Mobile Robot Self-Localization in Large-Scale Environments

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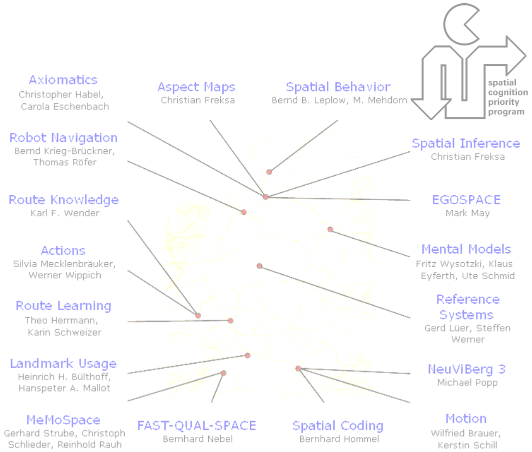
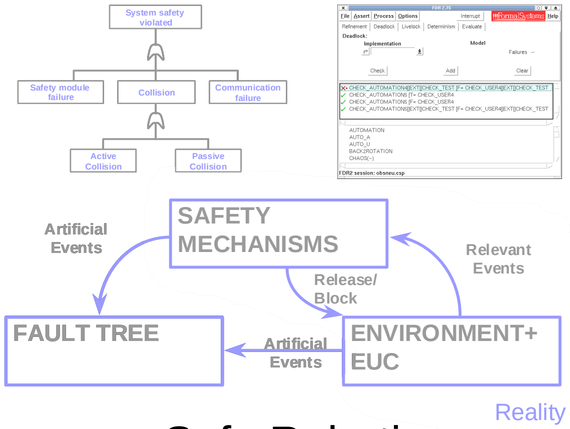
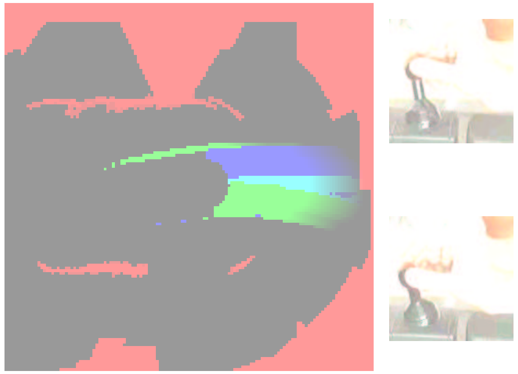


Spatial Cognition

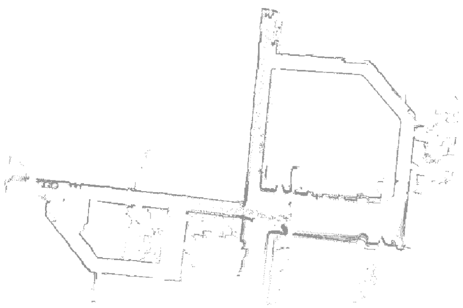


Safe Robotics



Driving Assistant

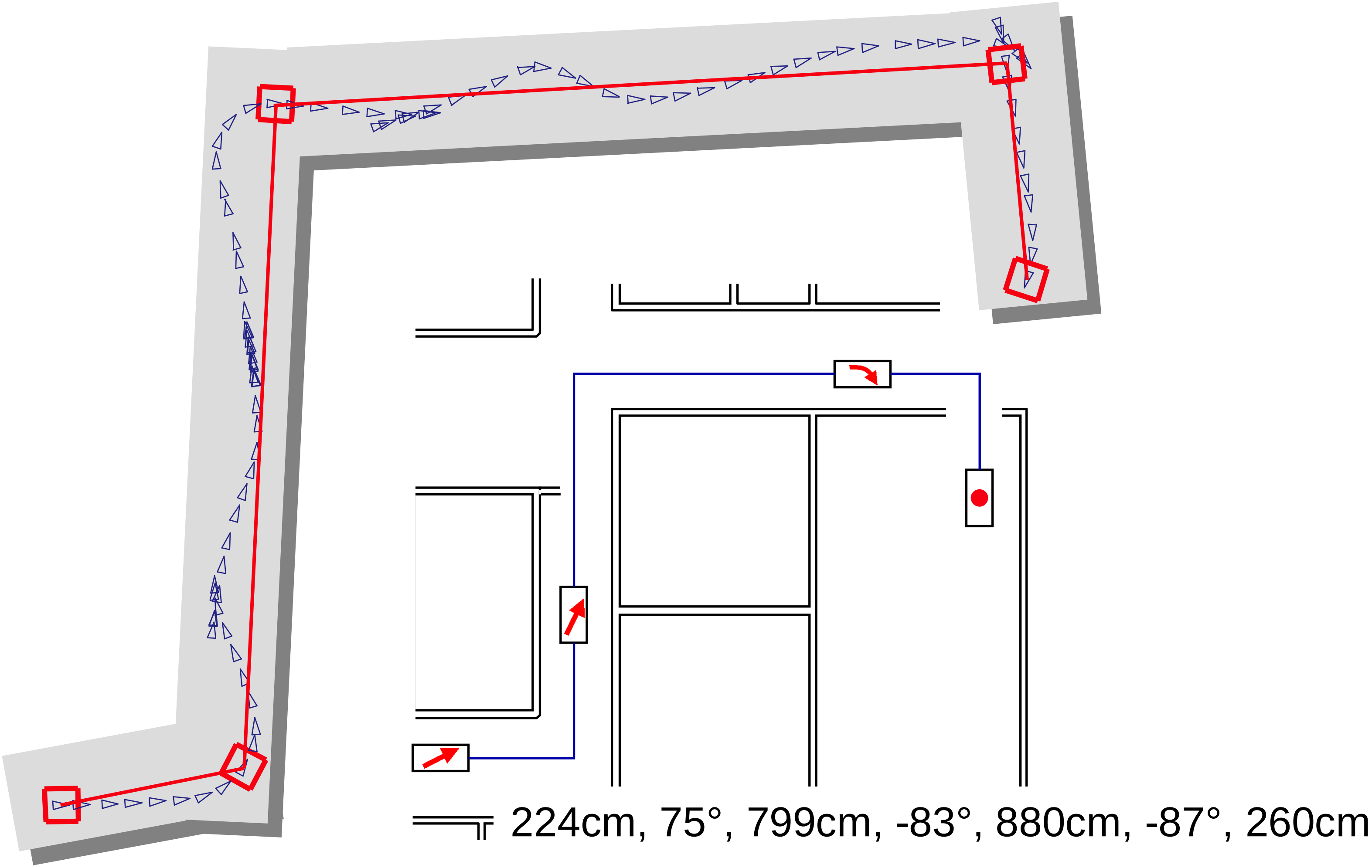
RoboCup



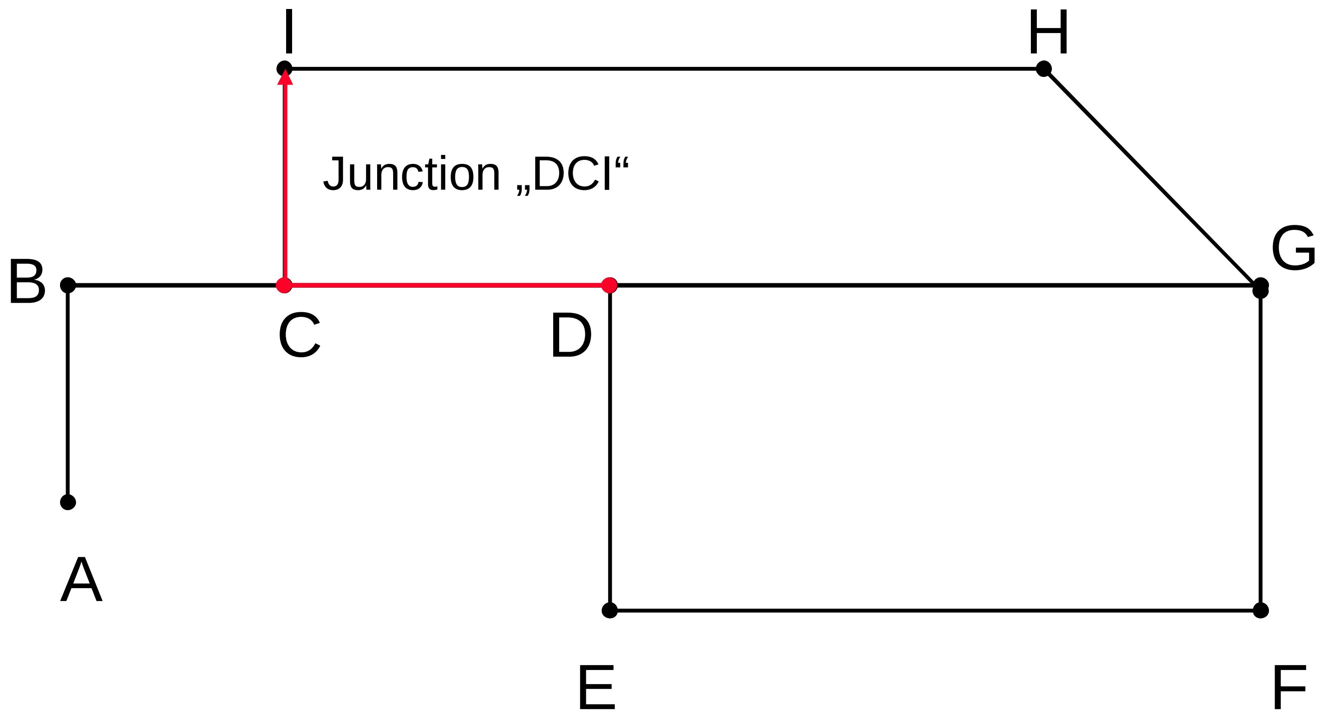
SLAM

Navigation Assistant

Generalization of Locomotion

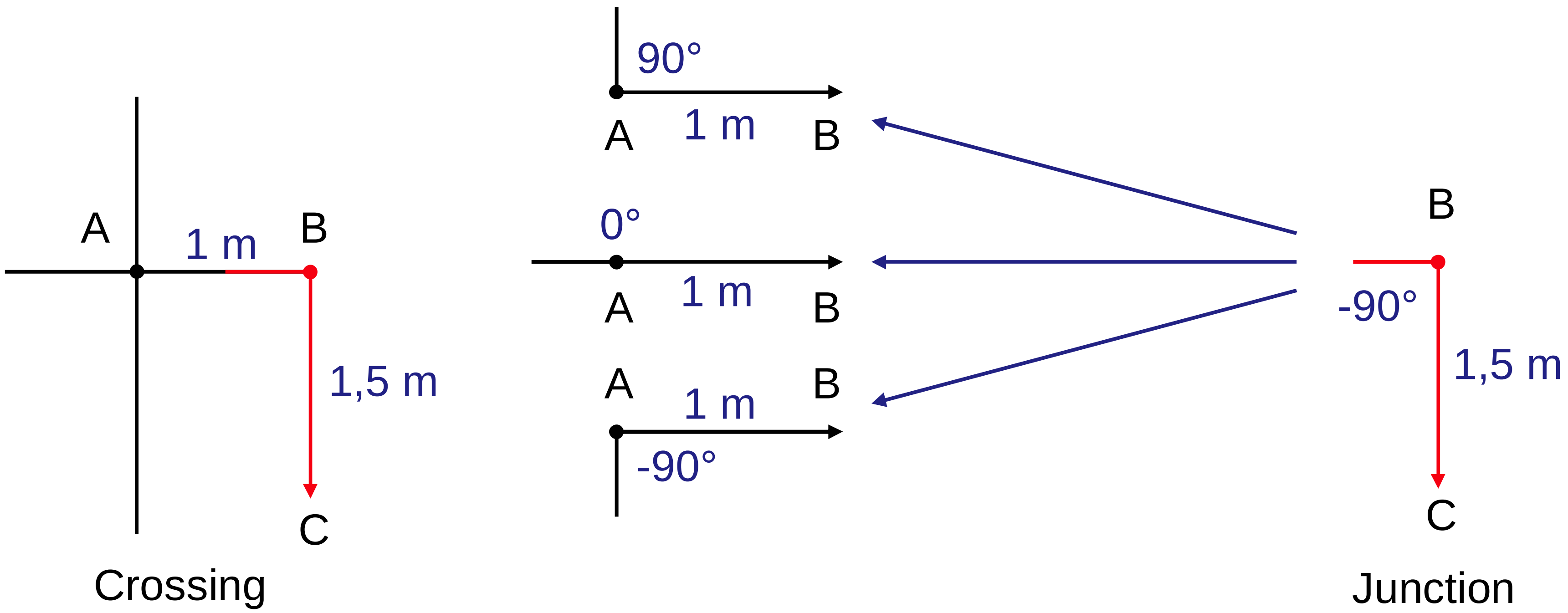


Modeling the Environment



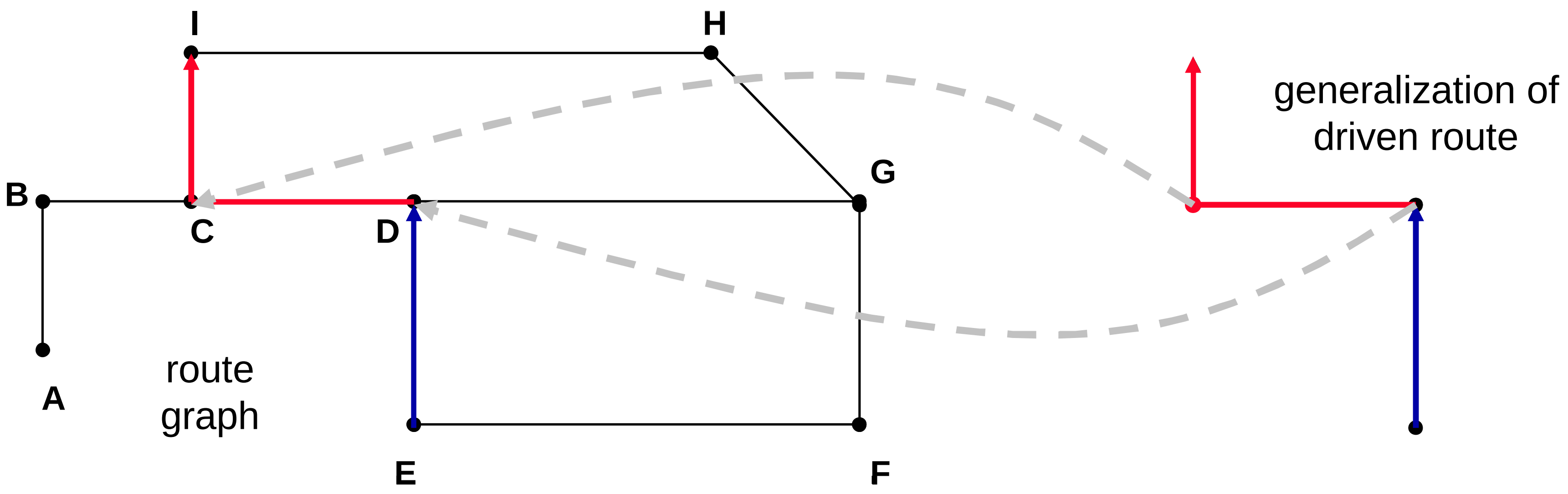
Junctions

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

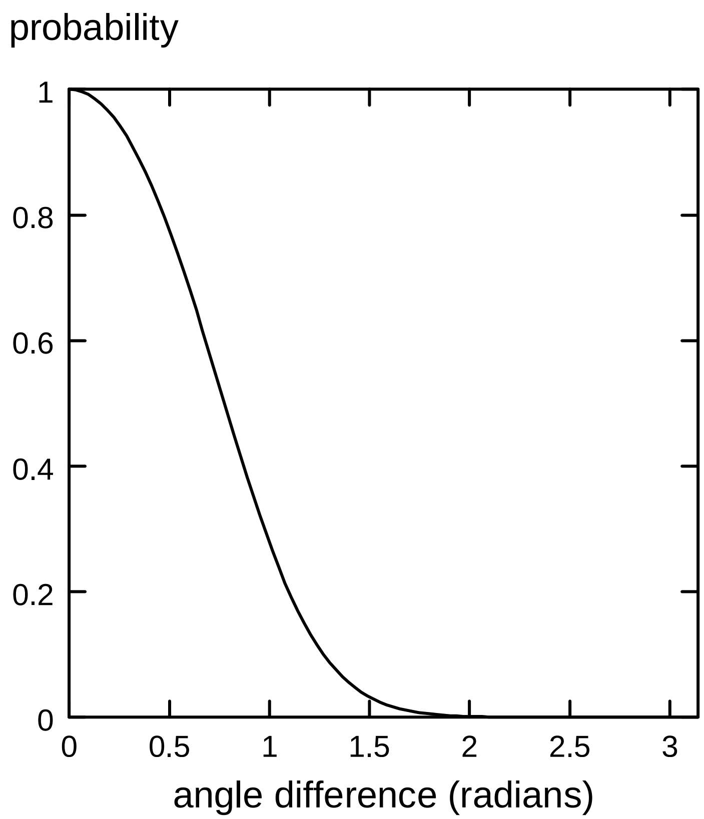


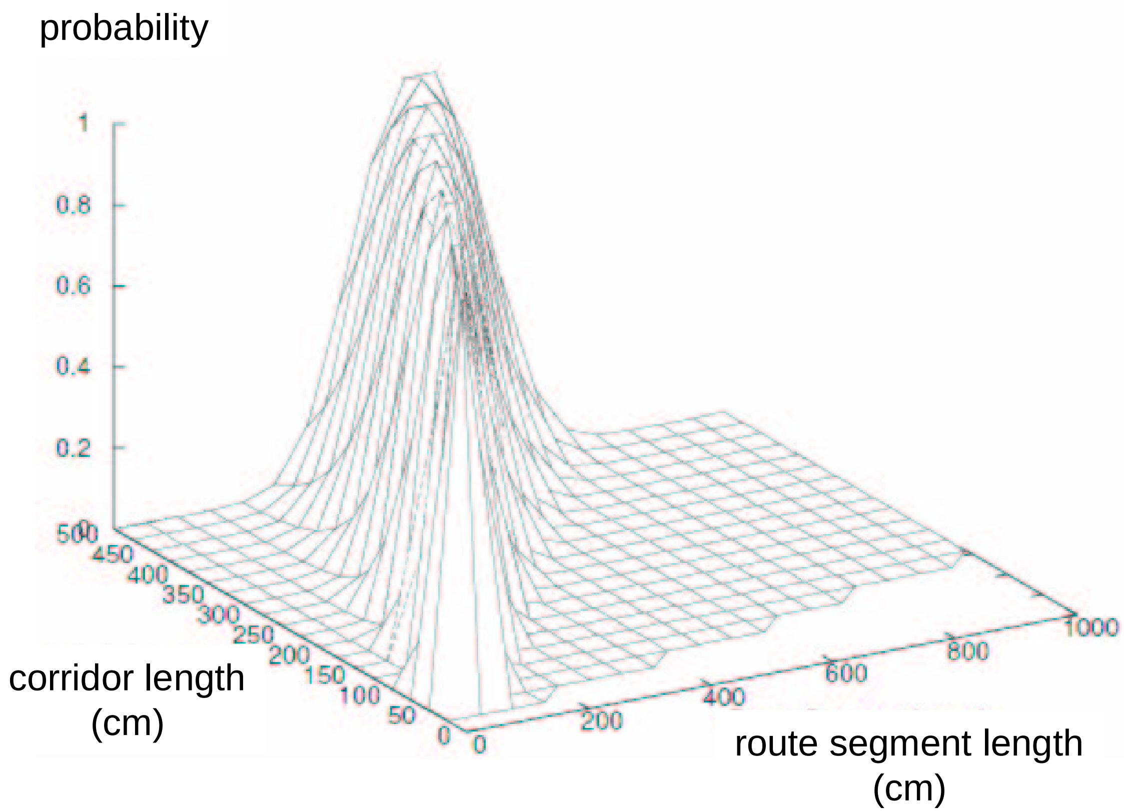
Inductive Approach

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



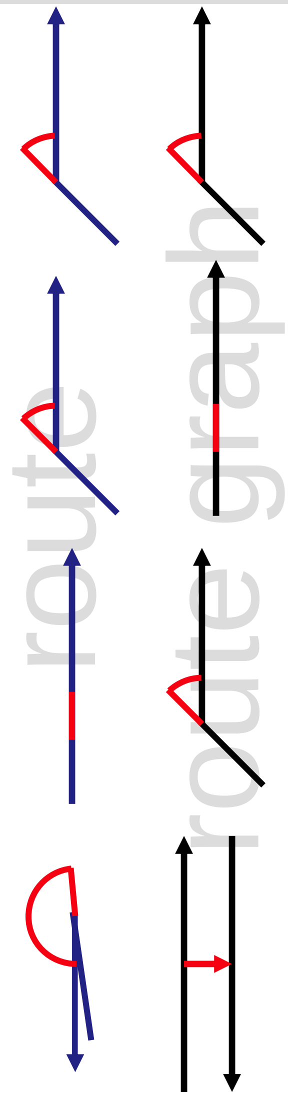
Probabilities from Similarities





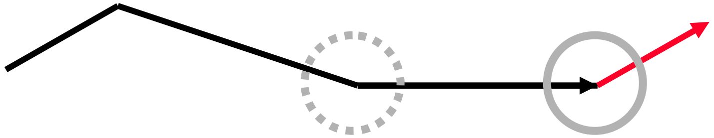
Probabilities: Matching Corners

- **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°*

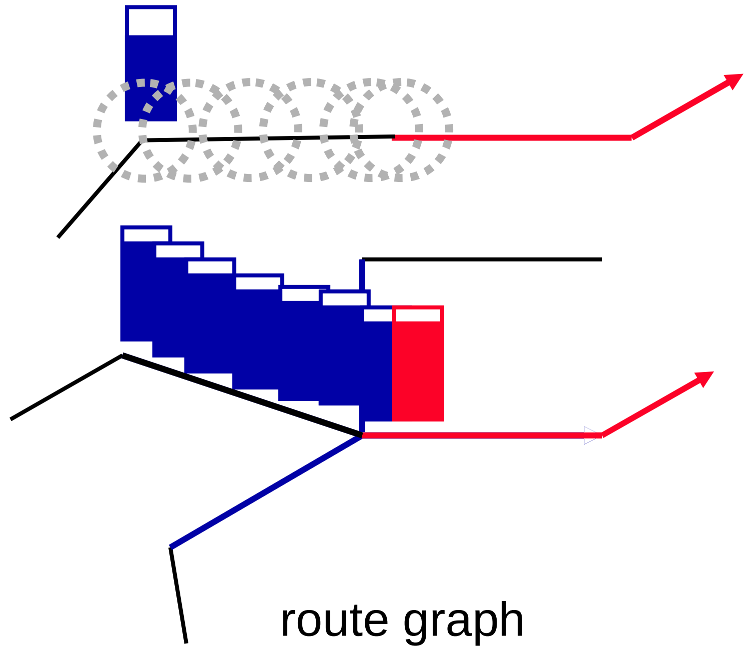


Propagation of Probabilities

- **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

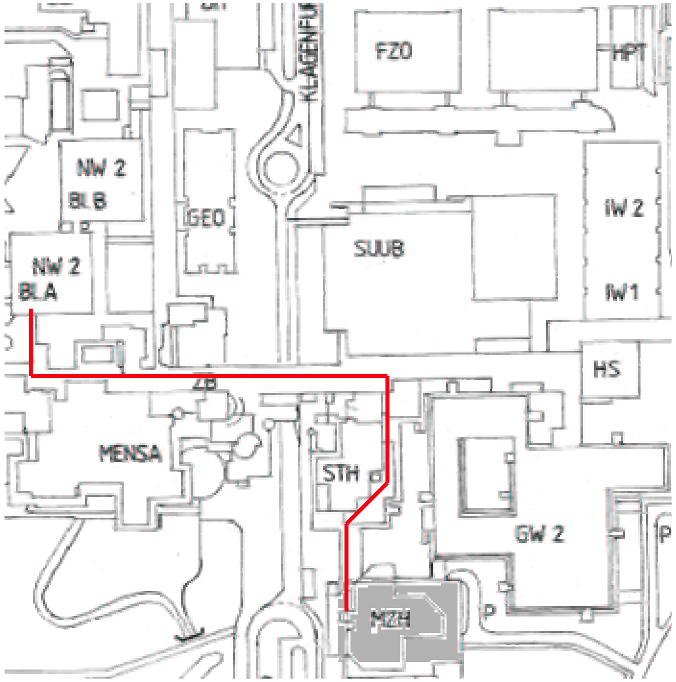


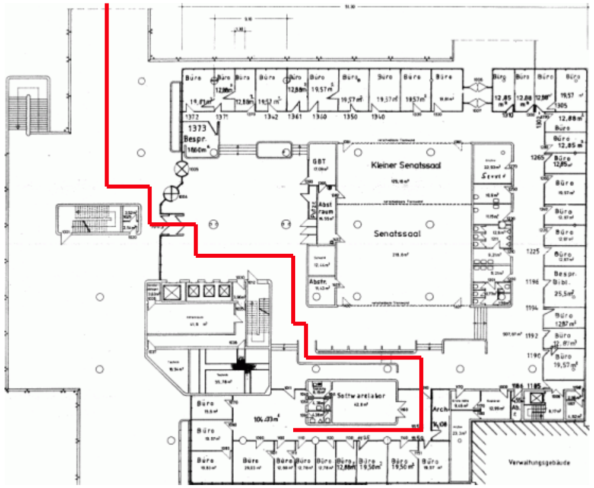
route



route graph

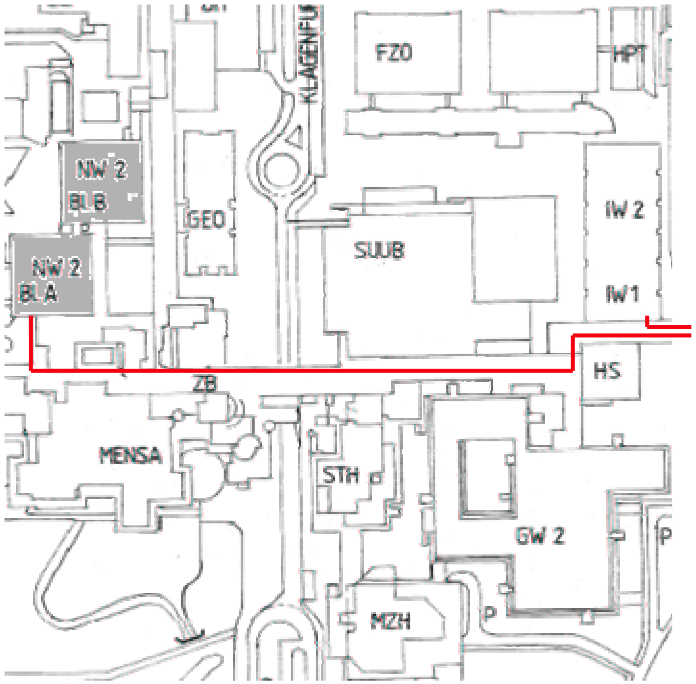
Indoor and Outdoor Navigation



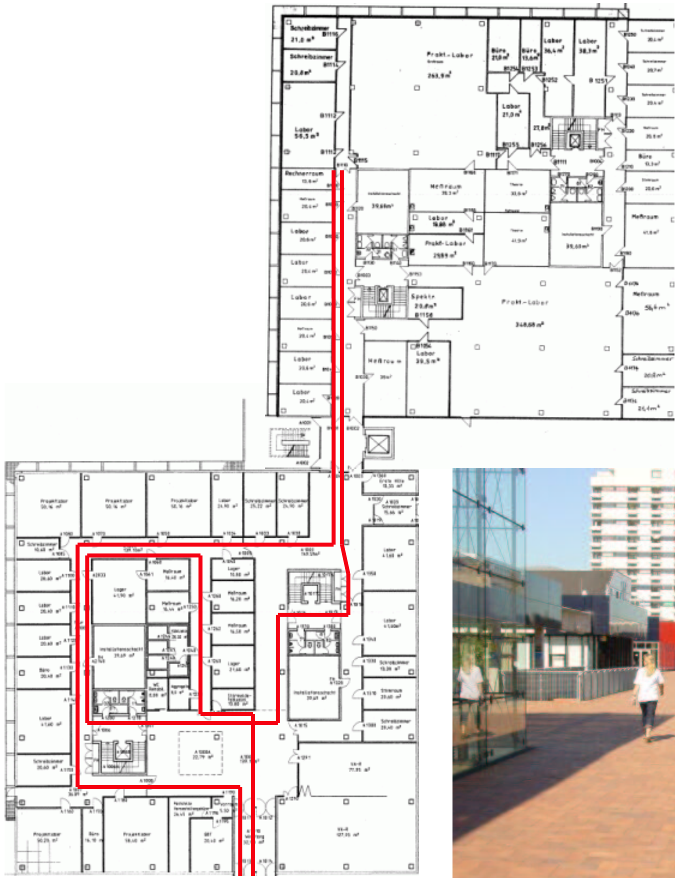


- **Building: MZH**

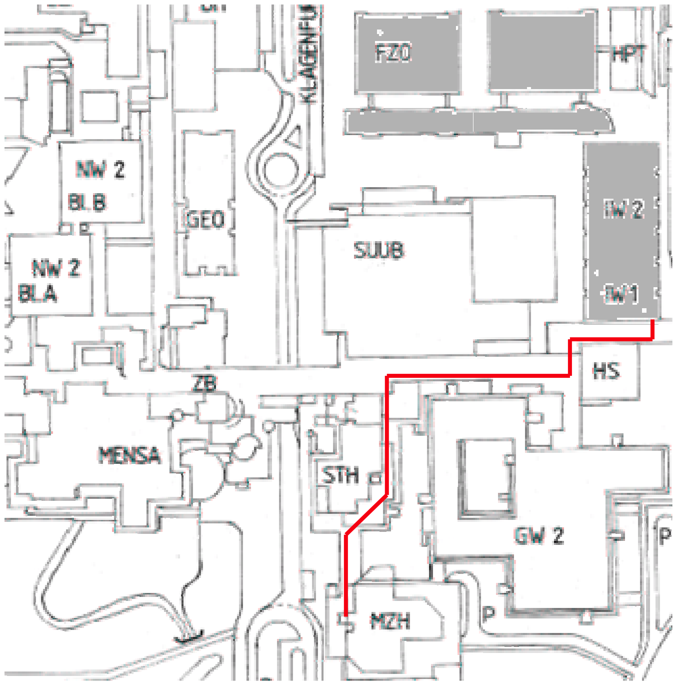
Indoor and Outdoor Navigation

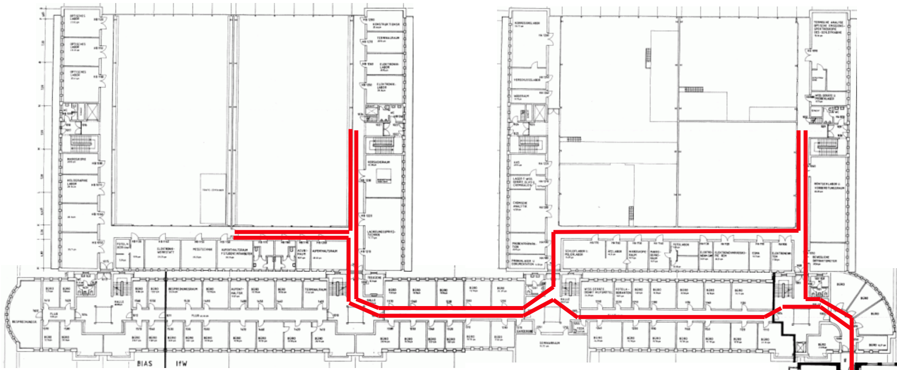


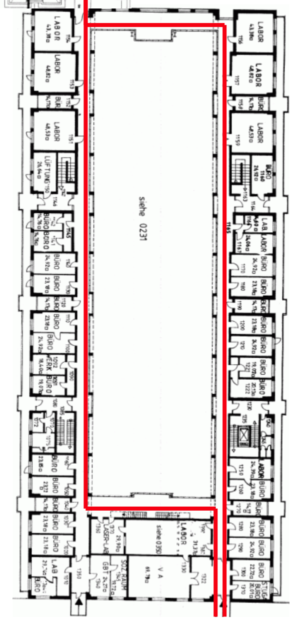
- **Building: NW 2**



Indoor and Outdoor Navigation

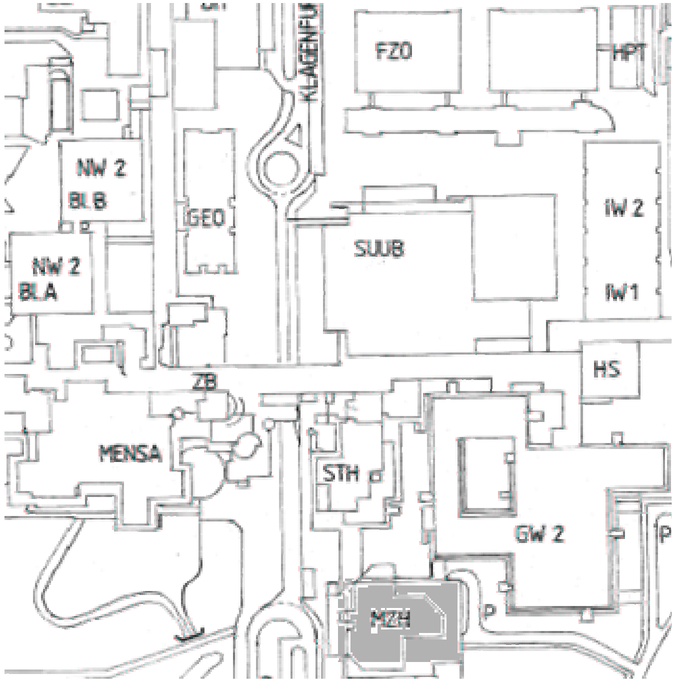


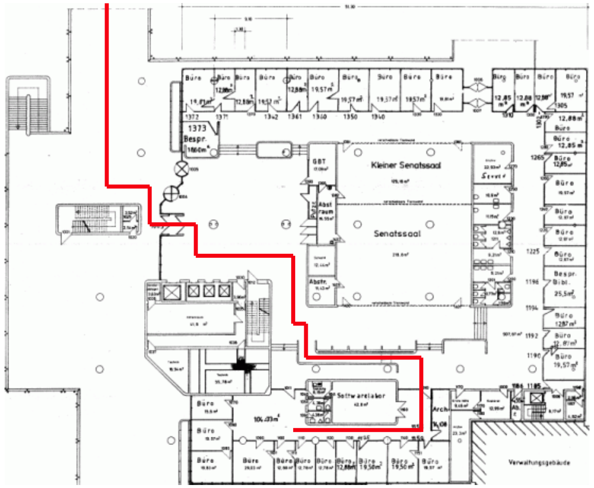




- **Buildings: IW + BIBA**

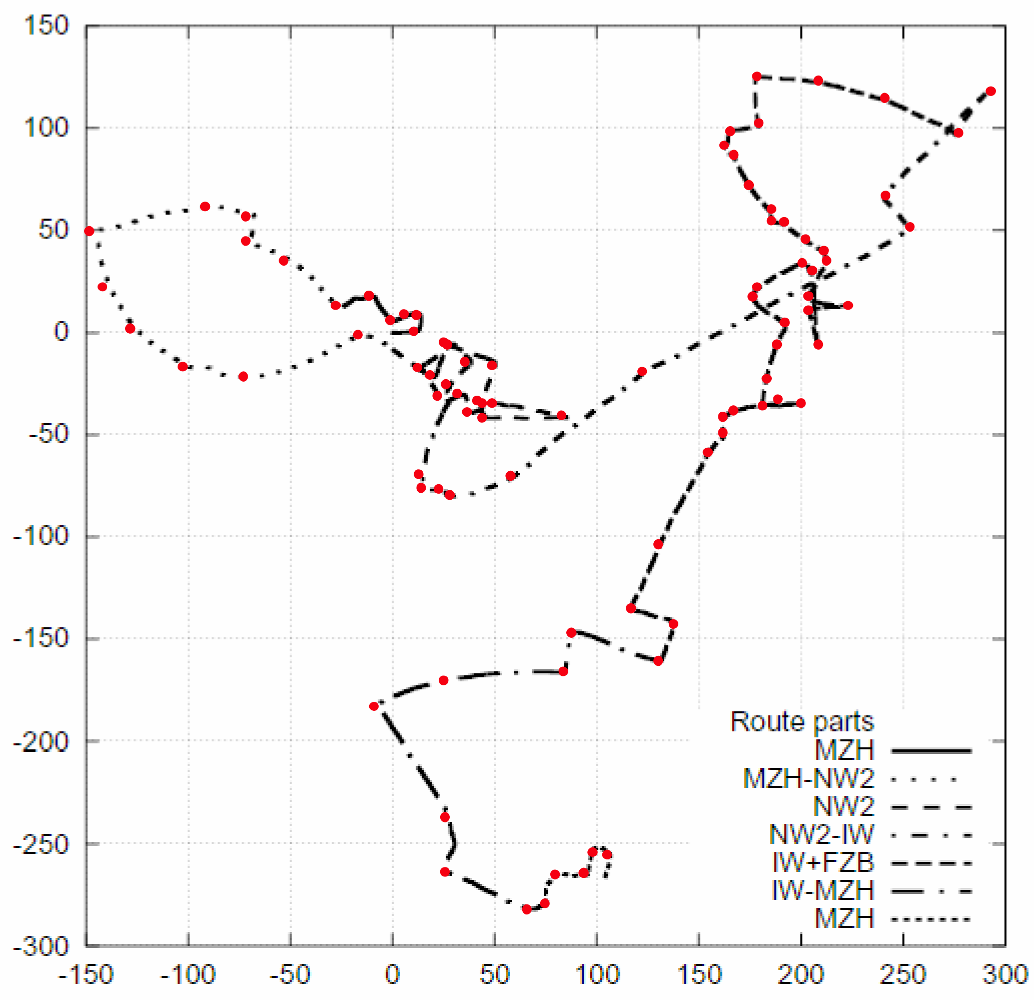
Indoor and Outdoor Navigation

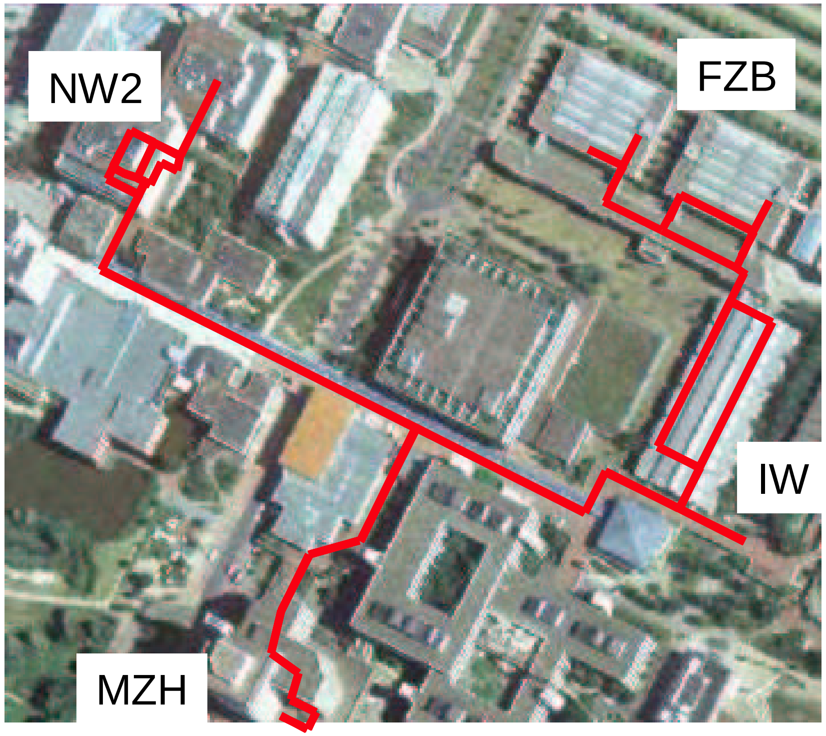




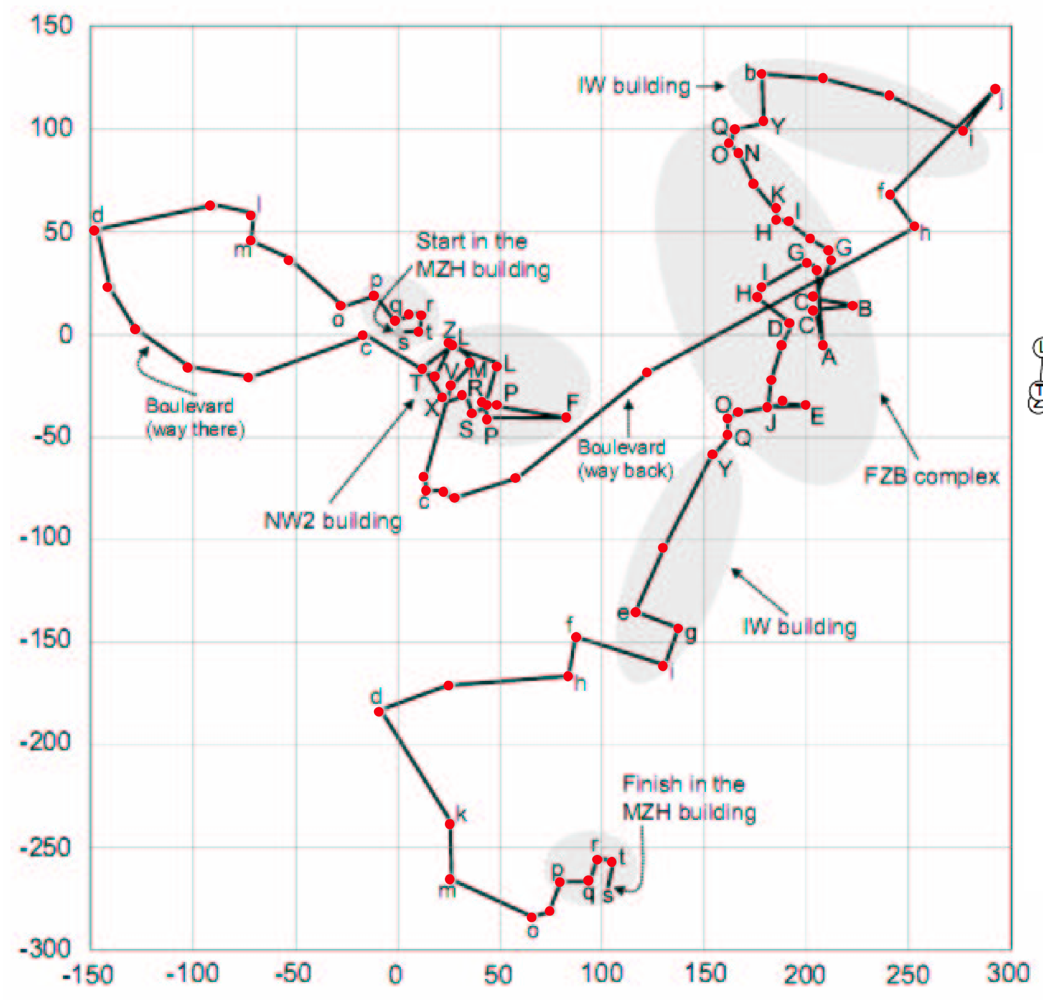
- **Building: MZH**
- **Overall length: 2176 m**

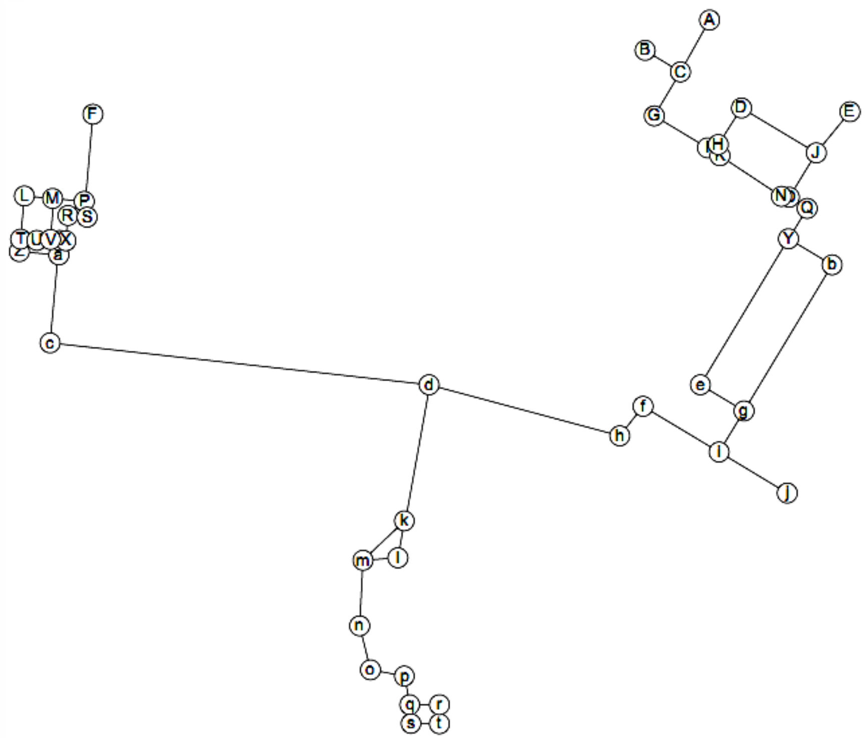
Odometry Data



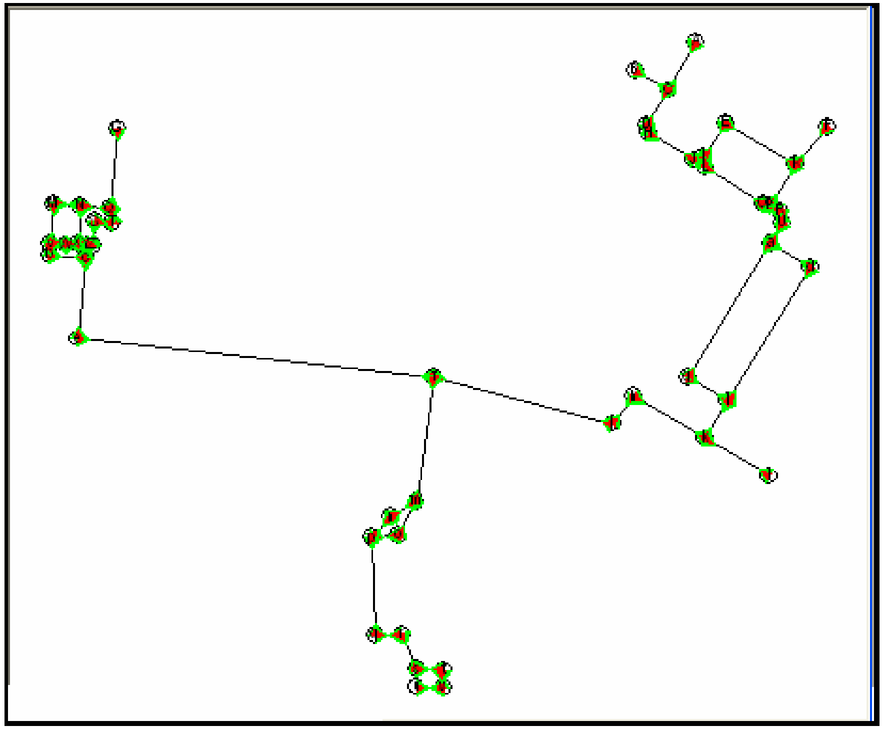


Route Graph


150
100
50
0
-50
-100
-150
-200
-250
-300
-150
-100
-50
0
50
100
150
200
250
300
IW building
Start in the
MZH building
Boulevard
(way there)
NW2 building
Boulevard
(way back)
FZB complex
IW building
Finish in the
MZH building



Results I

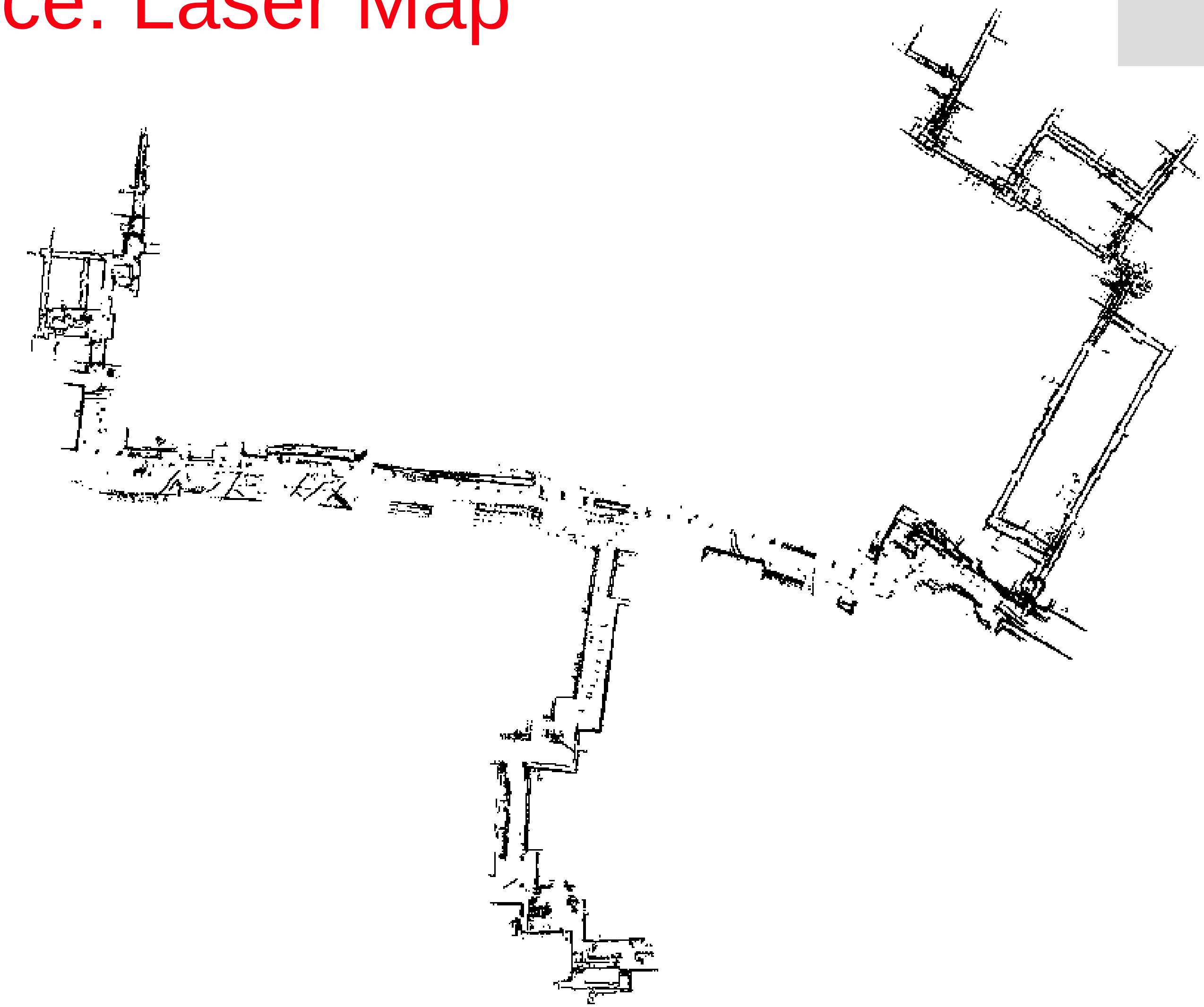


- Believed in previous corner
- Not believed in previous corner
- Most probable position

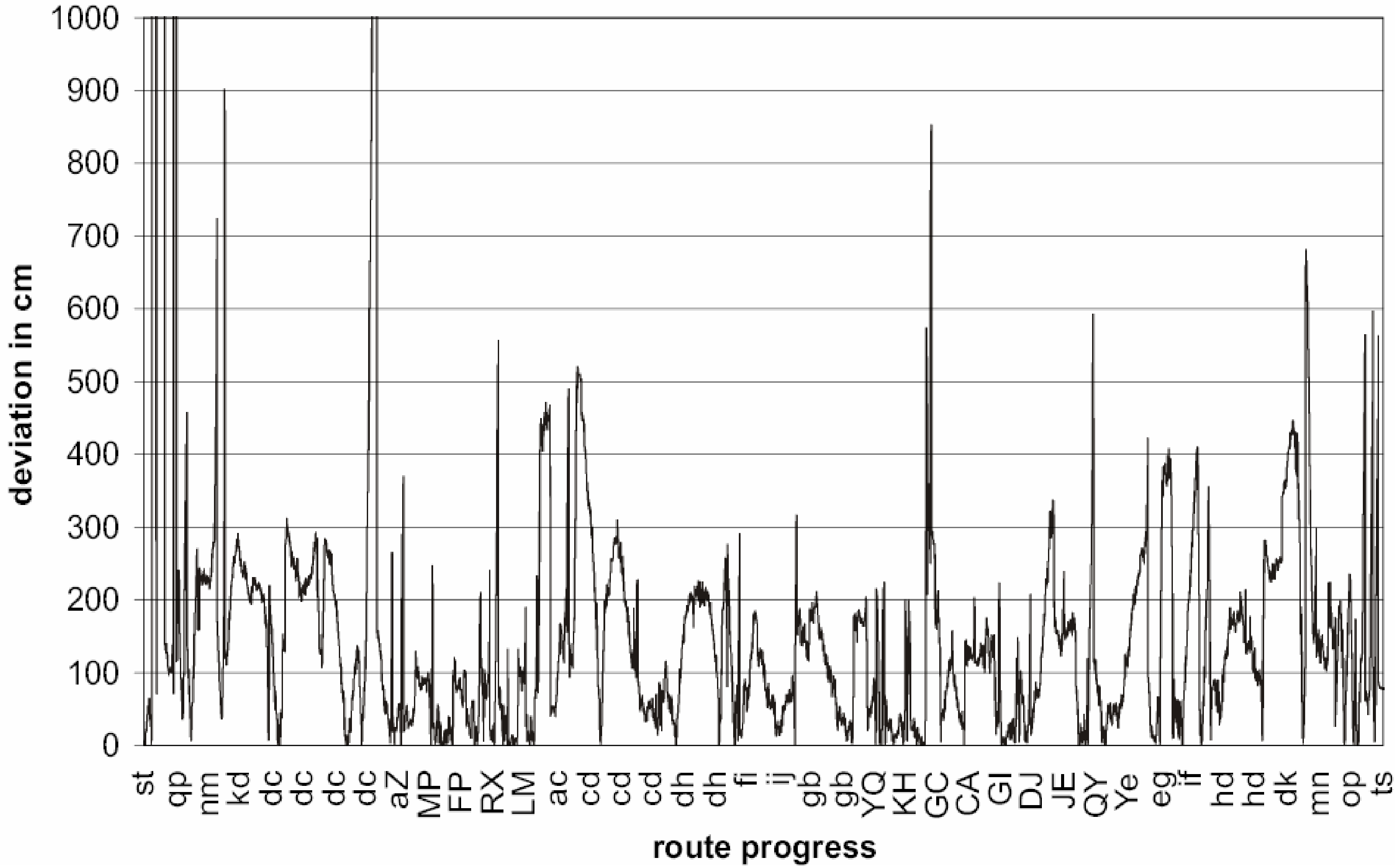
Intensity encodes confidence

Speeded up by factor 70

Reference: Laser Map



Results II


1000
900
800
700
600
500
400
300
200
100
0
deviation in cm
st qp nm kd dc dc dc dc aZ MP FP RX LM ac cd cd cd dh dh fi ij gb gb YQ KH GC CA GI DJ JE QY Ye eg if hd hd dk mn op ts
route progress

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 (anytime)
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**
  - SLAM
  - Integration of additional sensor measurements