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Designing Mobile-Optimized Cartograms

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Abstract:

Cartograms are maps that depict geographical areas proportionally to spatially extensive data, often significantly deviating from physical land area. For instance, compared to the area-preserving map of ASEAN countries displayed on the left of Figure 1a, Laos appears smaller in the population-based cartogram on the right because its population density is comparatively low. To promote the use of cartograms, various web-based cartogram generators have emerged over the past 15 years, but they often provide only a restricted set of pre-computed options or lack ongoing maintenance (e.g., van den Broek, 2012). Addressing this gap, the open-source web application go-cart.io (Tingsheng et al., 2019) was developed. The project aims to facilitate cartogram creation and distribution via SVG and GeoJson export functions. Despite algorithmic enhancements and usability improvements (e.g., Duncan et al., 2020, Fung et al., 2023), go-cart.io still faces limitations (Duncan and Gastner, 2024). Notably, its current user interface and interactivity are not optimized for mobile devices, despite their prevalence in contemporary daily life.

Research on information visualization for mobile devices has highlighted a scarcity of work on interactive maps in general (Blumenstein et al., 2016, Savino et al., 2021). Cartograms are no exceptions, as most studies of their effectiveness are still based on static images (e.g., Houtman, 2022). This gap in the literature misses valuable opportunities because mobile devices enable novel interactions with cartograms. However, the constraints of small touchscreens, typical of mobile devices, limit the amount of information that can be displayed. Additionally, small touchscreens exacerbate the “fat-finger” issue, whereby users may inadvertently select a neighboring region instead of their intended choice, potentially resulting in unhelpful system output and poor usability.

Our aim is to improve go-cart.io’s usability by designing a user-friendly interface tailored to both desktop computers and touch-based mobile devices. To achieve this goal, we propose a streamlined responsive layout (see Figure 1a) that retains go-cart.io’s interactive features, including linked brushing, the display of statistical data through infotips, seamless morphing between cartograms, and an adjustable area-to-value legend with accompanying grid lines. We have redesigned the legend to allow adjusting the grid size by tapping on tick marks along a horizontal ruler displayed above the legend square (Figure 1b). Alternatively, users can slide a finger parallel to and slightly off the ruler line, providing an unobstructed view while adjusting. Additionally, we have implemented standard finger gestures for view manipulations: panning, isotropic zooming, rotating, and resetting the view. Furthermore, we have introduced a “stretching” feature for non-isotropic (i.e., direction-dependent) zooming, activated by either three-finger pinching or, after deactivating a button for locked-ratio mode, two-finger pinching (Figure 1c). Zooming or stretching automatically updates the legend value, as both transformations multiply all areas by a constant. These view manipulations persist across datasets, allowing users to, for instance, switch between “Land Area” and “Population” or years “2014” and “2024” while keeping the previous magnification.

The stretching feature aims to overcome challenges posed by strongly elongated polygons, frequently encountered when generating cartograms from real-world data. For instance, the Laotian panhandle appears as a narrow strip in the cartogram displayed in Figure 1a, making it difficult to tap on the country to activate the corresponding infotip. While isotropic zooming might resolve this issue, it potentially pushes the far ends of Laos off the screen, thereby sacrificing the larger-scale map context. In contrast, stretching enables a one-dimensional adjustment of the scale in a user-specified direction, without changing the scale in the perpendicular direction. Because stretching expands the width of the Laotian panhandle while keeping the entire country visible on the screen, as depicted in Figure 1c, users can effortlessly tap on Laos while retaining a clear view of its borders with neighboring countries.

To address potential complexities arising from continuous changes in legend values during magnification, we propose an auto-snapping feature to adjust linear transformations after zooming or stretching interactions are completed. This feature aims to align legend values to “nice numbers” (i.e., powers of 10 multiplied by 1, 2, or 5), simplifying mental calculations for users. The vertical tick marks on the ruler at the top of the adjustable legend (Figure 1b) represent consecutive nice

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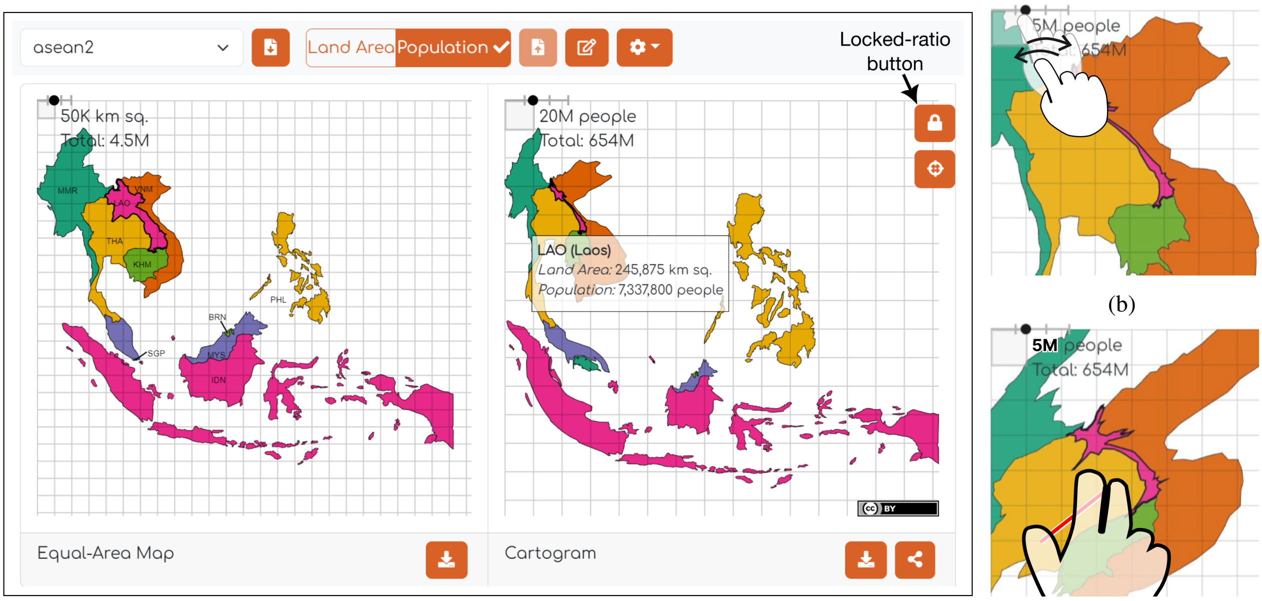

(a) (b) (c)

Figure 1. (a) Screenshot of our mobile-optimized cartogram web application, visualizing ASEAN countries using an equal-area projection on the left and a cartogram depicting population in 2021 on the right. (b) Adjustable area-to-value legend, represented by the light gray square in the top left corner of the map. Tapping on or sliding a finger along the horizontal ruler adjusts the grid size. (c) Stretch interaction enabled by three-finger pinching, which widens the cartogram along the pinching direction, visually indicated by a red line. Alternatively, users can tap the locked-ratio button in the top-right corner of the cartogram panel to use two-finger pinching for stretching.

numbers. The handle, representing the currently selected nice number, snaps to the nearest tick mark when releasing a finger from the slider to ensure precise alignment.

Our future efforts will involve evaluating these features and the application's usability through human-subject experiments. Additionally, we plan to conduct real-world tests of the deployed mobile application to facilitate adoption and encourage user engagement. These evaluations are essential for ensuring that cartograms meet the evolving needs and expectations of its users.

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