ESTABLISHING AN OBJECT IDENTIFICATION METHOD BASED ON THE DESCRIPTION OF NEIGHBOURING ELEMENTS

MSc Geomatics for the Built Environment
Cathelijne Kleijwegt • 25 - 01 - 2019
INTRODUCTION

Problem statement

• Fixi: application to report issues in public space

• Problems:
  • GNSS is turned off
  • Pointing out on a map is difficult
  • Reporting position of user, not of object

→ Describe the object
“Can an object identification method be established based on the description of neighbouring elements?”
INTRODUCTION

Research questions

1. What type of surrounding elements can be considered for the description of an object?
2. Which datasets are available that provide the position of those elements?
3. What kind of spatial relationships can be used as an input?
4. What method can be used to process the input?
5. To what extent does the developed method meet certain requirements?
INTRODUCTION

Scope

• **Spatial**
  Municipality of Westervoort, Amsterdam & Joure

• **Data**
  Data is correct and complete

• **Input of the user**
  Correct and complete
  User fill out a form

• **Implementation**
  Test version
INTRODUCTION

Research methodology

Phase 1
• Theoretical research
  • Problem definition
  • Literature review

Phase 2
• Development method
  • Develop elements
  • Improve and adjust

Phase 3
• Testing
  • Test elements upon functionality
  • Test method upon requirements

Phase 4
• Conclude
  • Documenting
  • Process, outcomes and conclusions
LITERATURE REVIEW

Positioning based on landmarks [Willems, 2017]

• Pure landmark approach
• Indoor
• Obstacles / visibility
• Structured input
Elements of a city – Models and definitions

- 5 Definitions of Lynch [Lynch, 1960]
  - Path, edge, district, node, landmark
- CityGML [Gröger and Plümer, 2012]
  - International model
  - Semantics of objects
  - 12 feature types, 5 Levels of Detail
- IMGeo [Geonovum, 2018]
  - “Plus objects” for BGT
  - Objects in public space
LITERATURE REVIEW

Spatial relationships [Egenhofer and Herring, 1990]

- Describe relationships between elements
- Point, line, & area elements
  - 4 Intersection Model
  - 9 Intersection Model
  - Dimension Extended Model
  - Calculus Based Model

### Calculus Based Model

<table>
<thead>
<tr>
<th></th>
<th>Point/point</th>
<th>Point/line</th>
<th>Point/area</th>
<th>Line/line</th>
<th>Line/area</th>
<th>Area/area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>In</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cross</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Overlap</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Disjoint</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
METHODOLOGY & IMPLEMENTATION

Introduction

Literature review

Methodology & Implementation

Demo

Tests & Results

Conclusion
METHODOLOGY & IMPLEMENTATION

**Input: Data**

- Reference data of described elements
- PDOK datasets
  - BGT: road, railroad, bin, pole, sign
  - NWB: road names
  - CBS: districts and neighbourhoods
  - BRK: municipality boundary
  - BRT: backgroundmap

---

<table>
<thead>
<tr>
<th>Element</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Path</td>
<td>Street</td>
</tr>
<tr>
<td>2. Edge</td>
<td>Railroad</td>
</tr>
<tr>
<td>3. District</td>
<td>Neighbourhood and roadtype</td>
</tr>
<tr>
<td>4. Node</td>
<td>Crossing of two streets</td>
</tr>
<tr>
<td>5. Landmark</td>
<td>Sign and bin</td>
</tr>
</tbody>
</table>
Preprocess datasets

- Explore data
- Remove attributes which are of no need
- Spatially restrict dataset to case boundary
  - Westervoort, Amsterdam, Joure
- Remove features that do not exist (end date)
METHODOLOGY & IMPLEMENTATION

Input: User

• Form to fill out
• Iterative with process element
  • Options dependent on input and process output

Preprocess data

Input: Data

Process

Output
METHODOLOGY & IMPLEMENTATION

Input: User

• Three versions:
  • Version 1: spatial relationships and indicated distances
  • Version 2: spatial relationships
  • Version 3: indicated distances

• Spatial relationships
  • Calculus Based Method
  • Fixi issues
  • QGIS spatial analysis

Spatial relationships
  • Langs (along)
  • In de buurt (close by)
  • Aanwezig binnen straal (present within radius)
  • Niet aanwezig binnen straal (absent within radius)
  • Op (on)
**Methodology & Implementation**

**Process**

- Technical method that identifies the object
- Spatial analysis
  - Vector approach
    - Vector data
    - Level of detail: object identification
  - Buffers, clipping, presence/absence
Output

- Preliminary outcomes
  - Visualized on the map
  - Number of objects
- Final output on the map
Introduction

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Methodology & Implementation

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Tests & Results

Conclusion

8 - Object ID: bd4a33be1-de40-11e7-8ec4-89be260623ee
Object type: afvalbak
Neighbourhood: Westervoort
Street: 5m Klapstraat
Street 2: xx
Object 1: 6m lichtmast
Object 2: 12m verkeersbord
Railroad: 389m
Roadtype: on tegels
Tests

- Scenarios selected at random
  - 10 for each municipality
- Object & description is known
  - To check output
- Two tests
  - Implemented elements
  - Overall method
**Tests & Results**

**Implemented elements**

- Reference (neighbouring) elements
- Degree of selectivity of each element
- First selection upon entire dataset
  - For each scenario and each element \((m \times n \text{ tests})\)
- Percentage remaining objects

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Element 1</th>
<th>Element 2</th>
<th>Element 3</th>
<th>Element n</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>..%</td>
<td>..%</td>
<td>..%</td>
<td>..%</td>
</tr>
<tr>
<td>2</td>
<td>..%</td>
<td>..%</td>
<td>..%</td>
<td>..%</td>
</tr>
<tr>
<td>3</td>
<td>..%</td>
<td>..%</td>
<td>..%</td>
<td>..%</td>
</tr>
<tr>
<td>m</td>
<td>..%</td>
<td>..%</td>
<td>..%</td>
<td>..%</td>
</tr>
</tbody>
</table>
## Tests & Results

### Implemented elements

- Each municipality different results
- Dependent on data and scenario
- Remaining percentage
- Street most selective for each municipality

### Table: Results

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Order</th>
<th>Neighbourhood</th>
<th>Street</th>
<th>Railroad</th>
<th>Roadtype</th>
<th>2 streets</th>
<th>Feature 1</th>
<th>Feature 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 8</td>
<td>1</td>
<td>56.3%</td>
<td>1.9%</td>
<td>34.2%</td>
<td>17.7%</td>
<td>100.0%</td>
<td>32.3%</td>
<td>36.7%</td>
</tr>
</tbody>
</table>

### Figures

(a) Westervoort

(b) Amsterdam

(c) Joure

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### Literature Review

### Methodology & Implementation

### Demo

### Tests & Results

### Conclusion
Six requirements:

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
</table>

- (Least desired)
- (Most ultimate)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Number of questions</td>
<td>&gt;5</td>
<td>3-5</td>
<td>&lt;3</td>
</tr>
<tr>
<td>2. Is the object present?</td>
<td>X &gt;15</td>
<td>5-15 m</td>
<td>&lt;5 m</td>
</tr>
<tr>
<td>3. Amount of suggested objects</td>
<td>&gt;500 m²</td>
<td>200-500 m²</td>
<td>&lt;200 m²</td>
</tr>
<tr>
<td>4. Average distance to elements</td>
<td>&gt;45 sec</td>
<td>20-45 sec</td>
<td>&lt;20 sec</td>
</tr>
<tr>
<td>5. Covered area of suggested objects</td>
<td>&gt;500 m²</td>
<td>200-500 m²</td>
<td>&lt;200 m²</td>
</tr>
<tr>
<td>6. Completion time of description</td>
<td>&gt;45 sec</td>
<td>20-45 sec</td>
<td>&lt;20 sec</td>
</tr>
</tbody>
</table>

Overall method:

Input: Data → Preprocess data → Input: User → Process → Output → Test
## 1. Number of questions

**High:** <3  |  **Middle:** 3 - 5  |  **Low:** >5 questions

<table>
<thead>
<tr>
<th></th>
<th>Westervoort</th>
<th>Amsterdam</th>
<th>Joure</th>
</tr>
</thead>
</table>
| **Version 1**  
(both)     | 0  | 2  | 8     |
|          | 2  | 2  | 6     |
|          | 2  | 1  | 4     |

| **Version 2**  
(spacial relationships) | 0  | 1  | 9     |
|                          | 2  | 0  | 8     |
|                          | 1  | 4  | 5     |

| **Version 3**  
(indicated distances) | 0  | 2  | 8     |
|                        | 4  | 1  | 5     |
|                        | 2  | 3  | 5     |
2. Is the object present?  **High:** present

<table>
<thead>
<tr>
<th></th>
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<th>Joure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Version 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(both)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Version 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(spatial relationships)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Version 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(indicated distances)</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Tests & Results

**Overall Method**

3. Amount of suggested objects **High**: <3 | **Middle**: 3 - 15 | **Low**: >15 objects

<table>
<thead>
<tr>
<th></th>
<th>Westervoort</th>
<th>Amsterdam</th>
<th>Joure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Version 1</strong></td>
<td><img src="image1" alt="Bar Chart" /></td>
<td><img src="image2" alt="Bar Chart" /></td>
<td><img src="image3" alt="Bar Chart" /></td>
</tr>
<tr>
<td><em>both</em></td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td><strong>Version 2</strong></td>
<td><img src="image4" alt="Bar Chart" /></td>
<td><img src="image5" alt="Bar Chart" /></td>
<td><img src="image6" alt="Bar Chart" /></td>
</tr>
<tr>
<td><em>spatial relationships</em></td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Version 3</strong></td>
<td><img src="image7" alt="Bar Chart" /></td>
<td><img src="image8" alt="Bar Chart" /></td>
<td><img src="image9" alt="Bar Chart" /></td>
</tr>
<tr>
<td><em>indicated distances</em></td>
<td>6</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

Introduction | Literature review | Methodology & Implementation | Demo | Tests & Results | Conclusion | 26
4. Average distance to elements **High**: <5 | **Middle**: 5 - 15 | **Low**: >15 meter

<table>
<thead>
<tr>
<th></th>
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<th>Amsterdam</th>
<th>Joure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Version 1</strong></td>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
<tr>
<td><em>(both)</em></td>
<td>5 5 0</td>
<td>4 5 1</td>
<td>4 6 0</td>
</tr>
<tr>
<td><strong>Version 2</strong></td>
<td><img src="image4.png" alt="Graph" /></td>
<td><img src="image5.png" alt="Graph" /></td>
<td><img src="image6.png" alt="Graph" /></td>
</tr>
<tr>
<td><em>(spatial relationships)</em></td>
<td>2 8 0</td>
<td>4 5 1</td>
<td>2 8 0</td>
</tr>
<tr>
<td><strong>Version 3</strong></td>
<td><img src="image7.png" alt="Graph" /></td>
<td><img src="image8.png" alt="Graph" /></td>
<td><img src="image9.png" alt="Graph" /></td>
</tr>
<tr>
<td><em>(indicated distances)</em></td>
<td>6 3 1</td>
<td>6 2 2</td>
<td>5 5 0</td>
</tr>
</tbody>
</table>
## Tests & Results

### Overall method

5. Covered area of suggested objects

- **High**: $< 200 \ m^2$
- **Middle**: $200 - 500 \ m^2$
- **Low**: $> 500 \ m^2$

<table>
<thead>
<tr>
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<th>Amsterdam</th>
<th>Joure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Version 1</strong></td>
<td><img src="9" alt="9" /></td>
<td><img src="8" alt="8" /></td>
<td><img src="9" alt="9" /></td>
</tr>
<tr>
<td><em>(both)</em></td>
<td>0 1</td>
<td>0 2</td>
<td>0 1</td>
</tr>
<tr>
<td><strong>Version 2</strong></td>
<td><img src="6" alt="6" /></td>
<td><img src="6" alt="6" /></td>
<td></td>
</tr>
<tr>
<td><em>(spatial relationships)</em></td>
<td>1 3</td>
<td>1 3</td>
<td></td>
</tr>
<tr>
<td><strong>Version 3</strong></td>
<td><img src="7" alt="7" /></td>
<td><img src="7" alt="7" /></td>
<td><img src="8" alt="8" /></td>
</tr>
<tr>
<td><em>(indicated distances)</em></td>
<td>0 3</td>
<td>1 2</td>
<td>0 2</td>
</tr>
</tbody>
</table>

### Introduction

- Literature review
- Methodology & Implementation
- Demo
- Tests & Results

### Conclusion

- 28
## 6. Completion time of description

**High:** $<20$ | **Middle:** $20 - 45$ | **Low:** $>45$ seconds

<table>
<thead>
<tr>
<th></th>
<th>Westervoort</th>
<th>Amsterdam</th>
<th>Joure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Version 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(both)</em></td>
<td><img src="chart1.png" alt="Bar Chart" /></td>
<td><img src="chart2.png" alt="Bar Chart" /></td>
<td><img src="chart3.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td><strong>Version 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(spatial relationships)</em></td>
<td><img src="chart4.png" alt="Bar Chart" /></td>
<td><img src="chart5.png" alt="Bar Chart" /></td>
<td><img src="chart6.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td><strong>Version 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>(indicated distances)</em></td>
<td><img src="chart7.png" alt="Bar Chart" /></td>
<td><img src="chart8.png" alt="Bar Chart" /></td>
<td><img src="chart9.png" alt="Bar Chart" /></td>
</tr>
</tbody>
</table>

### Notes:
- Introduction
- Literature review
- Methodology & Implementation
- Demo
- Tests & Results
- Conclusion
1. Questions

2. Presence

3. Number of objects

4. Average distance

5. Covered area

6. Time
Tests & Results

Overall method

General

- Version 3 scored best \(\text{(only distances)}\)
- Version 1 slightly worse \(\text{(distance and spatial relationships)} \rightarrow \text{time requirement}\)
- Version 2 scored worst \(\text{(only spatial relationships)} \rightarrow \text{less details}\)

- Improvements:
  - Number of questions
  - Average distance to elements
  - Completion time
1. What type of surrounding elements can be considered for the description of an object?
   • Position & relevance
   • Definitions of Lynch: path, edge, district, node, and landmark
   • Data models: CityGML and IMGeo

2. Which datasets are available that provide the position of those elements?
   • Official & open data
   • PDOK: BGT, NWB, CBS, BRK, BRT
3. What kind of spatial relationships can be used as an input?
   • CBM, Fixi notifications, QGIS spatial analysis
   • Along, close by, present within radius, absent within radius, on

4. What method can be used to process the input?
   • Vector approach: spatial analysis
   • Buffer/clipping, based on presence and absence

5. To what extent does the developed method meet certain requirements?
   • Six criteria and three scores per criteria to test
CONCLUSIONS

Research questions

Can an object identification method be established based on the description of neighbouring elements?

The method has been developed and tested, and it worked. But…

• **Reference elements**: relevant for the case and position known
• **Input**: distance provides valuable information
  • presence and absence of reference elements
• **Process**: preserve level of detail
• **Criteria**: not all criteria score high
CONCLUSIONS

Available information reference elements – only position

Efficiency code – no priority (but criteria)

Test scenarios – 30 scenarios & author executed the tests
CONCLUSIONS  Recommendations & Future work

• **Way of buffering** – doughnut or with orientation (*traffic sign*)

• **User experience** – improve the process for the user

• **Visibility analysis** – digital surface model and obstructions

• **Vector & raster approach** – compare the two versions
ESTABLISHING AN OBJECT IDENTIFICATION METHOD BASED ON THE DESCRIPTION OF NEIGHBOURING ELEMENTS

MSc Geomatics for the Built Environment
Cathelijne Kleijwegt • 25 - 01 - 2019
Appendix

Decrease objects version 1

Westervoor

Amsterdam

Joure

Introduction

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Appendix

Decrease objects version 3

Westervoor

Amsterdam

Joure

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