Discovering Group Movement Pattern by Measuring Individual Similarity from GPS Trajectories

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Abstract: Exploring useful knowledge from moving objects' trajectories can contribute to various application areas such as traffic monitoring, congestion prediction, individual daily activity recognition. Due to a large amount of trajectory data, the main challenge in trajectory pattern mining is to detect the group pattern effectively and efficiently. To address this, our purpose is to discover the group movement pattern from the vehicles' trajectories by comparing different trajectory similarity methods. Group pattern represents a group of moving objects (i.e people, animals, vehicles) that moves together along their trip. Firstly, we extract the similarity matrix to detect the individual's trajectory similarity, by applying trajectory similarity methods. Then, we discover the group movement pattern by using the density-based clustering algorithm. Experimental results are evaluated on real data.

Keywords: Trajectory Data, Group Pattern, Similarity Measurement, Clustering

1. Introduction

With the rapid development of location-acquisition technologies, a large amount of spatio-temporal data can be acquired from GPS, Wi-Fi, RFID, and social networks in the form of trajectory data. Such a large amount of trajectory motivates us to discover the group movement patterns of moving objects (i.e., people, animals, vehicles). Group movement pattern discovery reveals finding the travel-together moving objects along their trip. Identifying the groups that move together for a certain time period can contribute to the various applications. For example, in animals' trajectory data, group movement pattern discovery benefits for studying the migration and inhabitation of animals. In vehicles' trajectory data, the commuter can discover the co-traveler to share the carpool.

Recently, some researchers proposed various kinds of movement patterns such as convoy [1], traveling companion [2], loose companion [2], platoon [3], and group pattern [4]. The terms of the convoy, traveling companion and group pattern are identical (i.e., they discover the moving objects that move together for certain time periods). Loose companion and platoon allow some members leaving temporarily during their group movement.

Jeung et al. [1] proposed the convoy pattern and developed the CuTS (Convoy discovery using Trajectory Simplification) algorithm. Tang et al. [2] introduced a framework for traveling companion and loose companion discovery and developed a buddy-based discovery algorithm. Li et al. [3] also designed the platoon pattern to allows the strict requirement of the same members in convoy discovery. Zhu et al. [4] identified the tourists, as individual or group, who traveled around the Hainan by proposing a new similarity method.

In this paper, we focus on the group movement patterns discovery based on the variation of similarity methods from real trajectory data. Group pattern can be defined as a group of at least δ_s members that move together for δ_t time periods. Fig.1 illustrates the example of group pattern discovery. If we have given group size threshold (δ_s) =3, group duration threshold (δ_t) =3, then the objects: o_2, o_3, o_4 are in the form of group pattern within the timestamps s_1, s_2, s_3.

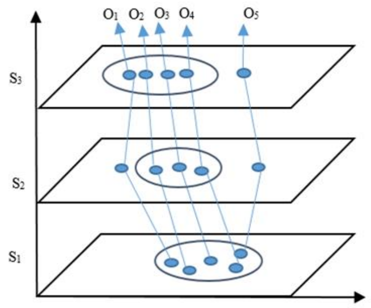

Fig.1 Example of group pattern discovery

2. Group Movement Pattern Discovery

Fig.2 illustrates the framework of our approach. Firstly, we compress the trajectory data as a preprocessing step by using a Douglas-Peucker algorithm [1]. The objective of trajectory compression is to reduce the computational time complexity by reducing undesired location without warping the trend of trajectory. And then, the similarities between any two trajectories are computed. Finally, we discovered the group patterns by applying a density-based clustering algorithm based on the values of trajectories' similarities.

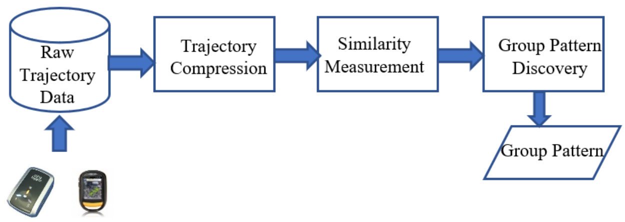

Fig.2 Group pattern discovery framework

2.1 Trajectory Similarity Measurement

Measuring the similarity between two trajectories refers to how close to each other in distance. In this research, we discovered the group pattern based on the following similarity measurements [5]:

1. Hausdorff Distance: Hausdorff distance is used to measure

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how close shape of trajectory A to shape of trajectory B. It calculates distance on every point of trajectory A overall points of trajectory B, (it is vice versa for trajectory B) and chooses the maximize overall distance values.

2. Symmetric Segment-Path Distance (SSPD): SSPD is also a shape-based distance and compares trajectories as a whole. It considers based on the total length of a trajectory, the variation, and distance between any two trajectories.

3. Dynamic Time Warping (DTW): Dynamic Time Warping (DTW) is to find the best mapping with minimum distance between any two trajectories. DTW allows computing the similarity between different trajectories' lengths but it is not robust to noise.

4. Longest Common Subsequences (LCSS): Longest Common Subsequence is proposed to handle the noise.

5. Edit distance with Real Penalty (ERP): It measures the similarity with edit distance based on normalized trajectory data. ERP allows the local time-shifting but it is not robust to noise.

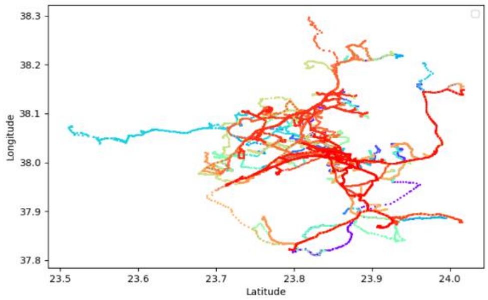
6. Edit distance with Real Sequence (ERS): The difference from ERP is that it uses a threshold, ε, for point matching and it handles the noise.

2.2 Group Pattern Discovery

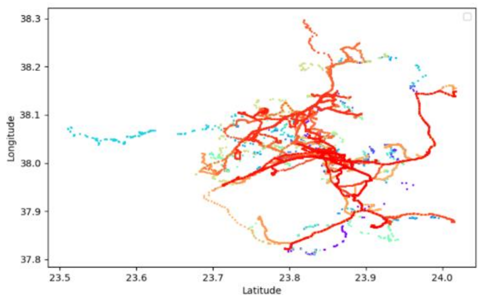
With the trajectory similarities' values, the group patterns were identified by applying a density-based clustering algorithm (DBSCAN) [1]. Although DBSCAN is one of the most baseline methods for group pattern discovery [1-3], it still has a problem in time complexity.

3. Experiment

We evaluate the experiment of group pattern discovery based on the real truck data set [7]. It was collected around the Greece metropolitan area. Fig.3 illustrates the comparison for (a) the original trajectories and (b) the compressed trajectories.



(a) Original Trajectories



(b) Compressed Trajectories

Fig.3 Trajectory compression

3.1 Efficiency in Trajectory Similarity

Fig.4 shows the running time comparison in trajectory similarity measurement.

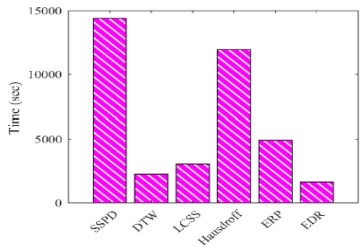


Fig.4 Time comparison for trajectory similarity

3.2 Efficiency in Group Pattern Discovery

Fig.5 illustrates the running time for group pattern discovery with δ_s =7, and δ_t =10 based on the variation of trajectory similarity measurements.

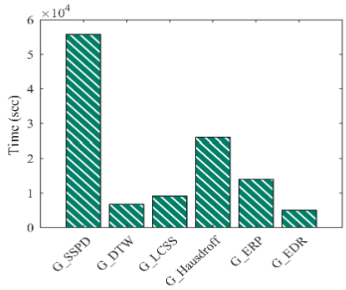


Fig.5 Time comparison for group pattern discovery based on similarity

4. Conclusion and Future Work

In this paper, we investigate the group pattern discovery from trajectories of vehicles. Firstly, we used the Douglas Peucker algorithm to compress the trajectories and discovered the group pattern based on different similarity methods. As future work, we will improve the efficiency in clustering and add the semantic meaning of each location, along the trip of group movement.

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