Analysis of mobility patterns in different neighborhoods, integrating GPS tracks with OpenStreetMap data

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Contents

Introduction

- Objectives
- Relevance

Methodology

- Tools
- Datasets

Implementation

- Theoretical performances
- Actual performances

Results

Conclusions & Future Research
Contents

Introduction
- Objectives
- Relevance

Methodology
- Tools
- Datasets

Implementation
- Theoretical performances
- Actual performances

Results

Conclusions & Future Research
Introduction

- Mobility patterns are complex
- Current trend: more and longer trips mostly by private car
- Policy makers and spatial planners: need of accurate information
Introduction

- Open data
- Volunteer Geographic Information (VGI)
- New technologies and tools

Facilities and built environment characteristics

Actual people travel behaviour

Theoretical Performances

Actual Performances
Objectives

- Validate theoretical performances (built environment characteristics) with actual performances (actual people travel behaviour)
- Develop a standard procedure to assess mobility patterns in the different neighborhoods

Main Research Question

“How do different neighbourhoods perform in terms of mobility patterns based on proximity, density, and accessibility?”
Relevance

- Add a new layer of knowledge to previous studies (maps and real data)
- Help policy makers to assess **actual** mobility patterns
- SDSS (Spatial Decision Support System)
- Neighbourhood renovation and future neighbourhood design
Contents

Introduction
• Objectives
• Relevance

Methodology
• Tools
• Datasets

Implementation
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• Actual performances

Results

Conclusions & Future Research
Tools

- **PostgreSQL/PostGIS**: DBMS (Database Management Systems)
- **QGIS**: GIS (Geographical Information Systems)
- **IBM SPSS**: Statistical analysis
- **PgRouting**: PostgreSQL extension for routing functionalities
Datasets

OpenStreetMap: infrastructure network and theoretical performances
Datasets

BBG (Bestand Bodemgebruik): land use
Datasets

BAG (Basisregister Adressen en Gebouwen): buildings
Datasets

**CBS (Central Bureau of Statistics):** population, neighbourhoods boundaries
Datasets

**GPS real data**: actual performances
Case study

10 neighborhoods in 3 different cities

GPS survey in 2012

Amersfoort: Nieuwland, Vathorst, Kattenbroek, Schohorst, city center, Leusderkwartier

Veenendaal: Dragonder-Noord and Dichtersbuurt & Schepenbuurt

Zeewolde: Horsterveld, Zeewolde-Zuid
Contents

Introduction
  • Objectives
  • Relevance

Methodology
  • Tools
  • Datasets

Implementation
  • Theoretical performances
  • Actual performances

Results

Conclusions & Future Research
Theoretical performances

17 Indicators

Literature review: 25 papers

Criteria:

- GIS-based
- Neighbourhood scale
- Available datasets
- Aim of the research

<table>
<thead>
<tr>
<th>Measure</th>
<th>Indicator description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximity</td>
<td>Distance (shortest path) to closest railway station (km)</td>
</tr>
<tr>
<td></td>
<td>Distance (shortest path) to the closest bus stop (m)</td>
</tr>
<tr>
<td></td>
<td>Distance (shortest path) to closest motorway exit (km)</td>
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<tr>
<td></td>
<td>Distance (shortest path) to several daily facilities (supermarket, school, etc.) (m)</td>
</tr>
<tr>
<td></td>
<td>Distance (shortest path) to city centre (km)</td>
</tr>
<tr>
<td>Density</td>
<td>Population density (residents/ km²)</td>
</tr>
<tr>
<td></td>
<td>Road, public transport, cycle and walk network density (km/km²)</td>
</tr>
<tr>
<td></td>
<td>Parks and green areas density (parks/ km²)</td>
</tr>
<tr>
<td></td>
<td>Buildings density (buildings/ km²)</td>
</tr>
<tr>
<td></td>
<td>Land use mix per neighbourhood (% land use type/total area)</td>
</tr>
<tr>
<td></td>
<td>Buildings function density (office, residential, industrial, etc.) (building function type/total n° buildings)</td>
</tr>
<tr>
<td>Accessibility</td>
<td>City centre accessibility (travel distance/travel time)</td>
</tr>
<tr>
<td></td>
<td>Ratio n° buildings with railway station within 1 km (Network/Euclidean distance)</td>
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<tr>
<td></td>
<td>% Buildings with railway station within 10 min travel time by car, bike and walking</td>
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<tr>
<td></td>
<td>Ratio n° buildings with bus stop within 500 m (Network/Euclidean distance)</td>
</tr>
<tr>
<td></td>
<td>N° shops within 10 min travel time by car, bike and walking</td>
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<tr>
<td></td>
<td>N° schools within 2 and 5 km (Euclidean distance)</td>
</tr>
</tbody>
</table>
Theoretical performance indicators

**Proximity:** distance from an origin to a destination

Closest railway station, bus stop, motorway exit, school, supermarket and city centre

**Density:** land use or activities intensity

Population, network, land use, parks, open area, and building function types

**Accessibility:** importance of a location based on distance/opportunities

Railway station, % buildings, shops, bus stops, shops, and school
Actual performances

Original GPS dataset: 40 millions of track points

1. GPS data filtering: 400 households selected

2. Households geolocation by postal codes

3. Actual performances implementation
   • Travel modes
   • Main destinations
   • Walking modal share
Actual performances

- **Modal share:** car, foot, bicycle and rail

![% GPS track points per travel mode chart](chart.png)
Actual performances

- Main destinations

GPS track points

Cluster main destinations according to number of visiting households
Actual performances

- Main destinations

  - Shops in Amersfoort city centre visited only by 30% of local households
  - Ikea in Vathorst visited only by 25% of local households
  - Amersfoort central station visited only by 20% of local households
Actual performances

• Walking modal share

Where do people actually walk?

• City centre and within their own neighbourhood
• Parks and green areas
Validation

**Theoretical Performances**
- Proximity
- Density
- Accessibility

**Actual Performances**
- Modal share
- Main destinations
- Walking travel mode
Validation

1. **Normalization**: z-scores

2. **Classification**:
   - Natural Breaks (Jenks) with 5 classes
   - Likert scale: Low, Medium-Low, Medium, Medium-High and High

3. **Correlation Test**: Spearman coefficients (between 1 and -1)
   - +1: positive correlation
   - 0: no correlation
   - -1: negative correlation
Validation

GPS tracks by walking  Positive correlation  wider building function type mix
higher population density

GPS tracks by train  Positive correlation  closeness to the railway station

GPS tracks by car  Negative correlation  closeness to the railway station

GPS tracks by walking  No correlation  wider land use mix
Contents

Introduction
• Objectives
• Relevance

Methodology
• Tools
• Datasets

Implementation
• Theoretical performances
• Actual performances

Results

Conclusions & Future Research
Theoretical performances: overall results
Theoretical performances: overall results

The most efficient neighbourhoods:
*Amersfoort city centre and Dichtersbuurt and Schepenbuurt*
- Wide building function types mix
- Closeness to railway station
- Great accessibility to shops by walking/cycling

The least efficient neighbourhoods:
*Horsterveld*
- Bad accessibility and closeness to railway station and motorway exit
- Low building density
Theoretical performances: overall results

Theoretical & actual performances

Performance levels:
1: Low
2: Medium-Low
3: Medium
4: Medium-High
5: High
Contents

Introduction

- Objectives
- Relevance

Methodology

- Tools
- Datasets

Implementation

- Theoretical performances
- Actual performances

Results

Conclusions & Future Research
Conclusions

Key aspects and points of innovation:

- **Real data (GPS tracks)** instead of traditional methods
  - Sample data but still reliable
- **Open data** and open source tools
  - OpenStreetMap
- **GIS-based indicators** rather than pure statistical indexes
- **Network distance** instead of Euclidean distance
- **PgRouting**: shortest path and accessibility maps
Conclusions

- **Neighbourhoods’ theoretical performances:** different scores
- **Match theoretical and actual performances:**
  - Perfect match 4/10 Neighbourhoods
  - In general assigned to neighbouring classes
- **Proximity, density and accessibility have impact on the way people travel**
- **Key factors for promoting sustainable mobility:**
  - Closeness to the city centre
  - Diverse building function types
  - Great accessibility to railway station
Future Research

• **Use a broader range of indicators**: traffic information, accidents information, job accessibility, income, parking density, sidewalks, public transport timetables

• **Use additional datasets** (e.g. Dutch Travel Survey, CBS, OpenOV)

• **Improve routing**: turns, traffic lights

• **Improve GPS data analysis**: modality algorithm, trip algorithm, travel diaries

• **Classification**: use thresholds and apply weights
Thank you!