

Spatio-Temporal Visual Analytics for Exploring Trajectory Patterns and Dynamic Spatial Interactions

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Abstract

In the Mobile Age, with the widespread use of location-awareness devices such as mobile phones and GPS sensors, it is possible to collect large-scale spatio-temporal data to study complex human-environment interactions. In this research, we present a spatio-temporal visual analytical framework including space-time path (STP), 3D vertical Bézier curves, time series graphs, and space-time kernel density estimation (STKDE), to explore trajectory patterns of mobile phone users and GPS-enabled taxis, as well as to analyze dynamic intra-urban spatial interactions based on the aggregated individual behaviors. Experiments are conducted using a large scale detailed records of mobile phone calls and taxi trajectories in different cities. The study demonstrates that a combination of good visual representations and statistics can help a better understanding of the spatio-temporal patterns of human mobility and urban dynamics. The research based on such urban big data has opened up several opportunities to obtain new insights on cities, and to investigate how cities function in short-term temporal scales compared with traditional long-term strategic planning. Related scientific questions such as spatio-temporal granularity, spatio-temporal neighbors, and spatio-temporal uncertainty are also discussed. Expeditions on the spatio-temporal analytical techniques also contribute to the future development of space-time GIS. The spatio-temporal visual analytical framework introduced in this paper can be applied in other spatio-temporal datasets (e.g., infectious diseases, crimes, and geo-tagged tweets) for facilitating knowledge discovery and decision support in urban informatics; and more broadly, it has a potential to be applied in other disciplines as well, e.g., environmental, human and social sciences.

Keywords: space-time; spatio-temporal visual analytics; space-time kernel density estimation; trajectory; spatial interactions