



Universität Bremen

# Self-Localization in Large-Scale Environments for the Bremen Autonomous Wheelchair

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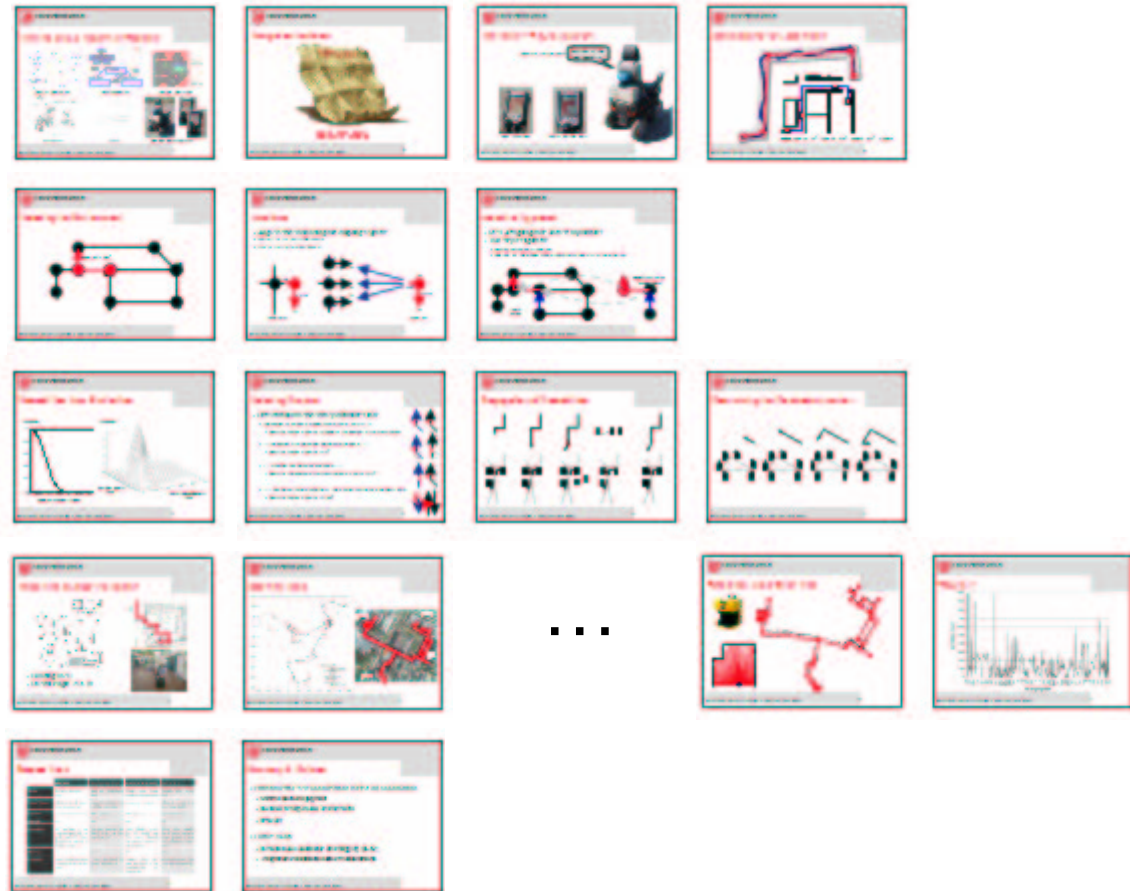
Bremen Institute of Safe Systems  
Center for Computing Technology (TZI)

Universität Bremen

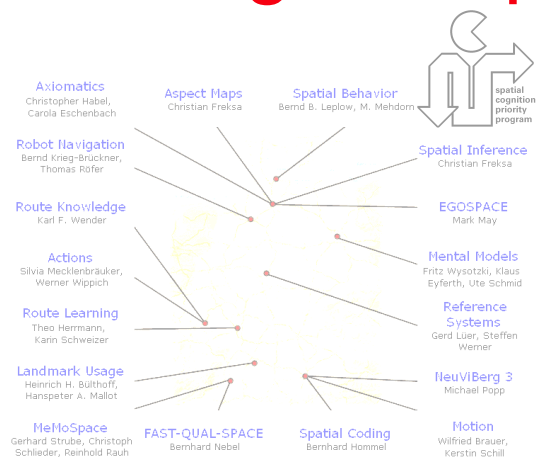
Germany

# Outline of the Talk

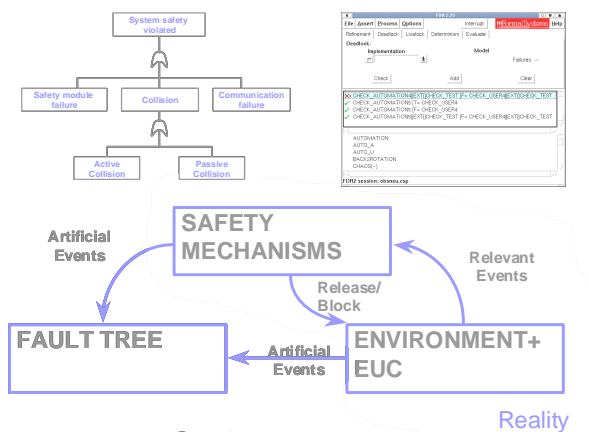
- ▶ Motivation
- ▶ Route Generalization
- ▶ Route Graph
- ▶ Probabilistic Approach to Self-Localization
- ▶ Experiment in Large-Scale Environment
- ▶ Related Work
- ▶ Summary & Outlook



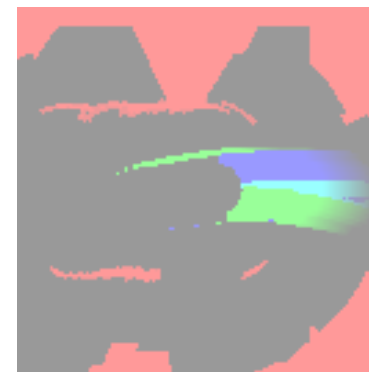
# Working Group "Cognitive Robotics"



Spatial Cognition



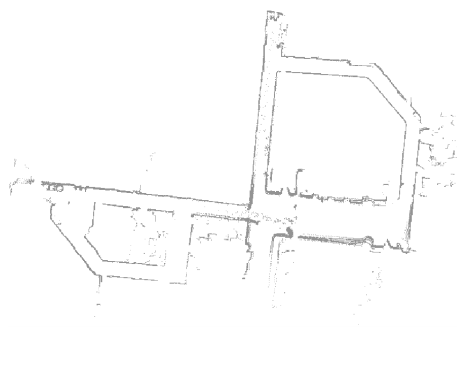
Safe Robotics



Driving Assistant



RoboCup



SLAM



Navigation Assistant





# Navigation Assistant



*Marauder's Map*



# Navigation Assistant – Rolland

acoustic instructions

Turn right at the next possibility



user interface

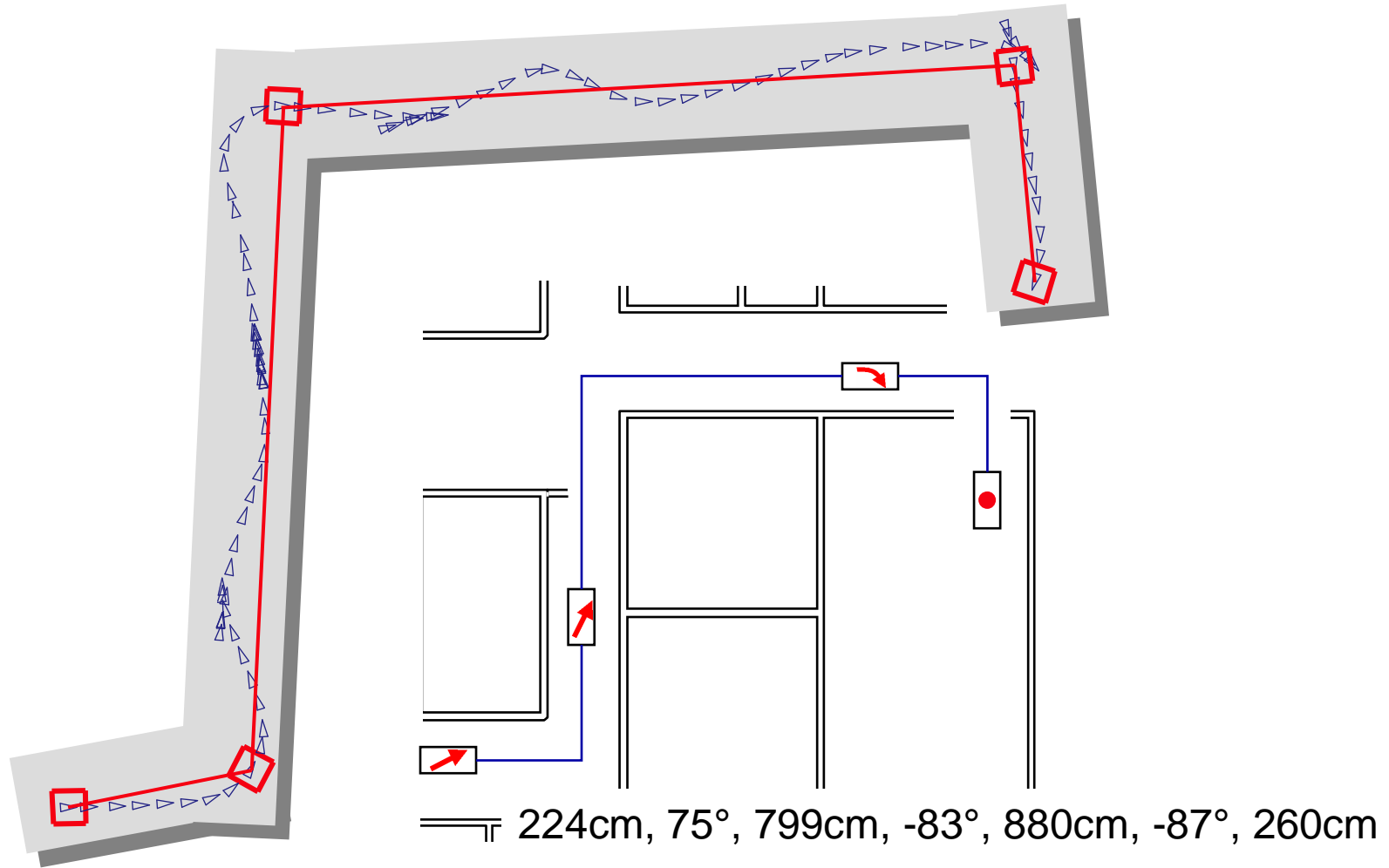


visual instructions



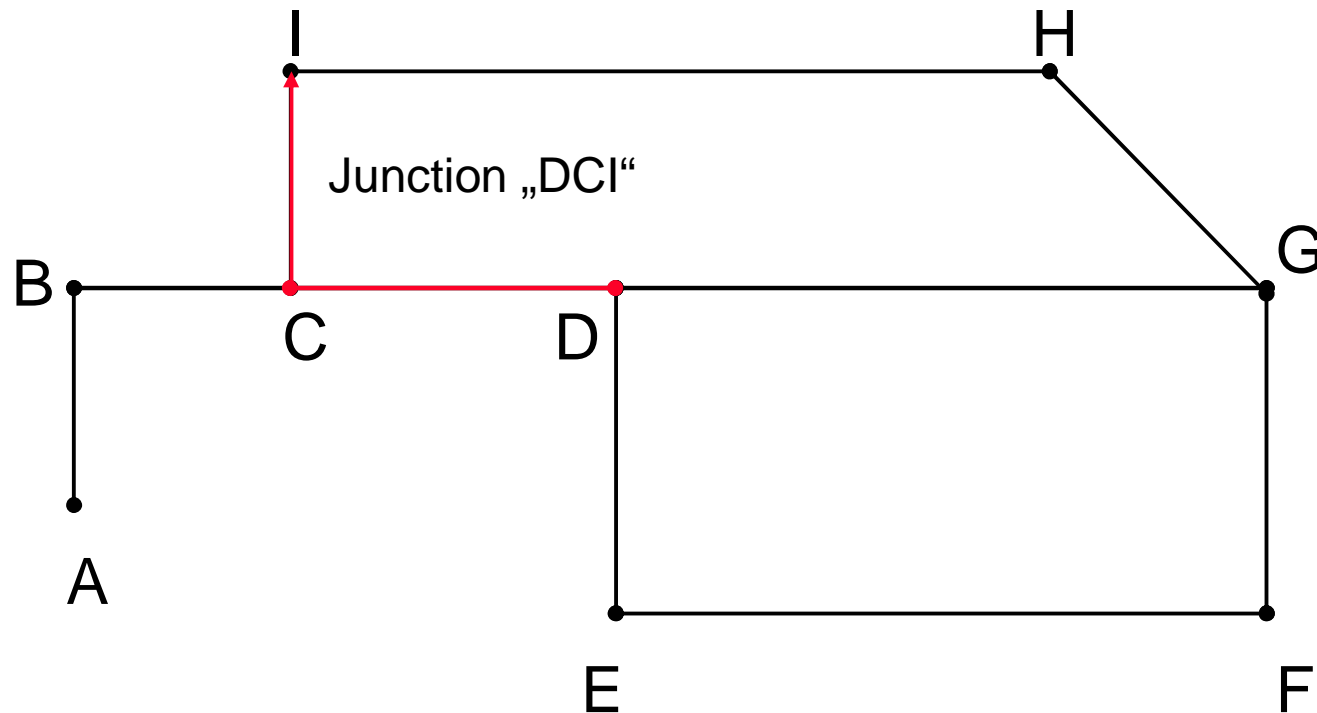


# Generalization of Locomotion



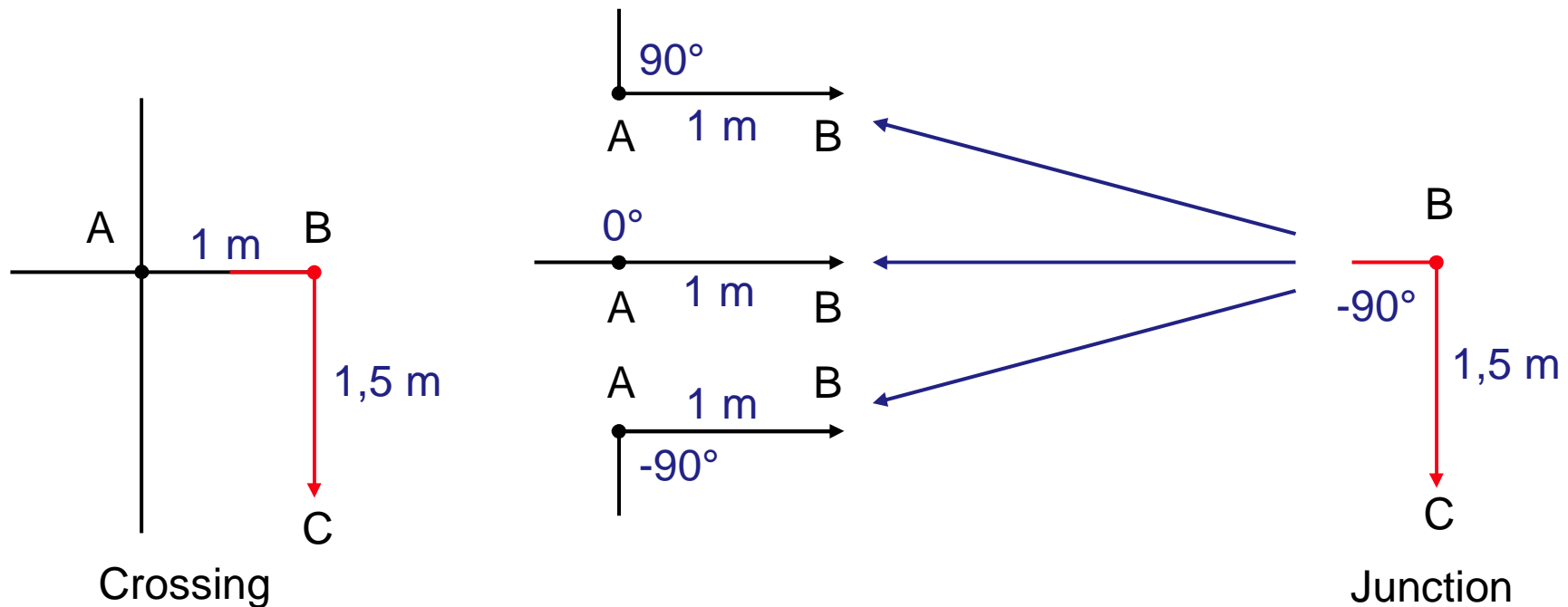


# Modeling the Environment



# Junctions

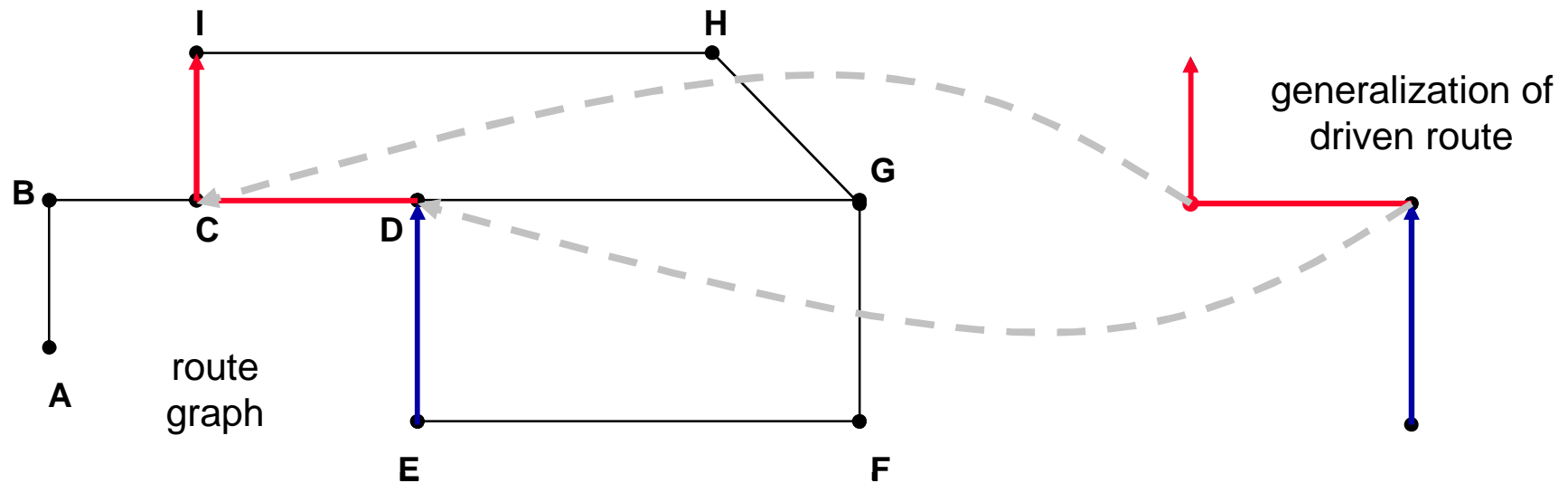
- ▶ Angle between incoming and outgoing segment
- ▶ Length of outgoing segment
- ▶ List of incoming segments





# Inductive Approach

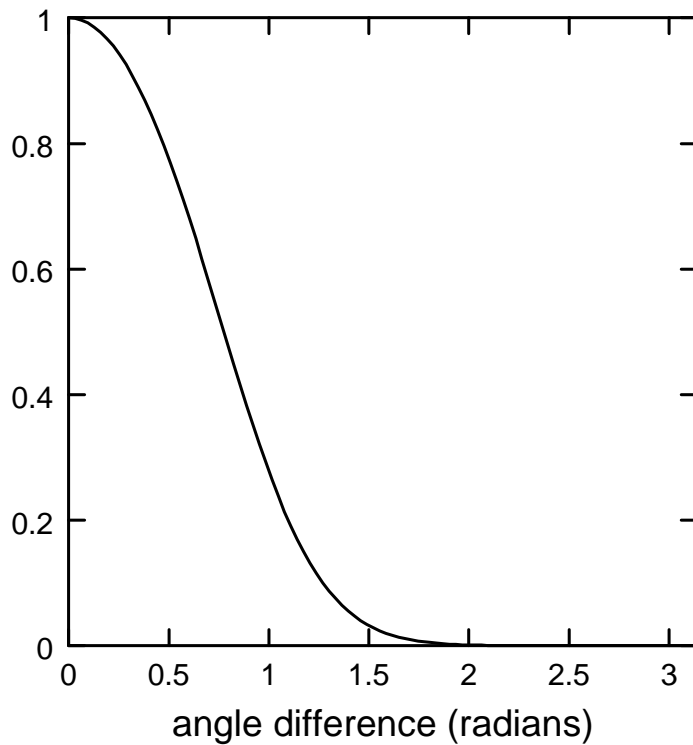
- ▶ **Idea: Assigning route corners to junctions**
- ▶ **Two-step assignment**
  - ▶ Corner matches a junction
  - ▶ The rest of the generalized route matches up to the junction



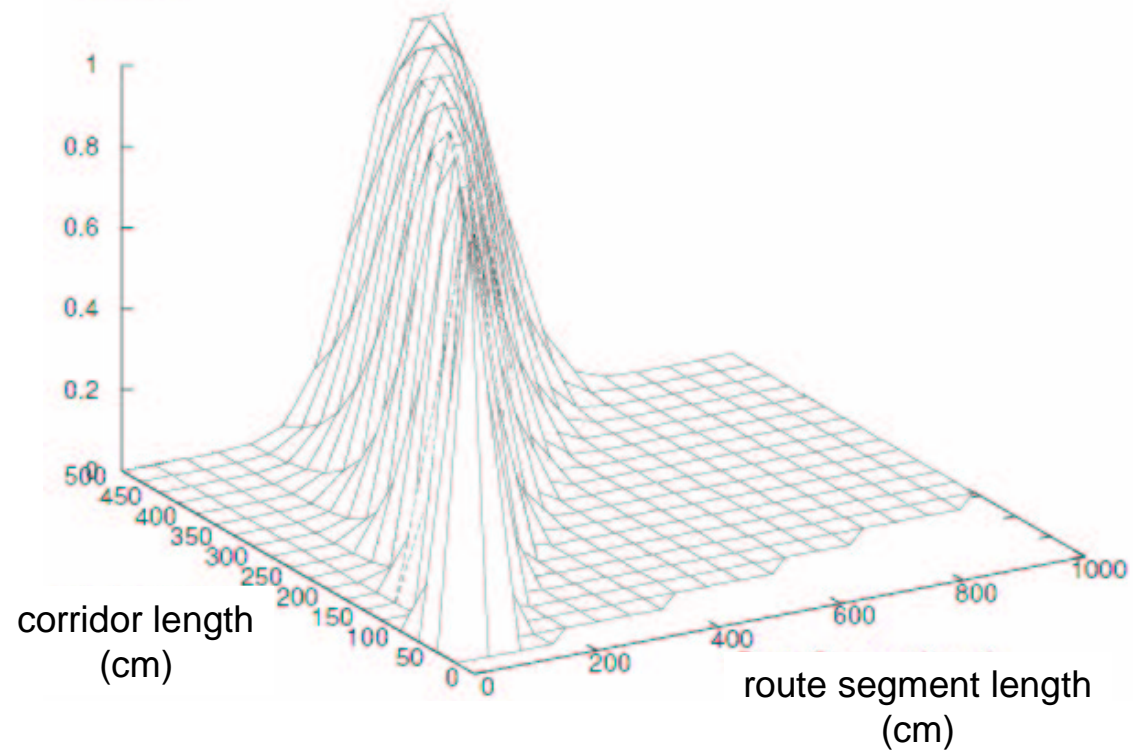


# Probabilities from Similarities

probability

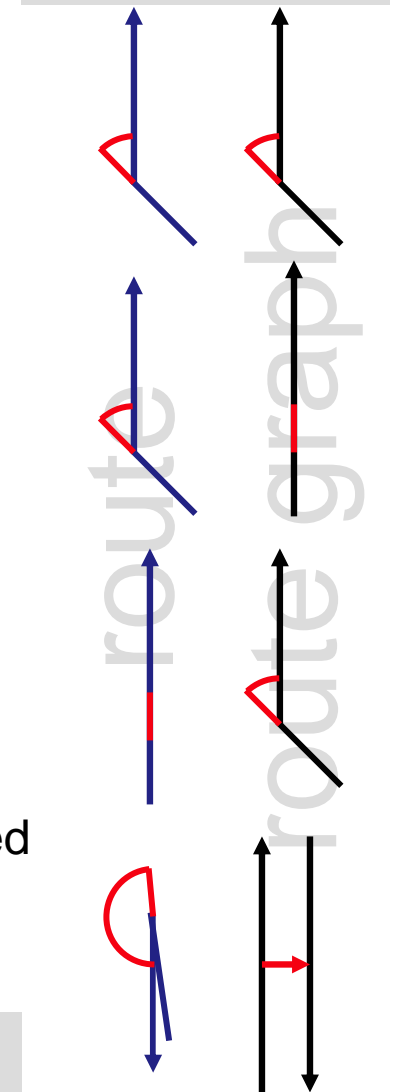


probability



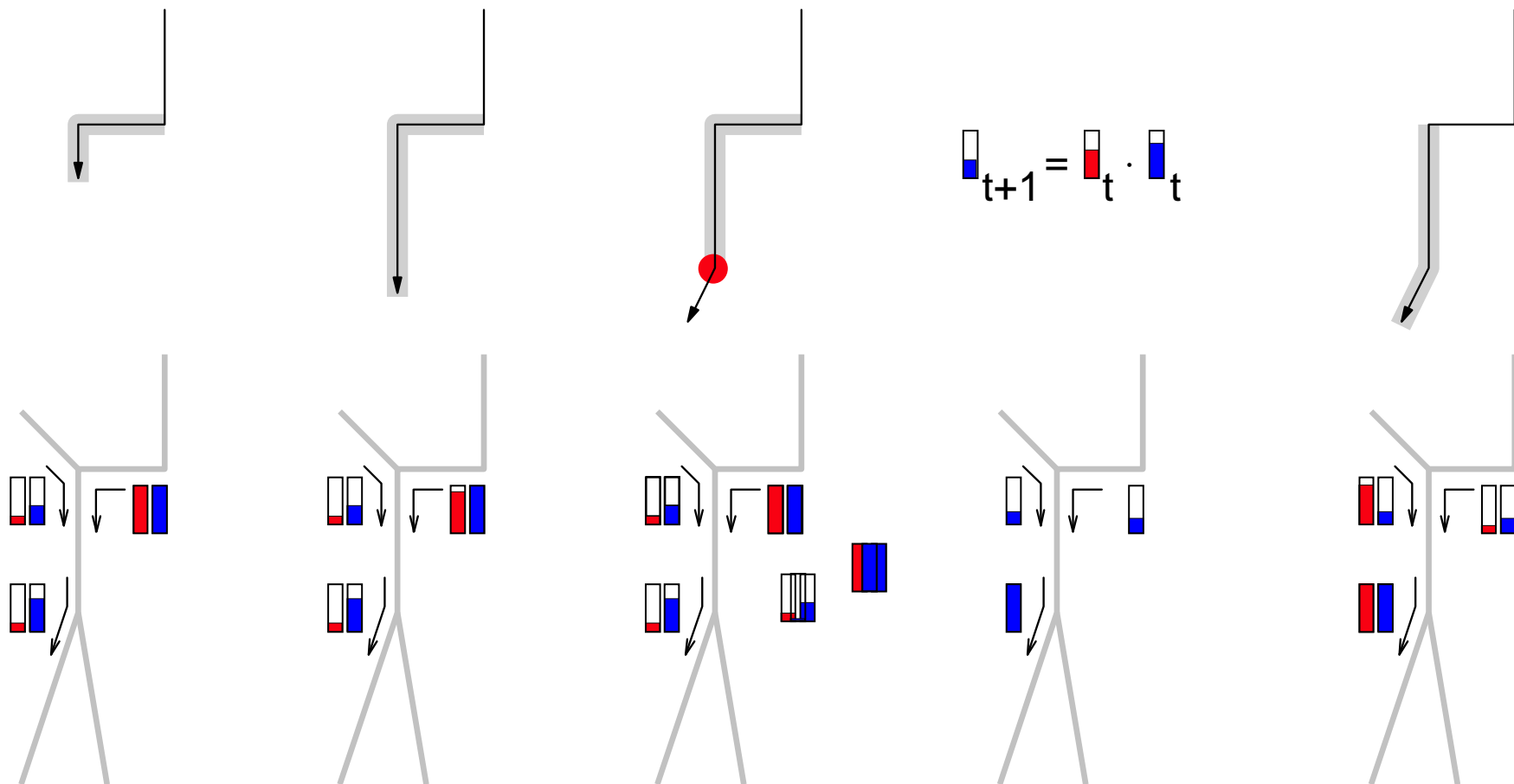
## Matching Corners

- ▶ **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  $0^\circ$*
  - ▶ ... a corner has been overlooked, ...
    - ▶ *Angle of the junction in the route graph is similar to  $0^\circ$*
  - ▶ ... it has been turned around at the corner previously generalized
    - ▶ *Angle of corner is similar to  $180^\circ$*



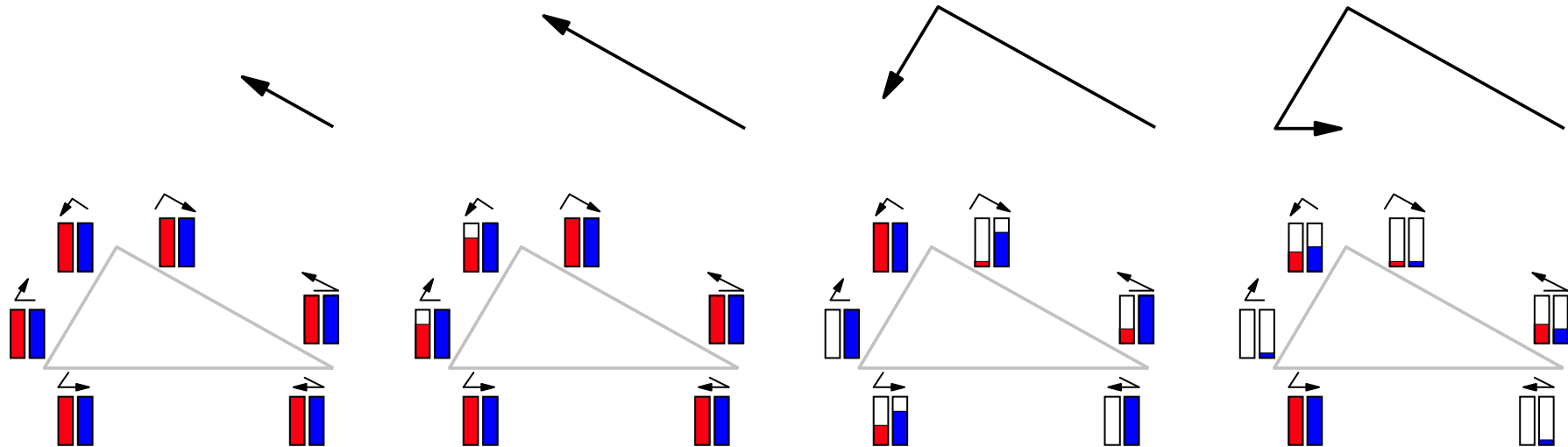


# Propagation of Probabilities



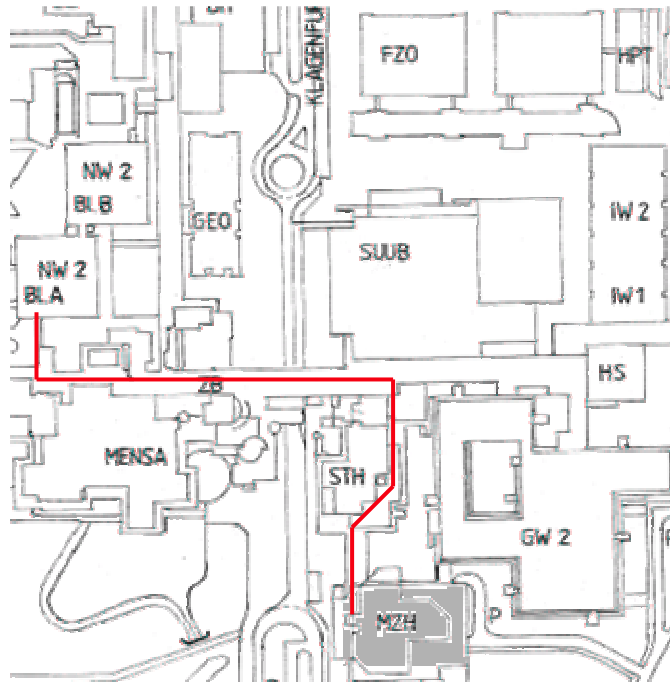


# Determining the Candidate Junction

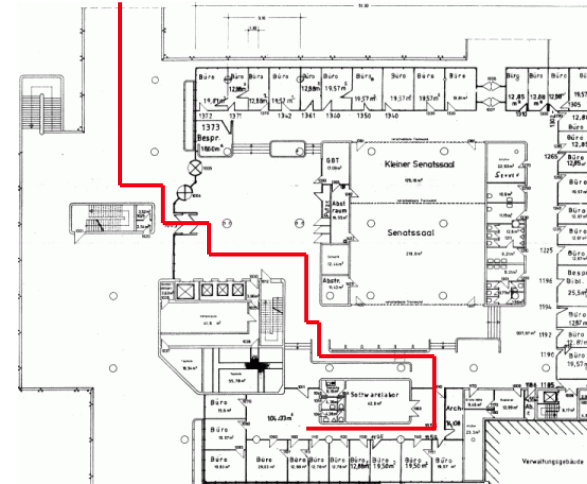




# Indoor and Outdoor Navigation



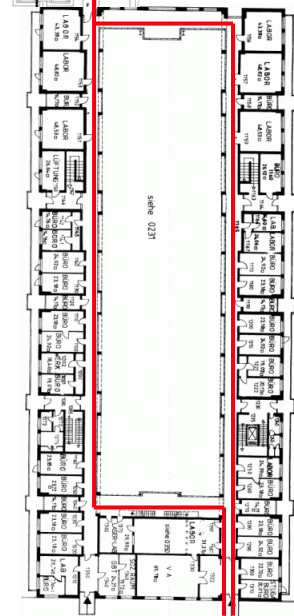
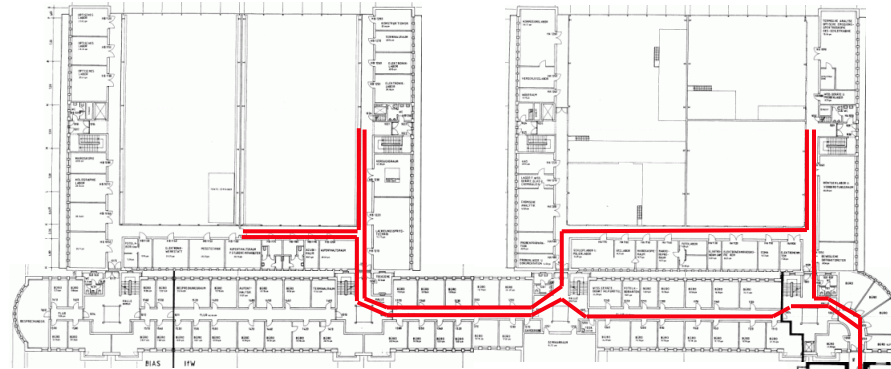
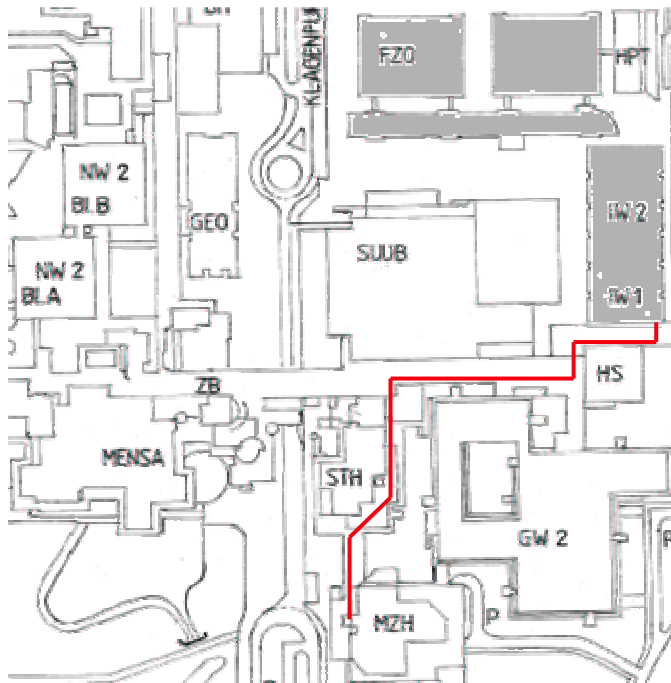
- ▶ Building: MZH







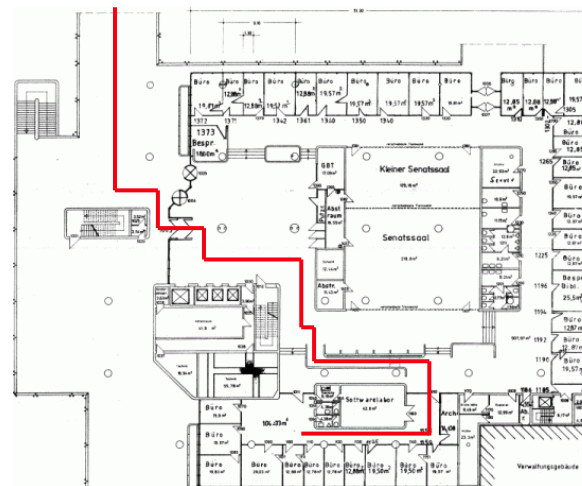
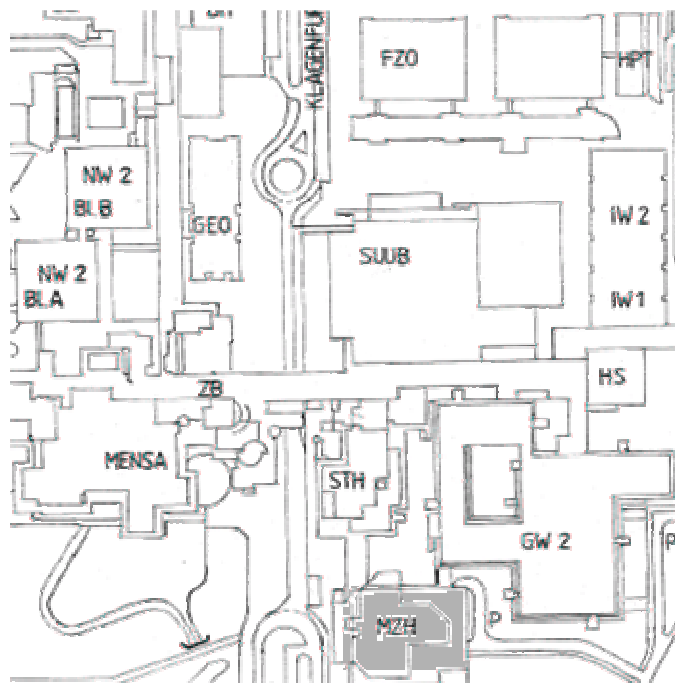
# Indoor and Outdoor Navigation



► Buildings: IW + BIBA

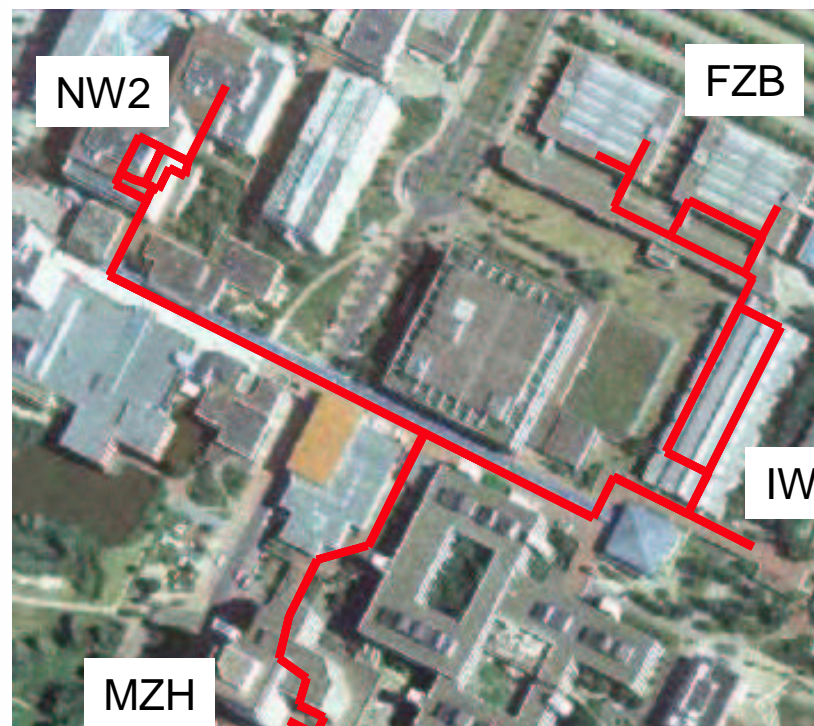
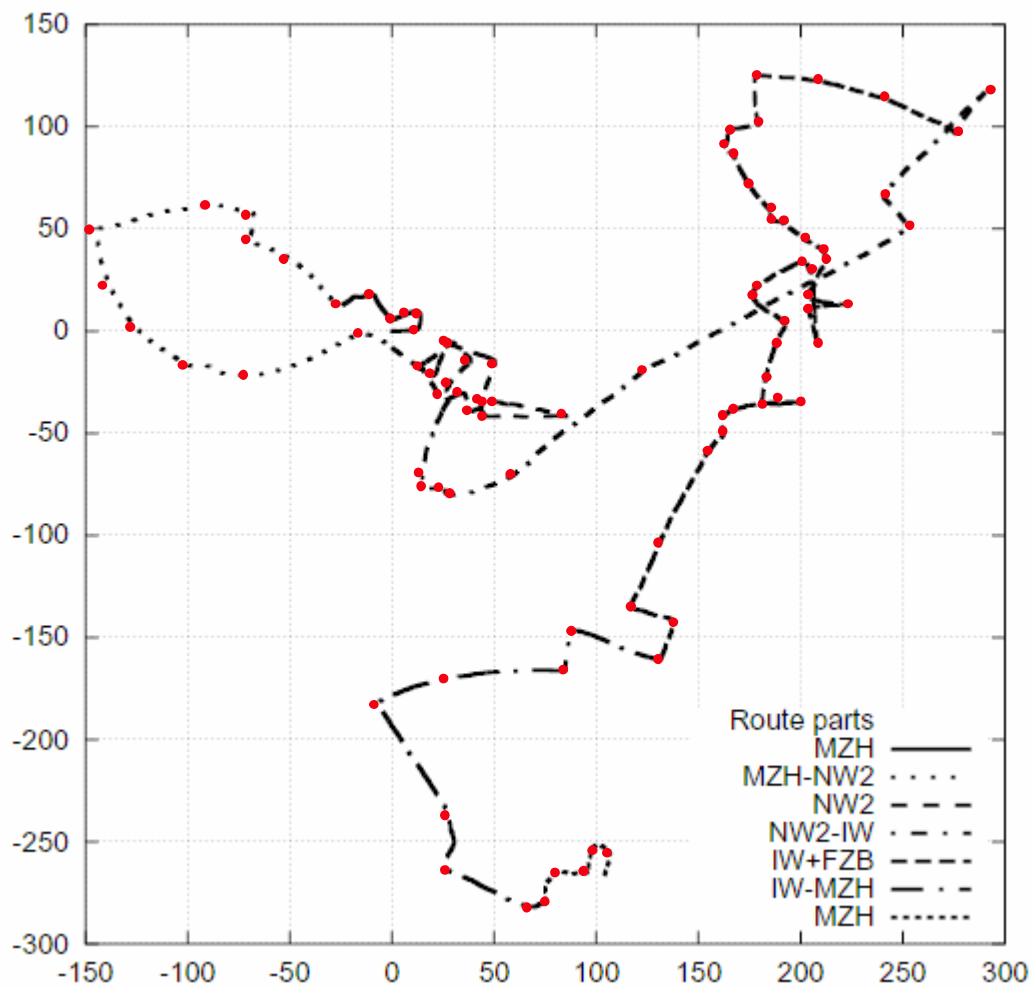


# Indoor and Outdoor Navigation



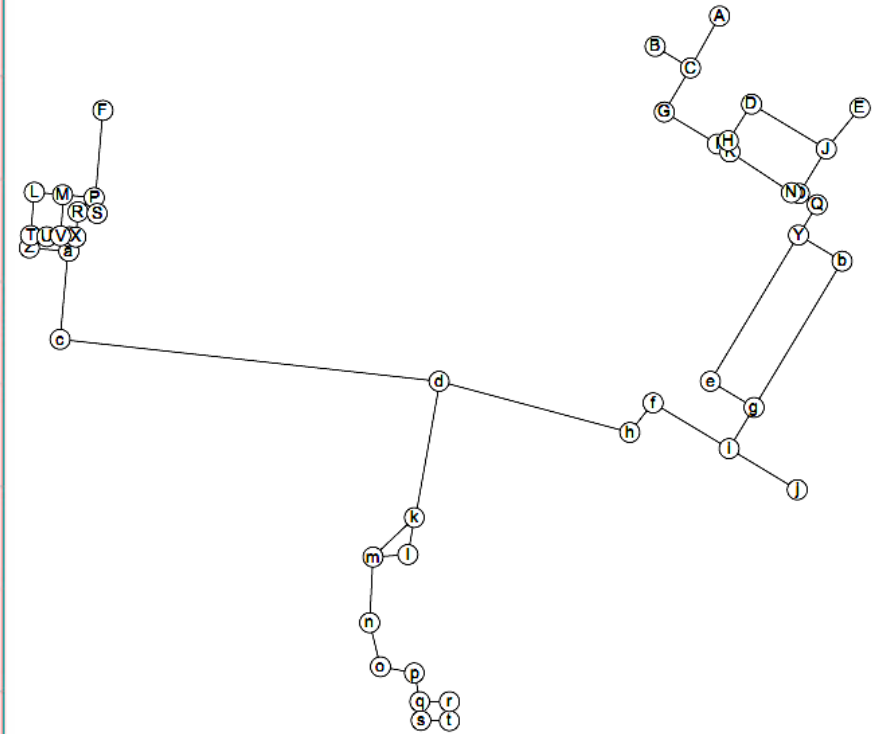
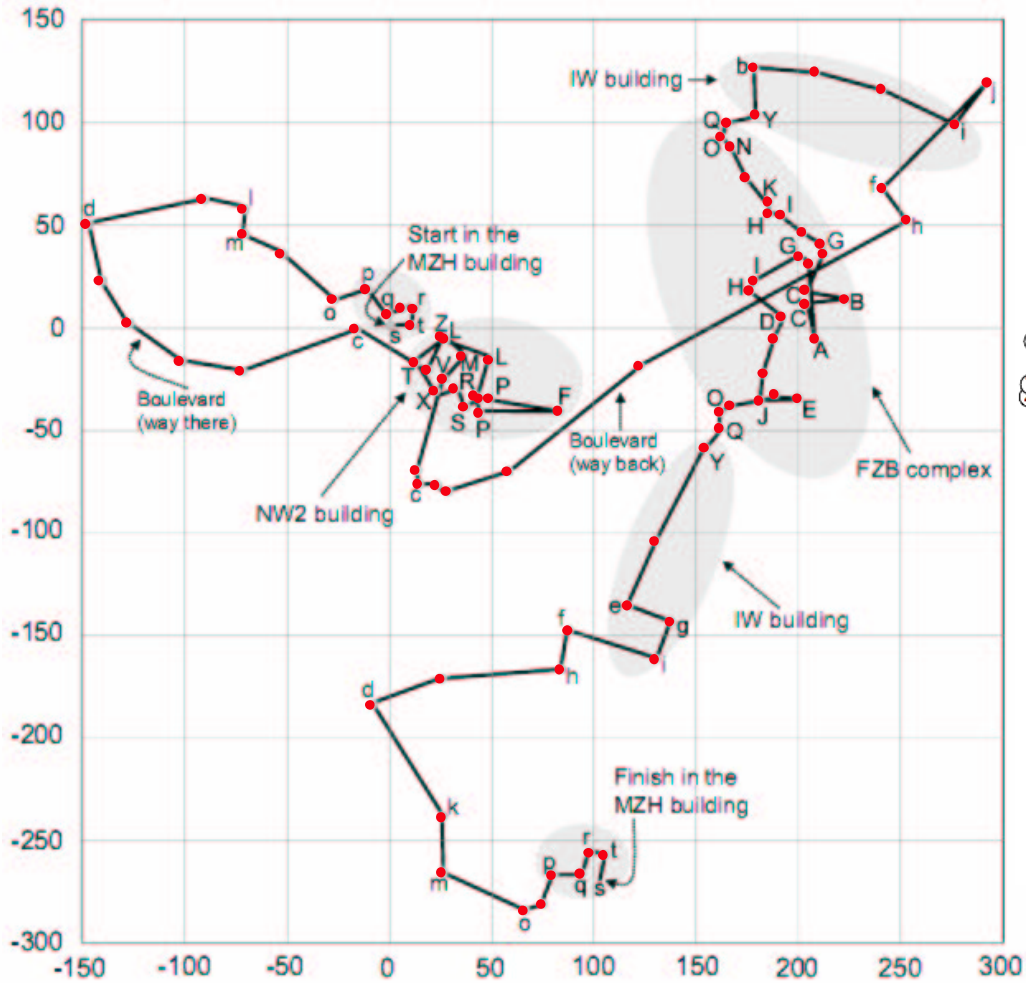
- ▶ **Building: MZH**
- ▶ **Overall length: 2176 m**

# Odometry Data



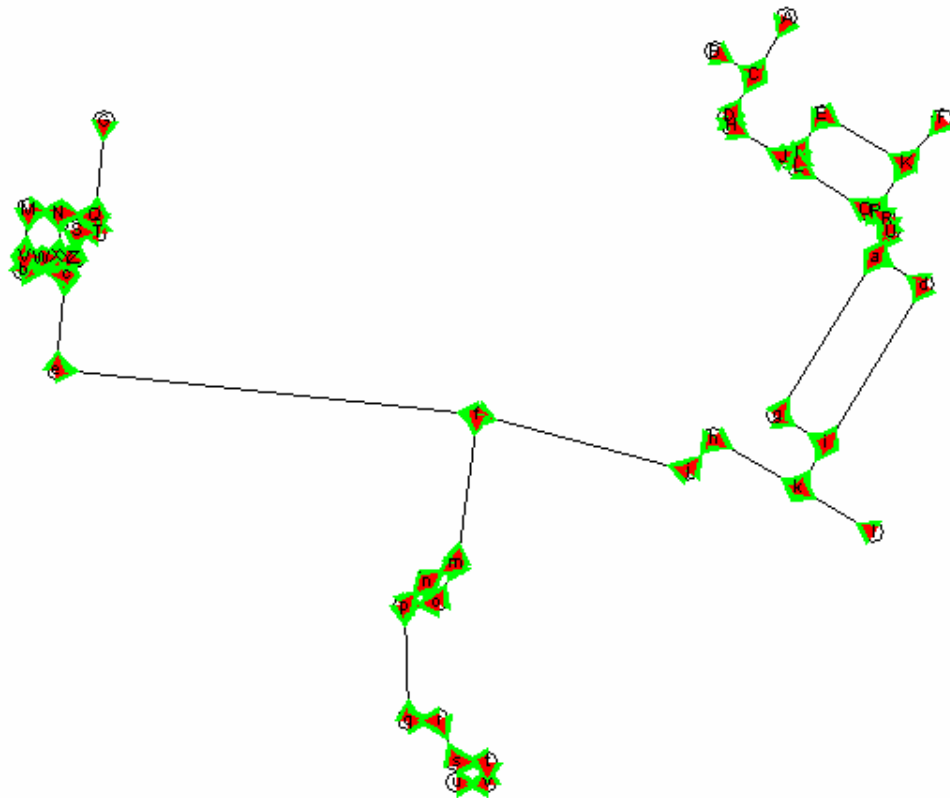





# Route Graph





# Results I

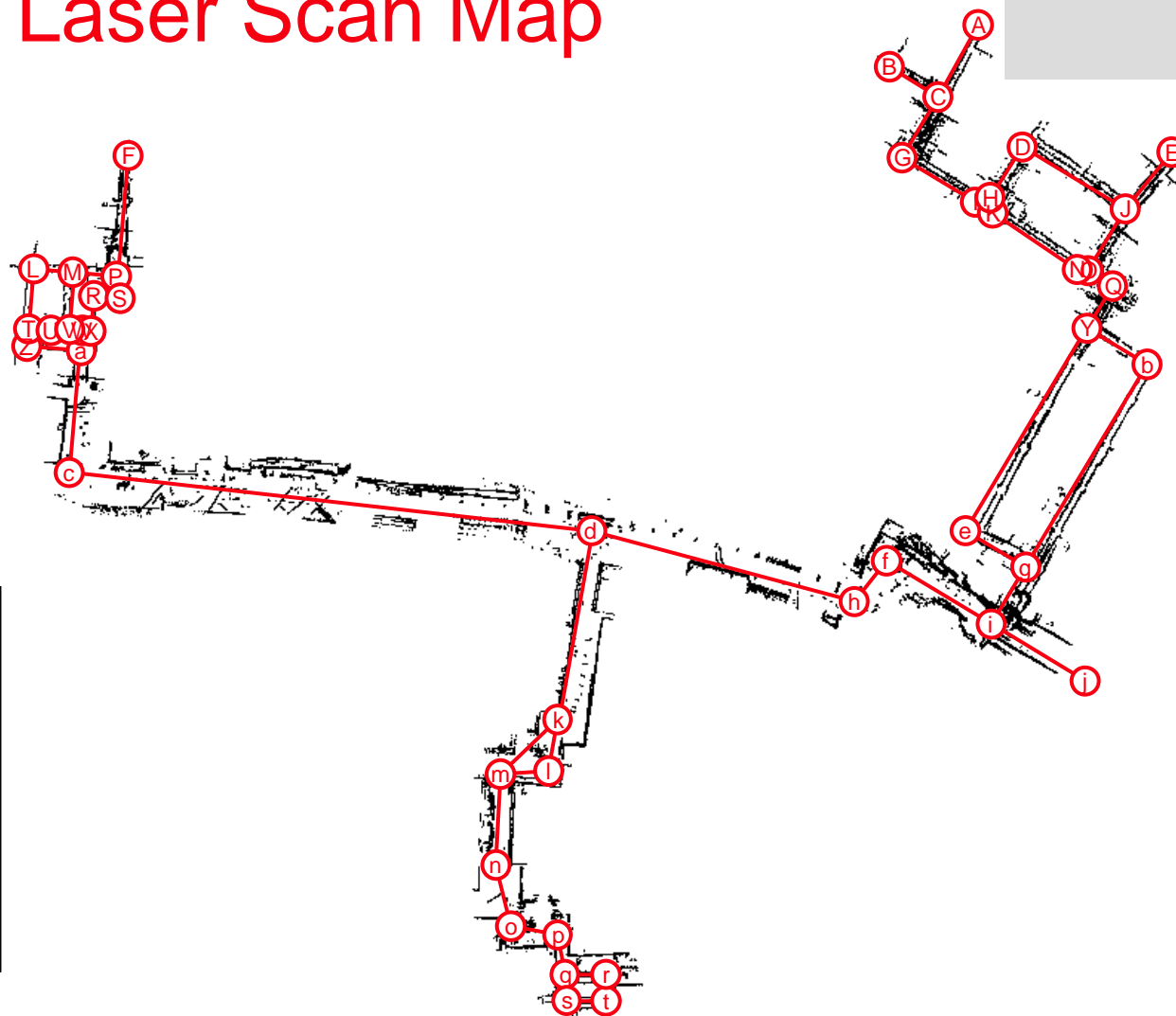
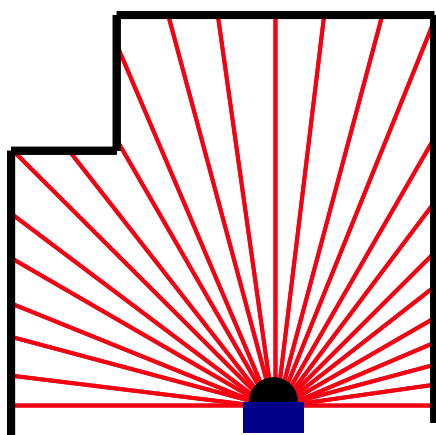


-  Believed in previous corner
-  Not believed in previous corner
-  Most probable position

Intensity encodes confidence

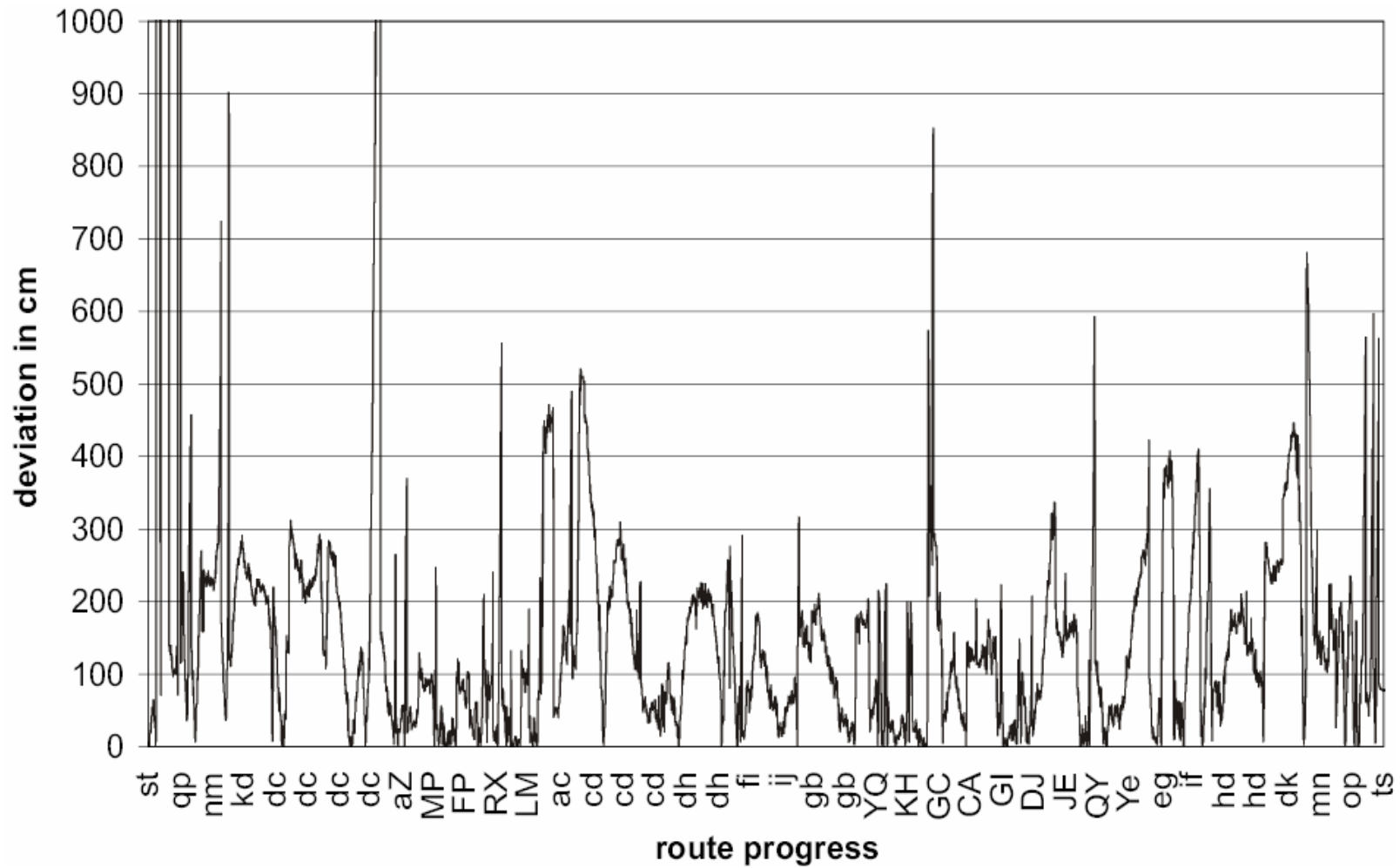
Speeded up by factor 70

# Reference: Laser Scan Map





## Results II





# Related Work

	RouteLoc	Nourbakhsh et al.	Simmons & Koenig	Thrun et al.
Model	Topological-metric map	State set / topological map	Markov states, hybrid topological-metric map	Particle filter, metric map
Sensor input	odometry (+ 2 sonars for generalization)	sonars (+ odometry for corridor centering)	odometry + sonars	odometry + camera or laser range finder
Scenario	campus (in & outdoor)	office (indoor)	office (indoor)	museum (indoor)
Markov	no	yes	yes	yes
Complexity	144 junctions + 102 turn-junctions for 46 nodes and 100 edges, depends on number of decision points	One state per node (decision point) or per edge (corridor)	3348 Markov states for 95 nodes and 180 edges, depends on metric extent of environment	About 1000 samples for an indoor environment, number of samples adaptable (any-time)
Memory	low	low	low	huge
Precision	Position estimate given by junction and metric offset	Corridor resolution, no metric information	Markov states provide resolution of 1m (translational), 90° (rotational)	Samples indicate position, only small errors



## Summary & Outlook

### ▶ **Probabilistic self-localization based on locomotion**

- ▶ Minimal sensor equipment
- ▶ Suitable for large-scale environments
- ▶ Efficient

### ▶ **Future Work**

- ▶ Simultaneous localization and mapping (SLAM)
- ▶ Integration of additional sensor measurements