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Inconsistent panning and zooming in globe views across leading geospatial services

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Abstract:

Digital maps maintain north-up just like paper maps do, fingers pan digital maps similar to moving a piece of paper on a table and magnification depends on the location of a lens, eye or finger (zoom-to-cursor). With the introduction of globe views into digital maps, these conventions are maintained through rotations of our planet, rather than the traditional offset (translation) applied to the projection. For Mercator, rotation around the polar axis looks no different from offset, which suggests the existence of unified conventions for pan/zoom across projections.

Contrary to this theory, Google Earth easily loses north-up, whilst ArcGIS Earth avoids that outside of edge cases. Topographic maps, on the other hand, keep north-up at the cost of no longer zooming to the cursor. The target stays closer to the cursor on Apple Maps in comparison to Mapbox Maps and in the case of Google Maps, the target may even end up on the other side of the globe. MapLibre simultaneously leads at zooming and trails at panning in terms of staying on target while maintaining north-up. Earth and Map applications each preserve all but one convention and minimize the violations of the one they have set aside. However, the two fields consistently choose a different priority, a divergence that may be justified whenever it is impossible to achieve both.

An initial prototype iteratively approaches projection transformations that adhere to all of the aforementioned conventions by repeatedly applying quaternion rotation and nullifying the tilt. Later on, a geometric solution for the orthographic projection was derived. Both implementations are not limited to north-up but can maintain an arbitrary tilt while keeping a target under the pointer. Usually, the target was below the initial pointer position, unless the pointer was outside the projection's extent, which most geospatial services allow. Google Earth and Bing Maps are the exception and even they only restrict panning outside the projection. Zooming is unrestricted and once panning started Bing allows the pointer to leave the projection's extent as well.

While it is challenging to pinpoint user expectations in this scenario, the implementation can be satisfied by zooming in until the pointer is contained within the projection's extent. Maintaining a tilt like north-up requires a zoom level that is equal to or higher, because the pointer's distance to the closest pole may be shorter than the distance to the fixed axis, which the pole cannot leave. Therefore, enforcing a minimum zoom level is an implicit requirement to fulfill all aforementioned conventions. It is impossible to conceal this from users and they might not comprehend why they are unable to zoom out further or why panning zooms.

These changes are likely to affect the usability of the service. A common measure of usability is the number of clutches, which refers to raising the finger on a touch screen, trackpad or mouse. Every action to reestablish northing or repositioning the pointer to account for a target that moves away involves clutches that can reduce efficiency. In extreme cases, users may lose orientation, which increases cognitive load. The aforementioned conventions are closely related to these usability pitfalls, but only an HCI experiment can determine whether the effect is positive or negative.

Processing clutches, clicks, and other relevant information is an inherent requirement of implementing panning and zooming according to the aforementioned conventions. Logging these events with timestamps already provides multiple objective usability metrics. Therefore, an automated tool was designed to switch between different implementations and record subjective self-assessments in between. These objective metrics can be anonymized and potentially correlate with the subjective usability metrics.

An open-source reactive web cartography framework was developed to validate solutions and make them easily reusable. It utilizes the geo module of D3, within the declarative HTML syntax of Vue. Both are popular open-source JavaScript libraries that have different responsibilities. D3 can load data from spatial file formats, display them in custom projections and perform spatial analysis. Reactivity automatically updates the map, but not the parts that did not

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change. Using these features, user interactions that lead to violations of conventions can be simulated, while providing visual cues and quantified metrics of the discrepancy.

Without these indicators, it can be difficult to spot and compare differences between the leading geospatial services. Ideally, an automated test suite would systematically perform equivalent interactions across all services and compare the results. However, the map is not necessarily in the same spot due to differences in the user interface. Therefore, interactions need to adapt to different user interfaces that are subject to change and error calculations depend on proprietary APIs. Consequently, previous explanations of differences in convention priorities and outside the projection's extent were limited to interactions that were performed manually.

These challenges also affect accessibility tools like screen readers. Alternatively, SVG can provide valuable context for everything displayed on the map. Some individuals may find the map difficult to use or even unusable without this context. However, performance suffers significantly and certain features are not supported. Fortunately, D3 supports both SVG and the more performant alternatives. With minimal effort, it is possible to hide this context to reduce the performance penalty while keeping the context for those that need it.

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