Uncovering patterns of movement suspension

Daniel Orellana
Monica Wachowicz
Henjo De Knegt
Arend Ligtenberg
Arnold Bregt

Motivation

Common task in movement analysis → Detect places where moving entities stop
Motivation

Common task in movement analysis → Detect places where moving entities stop

Objective: Develop a new approach to detect movement suspension patterns that represent the reduction of speed observed at places where moving entities stop.

Limitations on previous approaches

a) Predefined regions
b) Spatial thresholds
   + Temporal thresholds
c) Speed thresholds

Limitations related with observation

- There are no observations having speed=0

- Slow movement may be undistinguishable from inaccurate observations.
Our approach

A method to detect movement suspension patterns for collectives of objects using an index of local spatial association.

- For different applications and moving objects.
- No need of representing the whole trajectories.
- No need of spatial and temporal thresholds.
- Scale-independent.
Different representations of movement

Movement as trajectories

Movement as vectors
The LISA index

A Local Indicator of Spatial Association (LISA) is used to find spatial clusters of low speed vectors.

The LISA index

A Local Indicator of Spatial Association (LISA) is used to find spatial clusters of low speed vectors.
The LISA index

A Local Indicator of Spatial Association (LISA) is used to find spatial clusters of low speed vectors.

Given a movement dataset, the suspension patterns are spatial clusters of movement vectors that fulfill three conditions simultaneously: (a) having speed values below the average for a given data set; (b) having a positive local spatial association of these speed values; and (c) having a minimum statistical significance score of this association.
Implementation

Four datasets:

- Children playing an urban mobile game.
- Visitors walking in a recreational area.
- Trucks delivering cement in a city.
- Elephants moving in a Natural Park.
Urban Mobile Game

- 419 children in Amsterdam
- 61782 vectors
- 10 seconds for 6 days

55 Clusters:
- Checkpoints
- Game Events
- Pedestrian crossings

Dwingelderveld National Park

- 372 pedestrians visiting the park
- 141826 vectors
- Variable time rate for 14 days

152 Clusters:
- Parkings
- Attractions
- Facilities
- Cross-paths

Trucks in Athens

- 50 Trucks delivering cement
- 111,419 vectors
- 30 seconds for 40 days

252 Clusters:
- Distribution points
- Building projects
- Traffic jams?

Elephants in South Africa

[De Knecht, 2003]

- 5 Elephants in South Africa
- 100 337 vectors
- 1 hour for 30 months

85 Clusters:
- River banks
- Water bodies
- Fenced places
Overview of all experiments

Proportion of vectors classified as suspension and number of spatial clusters of movement suspension detected in each experiment.

<table>
<thead>
<tr>
<th>Category</th>
<th>Suspension Proportion</th>
<th>Number of Clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>18%</td>
<td>51 clusters</td>
</tr>
<tr>
<td>Visitors</td>
<td>6%</td>
<td>152 clusters</td>
</tr>
<tr>
<td>Trucks</td>
<td>32%</td>
<td>252 clusters</td>
</tr>
<tr>
<td>Elephants</td>
<td>7%</td>
<td>85 clusters</td>
</tr>
</tbody>
</table>
In the Dwingelderveld National Park, over 90% of movement vectors were associated to relevant spatial features.

Evaluation of the results

- True Positives: 90.9%
- False Positives: 9.1%

Vectors classified as suspension:
- Unknown
- Cross paths
- Facilities
- Attractions
- Parking lots
• Different kind of objects moving in different landscapes
• Different spatial and temporal scales
• Without thresholds
• Feasible to implement with your favourite GIS/Stats software.

Suspension patterns may represent some kind of interaction between moving entities and environmental features (e.g. attraction, restriction)
Limitations

- Different of moving entities together.
- Large datasets.
- Real time.
Future work

• Contextualisation and interpretation
• Temporal association of suspension patterns
Thank you!

Daniel Orellana
Centre for Geo-Information
Wageningen UR
daniel.orellana@wur.nl
http://ideasonmovement.wordpress.com