

Spatio-Temporal Pattern Analysis of Moving Point Objects Utilizing Eye Movement Data

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Abstract:

Movement pattern recognition and analysis are challenging problems in moving object databases. Moving point analysis has recently become the focus of many research projects in the area of GIScience. Many spatio-temporal data models and analytical methods have been proposed at the theoretical level, however only few of them have been implemented and applied in practice. A critical success factor for such research is the availability of relevant spatio-temporal data. The main problem is that moving point data are not easily available and accessible due to data security and privacy issues. Advances in positioning systems and tracking technologies generate a huge amount of spatio-temporal data but unfortunately they are most often not available for public use. In order to overcome this problem we utilize self-collected eye movement data from human subject experiments on graphic displays. The general goal of employing eye movement measurement and analysis is to gain insight into the viewer's attentive behavior and to characterize the eye movement signal in terms of salient eye movements, i.e., saccades and fixations (Duchowski, 2003). Fixations are a proxy of dwelling times at location (e.g., stops of a moving object in geographic space) and saccades are trajectories between dwelling locations.

In this research we aim to develop visual analytics methods and data exploration tools for the effective depiction and analysis of time-referenced spatial data sets at high resolution (e.g., eye gaze data). How can we efficiently mine time dependent spatial data patterns and effectively communicate results to humans with limited spatio-temporal processing capabilities? Specifically, how can we summarize large amounts of moving point data and discover recurring or surprising patterns?

At this stage of the project we have implemented an object-oriented preprocessing application in Java. Eye movement data are used as a proxy for other moving point data that are harder to obtain. We applied several filtering methods on different 2D space-time profiles created from eye movement data to detect movement patterns such as saccades and fixations. We implemented position-based fixation detection and velocity-based saccade detection methods as proposed by Anliker (1976). A systematic comparison of the two implemented approaches revealed that fixation and saccade identifications are highly dependent on two parameters: selected threshold and sampling window size. Different parameter values produce slightly different results. The parameterization of these two methods, including the selection of the optimal thresholds and window sizes remain an open question. We plan to extend the developed parameterization framework to include different kinds of eye movement patterns such as smooth pursuits. We are also considering to add resampling and filtering functions in the time and space dimension. A third step we consider is to explore and analyze eye movement patterns in relation to their underlying spatial structure, that is, the display space that was originally used to carry out the eye movement experiments.

While we are investigating moving point trajectories specifically stemming from eye movement experiments we believe that the analytical methods developed are generic enough to be useful for all types of moving entity types.