Universität Bremen

Working Group “Cognitive Robotics”

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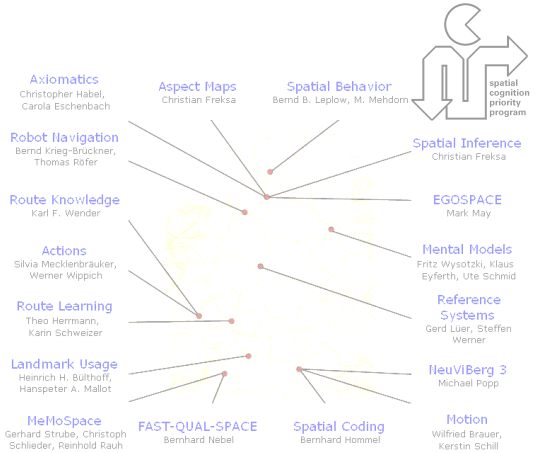
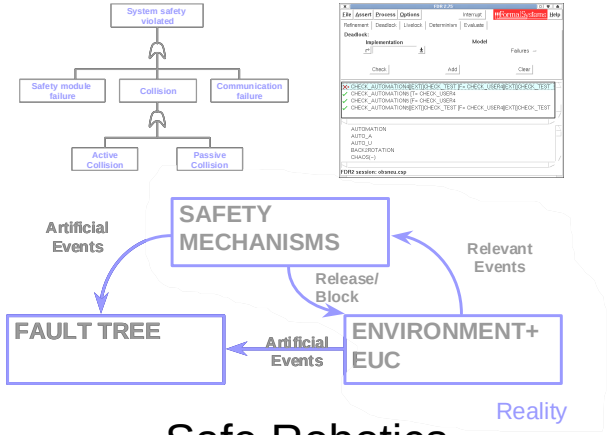
Bremen Institute of Safe Systems
Center for Computing Technology

Universität Bremen

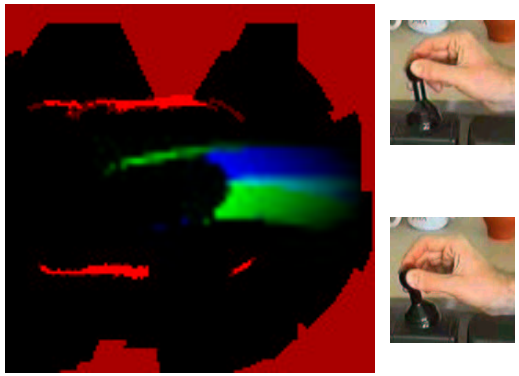
Overview



Spatial Cognition

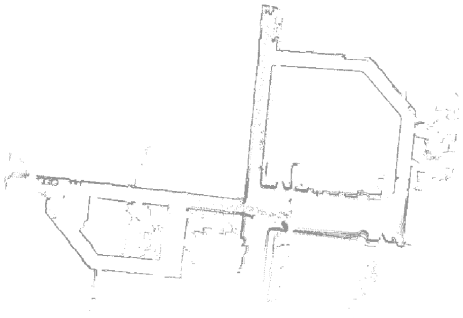


Safe Robotics



Safe Wheelchair

RoboCup



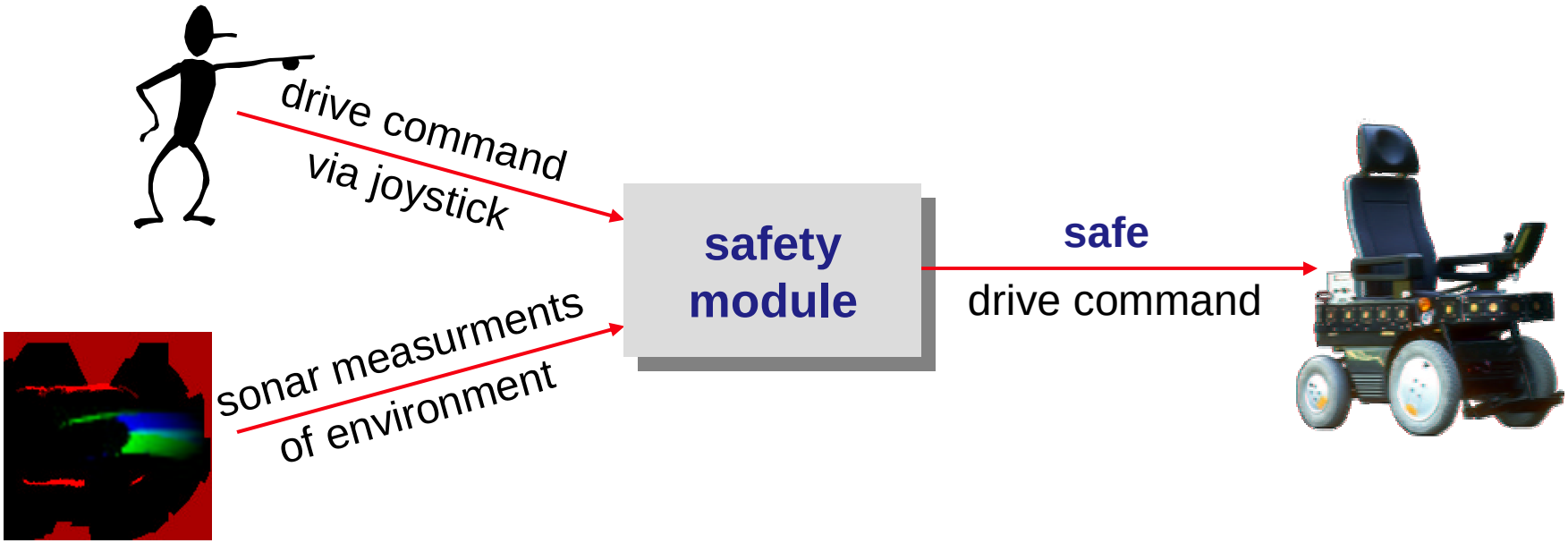
SLAM

Navigation Assistant

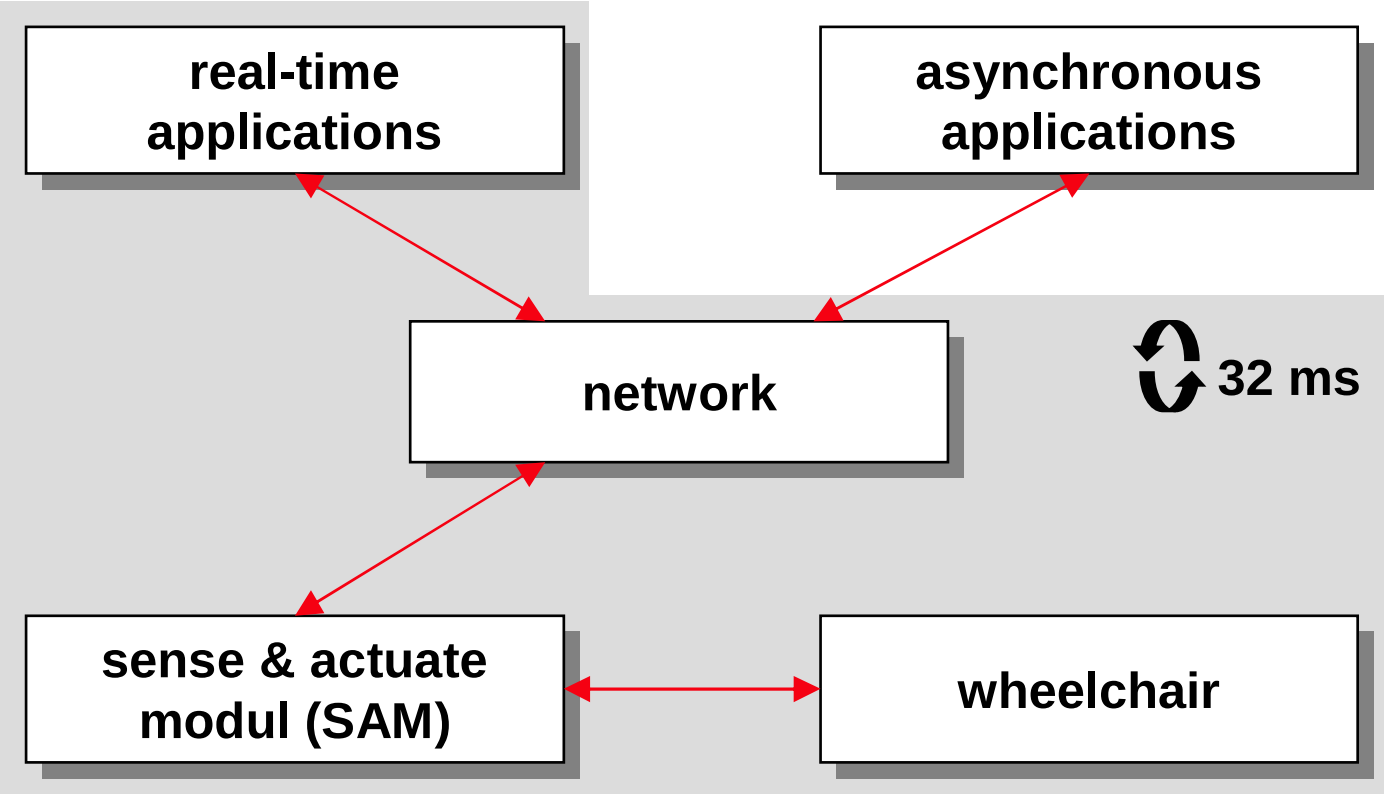
Rolland

- **Technical Information**
  - Meyra Model “Genius 1.522”
  - 84 cm/s maximum speed
  - Communication via two serial ports
- **Sensor Equipment**
  - Internal sensors (speed/steering angle)
  - 27 ultrasonic sensors (Nomadic)
- **On-Board Computer**
  - Industry-PC (Pentium III/600)
  - QNX (real-time operating system)

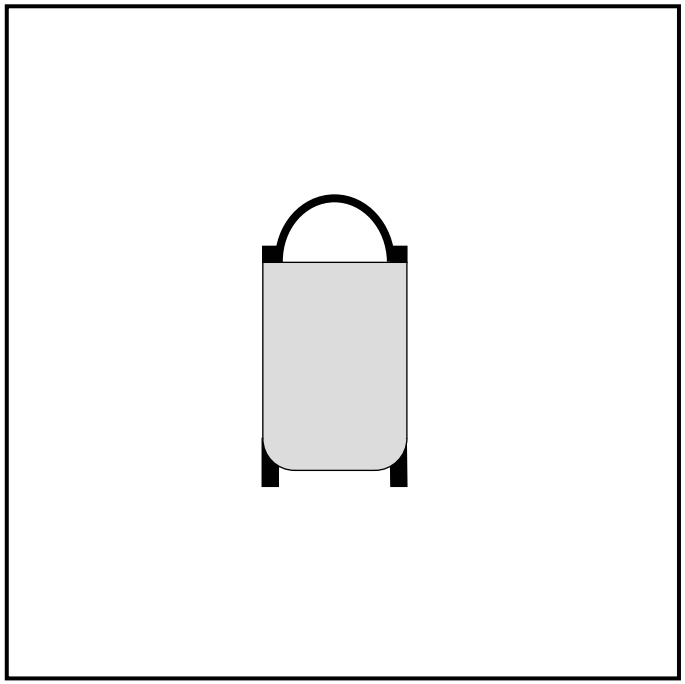
Safe Wheelchair – Motivation

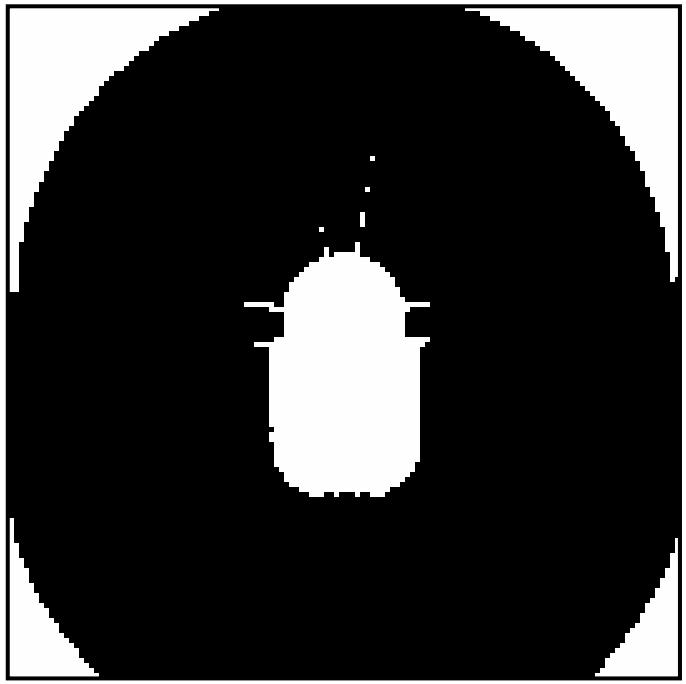


Safe Wheelchair – Architecture

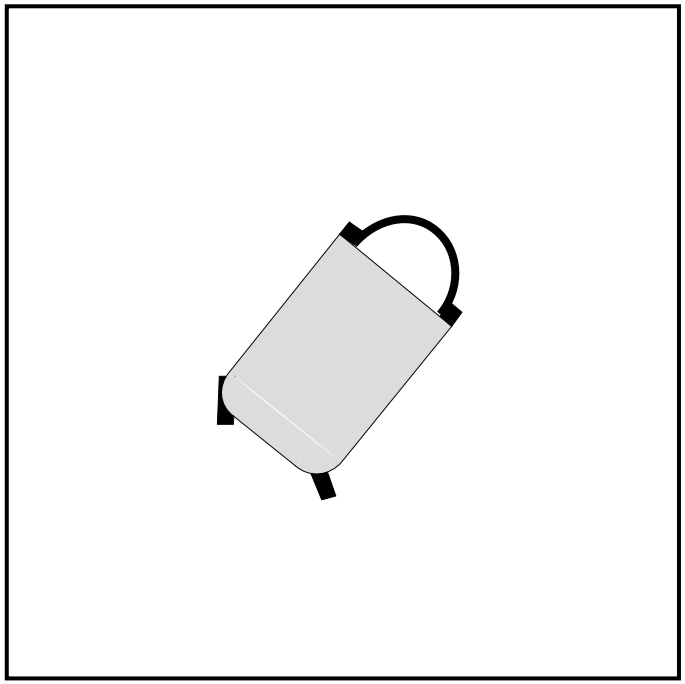


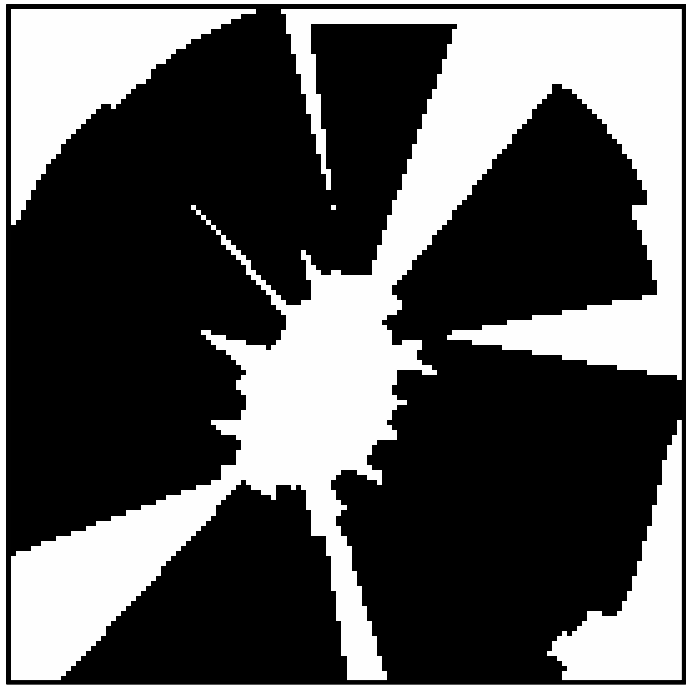
Safe Wheelchair – „Static“ Fire Sequence





Safe Wheelchair – „Static“ Fire Sequence (in motion)





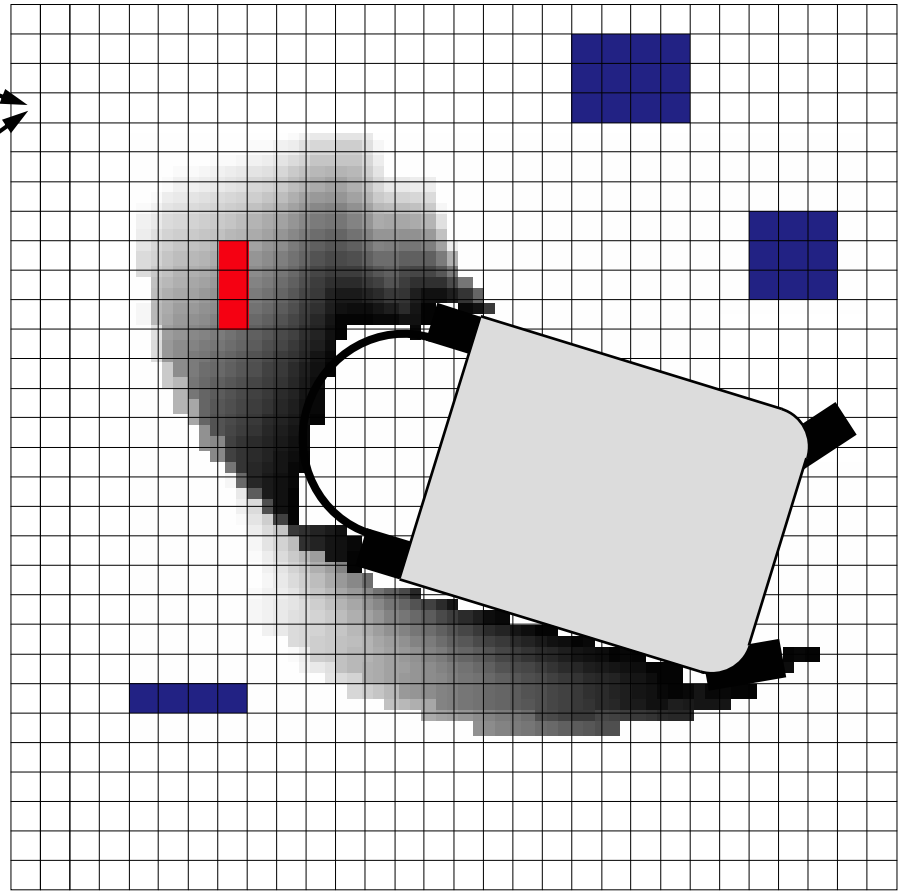
Safe Wheelchair – Obstacle Detection

age of measurement

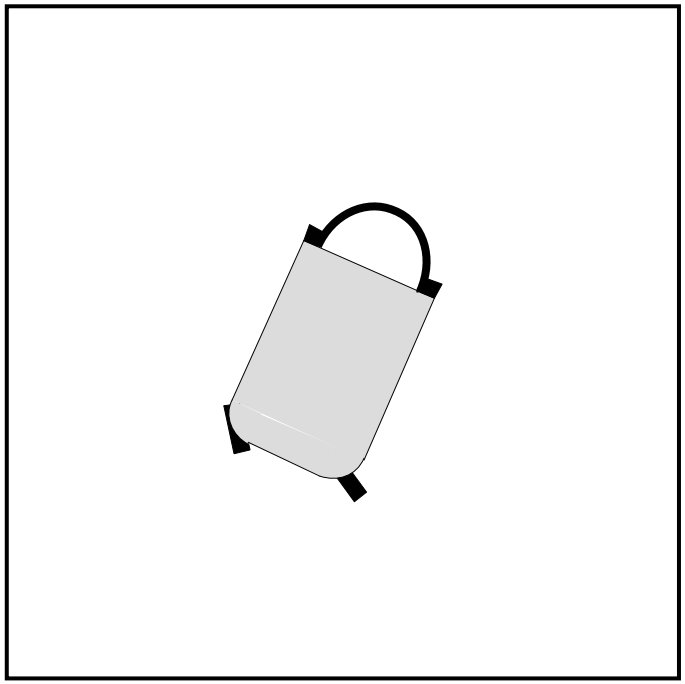
occupancy of cell

- never measured
- empty
- obstacle supposed
- obstacle confirmed

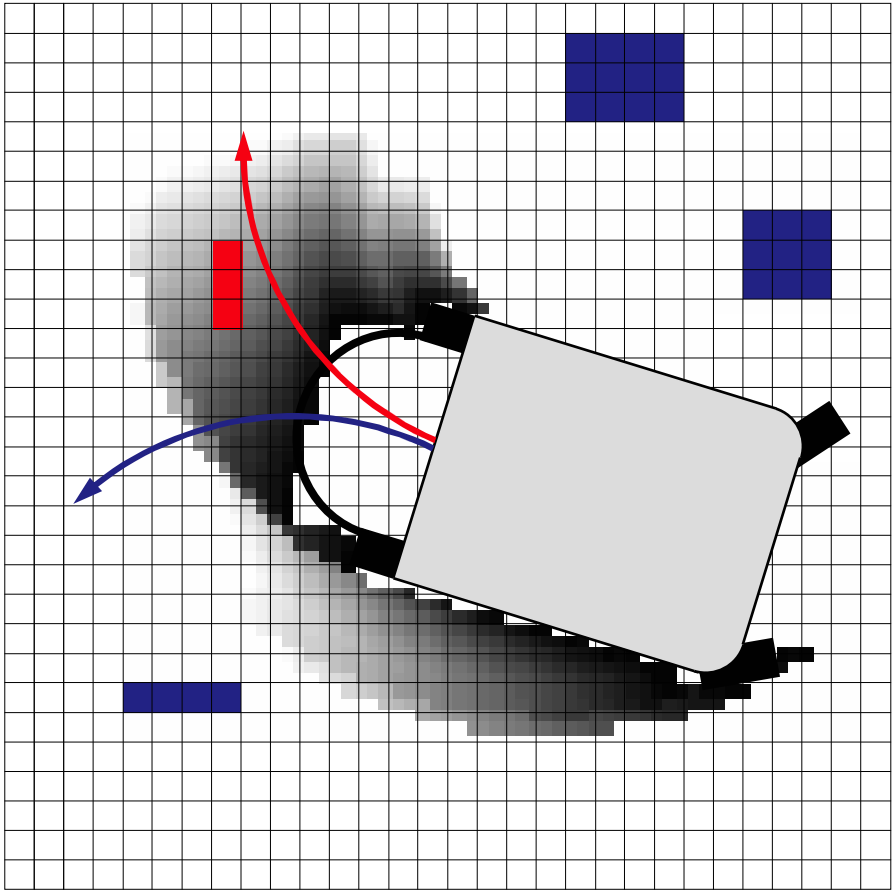
danger of collision!



Safe Wheelchair – Results

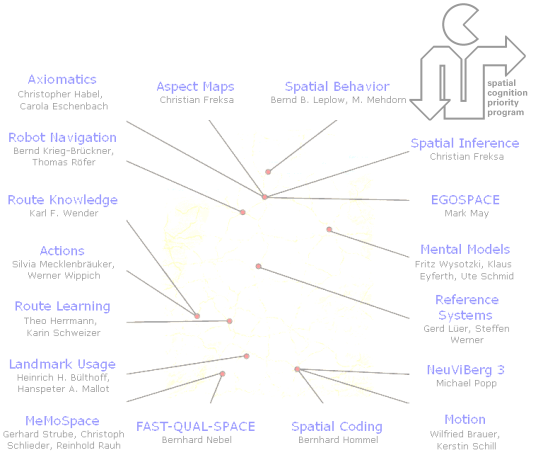


Driving Assistant – Avoidance

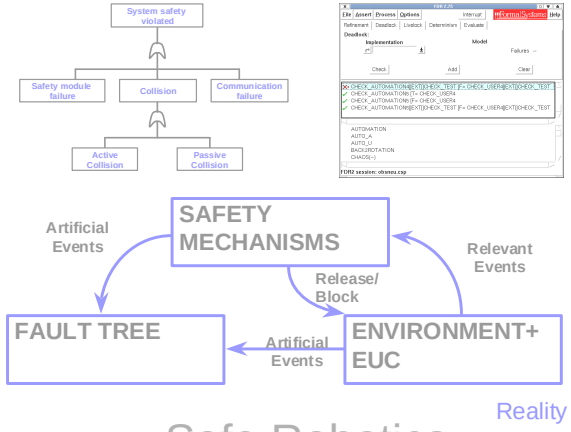


Driving Assistant – Demonstration

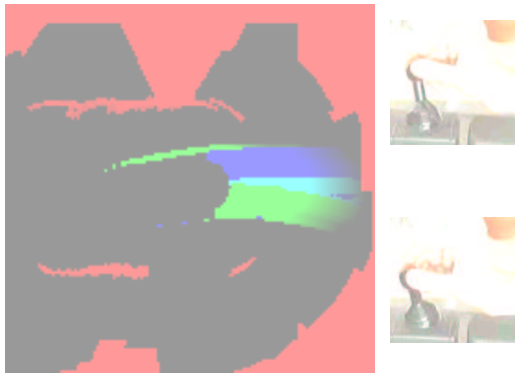
Overview



Spatial Cognition

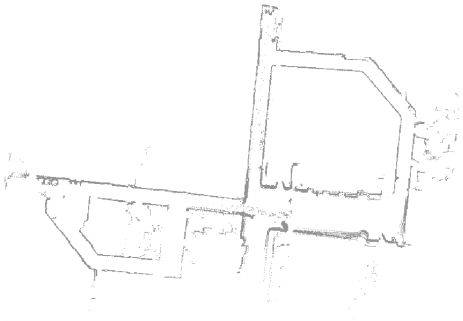


Safe Robotics



Safe Wheelchair

RoboCup



SLAM

Navigation Assistant

Navigation Assistant

Marauder's Map

Navigation Assistant – Rolland

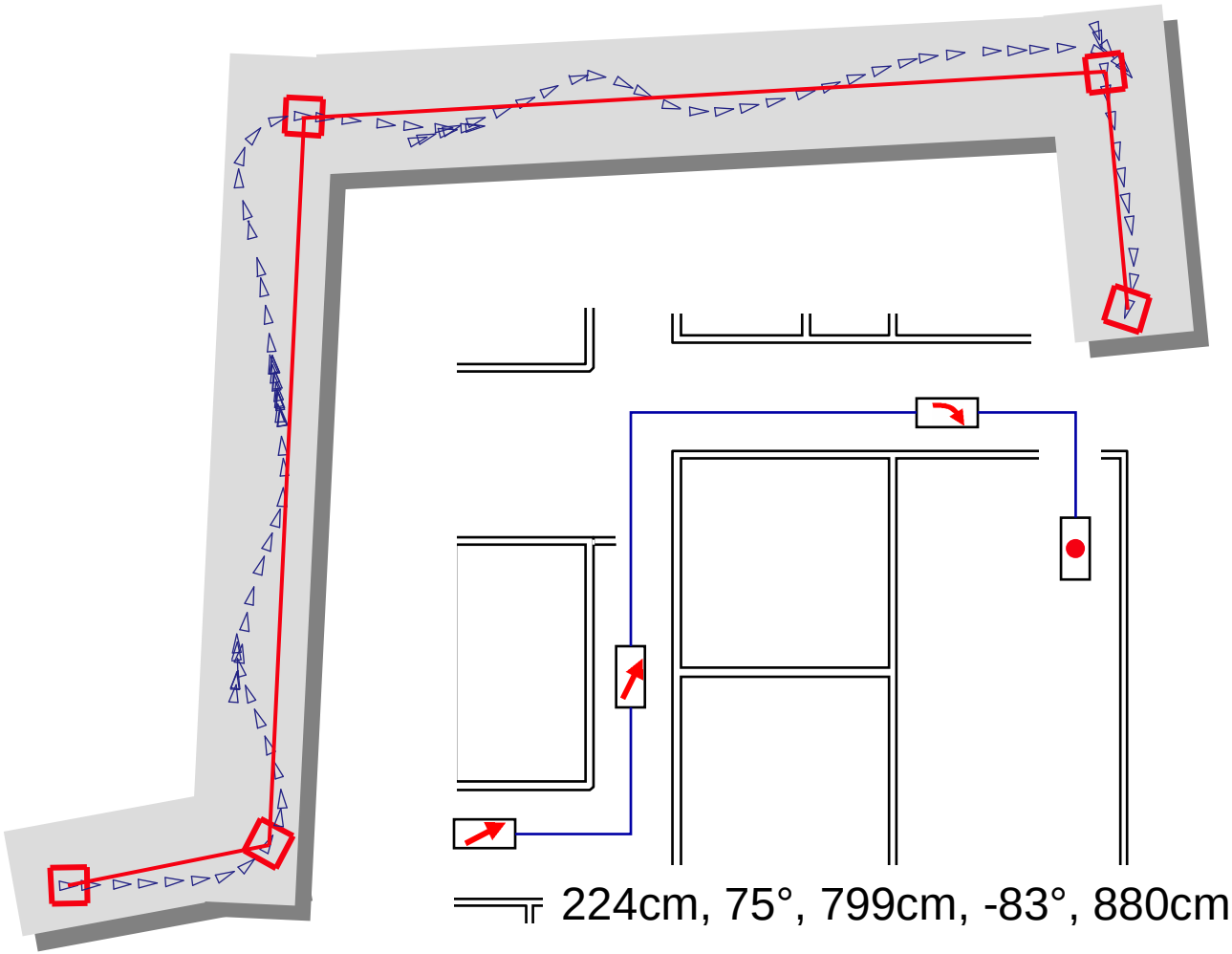
acoustic instructions

Turn right at the next possibility

user interface

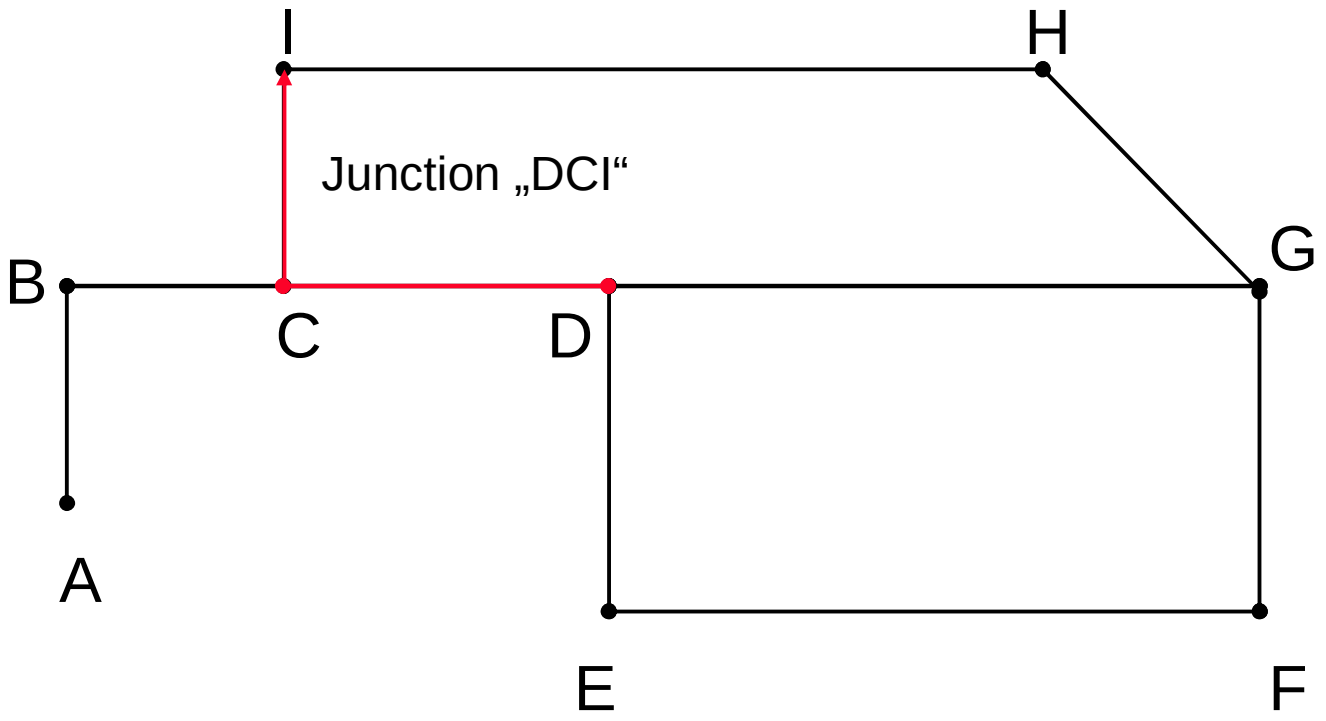
visual instructions

Generalization of Locomotion



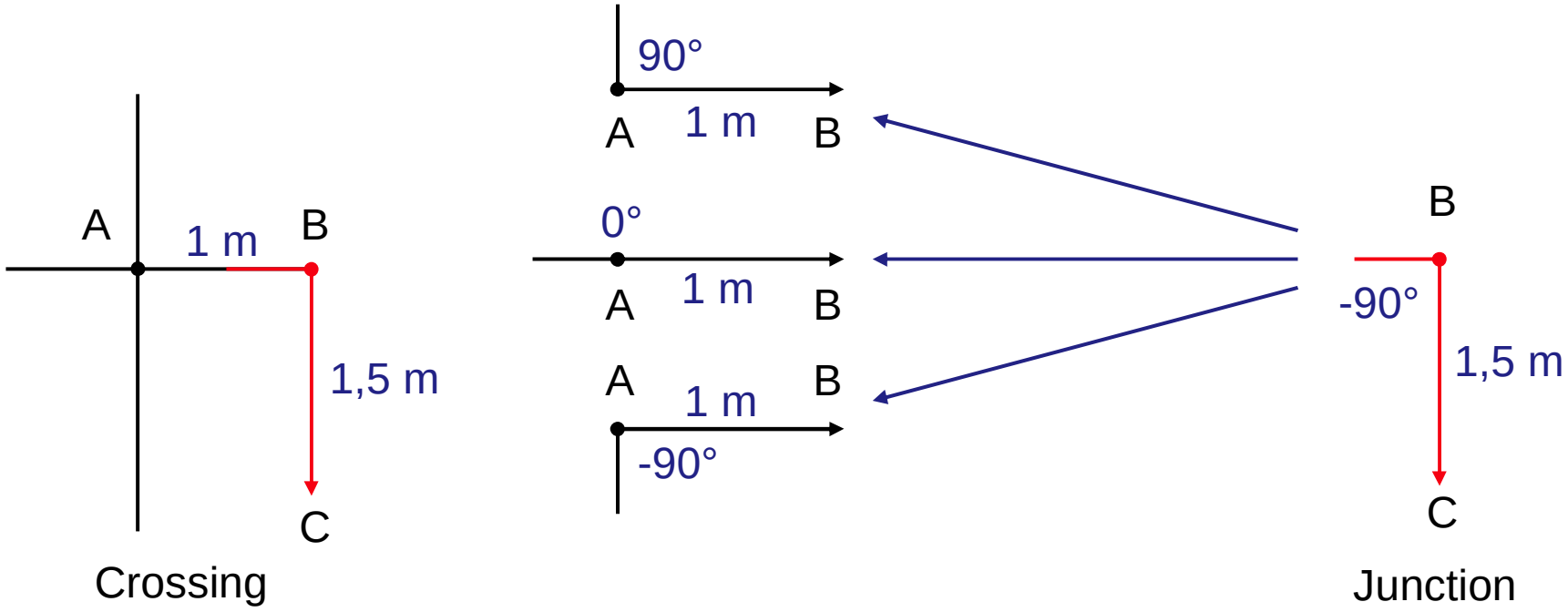
224cm, 75°, 799cm, -83°, 880cm, -87°, 260cm

Modeling the Environment



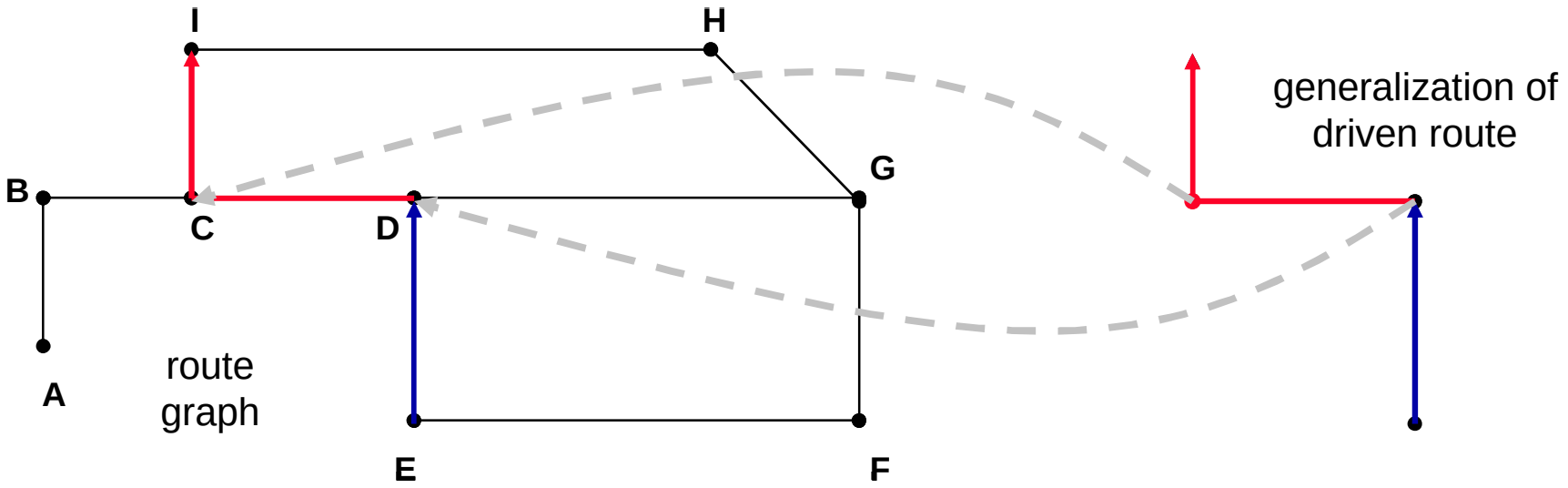
Junctions

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

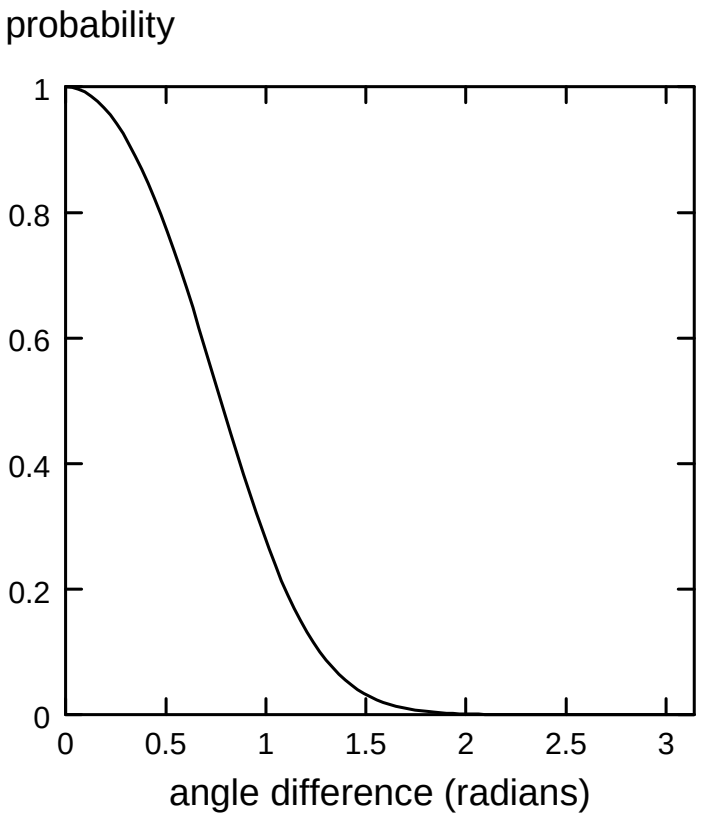


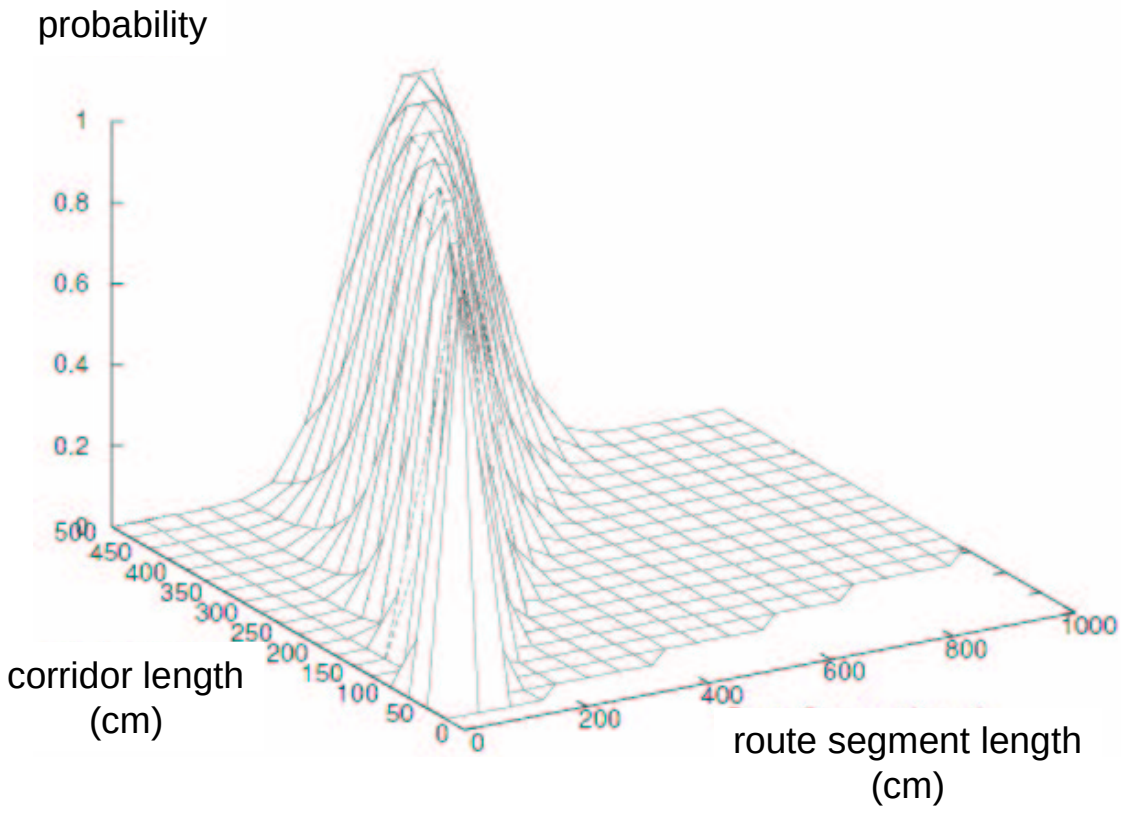
Inductive Approach

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



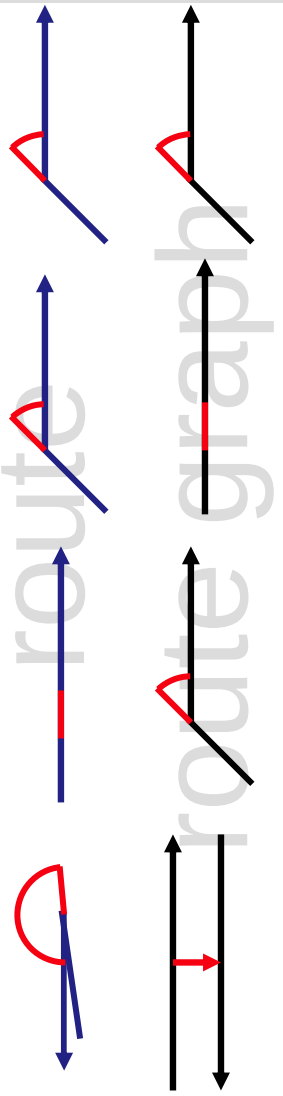
Probabilities from Similarities



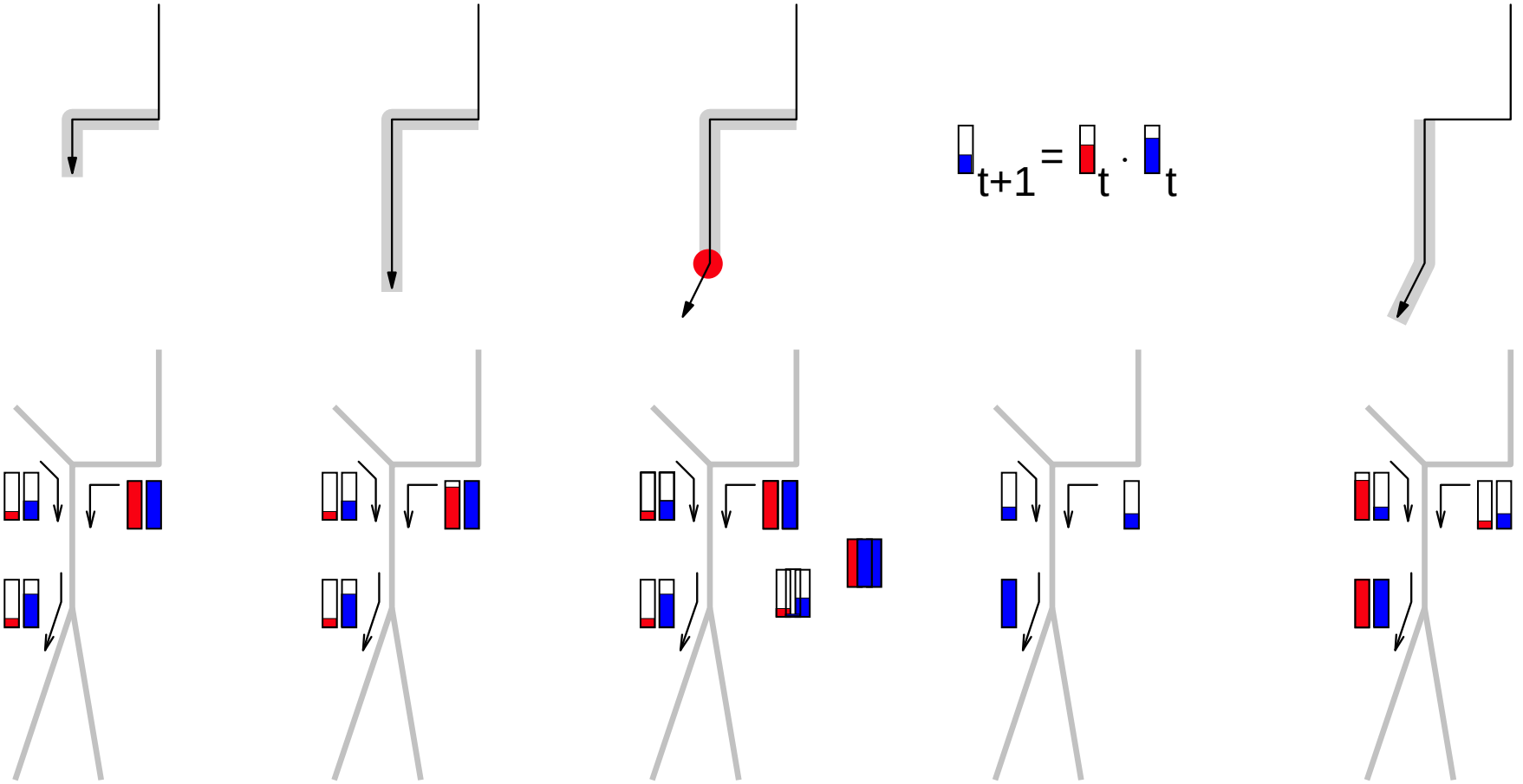


Matching Corners

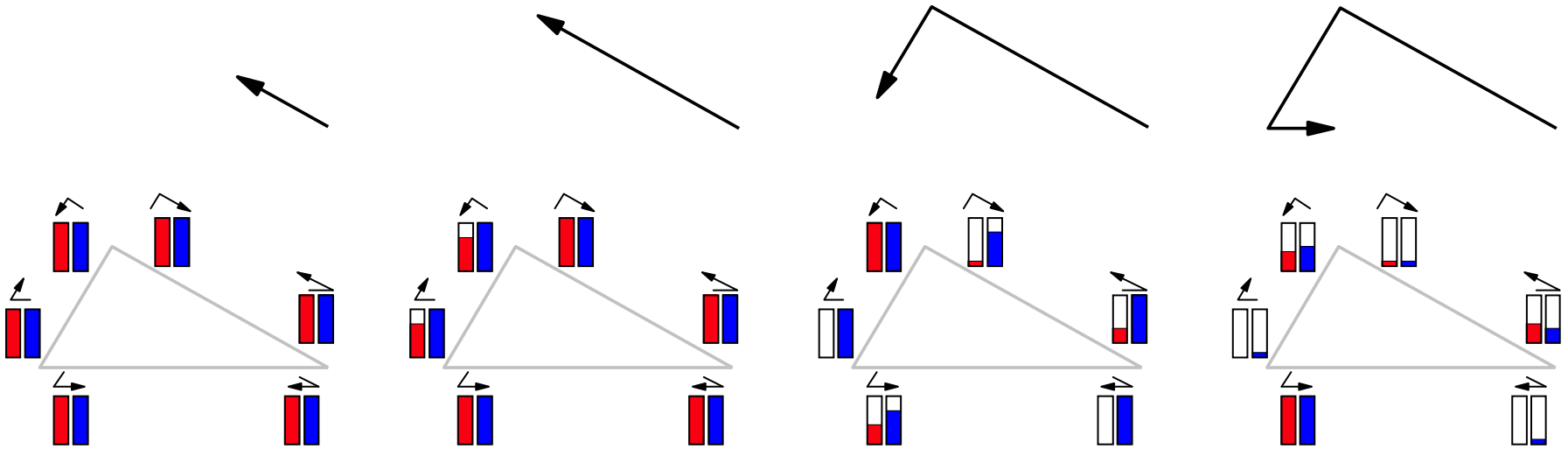
- **Differentiation between the probabilities that**
  - the corner previously generalized really exists, …
    - *Angle of corner is similar to angle of the junction in the route graph*
  - ... the corner has been detected erroneously, ...
    - *Angle of corner is similar to 0°*
  - ... a corner has 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°*



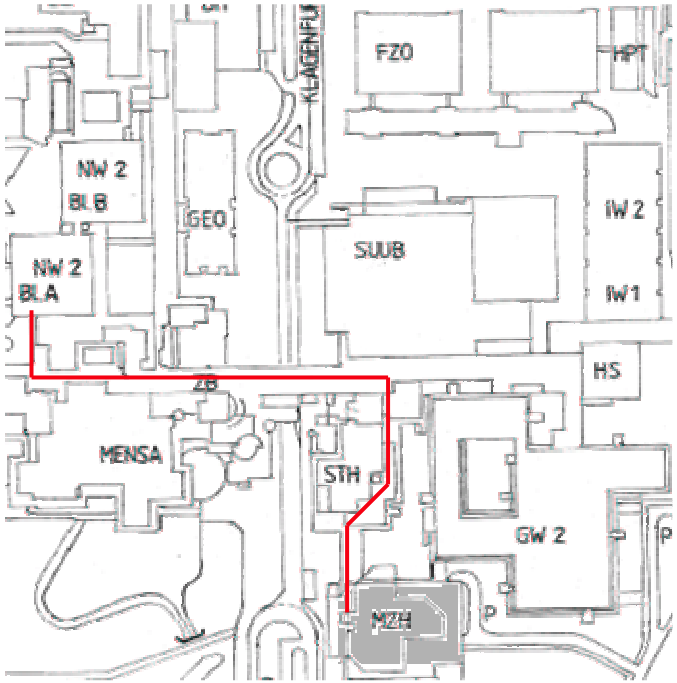
Propagation of Probabilities

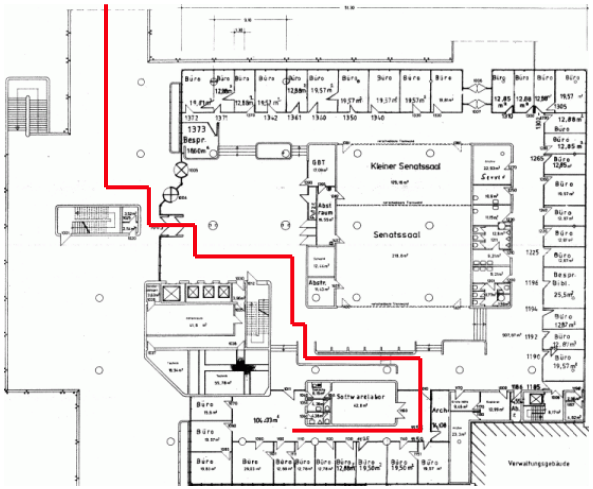


Determining the Candidate Junction



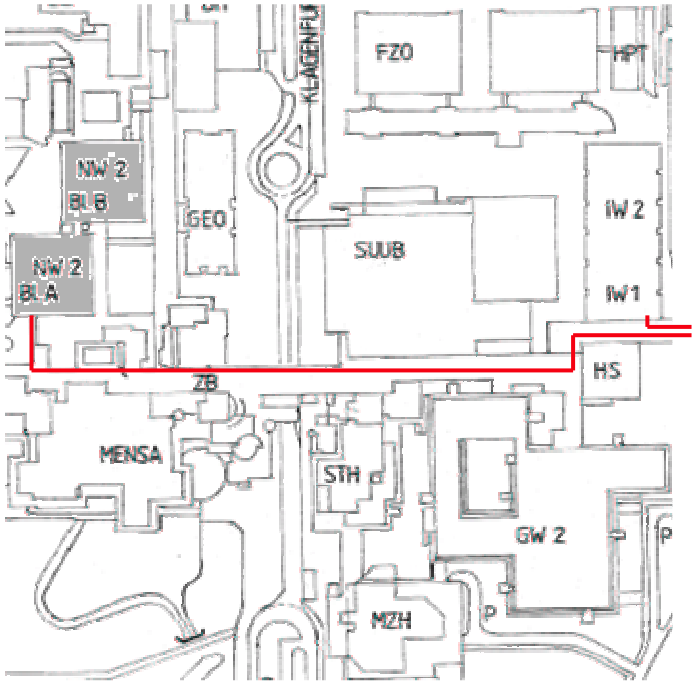
Indoor and Outdoor Navigation

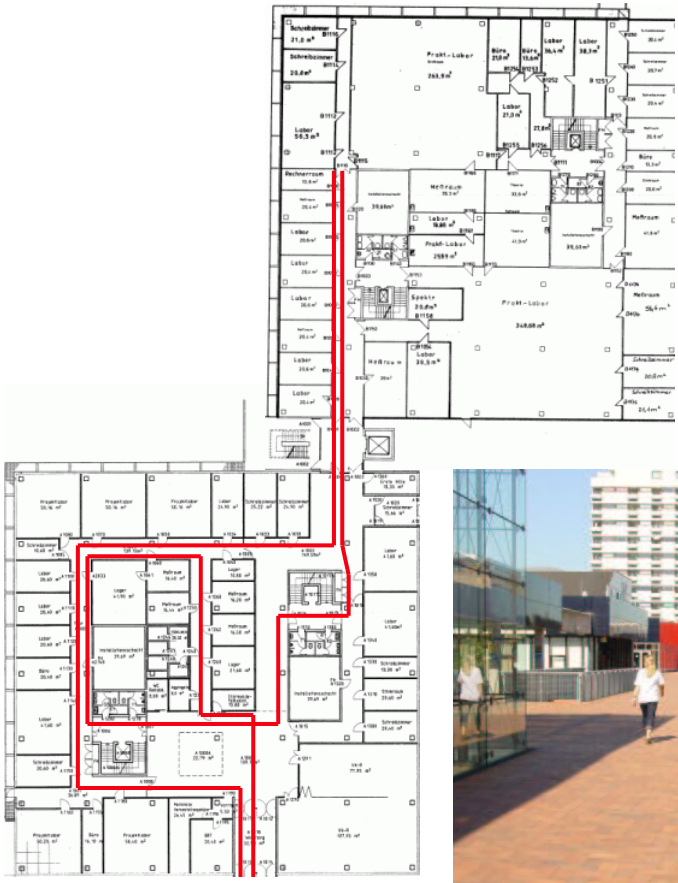




- **Building: MZH**

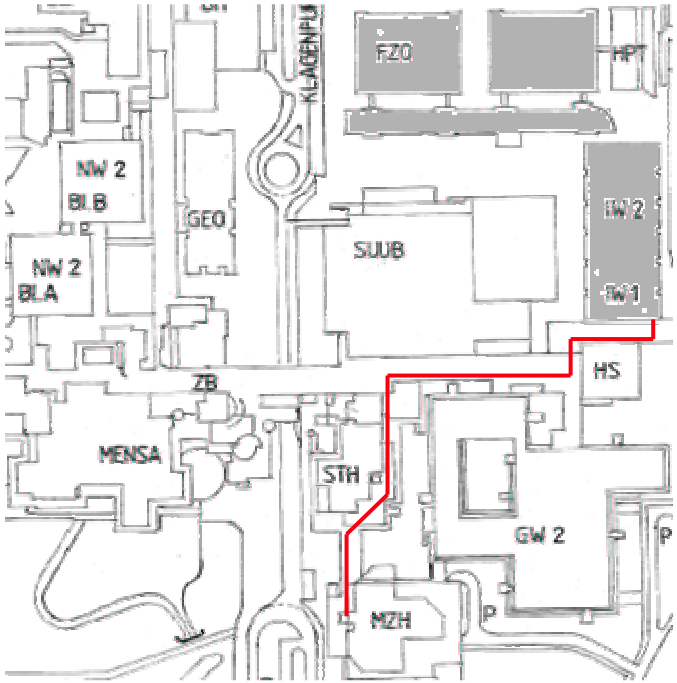
Indoor and Outdoor Navigation

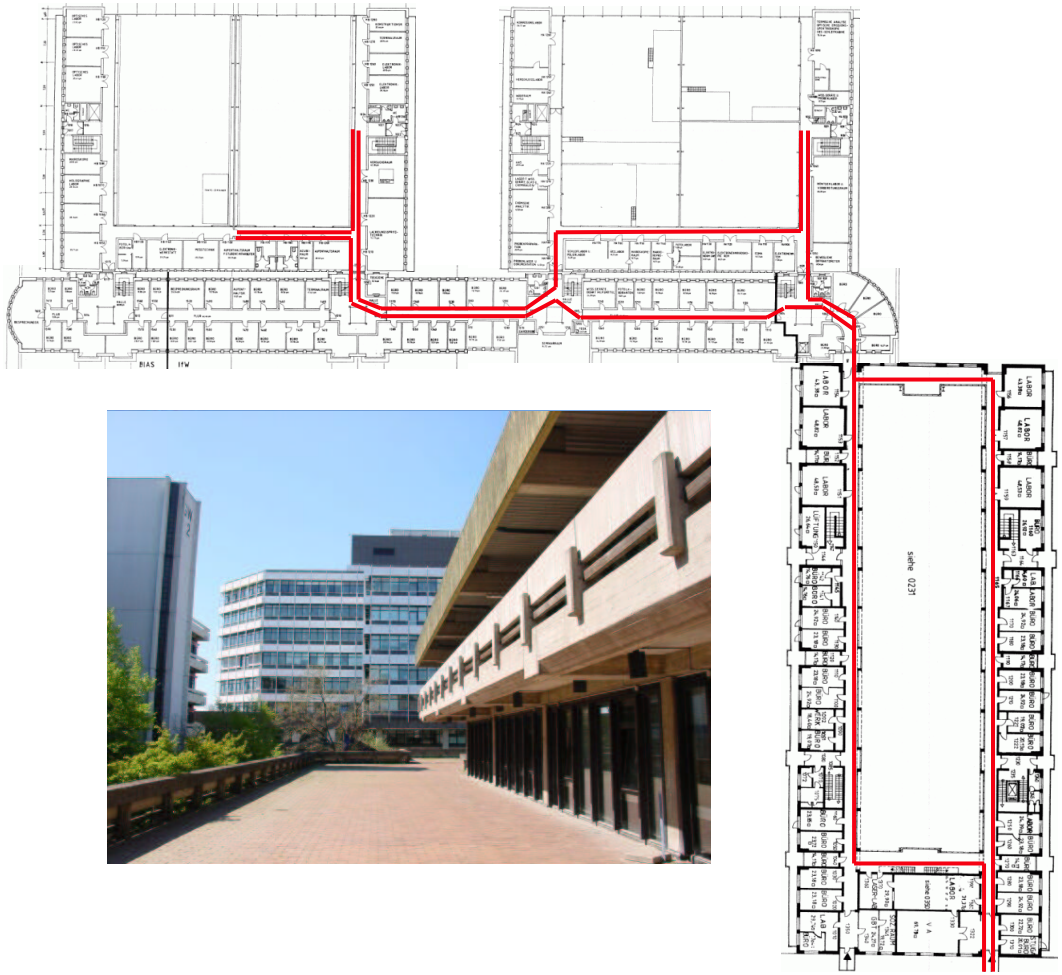




- **Building: NW 2**

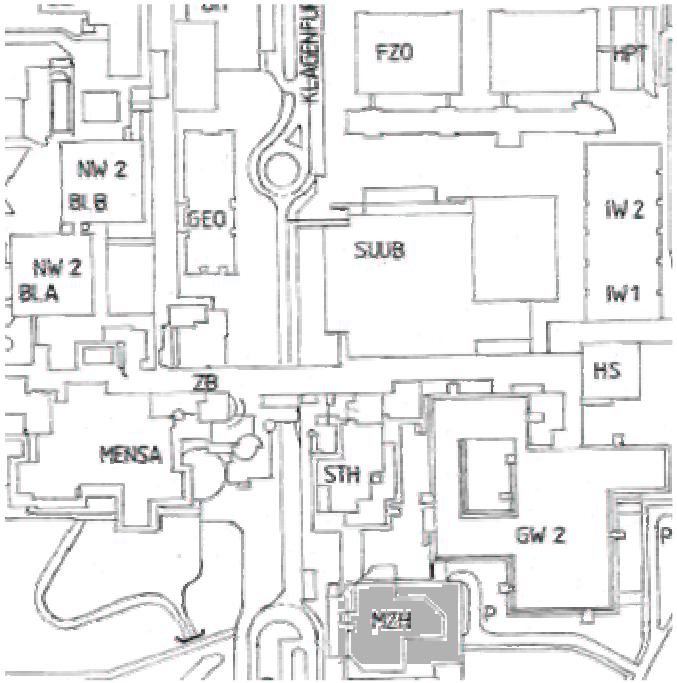
Indoor and Outdoor Navigation

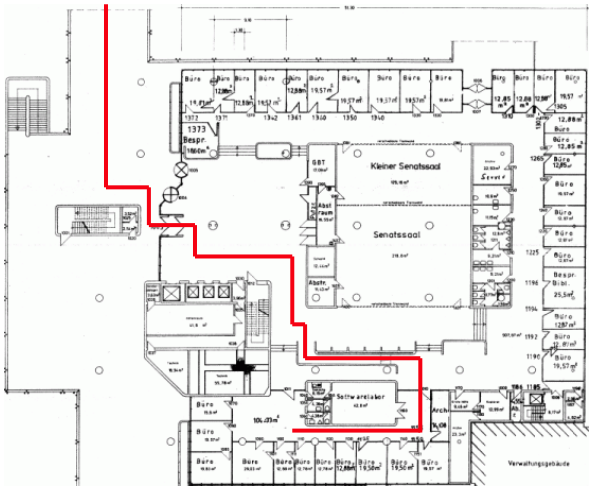




- **Buildings: IW + BIBA**

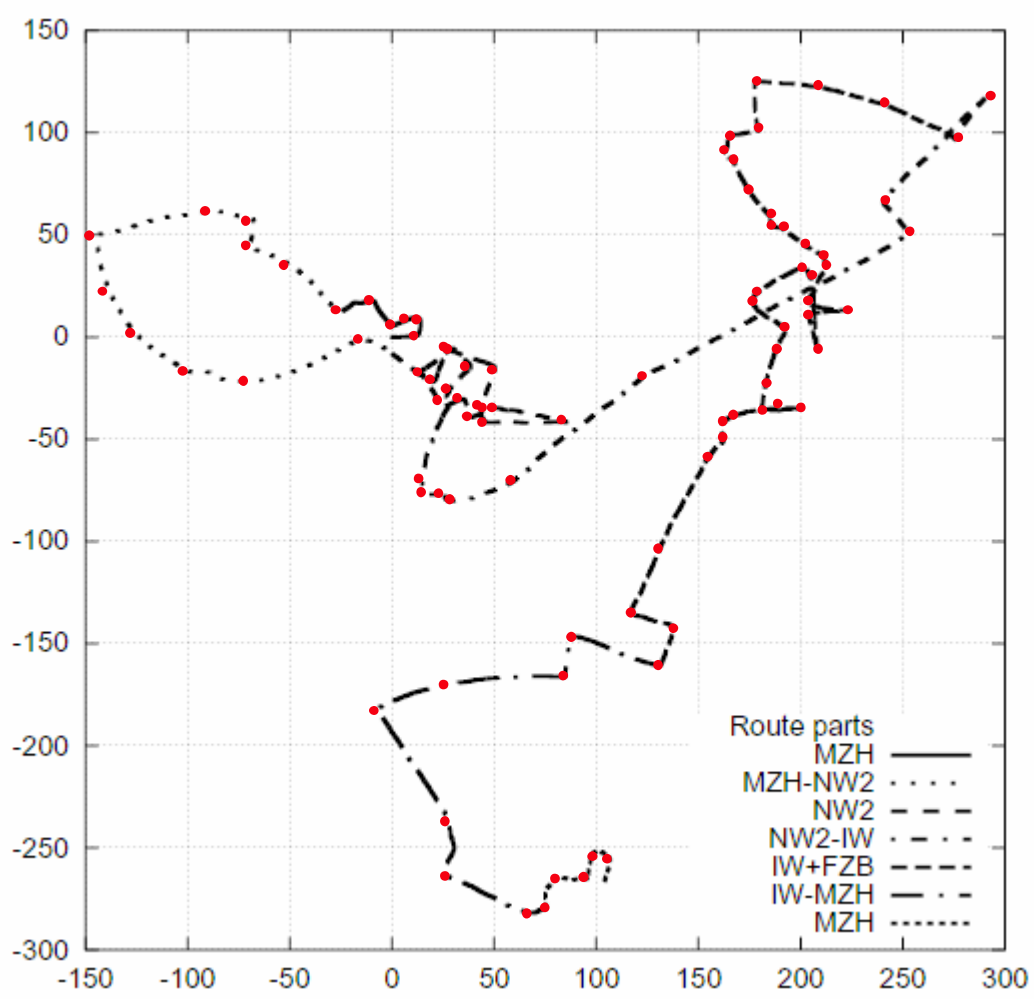
Indoor and Outdoor Navigation

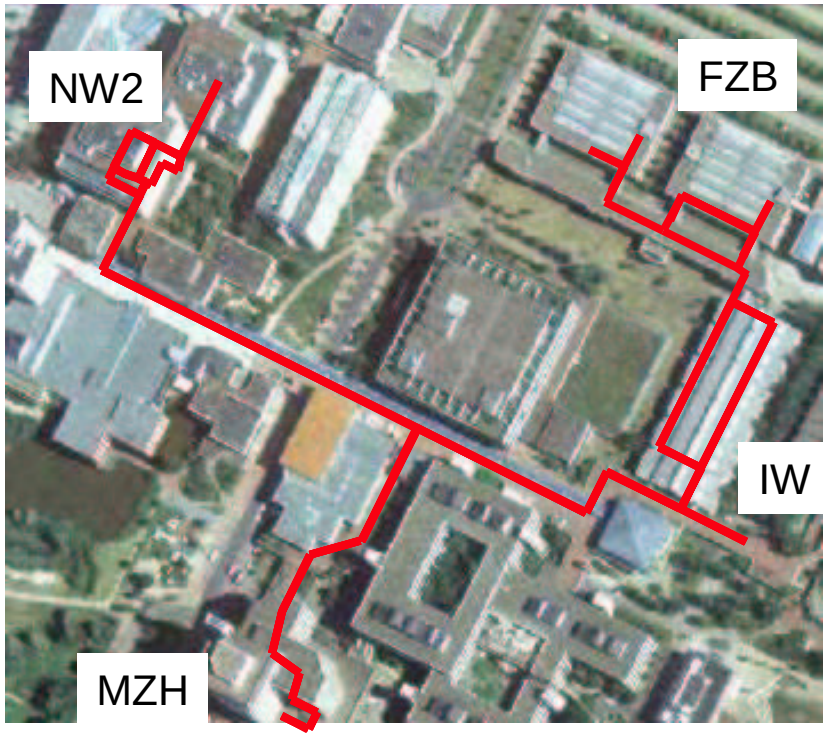




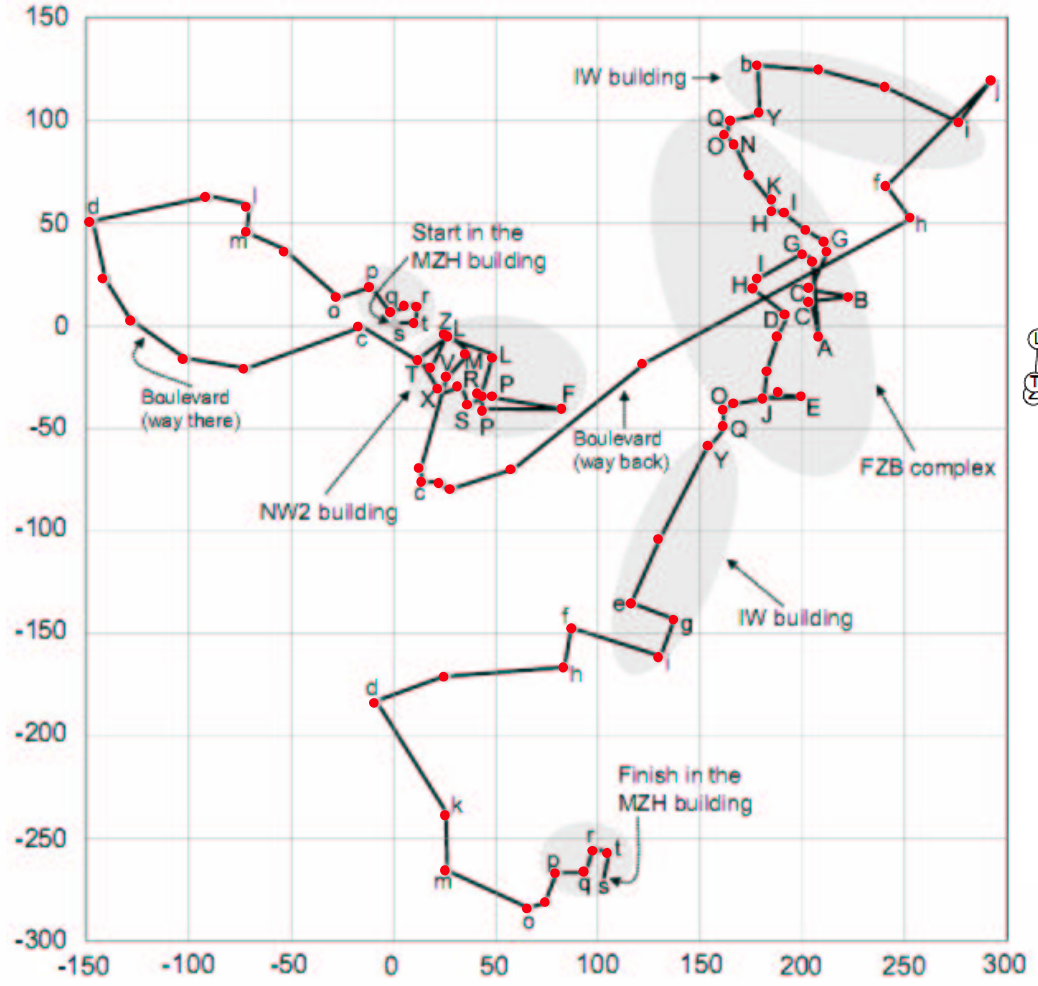
- **Building: MZH**
- **Overall length: 2176 m**

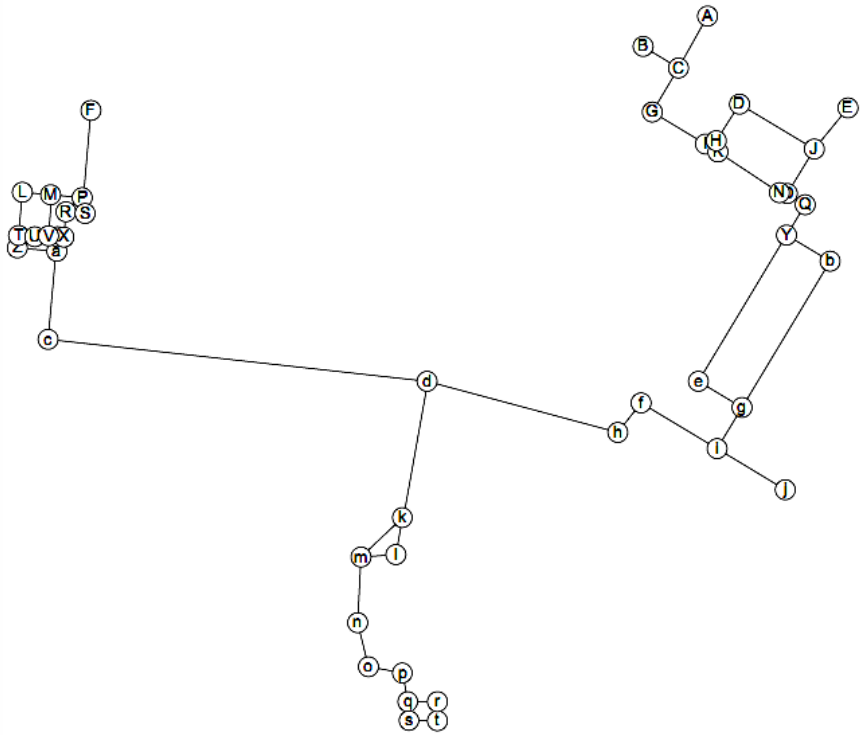
Odometry Data



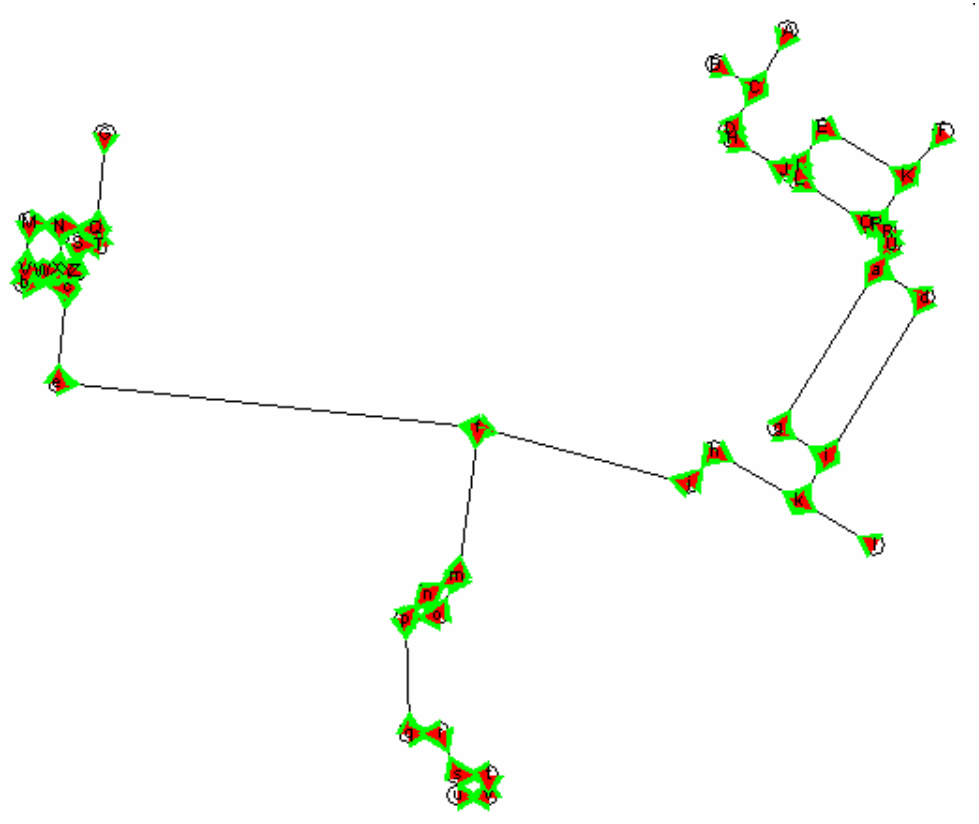


Route Graph


IW building
Start in the MZH building
Boulevard (way there)
Boulevard (way back)
FZB complex
NW2 building
IW building
Finish in the MZH building



Results I



Believed in previous corner

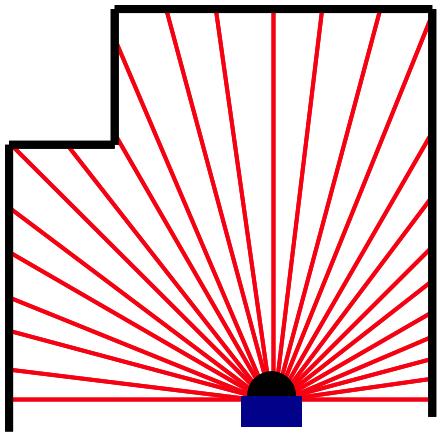
Not believed in previous corner

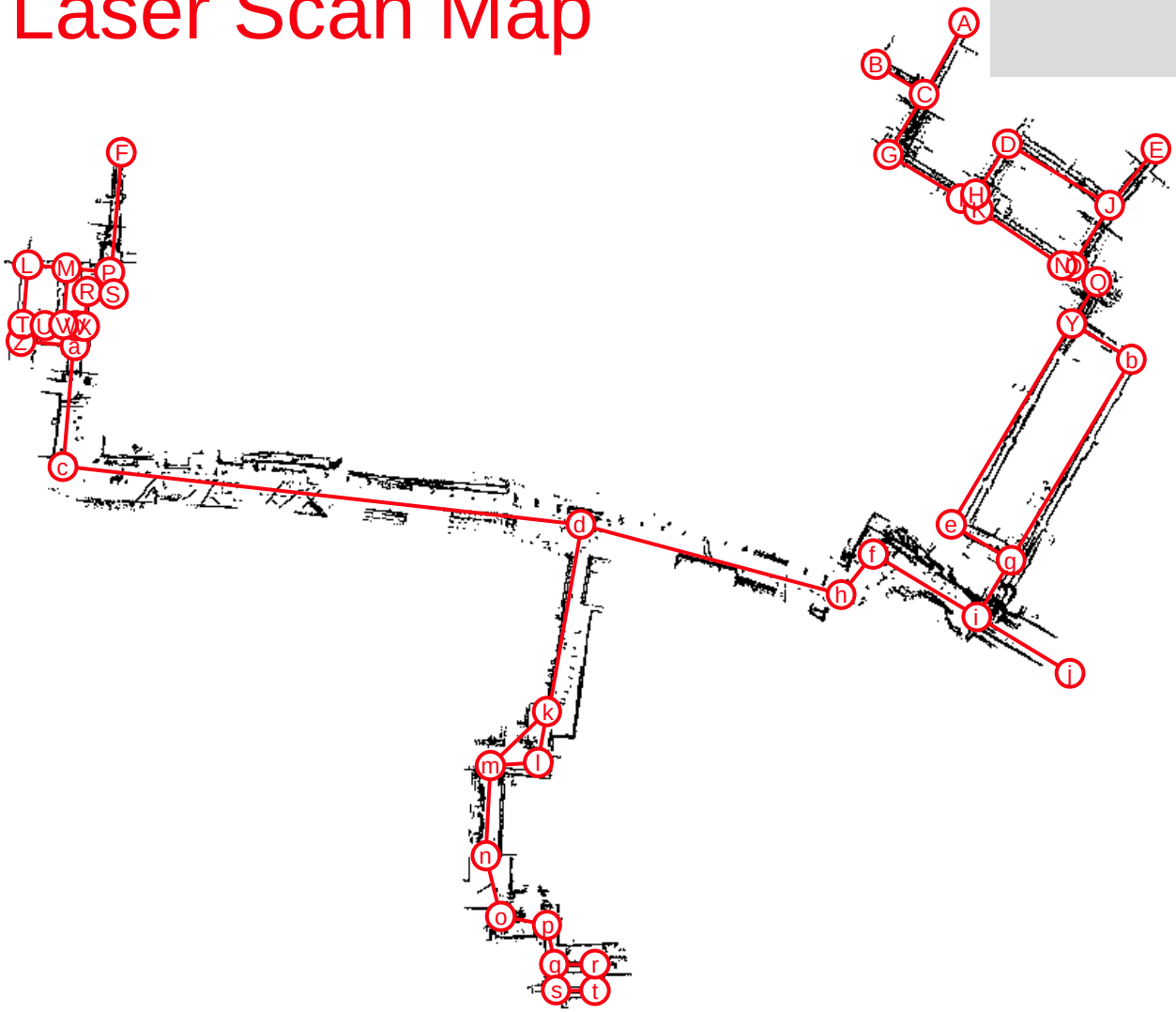
Most probable position

Intensity encodes confidence

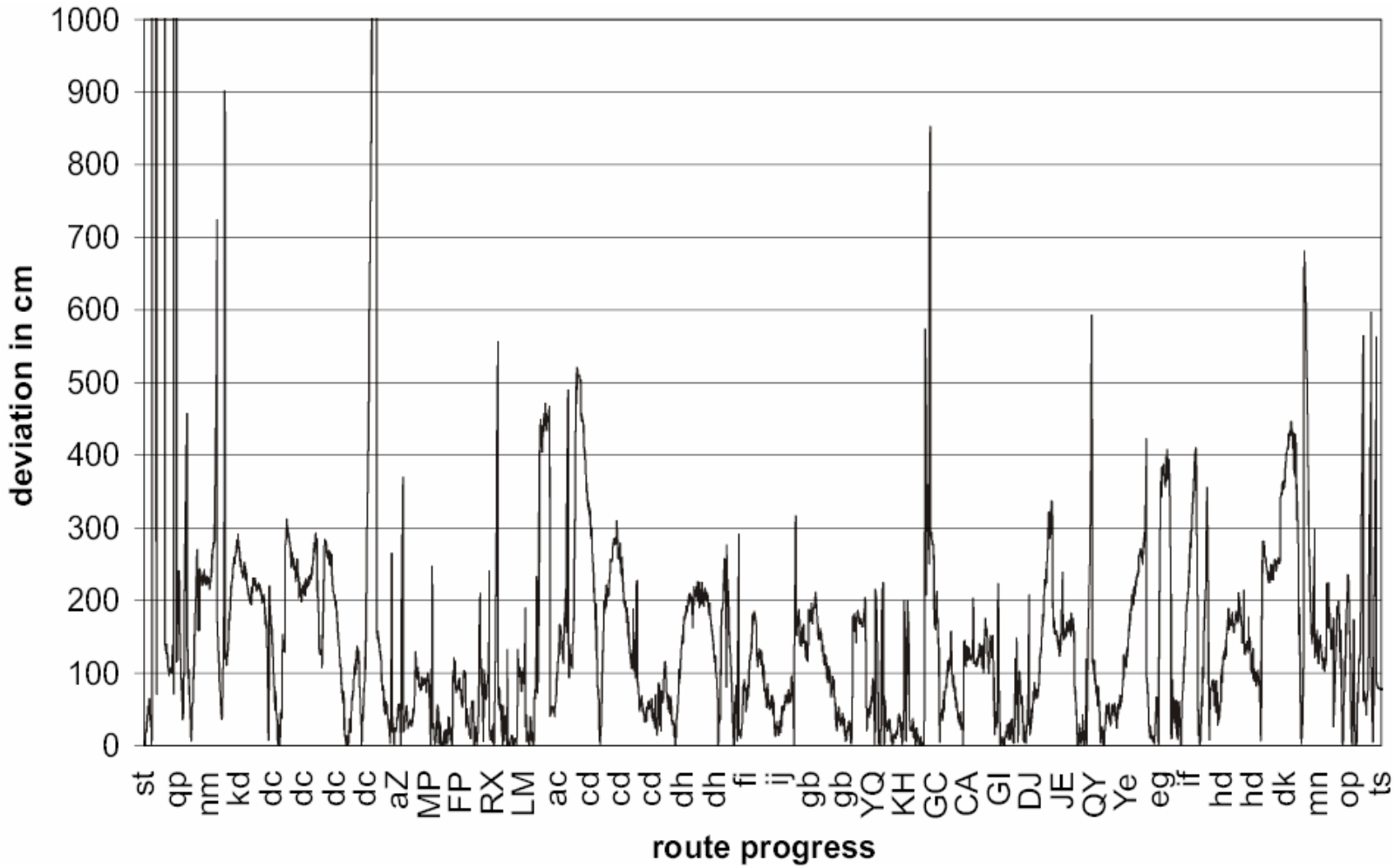
Speeded up by factor 70

Reference: Laser Scan Map

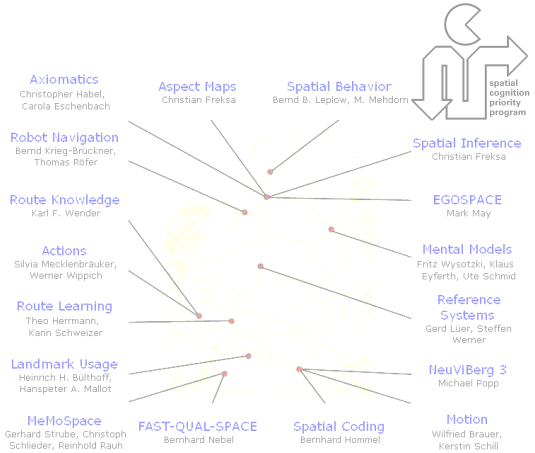




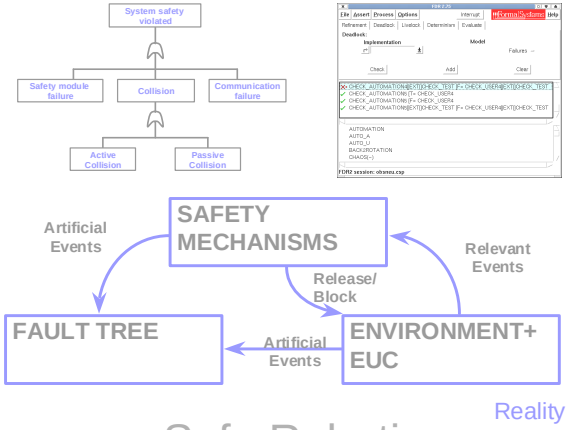
Results II


deviation in cm
1000
900
800
700
600
500
400
300
200
100
0
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

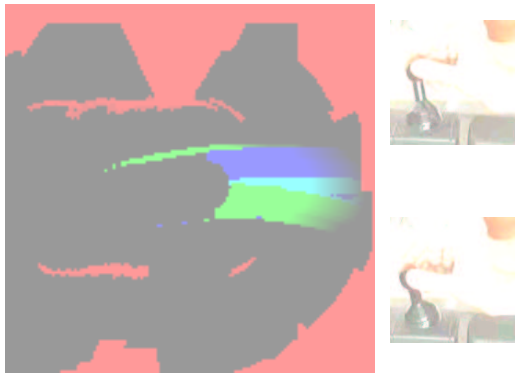
Overview



Spatial Cognition

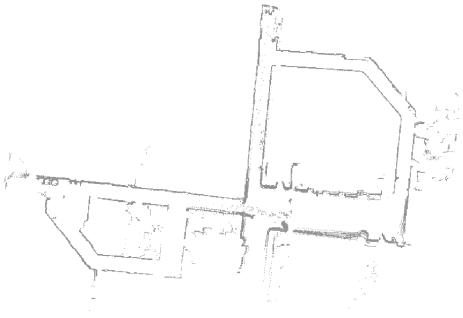


Safe Robotics



Safe Wheelchair

RoboCup

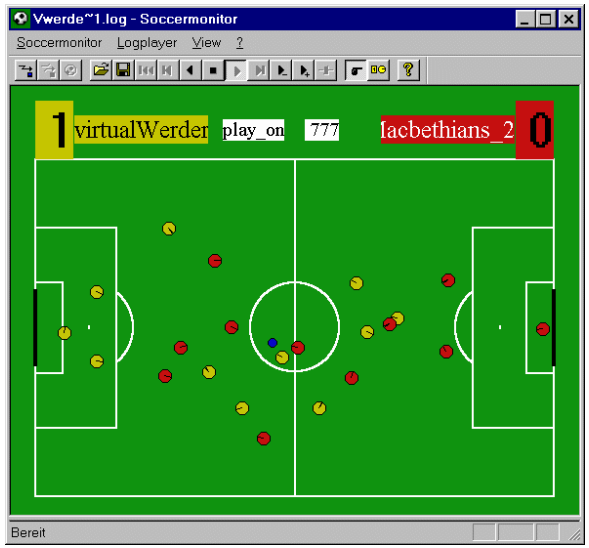


SLAM

Navigation Assistant

Our Teams

Simulation League



Virtual Werder

BUGS

Small-Size League

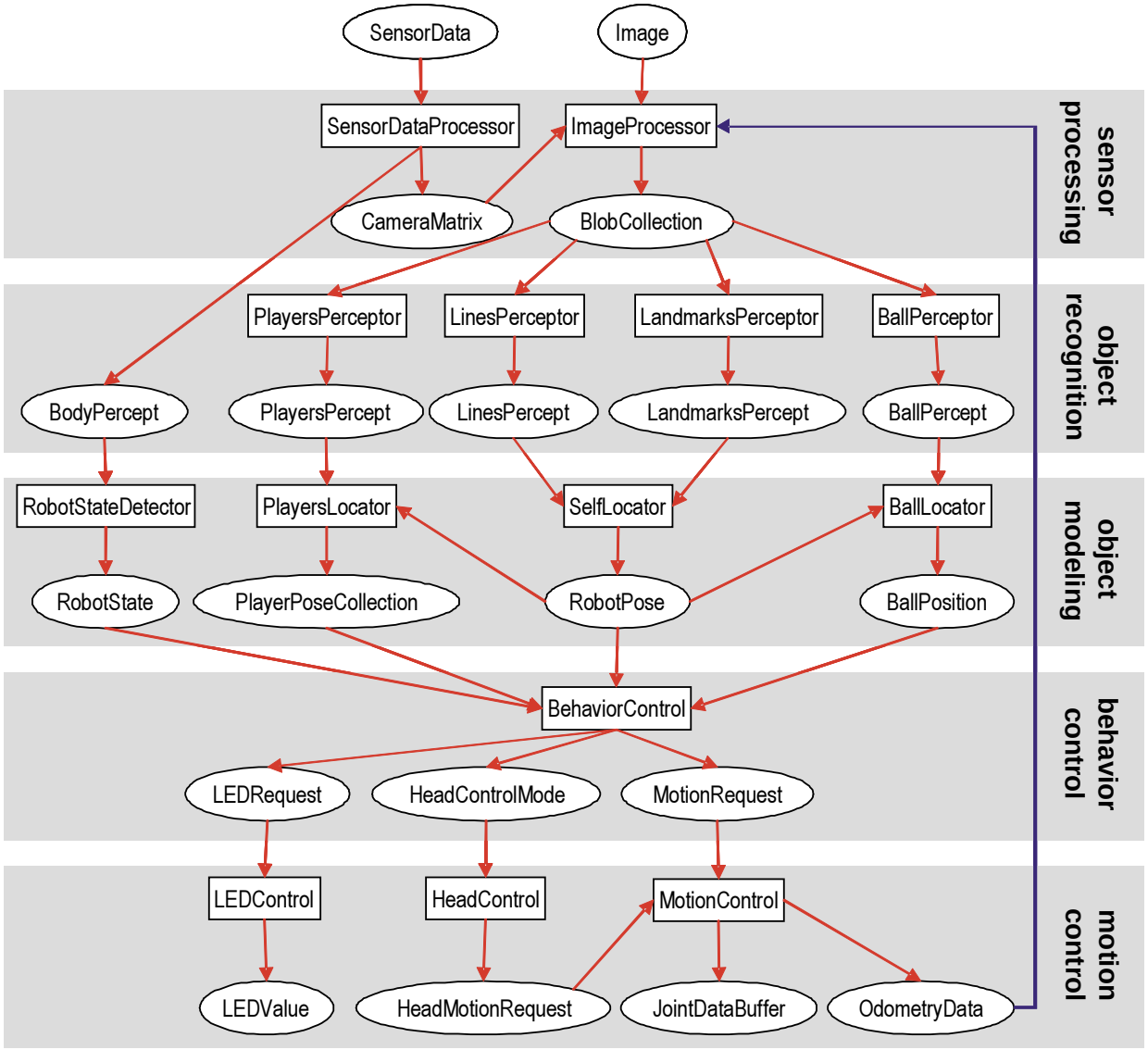
B-SMART

Sony Legged Robot League

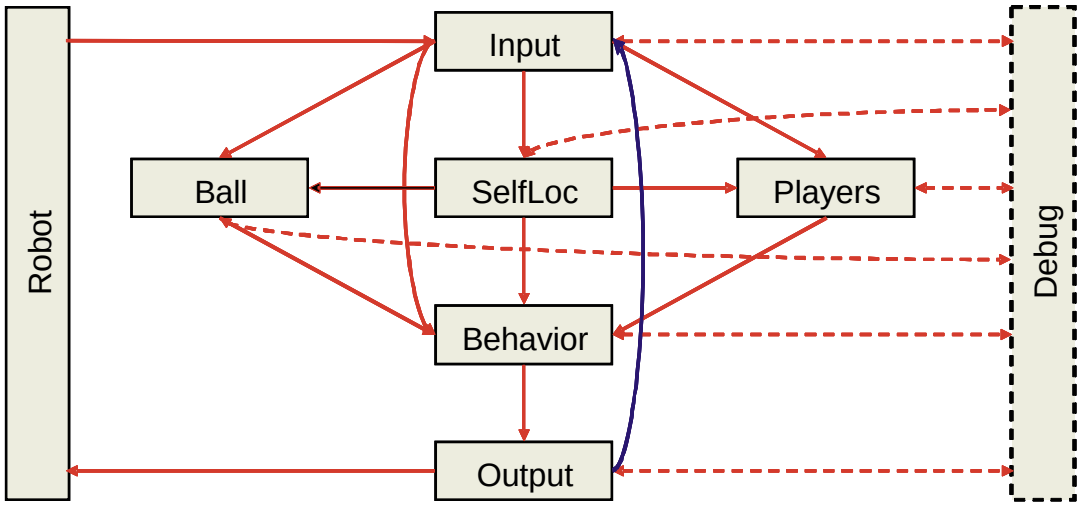
bremen byters

GT GERMANTEAM

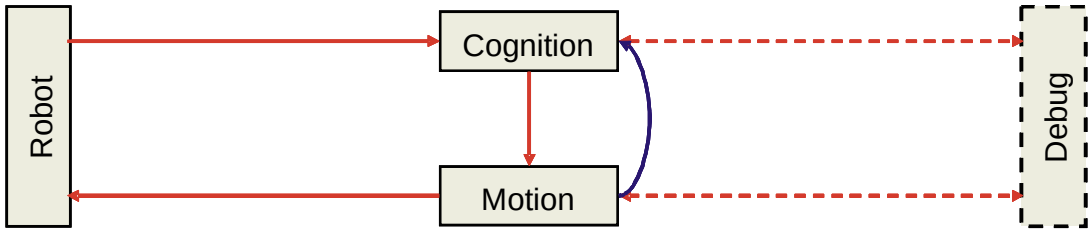
Tasks


SensorData
Image
SensorDataProcessor
ImageProcessor
CameraMatrix
BlobCollection
PlayersPerceptor
LinesPerceptor
LandmarksPerceptor
BallPerceptor
BodyPercept
PlayersPercept
LinesPercept
LandmarksPercept
BallPercept
RobotStateDetector
PlayersLocator
SelfLocator
BallLocator
RobotState
PlayerPoseCollection
RobotPose
BallPosition
BehaviorControl
LEDRequest
HeadControlMode
MotionRequest
LEDControl
HeadControl
MotionControl
LEDValue
HeadMotionRequest
JointDataBuffer
OdometryData
sensor processing
object recognition
object modeling
behavior control
motion control

Process Layouts

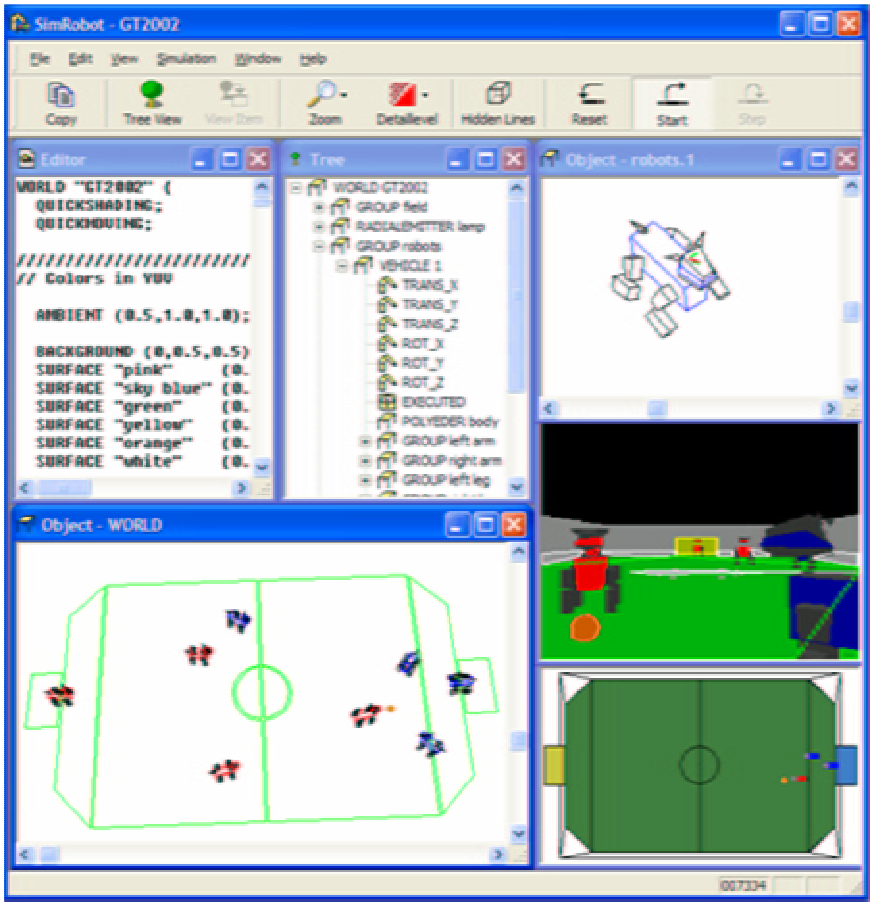


Bremen Byters

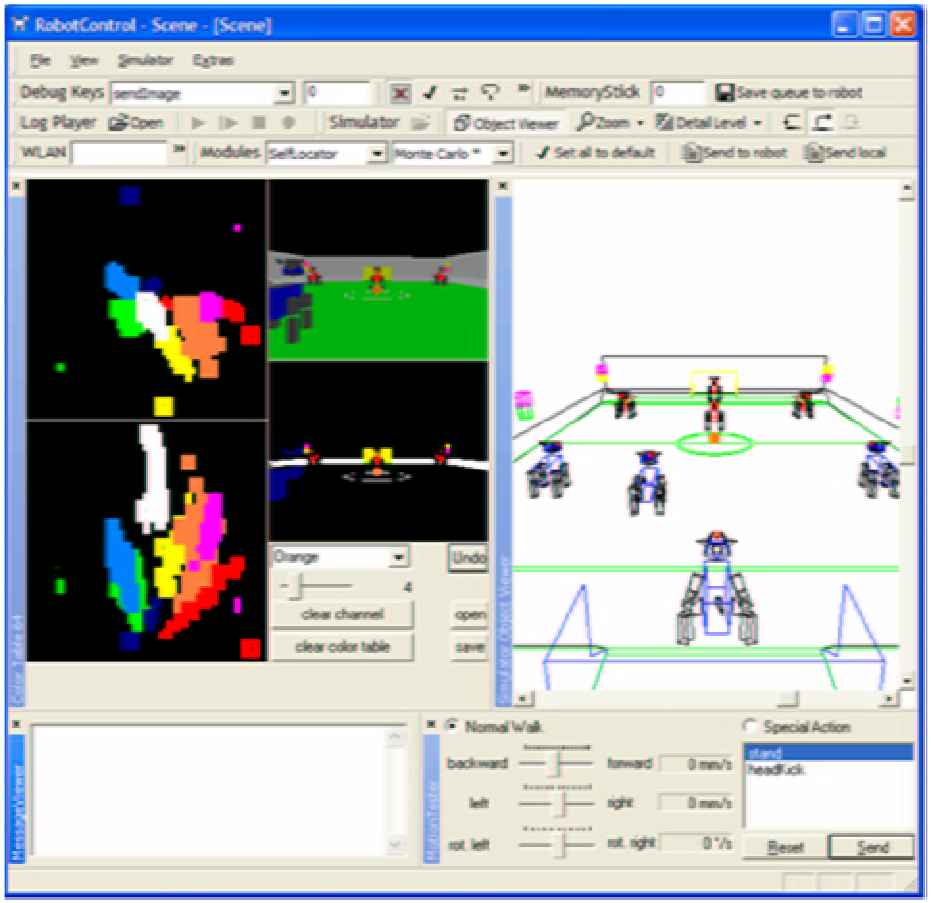


Humboldt 2002

GermanTeam 2002

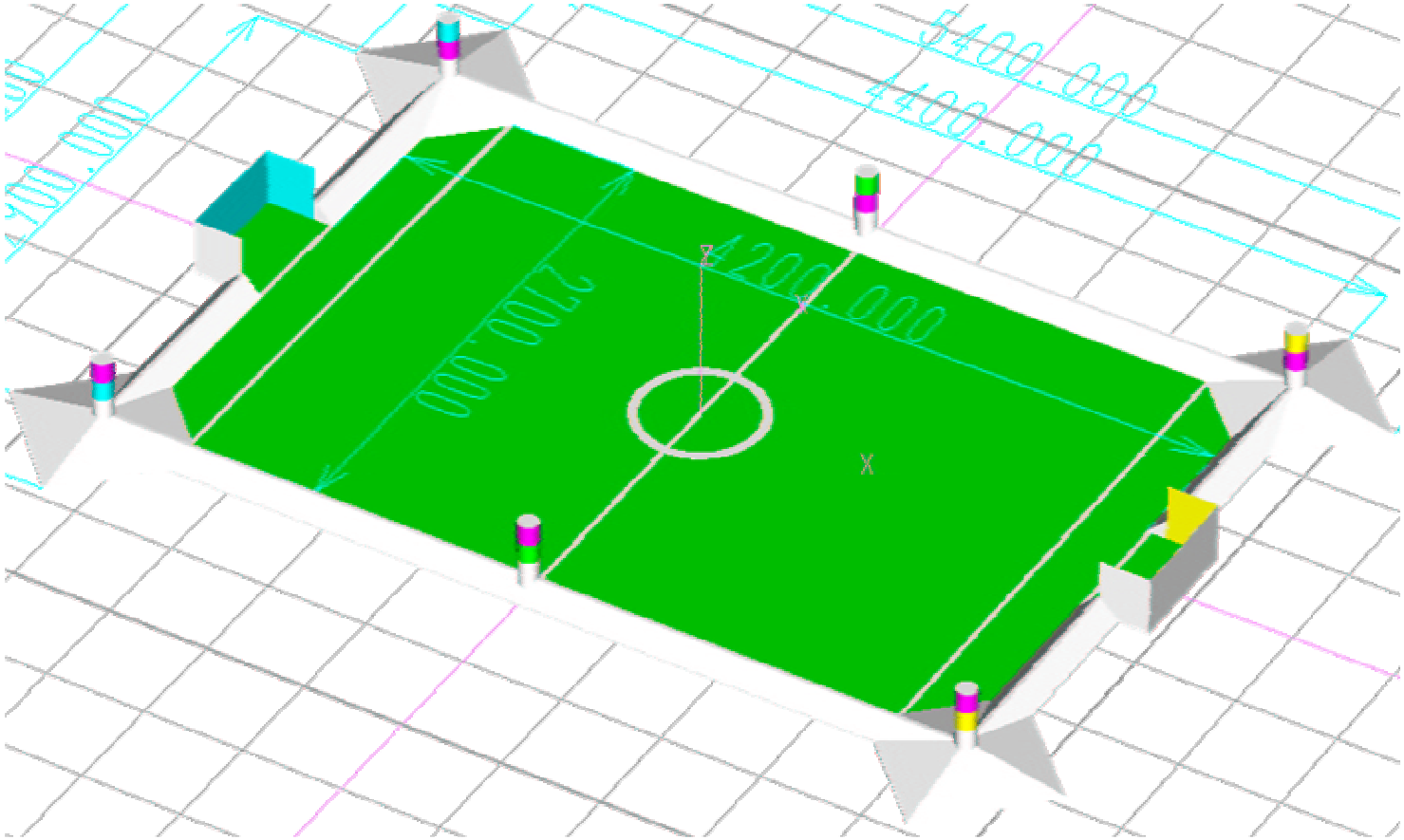


SimRobot

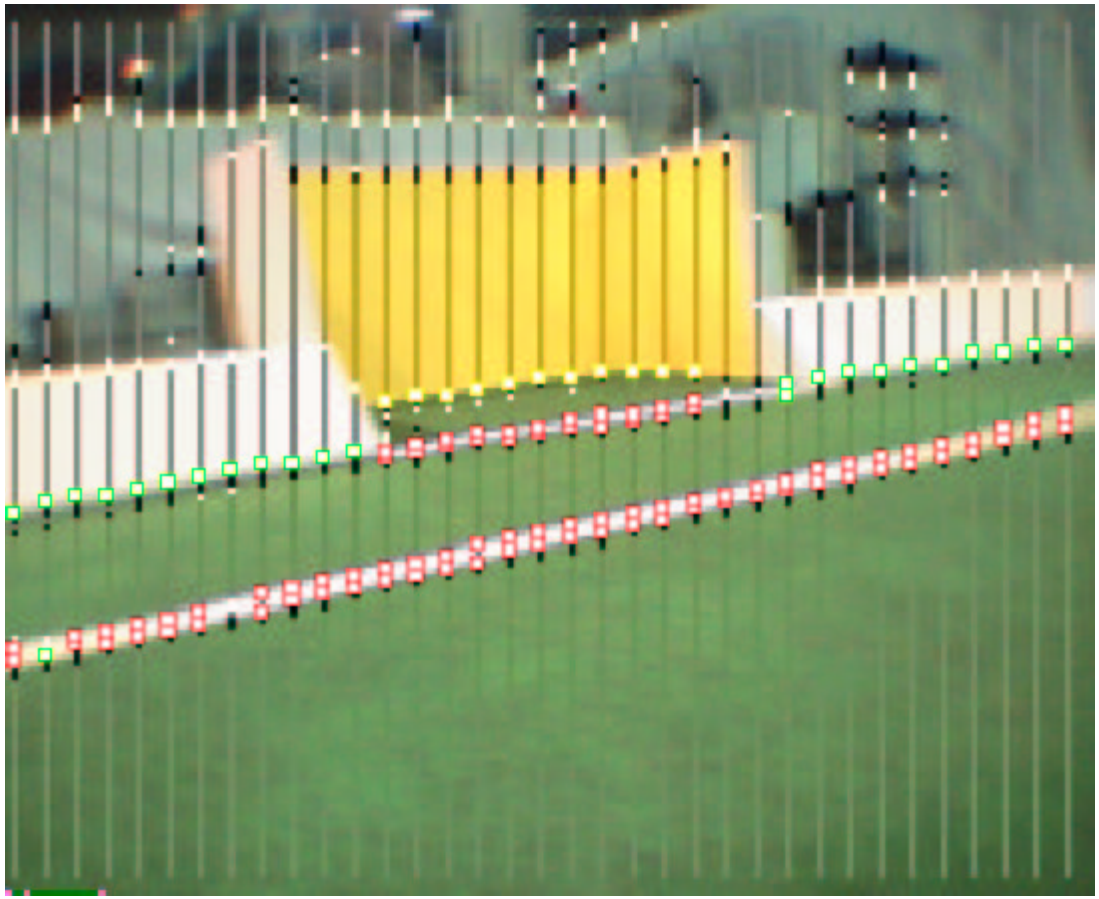


RobotControl

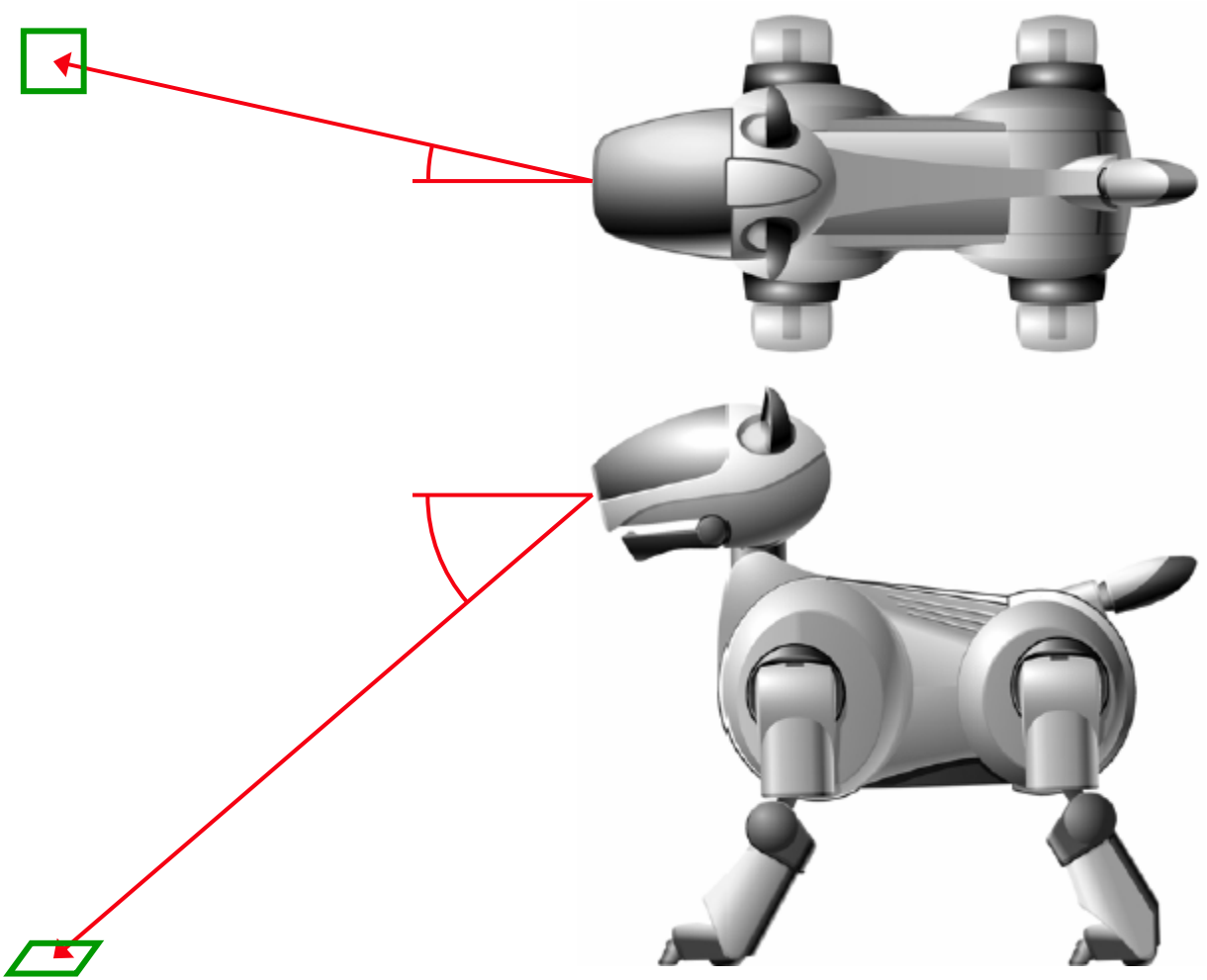
Localization



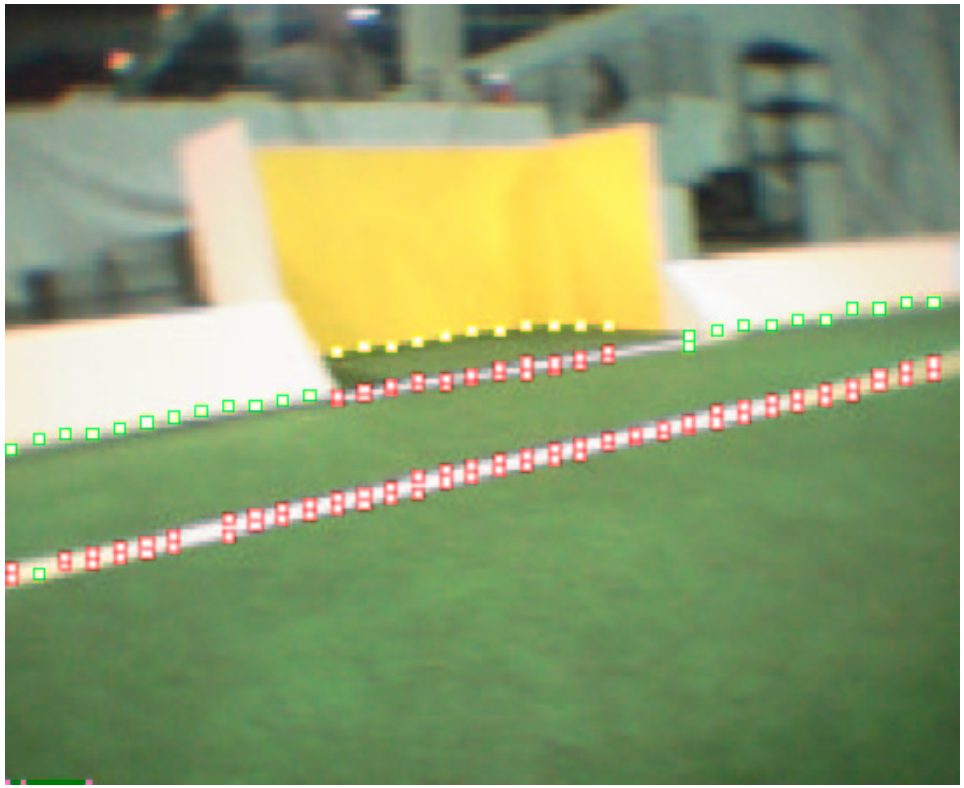
Detecting Field Lines

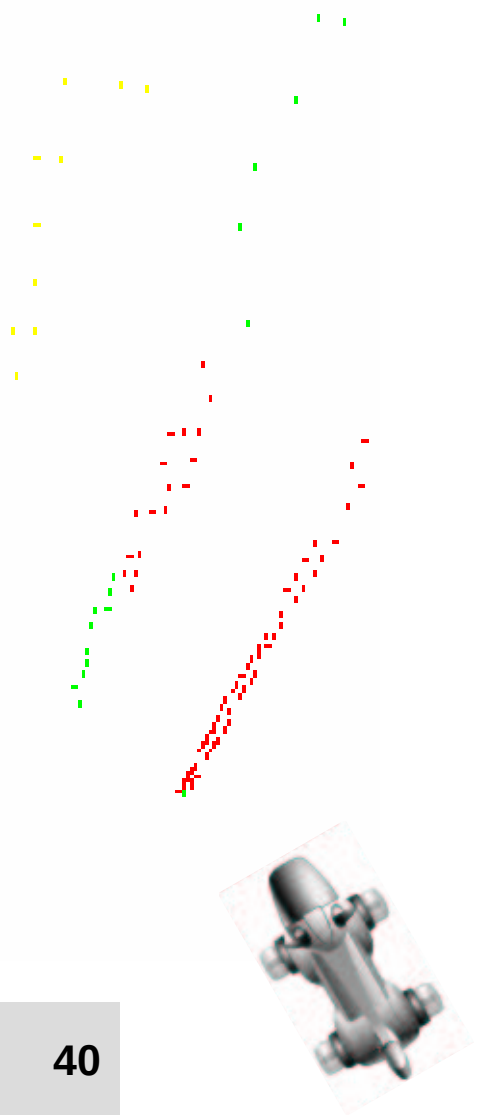


Projection on the Field

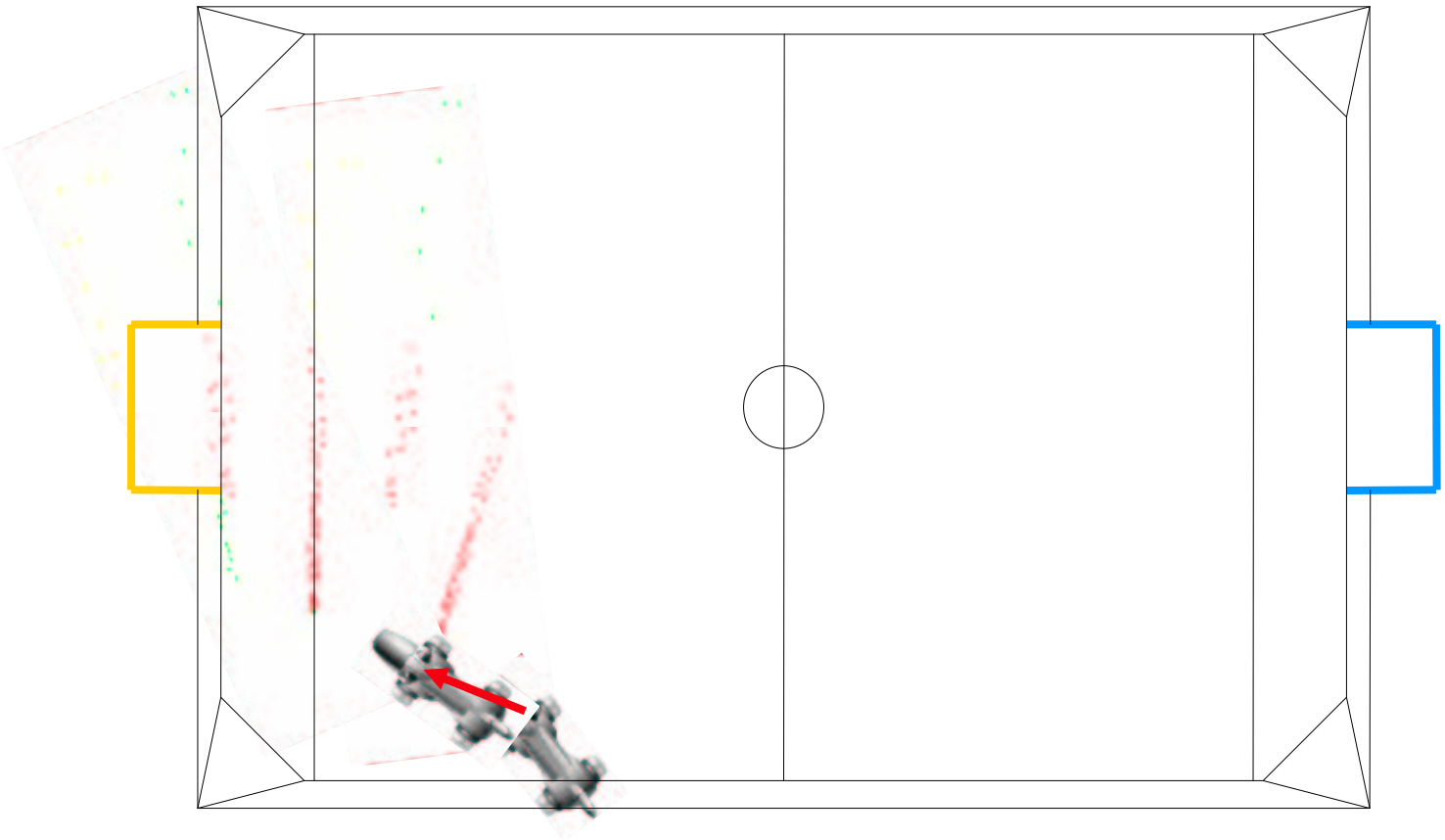


Projection on the Field

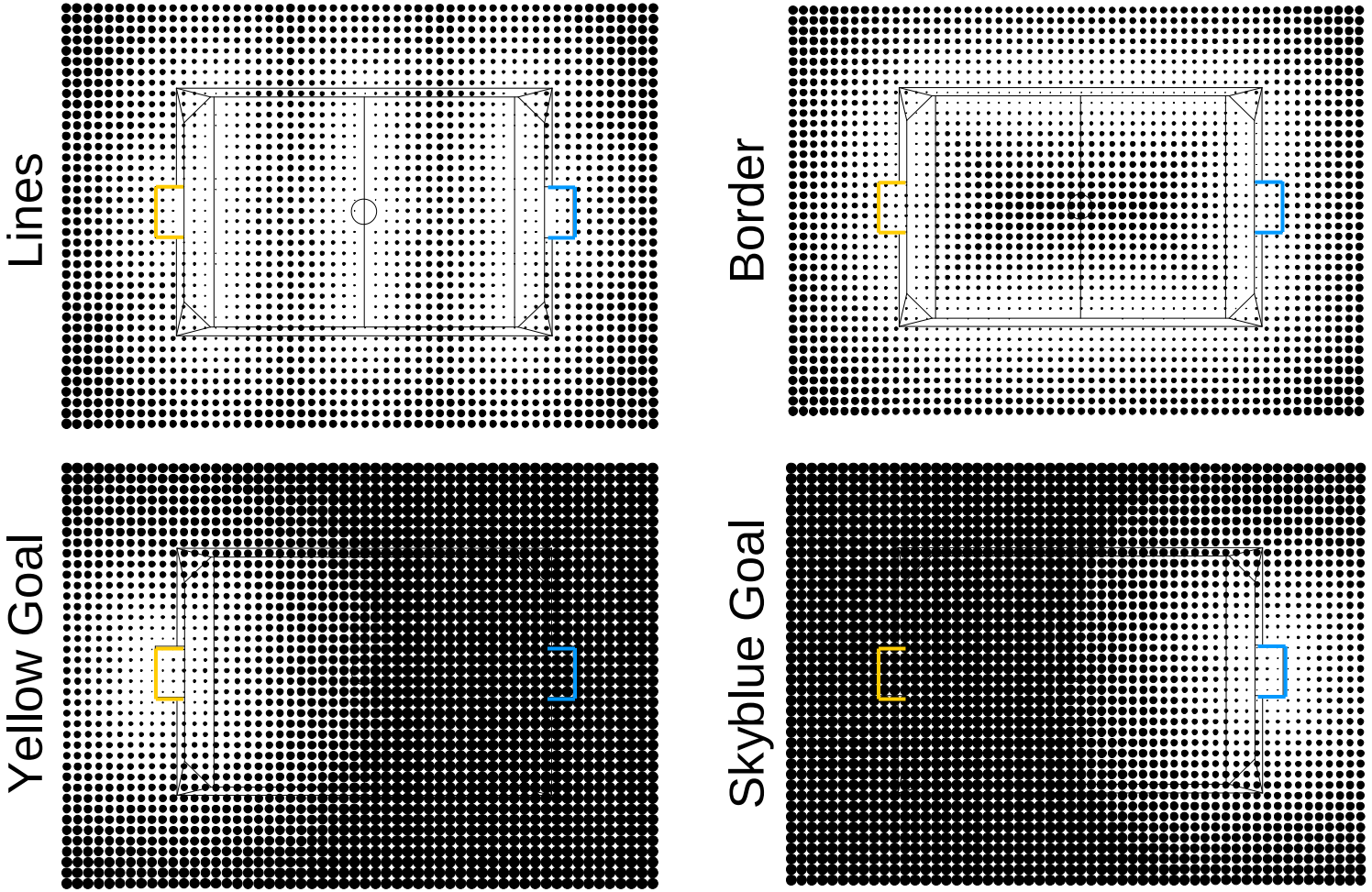




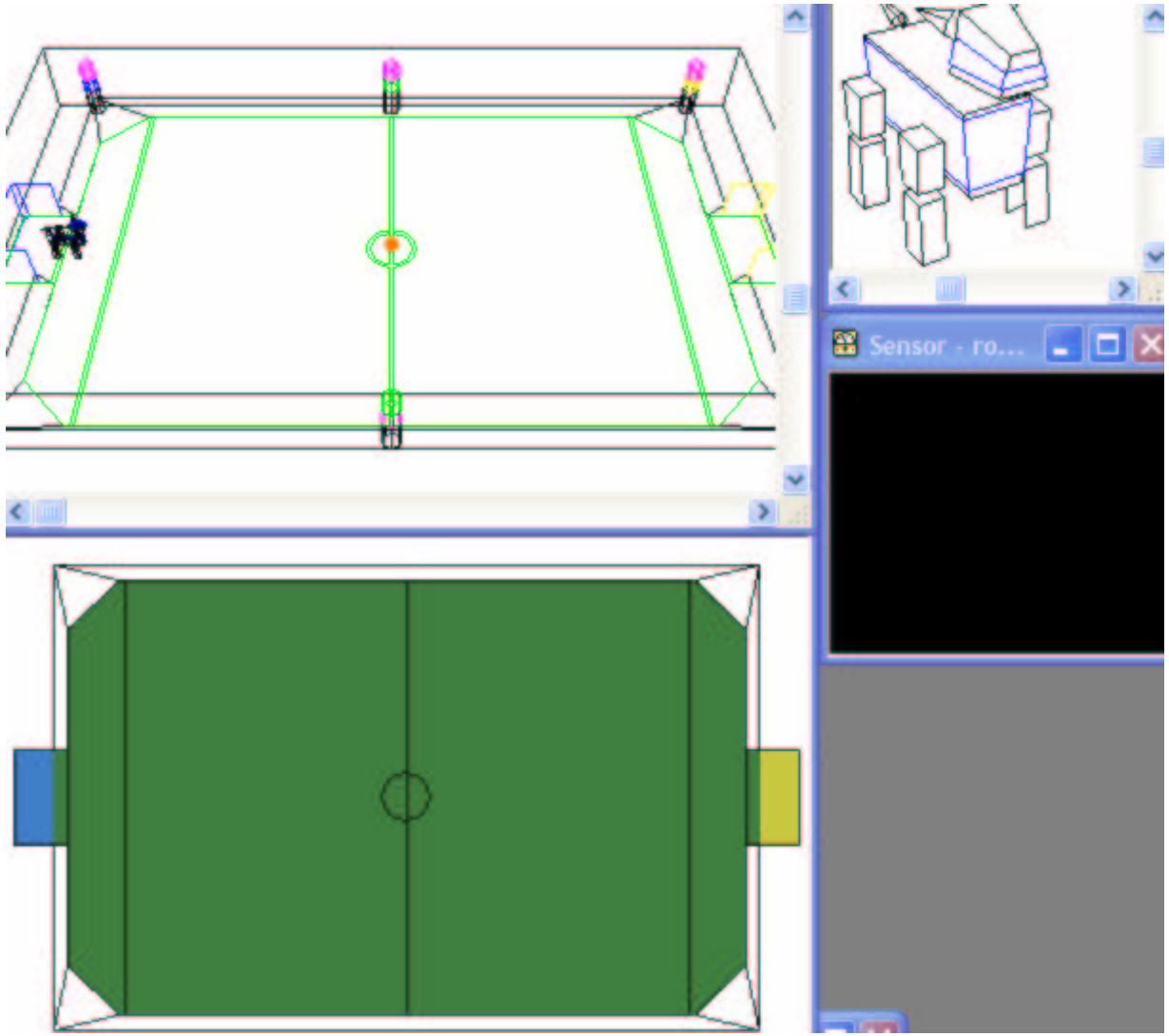
Localization



Assigning Observations to Field Model



Demo



Impressions from Fukuoka

Results of the GermanTeam

- **Round Robin**
  - GermanTeam – Rome 5 : 0
  - GermanTeam – Tokyo 4 : 0
  - GermanTeam – CMU 1 : 3
  - GermanTeam – GeorgiaTech 4 : 1
- **Quarterfinal**
  - GermanTeam – UNSW 1 : 6
- **CMU**
  - CMU – Rome 7 : 0
  - CMU – Tokyo 5 : 1
  - CMU – GeorgiaTech 7 : 0
  - CMU – Team Sweden 9 : 0
  - CMU – Melbourne 4 : 0
- **UNSW**
  - UNSW – Kyushu 7 : 0
  - UNSW – Balkan 16 : 0
  - UNSW – Washington 10 : 0
  - UNSW – NewCastle 3 : 0
- **Final**
  - CMU – UNSW 3 : 3 (5 : 4)

Outlook

- **Rolland**
  - Simultaneous localization and mapping (SLAM)
  - Place integration
  - Integration of additional sensor measurements
  - Human-machine dialogs
  - Augmenting maps by user interaction
- **RoboCup**
  - Probabilistic world modeling and behavior
  - German Open 2003 (Paderborn)
  - WM in Padua, Italien

SPATIAL COGNITION
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RoboCup GERMAN OPEN 2003

RoboCup-2003

For Further Information...