Exploring a pure landmark-based approach for indoor localisation

O.T. Willems

5\textsuperscript{rd} of November 2017 – P5 presentation
Supervisors: S. Zlatanova, E. Verbree
Co-reader: P. Nourian
Exploring a pure landmark-based approach for indoor localisation

O.T. Willems
5rd of November 2017 – P5 presentation
Supervisors: S. Zlatanova, E. Verbree
Co-reader: P. Nourian

vision and conceptual framework
Exploring

There is a need to move beyond sensor-based indoor localisation and navigation. (Winter, 2017)

• Context driven location based services (LBS)
• Seamless connection between outdoor and indoor environment
• LBS centred around the user

How can a pure landmark-based approach achieve adequate indoor localisation? To lay a foundation for landmark-based LBS
Landmark

• Traditionally (unique) salient objects in the urban landscape

• 5 parameters of salience: 1) visual salience, 2) cognitive salience, 3) structural salience, 4) visibility in advance, and 5) prototypicality.

• Indoor environment: (salient) objects with various levels of uniqueness

Any objects, agent or resource, that is visible from one to tens of meters and further, and that is distinguishable from its context or surroundings.
Indoor localisation (and positioning)

<table>
<thead>
<tr>
<th>Method</th>
<th>Landmarks</th>
<th>Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angulation</td>
<td>2+</td>
<td>yes (angle)</td>
</tr>
<tr>
<td>Lateration</td>
<td>3+</td>
<td>yes (distance)</td>
</tr>
<tr>
<td>Fingerprinting</td>
<td>1+ *</td>
<td>no</td>
</tr>
</tbody>
</table>

Location: East.bg.xxx
Position: (x,y)
Vision

- Describe the environment (i.e. what is visible and how visible objects relate to each other) and get a location from the system.
Conceptual framework

The system must be able to **interpret observations and translate it into action**, in this case, observations which landmarks are visible, and the relative locations of landmarks. For a system to understand observations, the observations require being according to a **machine-readable formal grammar**. The system must know where each landmark is located and where each landmark is visible. To calculate where each landmark is visible the systems must also know or be able to where there are obstacles that impair visibility. After interpreting the observations, the system should also be able to **cross reference or match the visibility** of various landmarks that are observed by the user. Given there might be observations that talk about the relative location of one landmark to another landmark, the system should provide **tools that narrow down location based on relative location**. With as a result a user’s location. The visibility of landmarks could be considered as a **fingerprint or a functional region**.
Conceptual framework: Workflow

• Pre-processing: fingerprinting

• Processing: localisation
Conceptual framework: data specifications

- Geometric representation
  - Based on size and visibility

- Data model
  - Uniqueness
  - Visibility modifiers
Workflow: data preparation

- Split objects into landmarks and obstacles
- Homogenise shapes
  - Subdivide linear landmarks
  - Create interior for obstacles

![Diagram](image)

- All shapes
- Landmarks
  - #1
  - #2
- Obstacles
- Line is split into segments
- Take endpoints of each segment
- Represent landmark as points
Workflow: calculate visibility

• Viewshed / isovist field analysis
• Ray-trace landmarks
• Stitch polygon together

Ray-trace to every corner
Extend rays to ‘look’ past corners
Stitch polygon together by azimuth angle
Workflow: fingerprint

- Single landmark visibility
- Combinations of landmarks
- Cross reference visibility
Workflow: machine-readable observations

- Interpret observations
- Calculate A-B specific location
  - Angle-based (unambiguous)
  - Distance-based (unambiguous)
- I see landmark A (and B)
- I see A left/right of B
- I am closer to A compared to B
Workflow: localisation

- Retrieve location
- Refine location
- Ask follow-up questions
Implementation

• PostgreSQL + PLPGSQL
• PostGIS + intarray extension
• FME and QGIS
Implementation: Artificial cases

Case to create minimal viable products
Case to test and evaluate MVPs
Implementation: Artificial case #1

- Initialise fingerprint (54 seconds)
- Localise (12 milliseconds)

- Initialise (2.5 seconds)
- Localise (25 milliseconds)
Artificial case #1

---/ Observation #1
I see 7, I see 8, I see 7 right of 17
---/ Observation #2
I see 11, I see 12, I see 13
---/ Observation #3
I see 14, I see 18
Implementation: Artificial case #2: BK-City

- Initialise 1.0m (9:30 minutes)
- Localise (25-30 milliseconds)

- Initialise 0.5m (14:38 minutes)
- Localise (25-30 milliseconds)
Artificial case #2: BK-City

I can see EspressoBar (53), I see BK-Expo (69), I see coffe corner (70)

I can see Geomatics Info (79), I can see Architecture Info (80)

I can see lecturer (61), I am in between clock (1) and B (21)
Challenges

- Precision

- Visibility polygon
  - Valid geometry
  - No self-intersection
  - No context intersection
Challenges

• Visibility
  • Estimate correctly
  • Boolean vs Fuzzy
  • Key-hole visibility

• 2D representation of 3D objects
Conclusion

*How can a pure landmark-based approach achieve adequate indoor localisation? To lay a foundation for landmark-based LBS*

- A landmark-based approach is achievable: a location can be obtained by using a visual fingerprinting adaptation and can be improved using lateration and angulation principles.
- Any object that distinguishes itself from surroundings is a landmark
  - Uniqueness is most important
  - Attributes that impact the visibility are optional
  - Hierarchy to improve user-interaction
Recommendations

• Extend the use of salience (i.e. for user interaction)
• Use a spatial standard as input for obstacles/landmarks (CityGML, …)
• Account for fuzzy visibility and ‘key-hole’ visibility

Future work

• Seamlessly connect with automatic data acquisition and navigation
• Provide the implementation in 3D
• Use landmarks in context-aware applications
Exploring a pure landmark-based approach for indoor localisation

Thank you for your attention!

O.T. Willems
o.t.Willems@student.tudelft.nl