Mobile Robot Self-Localization in Large-Scale Environments

Axel Lankenau, Thomas Röfer

Bremen Institute of Safe Systems
Center for Computing Technology (TZI)

Universität Bremen

Germany
Working Group “Cognitive Robotics”

Spatial Cognition

Safe Robotics

Driving Assistant

RoboCup

SLAM

Navigation Assistant

Mobile Robot Self-Localization in Large-Scale Environments
Generalization of Locomotion

224cm, 75°, 799cm, -83°, 880cm, -87°, 260cm
Modeling the Environment

Junction „DCI“
Junctions

- Angle between incoming and outgoing segment
- Length of outgoing segment
- List of incoming segments
Inductive Approach

- Idea: Assigning route corners to junctions
- Two-step assignment
  - Corner matches a junction
  - The rest of the generalized route matches up to the junction
Probabilities from Similarities

- Probability vs. Angle Difference (radians)
- Probability vs. Corridor Length (cm)
- Probability vs. Route Segment Length (cm)
Probabilities: Matching Corners

- Differentiation between the probabilities that
  - the corner previously generalized really exists, …
    - Angle of corner is similar to angle of the junction in the route graph
  - … the corner has been detected erroneously, …
    - Angle of corner is similar to 0°
  - … a corner has been overlooked, …
    - Angle of the junction in the route graph is similar to 0°
  - … it has been turned around at the corner previously generalized
    - Angle of corner is similar to 180°
Propagation of Probabilities

- **When no corner has been detected**
  - Probabilities of overlooked corners

- **When a corner has been detected**
  - Case 1: corner really exists (normal junction, turn around)
  - Case 2: corner does not exist
Indoor and Outdoor Navigation

- Building: MZH
Indoor and Outdoor Navigation

- Building: NW 2
Indoor and Outdoor Navigation

- Buildings: IW + BIBA
Indoor and Outdoor Navigation

- Building: MZH
- Overall length: 2176 m
Odometry Data

Mobile Robot Self-Localization in Large-Scale Environments
Route Graph
Results I

Believed in previous corner
Not believed in previous corner
Most probable position

Intensity encodes confidence
Speeded up by factor 70
Reference: Laser Map
Results II

[Graph showing deviation in cm over route progress]

Mobile Robot Self-Localization in Large-Scale Environments
## Related Work

<table>
<thead>
<tr>
<th>Model</th>
<th>RouteLoc</th>
<th>Nourbakhsh et al.</th>
<th>Simmons &amp; Koenig</th>
<th>Thrun et al.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor input</td>
<td>Topological-metric map</td>
<td>State set / topological map</td>
<td>Markov states, hybrid topological-metric map</td>
<td>Particle filter, metric map</td>
</tr>
<tr>
<td>Scenario</td>
<td>campus (in &amp; outdoor)</td>
<td>office (indoor)</td>
<td>office (indoor)</td>
<td>museum (indoor)</td>
</tr>
<tr>
<td>Markov</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Complexity</td>
<td>144 junctions + 102 turn-junctions for 46 nodes and 100 edges, depends on number of decision points</td>
<td>One state per node (decision point) or per edge (corridor)</td>
<td>3348 Markov states for 95 nodes and 180 edges, depends on metric extent of environment</td>
<td>About 1000 samples for an indoor environment, number of samples adaptable (anytime)</td>
</tr>
<tr>
<td>Memory</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>huge</td>
</tr>
<tr>
<td>Precision</td>
<td>Position estimate given by junction and metric offset</td>
<td>Corridor resolution, no metric information</td>
<td>Markov states provide resolution of 1m (translational), 90° (rotational)</td>
<td>Samples indicate position, only small errors</td>
</tr>
</tbody>
</table>
Summary & Outlook

- **Probabilistic self-localization based on locomotion**
  - Minimal sensor equipment
  - Suitable for large-scale environments
  - Efficient

- **Future Work**
  - SLAM
  - Integration of additional sensor measurements