Focus-Glue-Context Fisheye Transformations for Spatial Visualization

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Abstract Fisheye views magnify local detail while preserving context, yet projection-aware, scriptable tools for R spatial analysis remain limited. mapycusmaximus introduces a Focus–Glue–Context (FGC) fisheye transform for numeric coordinates and sf geometries. Acting radially around a chosen center, the transform defines a magnified focus (r_in), a smooth transitional glue zone (r_out), and a fixed exterior. Distances expand or compress via a zoom factor and power-law squeeze, with an optional angular twist enhancing continuity. The method is projection-conscious: lon/lat inputs are reprojected to suitable CRSs (e.g., GDA2020/MGA55), normalized for stable parameter control, and restored afterward. A geometry-safe engine (st_transform_custom) supports all feature types, maintaining ring closure and metadata. The high-level sf_fisheye() integrates with tidyverse, ggplot2, and Shiny, with built-in datasets and tests ensuring reproducibility. By coupling coherent radial warps with tidy, CRS-aware workflows, mapycusmaximus enables spatial exploration that emphasizes local structure without losing global context.

1 Introduction

Maps that reveal fine local structure without losing broader context face a persistent challenge: zooming in hides regional patterns, while small-scale views suppress local detail. Traditional solutions—insets, multi-panel displays, aggressive generalization—break spatial continuity and increase cognitive load. What if we could smoothly magnify a metropolitan core *while keeping it embedded* in its state-level context?

This package implements a Focus–Glue–Context (FGC) fisheye transformation that continuously warps geographic space: a chosen focus region magnifies, surrounding areas compress into a “glue” transition zone, and outer context remains stable. Unlike discrete zoom levels or disconnected insets, the transformation operates directly on vector geometry coordinates, preserving topology and enabling reproducible, pipeline-friendly cartography within R’s sf and ggplot2 ecosystem.

The intellectual lineage of focus+context visualization traces back to Furnas (1986)’s *degree-of-interest* function, which formalized how to prioritize salient regions while retaining global structure. Sarkar and Brown (1992) and Sarkar and Brown (1994) extended this to geometric distortion, demonstrating smooth magnification transitions for graph visualization. Subsequent innovations explored diverse lenses: hyperbolic geometry for hierarchies (Lamping et al., 1995), distortion-view frameworks (Carpendale and Montagnese, 2001), and “magic lens” overlays (Bier et al., 1993). By 2008, Cockburn et al. (2008)’s comprehensive review synthesized two decades of research across overview+detail, zooming, and focus+context paradigms.

In cartography, the need for nonlinear magnification emerged independently. Snyder (1987) developed “magnifying-glass” azimuthal projections with variable radial scales—mathematical foundations still cited today. Harrie et al. (2002) created variable-scale functions for mobile devices where user position appears large-scale against small-scale surroundings. The crucial breakthrough came from Yamamoto et al. (2009) and Yamamoto et al. (2012): their **Focus+Glue+Context model** introduced an intermediate “glue” region that absorbs distortion, preventing the excessively warped roads and boundaries that plagued earlier fisheye maps. This three-zone architecture proved particularly effective for pedestrian navigation and mobile web services.

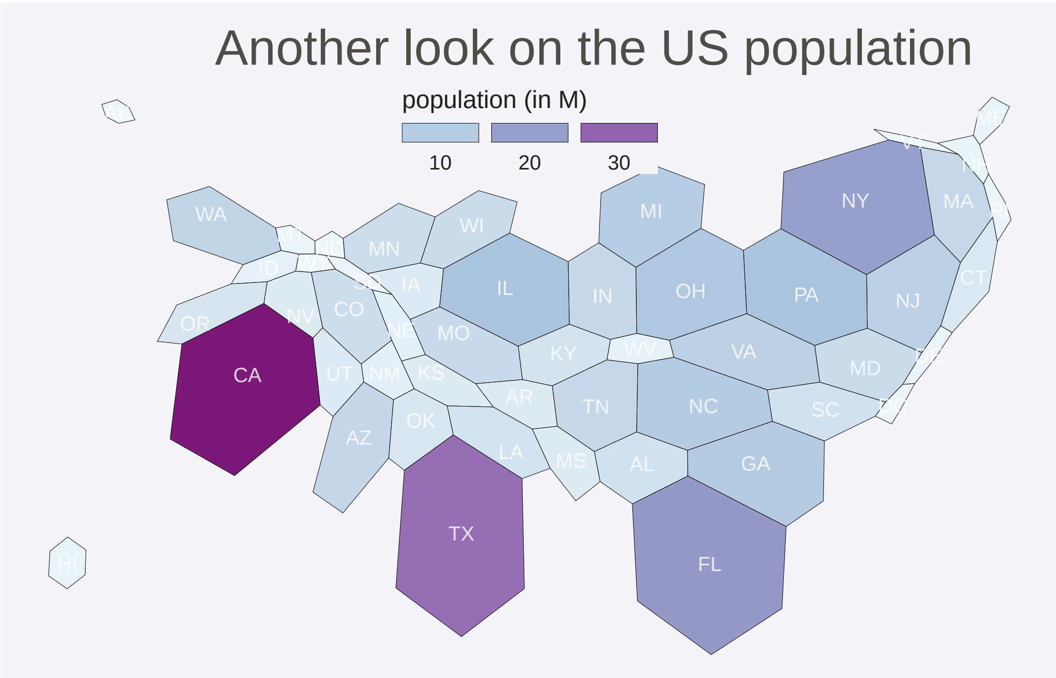
Parallel developments in statistical graphics tackled the “crowding problem”—high-dimensional data collapsing into projection centers. van der Maaten and Hinton (2008)’s t-SNE uses heavy-tailed distributions to spread points, while McInnes et al. (2020)’s UMAP leverages topological methods. Most relevant to our geometric approach: Laa et al. (2020) applies *radial transformations* to tour projections, maintaining the interpretability of linear methods while mitigating overplotting. Implemented in R's tourr package, it demonstrates how well-designed radial warps can reveal structure without the distortions of fully nonlinear embeddings.

Within R's spatial ecosystem, sf (Pebesma, 2018) provides robust vector handling and CRS transformations, while ggplot2 (Wickham, 2016) offers declarative visualization grammar. Yet a gap remained: existing tools addressed *related* distortion needs but not continuous geometric fisheye lenses. This package fills that niche by formalizing an sf-native FGC radial model with controllable zone parameters, optional angular effects, automatic normalization, and safe geometry handling across points, lines, and polygons.

2 Background: Alternative Approaches to the Detail-Context Problem

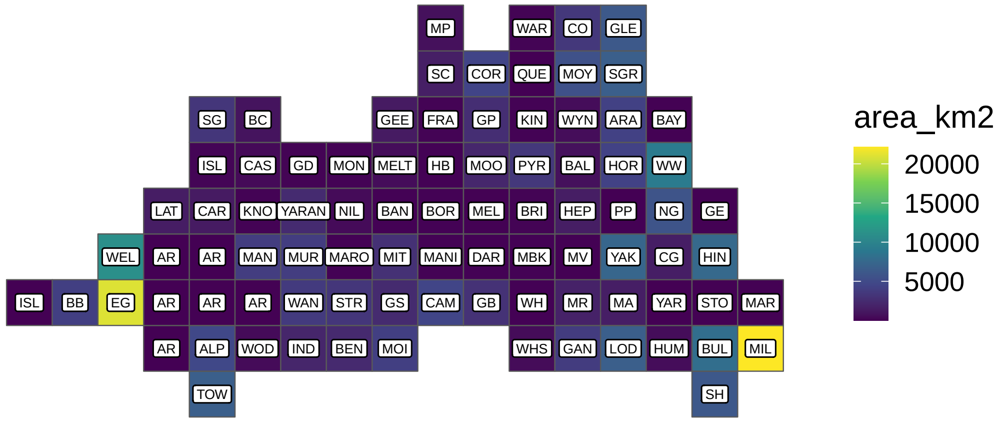
Before diving into fisheye mechanics, it's worth understanding how R's spatial ecosystem currently handles the detail-versus-context tradeoff—and why those solutions, while valuable, leave room for continuous lens-based warping.

Cartograms: Thematic distortion. The cartogram family (Gastner and Newman, 2004) intentionally distorts geographic areas to encode variables—population density reshapes regions so area becomes proportional to demographic weight.



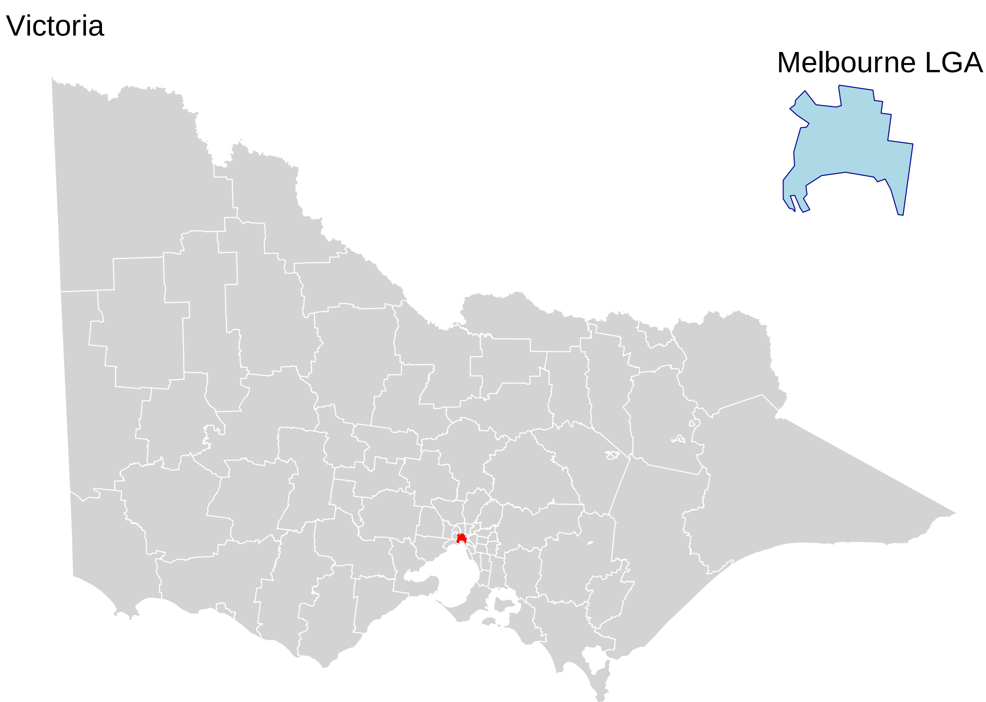
This fundamentally differs from focus+context: cartograms *substitute* spatial accuracy for data encoding, often severely disrupting shapes and adjacencies. A population cartogram makes California balloon while Wyoming shrinks, trading geographic fidelity for thematic insight. FGC fisheye, conversely, preserves relative positions and topology while magnifying a *chosen* spatial region, not a data-driven variable. The use cases diverge: cartograms answer "how does this variable dominate space?" while fisheye lenses answer "what local detail exists within this broader geography?"

Hexagon tile maps: Discrete abstraction. Packages like `geogrid` and visualizations using `sf::st_make_grid()` replace irregular polygons with regular hexagonal or square tiles, each representing an administrative unit.



As seen in the plot above, tile maps *abstracts away* precise geography entirely, treating space as a topology-preserving tessellation where "neighbors touch" matters more than accurate boundaries. Tile maps excel at avoiding size bias (Mildura gets equal visual weight to Yarra) and creating aesthetic, clutter-free layouts. However, they abandon continuous spatial relationships: you cannot identify precise locations, measure distances, or overlay point data meaningfully. Hexbin aggregation for point data (via `ggplot2::geom_hex()`) serves a different purpose—density estimation—rather than focus+context navigation.

Multi-panel approaches: Spatial separation. Tools like `cowplot::ggdraw()`(Wilke, 2025) create side-by-side views: one panel shows overview, another shows zoomed detail.



These are effective for static reports but require viewers to mentally integrate separate views, and they don't preserve the *embedded* relationship between focus and context within a single continuous geography. Futhermore, if you introduce one or more elements into the plot like filling value equal to a variable, the audience will have a hard time identify the zoomed detail.

Why FGC fisheye offers something distinct. None of these approaches provide *continuous geometric magnification within a single, topology-preserving map*. Cartograms distort for data, not user-chosen focus. Tile maps abstract away geography. Multi-panel tools spatially separate context. The fisheye lens keeps everything in one frame—roads bend smoothly, metropolitan detail enlarges, but you still see how the city sits within its state. It's a geometric *warp* rather than a data-driven *substitution* or panel-based *separation*. This matters for use cases like: examining hospital networks in Melbourne while maintaining Victorian context, exploring census tracts in a metro core without losing county boundaries, or analyzing transit lines with their regional hinterland visible.

With this landscape established, we now turn to the technical implementation: how does the Focus–Glue–Context transformation actually work, and how does this package make it accessible within R's spatial workflows?

3 Focus–Glue–Context Transformation

HERE YOU EXPLAIN THE ALGORITHM AND INCLUDE SOME CODE FROM PACKAGE THAT DOES THE PARTS. USE A SIMPLE EXAMPLE LIKE THE RECTANGLE OF DOTS TO EXPLAIN

3.1 Algorithm

3.2 Parameters

3.3 Common choices

4 Examples of use

SHOW THE WAYS THAT IT CAN BE USED FOR THE VICTORIAN AMBULANCE DATA: Just the map with hospital locations, map with transfers, map with convex hulls, map with two focal points, then maybe a raster map

5 Discussion

HERE YOU SUMMARISE WHAT THE PAPER CONTRIBUTED IN ONE PARAGRAPH AND SUGGEST NEW WORK THAT MIGHT BE DONE THAT YOU DIDN'T HAVE TIME TO DO

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