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Visual Analytics for Understanding Traffic Flows of Transport Hubs from Movement Data

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Abstract

Transport hubs such as airports, railway stations play an important role in the transportation system and urban development. These terminals absorb and reflect huge amounts of traffic flows from/to the road network and have considerable social and economic impacts of the surrounding regions. Understanding the traffic flows of the transport hubs helps traffic engineers and policy makers to better improve the transportation planning, and helps passengers to efficiently plan their trips, etc. However, analyzing the movement data is very challenging due to their large data volume, implicit spatio-temporal relationship, and uncertain semantics.

In this paper, we investigate effective visual analytics for exploring spatio-temporal, semantic patterns in the traffic flows in/out of the transport hubs. The novelty of this work relies in the grained scale being considered and the multivariate perspectives. To achieve this goal, a web-based interactive visual analytic system is developed to process and visualize massive taxi trajectories through transport hubs. The system combines interactive visual techniques with computational data mining methods. The mining module implement a mining procedure mainly consists of three steps: 1) Spatial clustering of the origin/destination locations of the movements that flow into/out from a transport hub to identify significant places with a certain spatial extension; 2) Classification of the places to infer their semantics with respect to the predefined classes (e.g. commercial, industrial, residential, institutional and recreational) using mobility information exclusively, i.e. intra-cluster interactions among the movements, etc. 3) Mined information is organized in a data structure that support efficient online queries.

The interactive visual interface comprises three linked views: (1) A map view showing an overall spatial distribution of the trajectory data for a specific transport hub. The trajectories of occupied taxis starting from or ending to the transport hubs can be directly rendered as line features on the map. (2) A spoke-hub view that employs a graph representation to visualize the traffic connections between a transport hub and the significant places extracted from the movement data across the urban area. It largely compensates the clutter effects in the map view. In the graph, nodes correspond the significant places mined from the origin/destination locations. The edges bear the information between the nodes and a hub, such as the amount of trajectories, the relative distance and direction from the hub. (3) A time line graph view to show the temporal information of specific trajectories. For example, when the user selects a node, the corresponding trajectories are ordered by the time series and are visualized in a compact way, which helps to detect possible periodical patterns. At the same time, the spatial distribution of the selected trajectories is illustrated on the map view.

To evaluate the effectiveness of the system, we perform tests using a real world dataset,

Shanghai floating taxi data. The test data contain GPS records of 2000 taxis in 50 days (10.05.2010 – 30.06.2010) with a time interval of about 10 seconds. Attributes for each record include the timestamp, company code, car-ids, coordinates, instantaneous velocity, and car-status (meaning taxi occupied or empty). We extract about 5,000 occupied trajectories of the airport (Shanghai Pudong International Airport) from the data. Experiments show that the system can effectively support visual exploration and identification of interesting traffic flow patterns. For instance, we found that hot spots of the origin/destination locations of the movements that flow into/out from a transport hub are mostly hotels, and other transport hubs. We also perceive diverse traffic flow patterns between weekdays and weekends/holidays.

Keywords

Visual analytics, Traffic flow visualization, Transport hubs, place classification