

Visualizing Animal Movement in Static Maps: A Case Study of White Stork Migration

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Abstract:

This research investigates the cartographic visualization of animal movement, focusing on the seasonal migration of the white stork (*Ciconia ciconia*) as a case study for representing spatial-temporal data in thematic cartography. The study is positioned within the field of animal tracking cartography, addressing a key challenge in geovisualization: how to effectively communicate dynamic movement processes using static cartographic representations.

The main objective is to develop a clear, informative, and visually effective flow map based on high-resolution tracking data, while simultaneously proposing practical design guidelines for mapping animal movement. The study combines concepts from cartography and movement ecology, emphasizing the importance of user-oriented visual communication for interpreting complex spatial-temporal patterns.

Movement data were obtained from the *Movebank* repository (Flack et al., 2016), providing high-frequency GPS observations of a single tracked individual. Additional base map data were sourced from Natural Earth. The methodological workflow includes data filtering, temporal aggregation, spatial generalization, and transformation into a continuous movement path. The resulting dataset was visualized using a combination of GIS-based processing and graphic design tools, enabling both analytical accuracy and refined cartographic design.

In addition to the practical implementation, the study includes a comparative analysis of twenty existing maps depicting animal movement. The analysis focuses on thematic classification, graphical variables, interactivity, and communication purpose. Results indicate that most maps rely heavily on colour hue and directional symbols, while temporal aspects are often underrepresented or simplified. Differences between scientific and public-oriented maps highlight the trade-off between analytical precision and visual storytelling.

Based on this analysis, the paper proposes a set of design principles for static flow maps of animal movement, including prioritization of movement paths in visual hierarchy, controlled use of graphical variables, simplification of base maps, and integration of narrative elements. A particular contribution of this work is the structured integration of a temporal component into a static map through a linear timeline aligned with the movement path, enabling users to interpret variations in speed and duration along the migration route.

The results demonstrate that open data and open-source tools can support the creation of effective and accessible cartographic products, even for complex spatial-temporal phenomena. The produced map combines scientific data with narrative and visual elements to enhance user engagement and understanding, making it suitable for both educational and communicative purposes.

This work contributes to thematic cartography and geovisualization by bridging the gap between data-rich movement analysis and user-centered map design. It highlights the need for improved methods and semi-automated tools for visualizing large movement datasets, while providing practical insights applicable to a wide range of domains, including ecology, environmental communication, and spatial data literacy.

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