# Minimum Dimensions for Cartographic Point Symbols on Mobile Phone Screens: Theoretical Considerations and Empirical Verification

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**Abstract:**

Guidelines for minimum dimensions for cartographic symbology have been proposed in many textbooks and cartographic publications (e.g. Arnberger and Kretschmer 1975; Hake, Grünreich, and Meng 2002; Schweizerische Gesellschaft für Kartografie 2002). For point symbols on printed maps, such specifications usually state a minimum diameter that should be used for the map user to be able to reliably discriminate simple geometric figures. It is presently unclear how such minimum dimensions need to be adjusted for arbitrary iconographic symbols, which are widely used on modern digital maps. For digital devices, it has generally been suggested that much larger symbol sizes as for printed maps need to be used (Jenny, Jenny, and Räber 2008; Malić 1998; Muehlenhaus 2014; Neudeck 2001) – however, in the face of recent developments of high- and ultra-high-resolution phone screens, it is unclear how the guidelines for minimum dimensions need to be adjusted (Ledermann 2022).

But what does “minimum dimension” even mean? Extending upon Arnberger & Kretschmer (1975), a framework of three distinct fundamental goals for map symbol legibility is proposed: (a) detectability (being able to detect the presence of a symbol versus it absence); (b) discriminability (being able to discriminate a given map symbol from a different one); and (c) countability (being able to count symbols of a given kind on a map showing a multitude of symbols). When using multiple iconographic symbols on a map, goals (b) and (c) become particularly relevant. The minimum sizes required to accomplish these goals clearly vary with the specific set of symbols to be used – a triangle and a circle can be expected to be discriminable at a smaller size than the icons for “waste basket” and “cemetery” from the Maki icon set (Figure 1, left), for example.

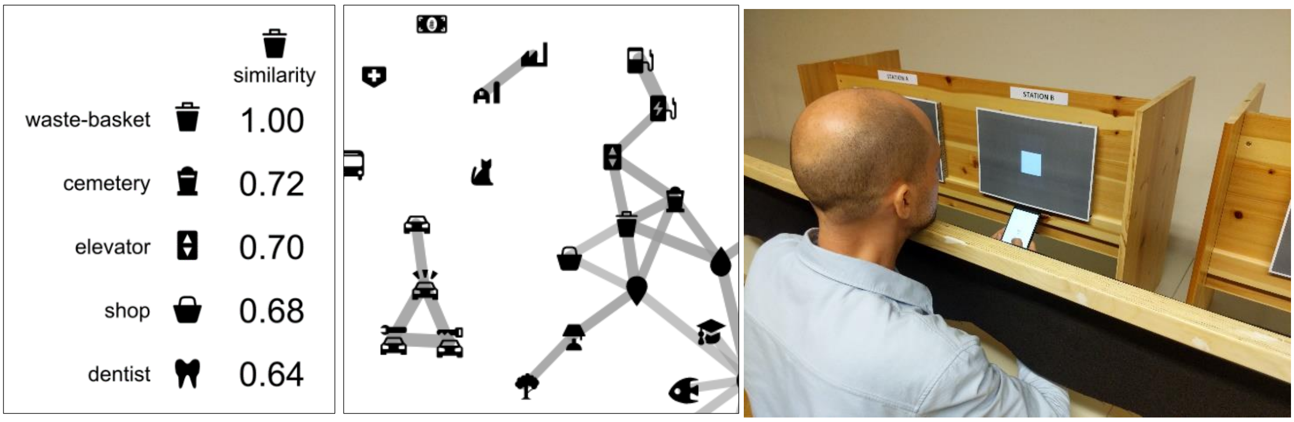


Figure 1. Left: similarity metrics for icons from the “Maki” icon set. Center: Clusters of similar icons identified among over 700 icons with the proposed method. Right: Controlled lab study to verify minimum dimensions for discriminating icons within a cluster.

How then to establish minimum dimensions for realistic application scenarios? Using a raster-based analysis that will be presented in the paper, we have ranked the *most similar* map icons from three large, open-source map icon collections (over 700 icons in total – for an example, see Fig. 1, left). Using this similarity metric, clusters of similar icons were identified (Fig. 1, center) which were then used in a controlled lab study for

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empirical establishment of the minimum sizes. The study was implemented using the stimsrv framework (Ledermann and Gartner 2021) and included tasks to discriminate icons from a cluster from each other in isolation (goal b above), as well as tasks to count icons on a map showing multiple icons form the same cluster (goal c above). In order to investigate the effect of display resolution on symbol discriminability, and to provide valid guidelines for the full range of mobile phone displays available today, each participant in our study performed these tasks on three different mobile phone displays, representing low, high and ultra-high resolutions from the spectrum of display resolutions available today.

For most clusters of similar icons, we found that users could discriminate between them reliably (success rate > 98%) for sizes of 1.25mm or larger, with little effect of screen resolution. This size is significantly smaller than what has previously been recommended as minimum size for screen-based maps. On high-resolution phone screens, discriminability remained high (success rate > 94%) for sizes as small as 0.7mm, dropping below acceptable levels for sizes smaller than that. For counting icons on a map, performance of participants was generally lower at all sizes (about 90% of trials completed correctly for sizes ≥ 1.25mm), with a noticeable drop in performance, independent of screen resolution, for sizes below that. We will present detailed results and further analysis at the conference.

Since impact of display resolution was found to be low, our recommendation for cartographers is to adapt our empirical method using only a single high-resolution device to verify the minimum dimensions needed, and add a “safety margin” of 25% of the established minimum size to account for low-resolution devices. We therefore hope our research will provide cartographers with a set of simple guidelines for sizing map symbols for mobile applications, and a standardized procedure for empirically refining the guidelines for specific sets of map icons and application scenarios.

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