Forensic Vehicle Convoy Analysis Using ANPR Data

1 Haiyue Yuan, Shujun Li, Anthony T.S. Ho
2 Paul Palmer, Andy Lloyd and 3 Graham Head
1Department of Computer Science, University of Surrey, UK
2Surrey Police, UK 4Independent advisor, UK

1. Introduction

- Growing need for using Automated Number Plate Recognition (ANPR) data to detect and prevent crimes
- 30 million ANPR reads per day across the UK (2015), and lack of software tools enabling efficient automatic processing data
- We are developing a digital forensic tool to identify unknown and suspicious vehicles traveling in convoy "hid" in ANPR data.
  - Enhance functionalities of current analysis tool
  - Combining data from multiple data sources
  - No known number plate is needed

2. Background information

2.1 Data sources

- ANPR data from Surrey Police: contains Vehicle Registration Mark (VRM), date, time, camera ID, and camera GPS location.

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<tr>
<th>VRM</th>
<th>DATE</th>
<th>TIME</th>
<th>CAM ID</th>
<th>LATITUDE</th>
<th>LONGITUDE</th>
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<td>52.0000</td>
<td>11.0000</td>
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<tr>
<td>B</td>
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<td>2</td>
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<td>12.0000</td>
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<td>C</td>
<td>01/01/2015</td>
<td>08:00:00</td>
<td>1</td>
<td>54.0000</td>
<td>13.0000</td>
</tr>
</tbody>
</table>

- Data from UK’s Driver and Vehicle Licensing Agency (DVLA): vehicle’s make, model, color, and tax code
- Crime map from police.uk: public crime statistics
- Google Map: travel time estimation

2.2 Concepts

- Single vehicle journey: describes all travel activities of a single vehicle during a period of time.

Figure 1: Illustration of a journey

- Single vehicle session: refers to a single vehicle continuously traveling for a period of time without a break.

Figure 2: Illustration of sessions

- Convoy session: two or more vehicles traveling together for a period of time.

Figure 3: Illustration of a convoy session

3. Selected related work

- [1] uses data clustering techniques to extract and identify unusual patterns of multi-vehicle convoy activities using ANPR data.
- [3] investigates behavior of intentional following using ANPR data.
- [4] applies data mining techniques to discover vehicle activity patterns from ANPR data.

4. Simple rule based algorithm

The work presented in this section is an extended edition of a previous study [1].

5. Adaptive threshold based algorithm

- Aims to replace hard thresholds with adaptive ones using historical ANPR data and public traffic data.
- Aims to adjust all parameters to control the number of outputs to make them manageable.

Figure 4: Flow chart of the rule based algorithm

Figure 5: Flow chart of the algorithm with adaptive thresholds

6. Micro-behaviors of drivers in convoy sessions

6.1 Related driving behaviors

- Time difference (headway, daytime/night time, criminal behavior)
- Change order of driving (usual overtaking behavior)
- Change of lanes
- Number of intervening vehicles

6.2 Machine learning based analysis

- Features based on micro-behaviors
- Refinement and clustering of convoy sessions (see Figure 7)
- Prioritizing/Ranking convoy sessions based on behavioral features

Figure 6: (a) Distribution of travel times of all vehicles passing A and B on Monday (b) Distribution of the number of vehicles passing between A and B at different hours on Monday (c) Distribution of travel time of all vehicles passing between A and B from 08:00 to 09:00 on Monday (d) Distribution of travel time of all vehicles passing between A and B from 21:00 to 22:00 on Monday

Figure 7: Clustering convoy sessions using two features derived from time differences

7. Acknowledgments

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References