sets of similar point symbols from larger collections of map icons, which are suitable for testing map symbol legibility, has already been proposed in earlier work (Ledermann, 2022b). For detecting the drop in performance, authors have historically required a certain fixed success rate (e.g. 90%) as a threshold level, or have adopted methods from psychophysics, which are often optimized towards detecting a threshold at even lower success rates (e.g. 75% or lower) (Bach, 2007; Ledermann, 2022c). However, depending on the task difficulty and other aspects of the map-viewing situation, map creators may want to ensure that the success rates of map reading tasks are higher than that. Thus, an assessment framework is needed in which the performance at smaller sizes is compared to performance for the same task at larger size levels within the same experimental configuration, in order to detect the point at which performance drops significantly upon a reduction in size. Such a framework and corresponding experimental procedure and statistical evaluation method will be presented at the conference.

Figure 1 shows example results of a single map reading task – identifying the direction of white arrows embedded in a solid black line – for a specific set of experimental conditions, which can be stated in accordance with above definition as follows: the viewing situation approached ideal circumstances (indoor lighting, stable image, optimal viewing distance,

Abstracts of the International Cartographic Association, 6, 134, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-134-2023

high contrast etc.), participants were selected to have good visual acuity (logMAR 0 = “20/20 vision” or better), and the task was simply to discriminate among two possible orientations of the arrows. The sizes (line widths) at which the stimuli were presented are shown on the x-axis of Figure 1 (starting with a line width of 0.8mm for 4 trials for each participant, then progressing to 0.6mm et cetera), and the overall success rates of all 25 participants are shown as stacked bars. The first significant drop in performance, detected with Fisher’s exact test comparing performance at any given size with performance at all larger sizes, occurs at the reduction of line width from 0.5mm to 0.4mm Thus, a minimum recommended line width of 0.5mm can be derived for this specific line symbol when used in conditions similar to the experiment.

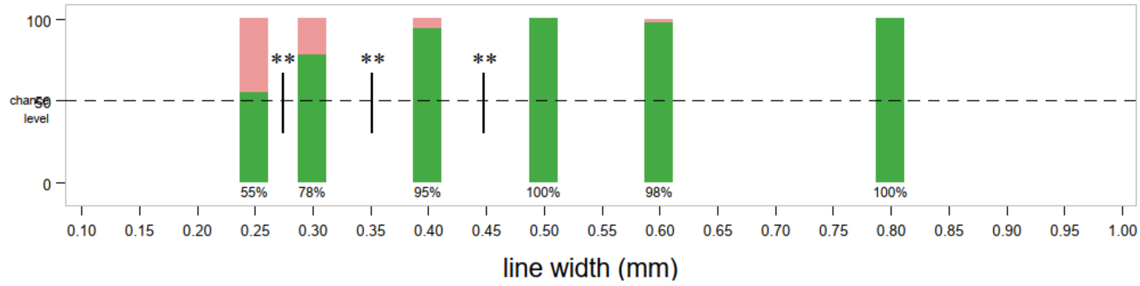

Figure 1. Success rate of participants with good visual acuity (logMAR < -0.05) for recognizing the direction of white arrows embedded in a black line, at various line widths (n=92). The dashed line denotes the success rate expected for random answers (50%). Fisher’s exact test allows for the detection of significant drops in performance (**: $p < 0.01$) as compared to larger sizes. This example would result in a recommended minimum line width of 0.5 mm.

The proposed definition and assessment framework allows for the empirical testing of minimum dimensions, and should encourage researchers to clearly state the examined map symbols, viewing situation, user group and map reading tasks used in such empirical examinations. The framework has been used to empirically derive guidelines for minimum dimensions for various cartographic point and line symbols on smartphone screens in a series of lab-based user studies (Ledermann, 2022a). The proposed definition and framework could be adapted to other aspects of symbology design, such as graphical contrast or information density, in the future. With the proposed comprehensive definition and simple assessment framework, we hope to contribute towards making cartographic design recommendations comparable across authors and giving map creators clear yet versatile guidance on symbology design.

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https://doi.org/10.5194/ica-abs-6-134-2023 |