Developing a Design Space for Data Visualization on Spherical Displays

Développement d'un espace de conception pour la visualisation de données sur des écrans sphériques

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Abstract / Resume—We present a design space for data visualization on spherical displays that articulates sphere-specific dimensions, perceptual properties, and trade-offs related to visualization and interaction strategies. Spherical displays distribute visibility and content across a continuous curved surface and eliminate the inherent notion of a front or back. The structural properties reshape the construction of overview, comparison, and interaction for non-planar displays and expand applications beyond astronomy and geographical maps. Yet, no systematic design space for spherical visualization exists, leaving designers to adapt techniques originally designed for flat screens to spherical displays and limiting visualization and interaction potential. We operationalize this space through structured workshops with visualization experts, combining sketch-based exploration and card-based ideation. This approach surfaced sphere-native strategies and application directions, demonstrating how spherical displays facilitate genuinely different visualization approaches—not merely adaptations of flat ones.

1 Introduction

A sphere is arguably the most natural display for a globe, and that is precisely the problem. Data visualization transforms abstract information into visual representations that support perception, reasoning, and insight [5]. The displays on which these representations appear are not neutral surfaces, they shape what can be shown, how it can be compared, and how users engage with them. Spherical displays are publicly deployed and technically mature, yet their use remains mainly confined to geographic and astronomical data where the form mirrors the content. The structural properties that make spheres genuinely distinct as a display medium, such as no edges, no inherent front, and continuous curvature [3], remain un-leveraged for visualization purposes. As display technologies expand beyond flatness [2] [4], this lack of design exploration can be reconsidered.

Planar displays, for which visualizations are normally designed, afford stable viewpoints, binary axes, and a simultaneous global overview [5]. These properties are so foundational that they have become invisible norms in encoding models, interaction techniques, and design guidelines. Spherical displays actively break these norms. Overview is not simultaneous anymore but achieved through movement or interaction. Comparison becomes spatially distributed or antipodal rather than co-planar. Interaction becomes embodied and tied to a surface that collapses linear axes assumptions. Beyond geometry, spheres carry cultural familiarity and embodied metaphors of immersion, containment, and worldhood that flat surfaces may not invoke [6]. These properties challenge visualization conventions and also open up new design possibilities.

In related curved and volumetric displays, planar guidelines are often adapted to non-planar surfaces, implicitly preserving rectangular framing assumptions [1]. Without a structured vocabulary, trade-offs such as occlusion facilitating progressive discovery at the cost of simultaneous overview, antipodal contrast supporting oppositional reasoning at the cost of local comparison, or edgelessness affording continuous data flow at the cost of a frame of reference cannot be reasoned about or deliberately designed for. We address this gap by proposing a design space organized around four categories of sphere-specific considerations: geometric properties, perceptual properties, interaction strategies, and application domains.

2 Approach

We approach the work in two parts: an analytical phase that constructs the design space from geometric principles, existing literature, and sphere-related metaphors; and a generative phase that assesses its potential through structured workshops.

We built the design space from three inputs: (i) a geometric analysis of spherical properties and their implications for visibility, comparison, and interaction, (ii) a synthesis of prior work on spherical visualization and non-planar displays, and (iii) a curated set of sphere-related metaphors (everyday associative framings such as planets, fruit, and play-objects) that surface viewer-side assumptions. We organized

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the space into three categories and associated design questions: geometric properties and their perceptual implications; data types; and interaction dimensions.

To assess its generative potential, we conducted three structured workshops with 21 visualization experts, each comprising two phases. In the first, sketch-based exploration phase, participants picked two randomized prompts from a set of 20 open-ended provocations and they produced freehand sketches to break flat-display assumptions. In the second card-based ideation phase, participants drew one card from the data-type category and one from the interaction category. They then sketched an original visualization concept using the combination. We recorded the sessions and thematically analyzed the outputs to identify recurring sphere-native strategies.

3 Design Space

In our design space we organize spherical display visualization across four dimensions. Two are fixed by geometry: physical properties including edgelessness, uniform curvature, occlusion, antipodal structure, and the absence of a canonical viewpoint; and display and materiality considerations such as scale, surface, number of users, and orientation cues. We articulate each property through what it facilitates, what it costs, and the key design question it raises.

Two further dimensions reflect designer choices: data mapping, organized around seven sphere-native data types such as cyclical, oppositional, axis-independent, and layered structures that align with spherical topology; and interaction, structured across three tiers: physical strategies (tactile, proxemic, kinetic, rotational navigation), social encounters (solo, dyadic, small group, public), and affective encounters that reflect how bodies individually and collectively engage with a spherical display (Fig. 1).

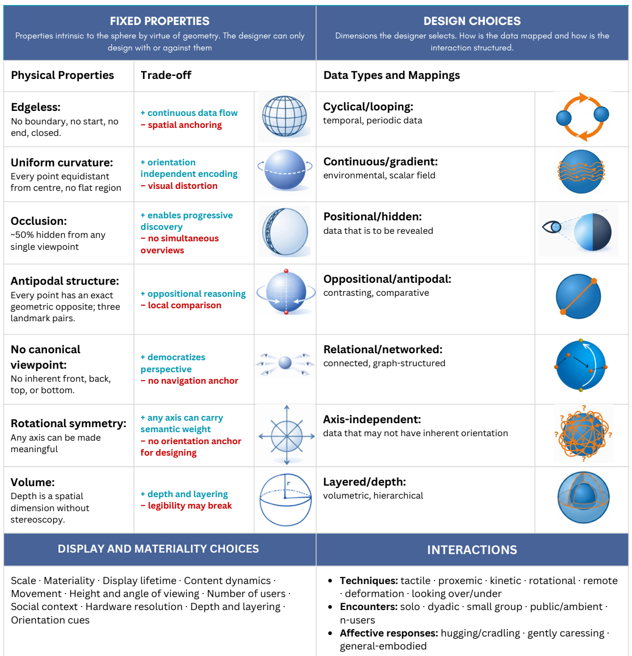

Fig. 1. Summary of our design space.

Together, the four dimensions provide designers with a structured vocabulary for reasoning about what a sphere physically is, what hardware decisions a designer must make, which data structures are native to spherical topology, and how interaction emerges from the surface itself (Fig. 2).

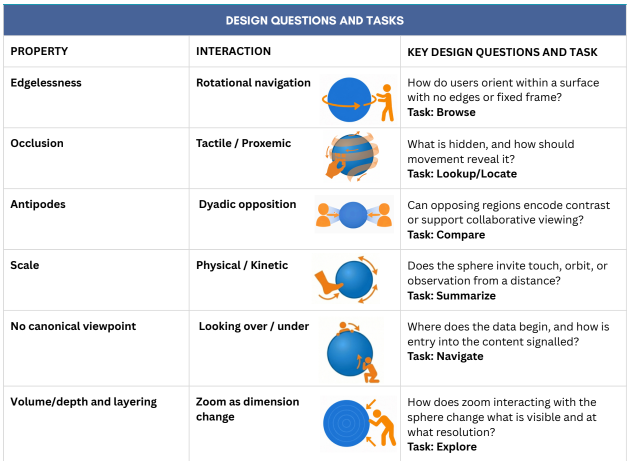

Fig. 2. Interactions and key design questions.

4 Conclusion

With this work we take a step toward a systematic design practice for spherical displays, building on emerging efforts in the field [2]. The design space and workshop findings suggest that spherical displays are not simply curved screens but a genuinely distinct display medium with its own vocabulary of data types, trade-offs, and interaction strategies. Future work needs to implement and evaluate sphere-native visualizations on a spherical display, using the design space as a generative and evaluative framework.

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