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Conveying Uncertainty in Visual Cluster Representations of Soccer Player Trajectories

Halldor Janetzko and Sara Irina Fabrikant

Department of Geography, University of Zurich, Switzerland; {halldor.janetzko, sara.fabrikant}@geo.uzh.zh

Advances in positioning technology (i.e., GPS) are resulting in rapidly increasing amounts of location-based data records, at increasingly fine-grained spatio-temporal resolutions. Movement analyses in sports, for instance, are a typical example of mentioned trends. However, larger amounts of data do not necessarily enhance insight in and knowledge generation from space-time phenomena. Automated analysis methods are only useful if the data analyst already knows what to expect. Conversely, exploratory analyses require the analyst to generate new and/or validate old hypotheses. Visualization is one of the key supporting factors in this process. However, the visualization of raw movement trajectories (i.e., collected in soccer games) will rarely be useful for insight generation, typically because of massive trajectory overplotting. Hence, classic cartographic generalization steps including aggregation, simplification, abstraction, and generalization are especially needed for the visualization of movement trajectory data in sports.

From a data analysis perspective, space-time trajectory clustering is often employed to first reduce visual clutter by grouping similar trajectories, or trajectory segments. Resulting clusters are then commonly displayed by means of trajectory representatives (Andrienko et al. 2008). This approach has been successfully applied for the visualization and analysis of urban traffic (Andrienko et al. 2009), eye movement behavior in empirical visualization studies (Fabrikant et al. 2008), and in other data collection domains including motion tracking with video surveillance cameras (Hoeferlin et al. 2013) or animal tracking (Janetzko et al. 2013).

While cluster depictions compellingly help to mitigate clutter, and thus can help analysts to uncover unforeseen data relationships hidden in a haystack of raw data, severe pitfalls might still occur when visualizing clustered data only by cluster representatives. There is a thin line between meaningful generalization, and oversimplification. Especially for complex and dense movement trajectories, cluster representatives that look attractively simple, might mislead the analyst. Humans wish to believe what they see, and thus it is critical to convey data uncertainties resulting from geometric and semantic generalizations (Mackaness et al. 2011).

In this work, we propose and discuss three different visualization methods to depict uncertainty in cluster representatives of movement trajectories in soccer games. The first technique follows Shneiderman's "overview first and details on demand" mantra. Firstly, cluster representatives are shown to the data analyst to provide a visual overview of the movement pattern. Trajectory segments related to the cluster representative are dynamically depicted only on demand, i.e., triggered by user interaction (e.g., "mouse hovering"). A second technique is a density-based aggregation of the trajectories belonging to the same cluster. The third proposed technique encodes uncertainty by means of visual variables (Bertin, 1967/83). Transparency, texture, and sketchiness visually encode the inherent data uncertainty in the emerging visual patterns due to geometric generalization procedures (Kinkeldey et al. 2014).

We will present a systematic visual comparison including an in-depth discussion of strengths and weaknesses of these three proposed visualization methods, in the context of analyzing soccer player trajectories. In doing so, we hope to provide further insights which of the methods will suit what visual analytics goal and which data analysis purpose most effectively and efficiently.

Keywords: geovisual analytics, spatio-temporal analysis, generalization

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