Modeling, Storing and Mining Moving Object Databases

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 Presented by Nermin Mudzelet
Motivation

- **Problems in traffic management**
  - Find alternatives for troublesome situations (e.g. traffic jams)

![Figure 1: Rush hour](image)
Motivation

- **Build MOD (Moving Object Database)**
  - Spatial data (roads, buildings, obstructions)
  - Non-spatial data (attributes, texts, pictures)
  - Trajectory data

- **Spatial Mining Language (SML)**

- **ΙΧΝΗΛΑΤΗΣ (Pathfinder) – Traffic Management System**
  - General Secretariat of Research and Development, Greece
  - Use real data from a fleet of moving vehicles to analyze, model, process and extract further knowledge
  - Routing optimization
Concepts

- **Moving object**
  - e.g. delivery truck, public transport, taxi

- **Trajectory (trace of the vehicle in time)**
  - Properties (speed, heading, covering area, etc.)
  - Relations (stay within, leave, enter, cross, bypass)

Figure 2: Trajectory of moving object

Figure 3: Relationships: trajectory/environment
Figure 4: Database scheme of MOD
Storing

- **Trajectory data storage**
  - NW_TRAJECTORY(trajectory_id, edge_id, time1, time2)
    - records trajectory segments
  - NODE(node_id, 2D-point)
    - represents the spatial aspect of the street network
  - EDGE_NODES(edge_id, node_id1, node_id2)
    - start/end nodes for each network edge
  - NODE_EDGES(node_id, edge_id)
    - capture the incident edges of nodes

![Figure 5: Relations between tables](image-url)
Storing

- For query optimization used various indexes
  - Spatial, B-tree index

- Stored 26000 trajectories
  - Size in database 1GB

<table>
<thead>
<tr>
<th>Network Schema</th>
<th>Size (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table or Index</td>
<td></td>
</tr>
<tr>
<td>NW_TRAJECTORY</td>
<td>476.41</td>
</tr>
<tr>
<td>NW_TRAJECTORY_INDEX</td>
<td>480.2</td>
</tr>
<tr>
<td>NODE</td>
<td>5.95</td>
</tr>
<tr>
<td>NODE_INDEX</td>
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<tr>
<td>NODE_EDGES</td>
<td>6.12</td>
</tr>
<tr>
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<tr>
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<tr>
<td>EDGE_NODES_INDEX</td>
<td>3.4</td>
</tr>
<tr>
<td>Total</td>
<td>999.73</td>
</tr>
</tbody>
</table>

Table 1: Trajectory data storage occupation
Overview

1. Motivation
2. Modeling, Storing and Mining
3. Related Work
4. Relation to Our Projects
5. Strong and Weak Points
Data mining functions – query existing information to extract knowledge

- Characterization
  - assigning a new attribute to a class based on some attribute values
- Clustering
  - new object class based on the values of some attributes
- Association
  - relationship between object classes

Spatial Mining Language (SML) of the ΙΧΝΗΛΑΤΗΣ system

Generic syntax:

```
MINE mining function
ON/AMONG object class(-es)
AS composite spatial constraint
```
Mining

Example

- **Query**: Find all vehicles with a traveled distance of 15 to 20 km from the center of Athens towards South, between 10:00 to 10:30 and cluster them as ‘equivalent_routes’.

```
MINE CLUSTERING 'equivalent_routes'
ON trajectory
AS (15 km < distance(GetPosition(10:00) -
GetPosition(10:30)) < 20 km) and (170 <
GetHeading(spatial extent: center±20km,
temporal extent: 10:00 - 10:30) < 190
(degrees))
```

Figure 7: Spatiotemporal range
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Most of the related work includes tools in spatial data mining and traffic management

- The paper provides abstract data type extension to a DBMS data model and query language for moving objects, and it is basis for data types in this paper

“Querying the Trajectories of On-Line Mobile Objects” by Dieter Pfoser and Christian S. Jensen
- The paper presents a technique for querying trajectories, and it is used as basis on this paper for manipulating trajectories
Relation to our projects

- **Motivation close to ours**
  - Analyses and processing of traffic data
- **GPS data points are map matched to road segments**
- **We are using data warehouse**
  - Discrete spatial locations and trajectories approach
- **We can use storage model**
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Strong and weak points

**Strong points**
- Contribution of paper is clearly pointed out
- Explanation of SML language includes examples

**Weak points**
- Actual implementation and performance of system not included
- Explanation of Figure 3 in the paper not clear enough
Thank You!