Fast and Robust Edge-Based Localization in the Sony Four-Legged Robot League

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Outline of the Talk

- Motivation
- Detecting edges
- Monte-Carlo Localization
  - Sensor model
  - Details
- Experiments
- Localization in real games
- Conclusions

Localization in the Sony Four-Legged Robot League

- Advantages
  - Automatic positioning
  - Sharing perceptions
  - Full support of referee commands
- Challenges
  - Vision-based
  - Directed vision
  - Variable camera position
  - Limited computing power

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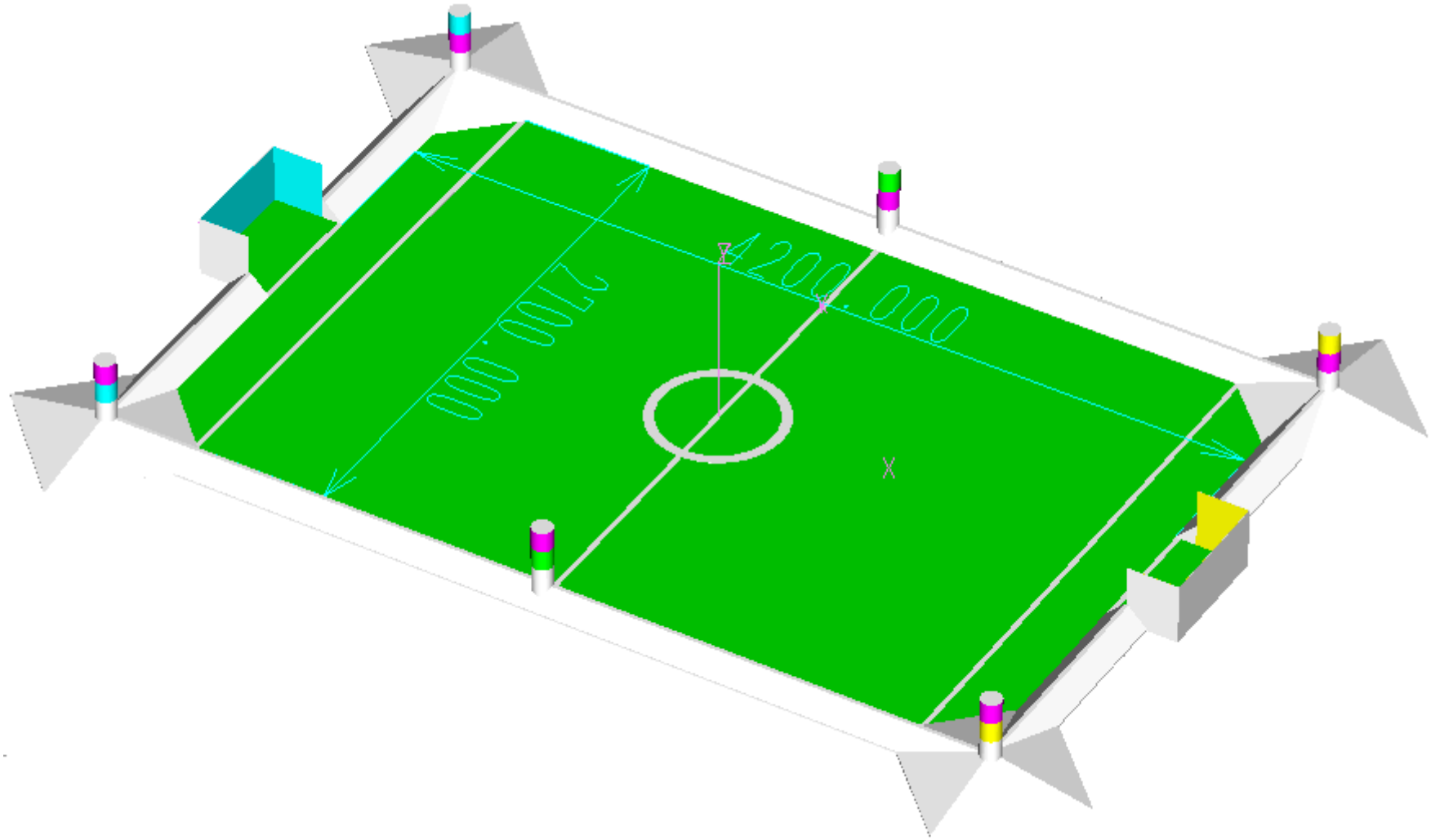
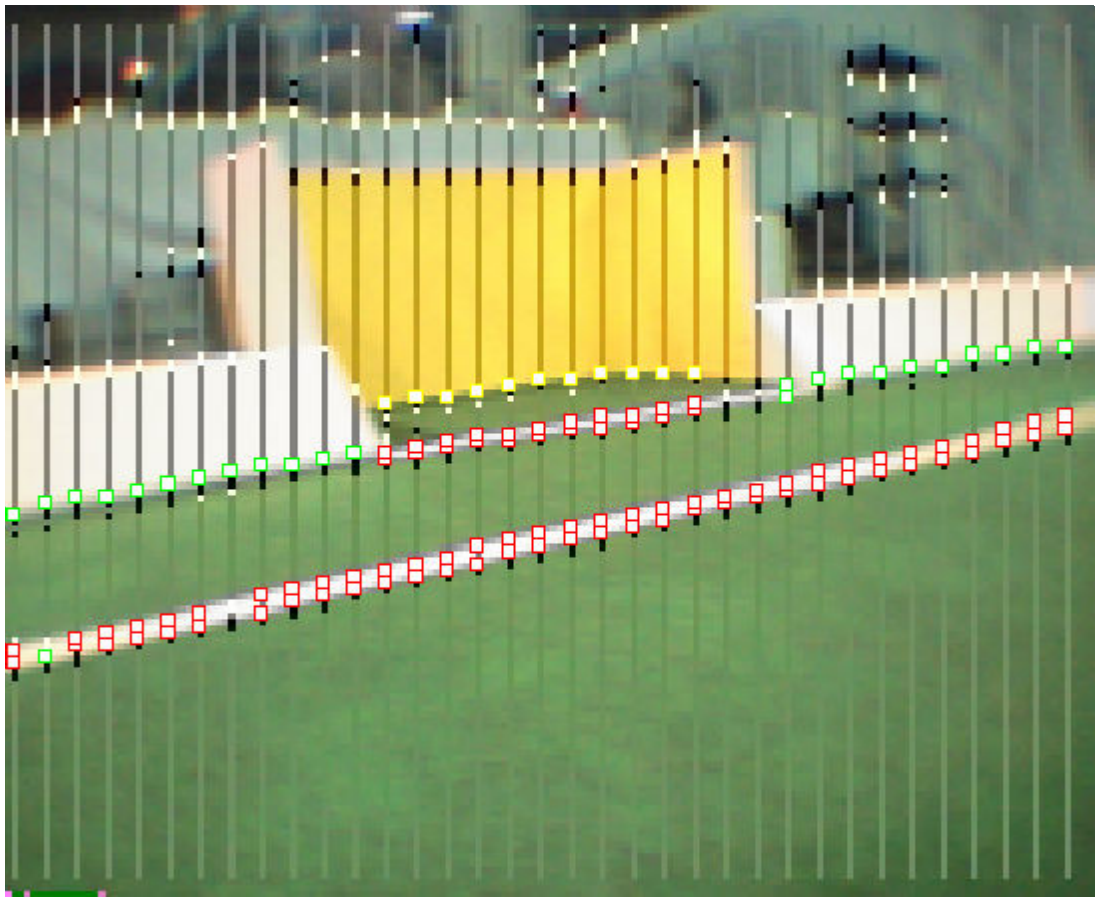
The Field

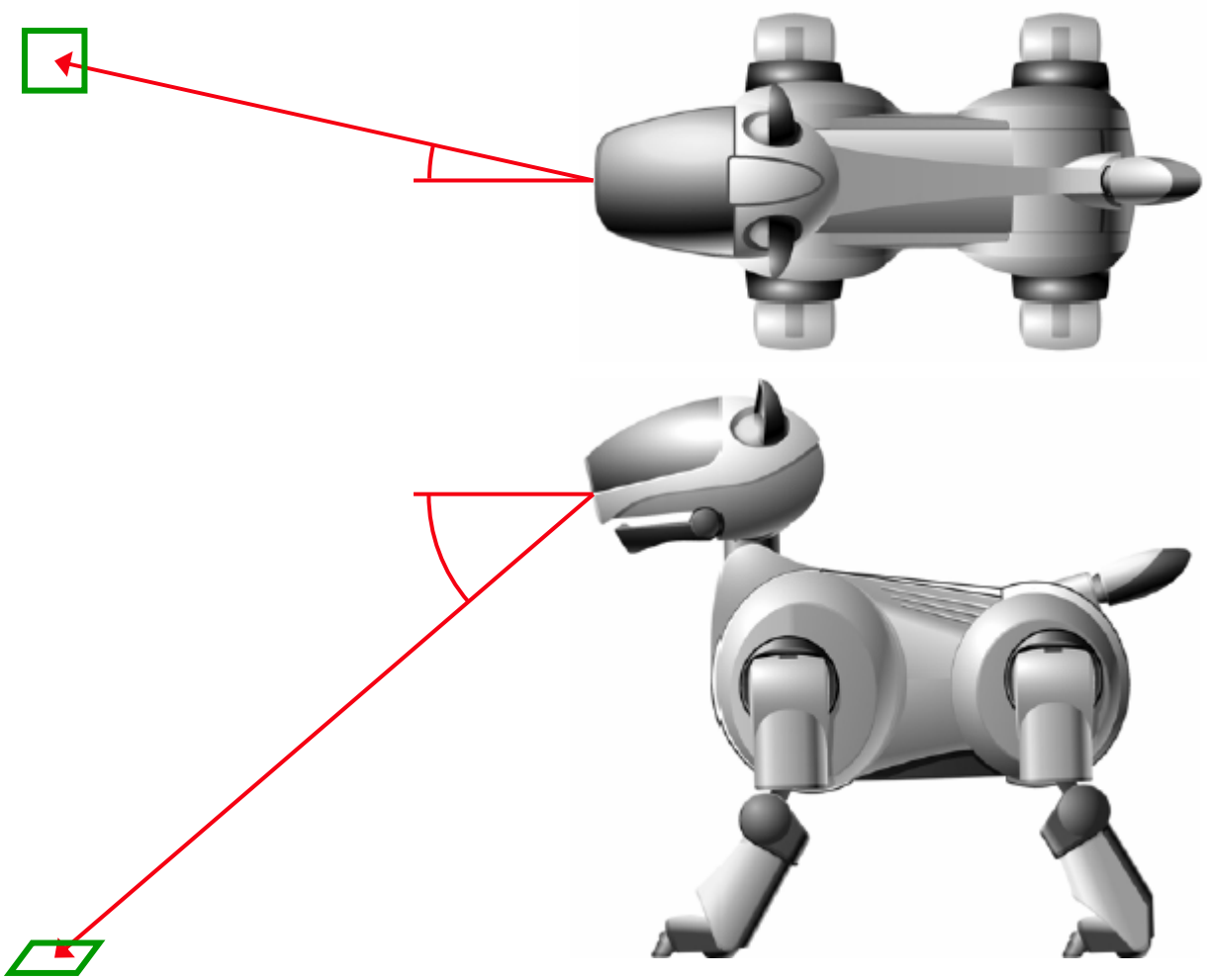


Detecting Edges

- Between field and
  - Border
  - Field lines
  - Goals
    - yellow
    - skyblue



Projection on the Field



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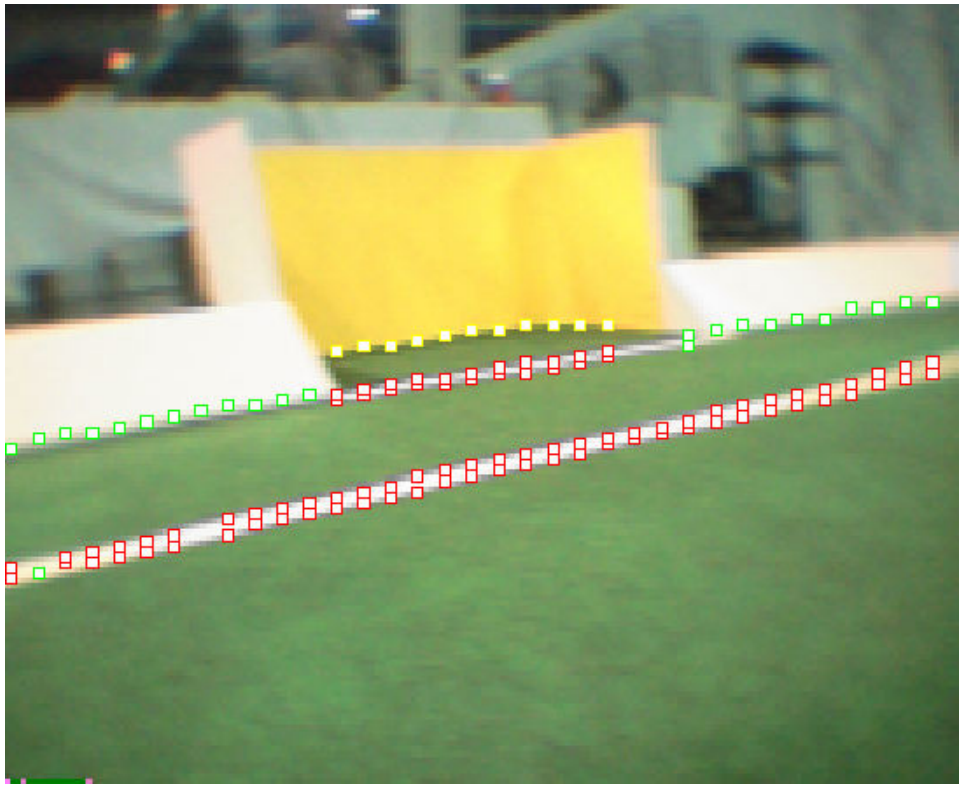
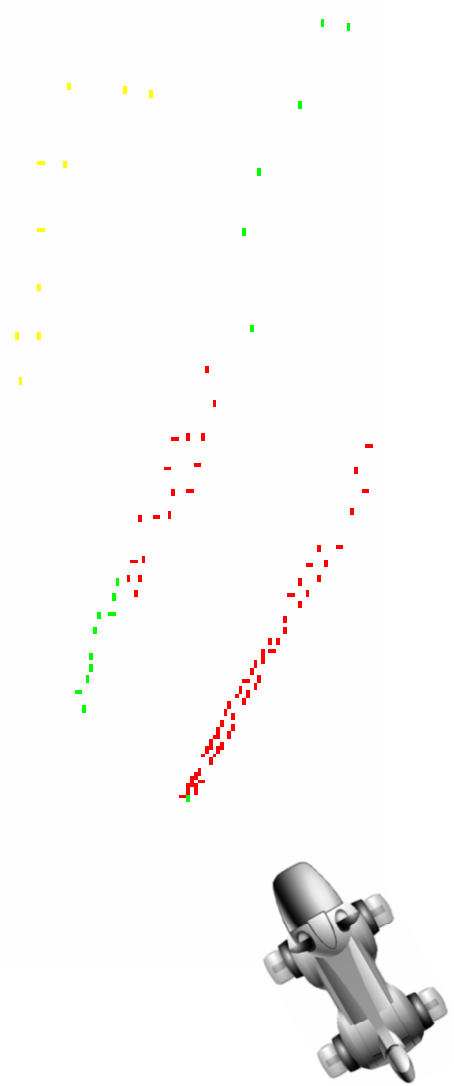
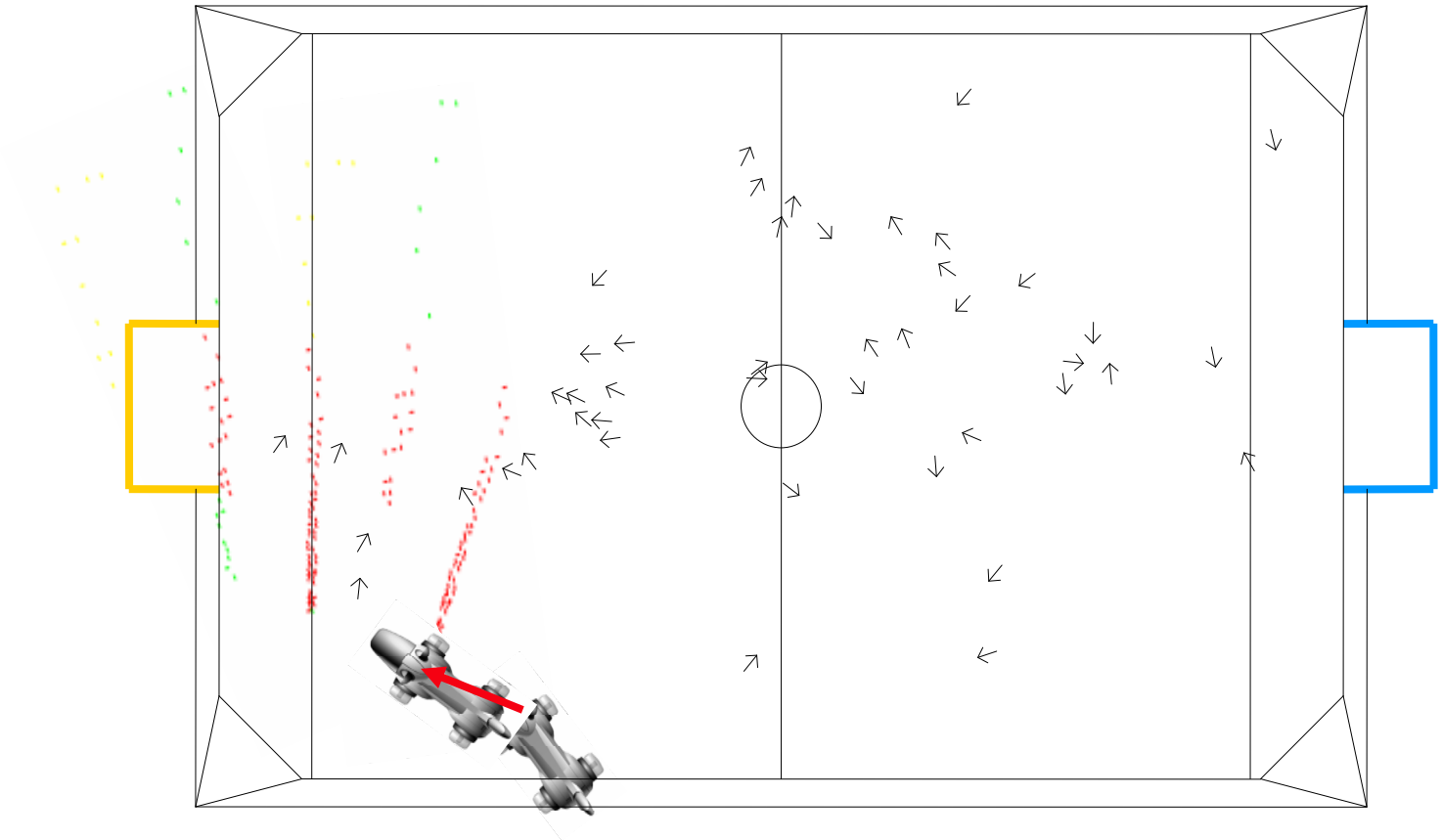
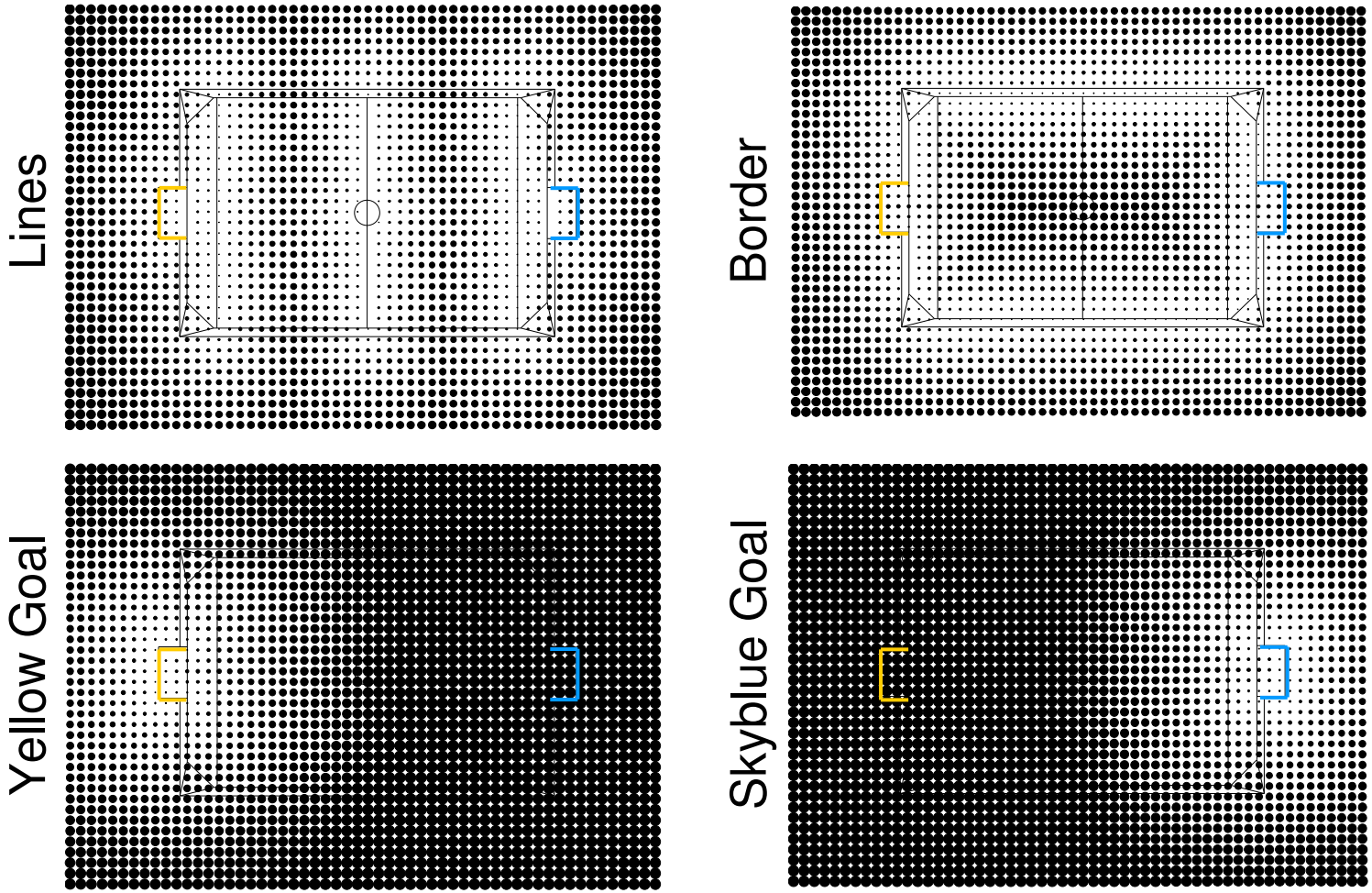




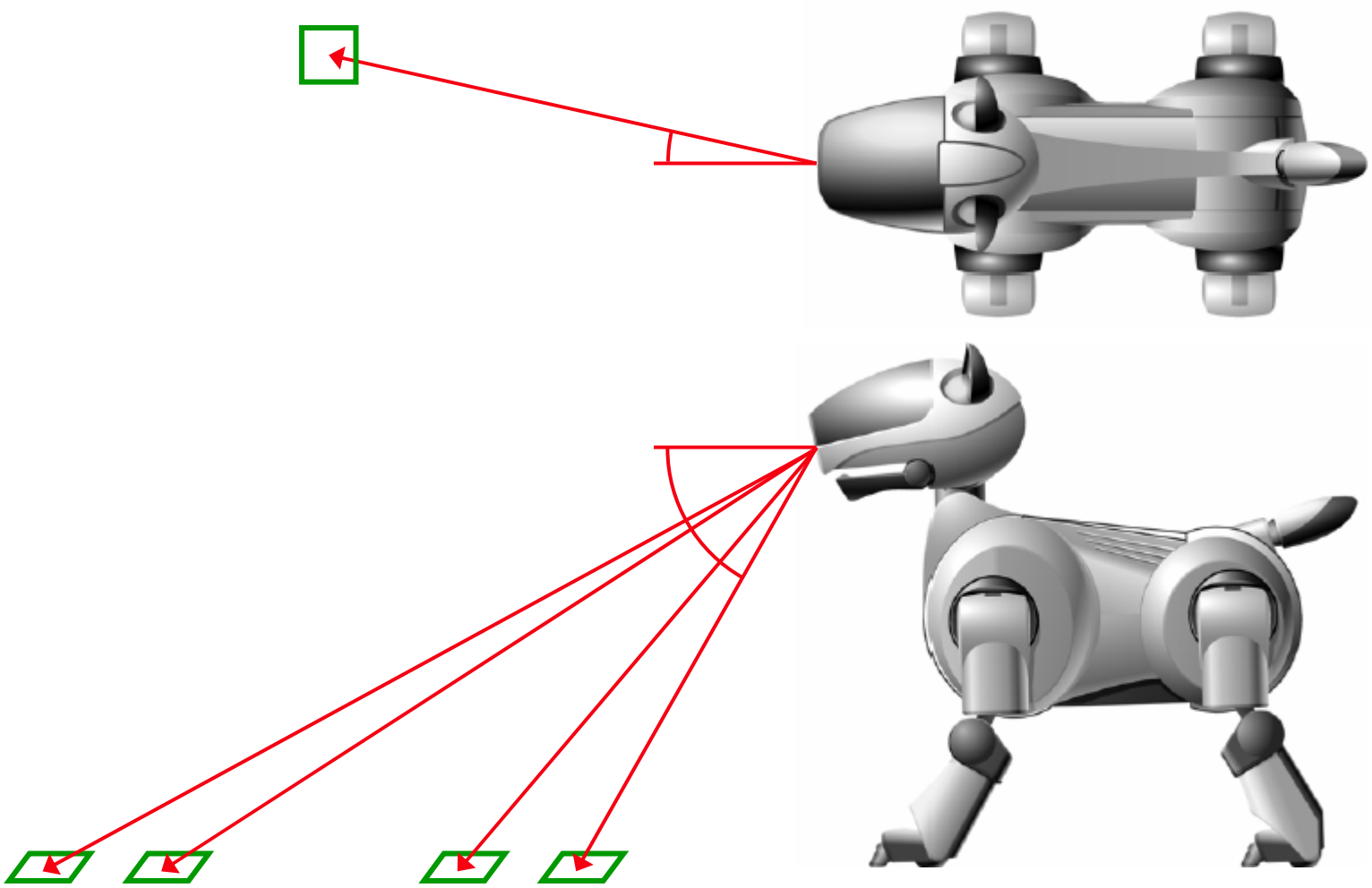
Approach



Assigning Observations to Field Model



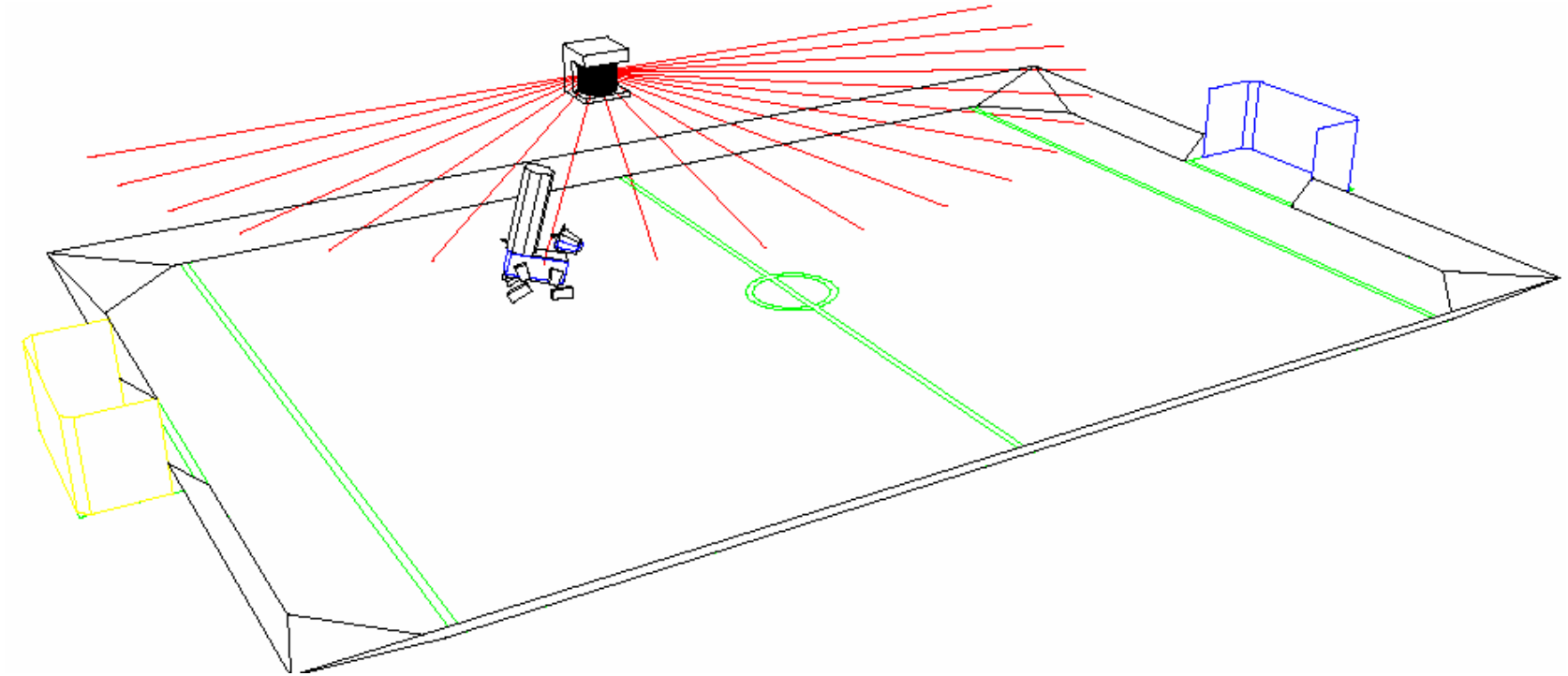
Sensor Model



Details

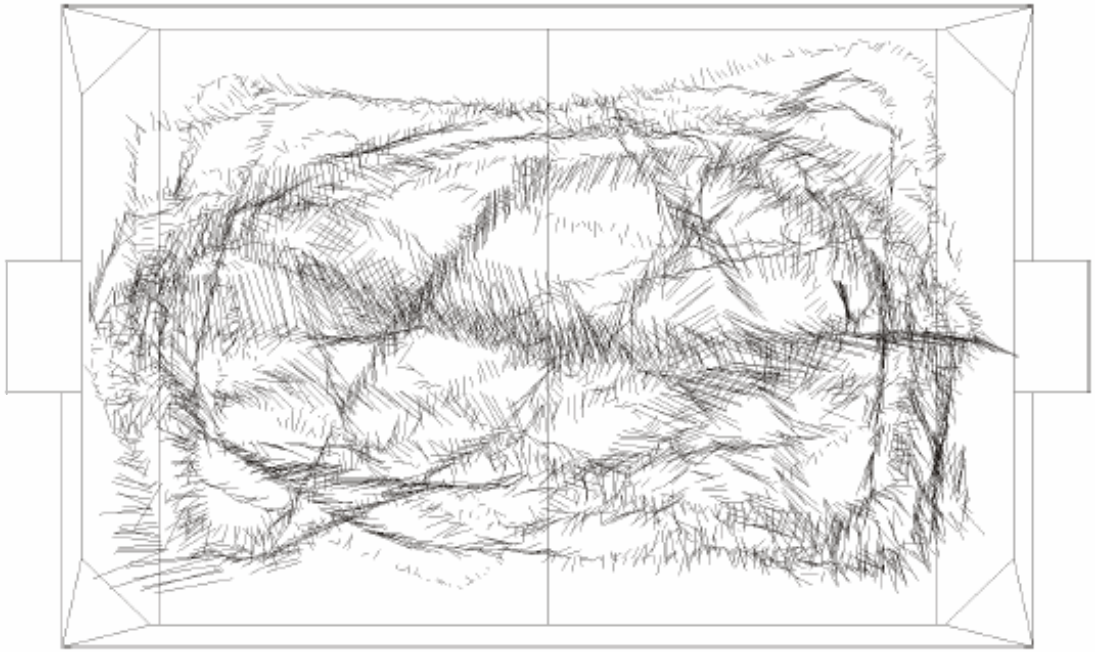
- Probability of samples
  - Probability is adapted slowly
  - Separate probabilities for different edge types
  - Samples are randomly moved, weighted by their probabilities
- Sensor resetting
  - Draw samples based on the ratio of their probability and the average probability
  - Replace them by candidate postures that can be derived from observations
- Calculating candidates in advance
  - A large number of random postures is generated
  - Their distance to the edge they are pointing to is determined
  - The postures are indexed by their distance and edge type

Experimental Setup



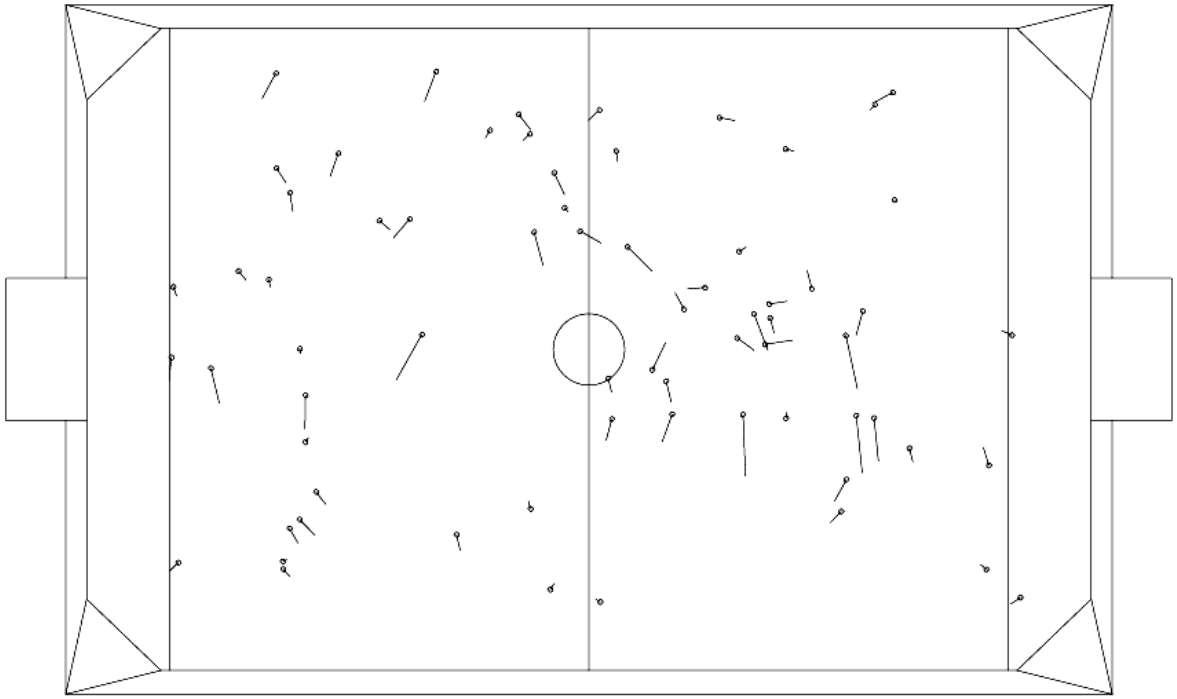
Experiment 1

- Robot continuously moving (by joystick)
- Approx. 5300 measurements
- Average error < 10.5 cm
  (field size is 420 x 270 cm²)

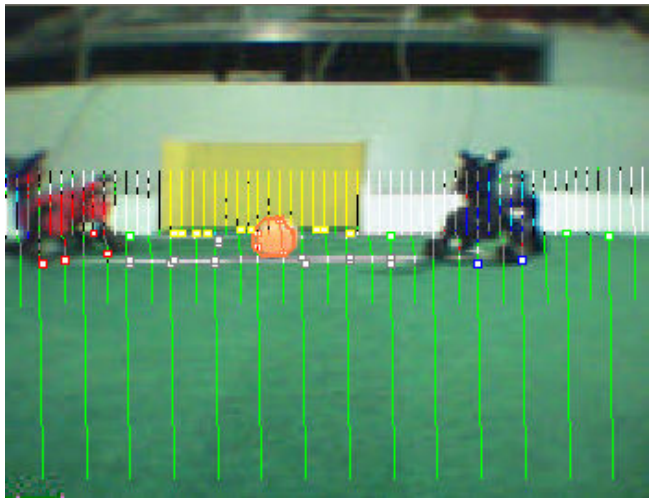


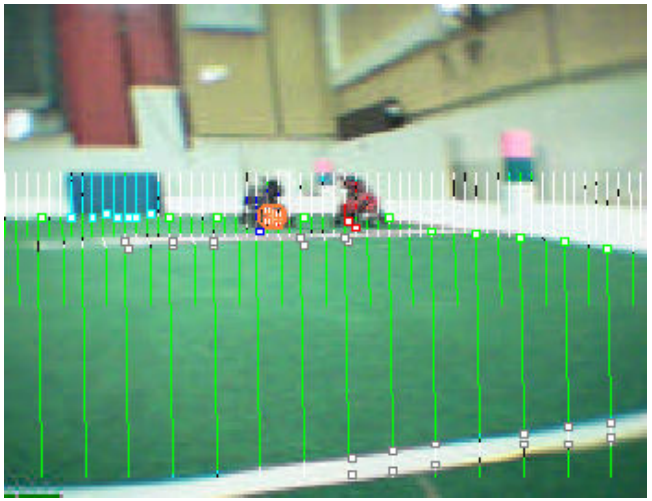
Experiment 2

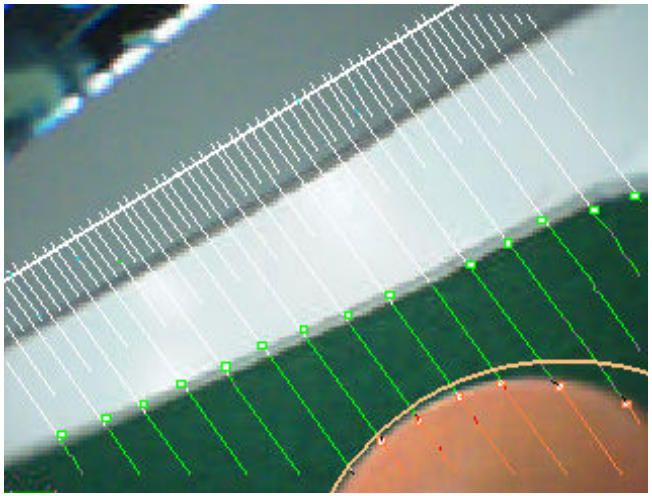
- Robot walks to random positions (approx. 70)
- Average error in positioning < 9.5 cm
- Average error in localization < 8.5 cm



Edge-based Localization in Real Games



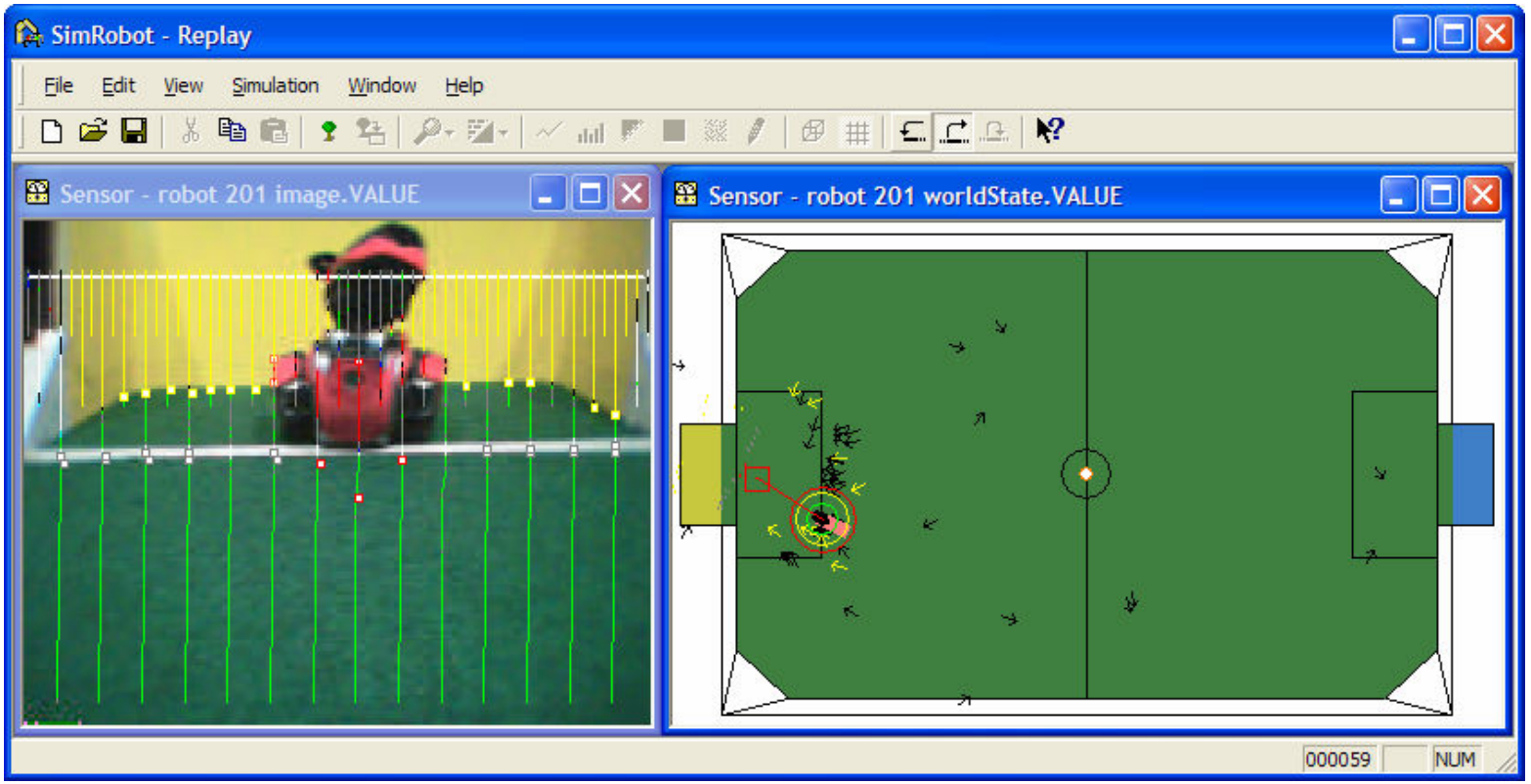




Improvements since Writing the Paper

- Candidate postures only result from goal points
- Samples are moved in direction of candidate postures, they are not replaced by them
- The speed of this motion depends on the speed of the robot (the faster the robot walks, the slower the samples adapt)
- Samples are also moved according to the assignment of measured points to model points (weighted by the distance to the measured points)

Example


SimRobot - Replay
File Edit View Simulation Window Help
Sensor - robot 201 image.VALUE
Sensor - robot 201 worldState.VALUE
000059
NUM

Conclusions

- Fast and robust Monte-Carlo localization
- Using edges between field and border/lines/goals
- Average error < 10.5 cm
- Works in real games

- In RoboCup 2003
  - Played with combined localizer (edges + landmarks)
  - Demonstrated match (GT vs. GT) without landmarks
- In RoboCup 2004
  - Removal of landmarks?

Other Talks by Members of the GermanTeam

Vision 1, 1.1 Thursday 14:30	Matthias Jüngel, Jan Hoffmann, Martin Lötzsch *A Real-Time Auto-Adjusting Vision System for Robotic Soccer*
Vision 1, 1.2 Thursday, 14:55	Ingo Dahm, Sebastian Deutsch, Matthias Hebbel, André Osterhues *Fully Autonomous Robust Color Classification*
AI 1, 1.2 Thursday 14:55	Andrea Miene, Ubbo Visser, Otthein Herzog *Recognition and prediction of motion situations based on a qualitative motion description*
AI 2, 2.1 Thursday 16:25	Martin Lötzsch, Joscha Bach, Hans-Dieter Burkhard, Matthias Jüngel *Designing Agent Behavior with the Extensible Agent Behavior Specification Language*
Vision 2, 2.3 Thursday, 17:15	Thomas Röfer, Matthias Jüngel *Fast and Robust Edge-Based Localization in the Sony Four-Legged Robot League*
Vision 2, 2.4 Thursday, 17:40	Kai Hübner *A Symmetry Operator and its Application to the RoboCup*