Vision-Based Fast and Reactive Monte-Carlo Localization

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RoboCup – The Goal

- By the year 2050,
develop a team of fully autonomous humanoid robots
that can win against the human world soccer champion team. -

Localization in the Sony Four-Legged Robot League

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

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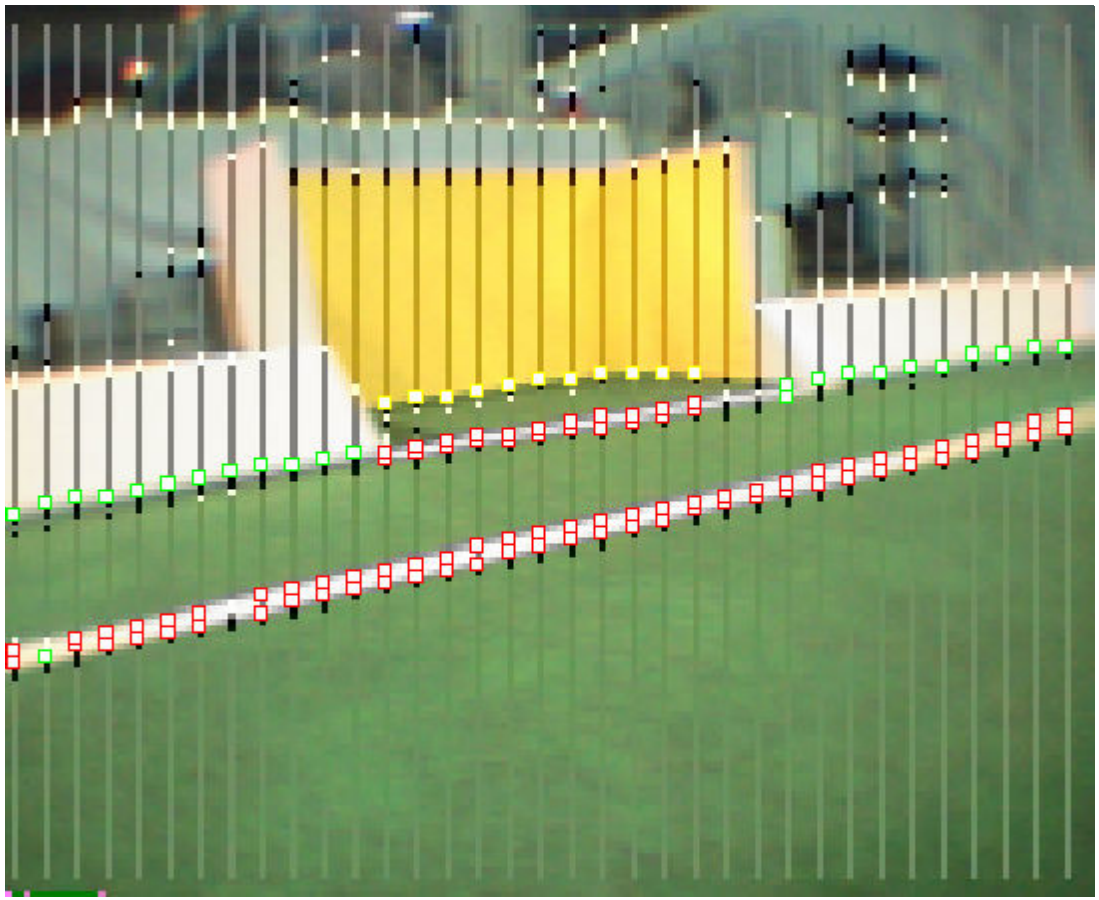
The Field

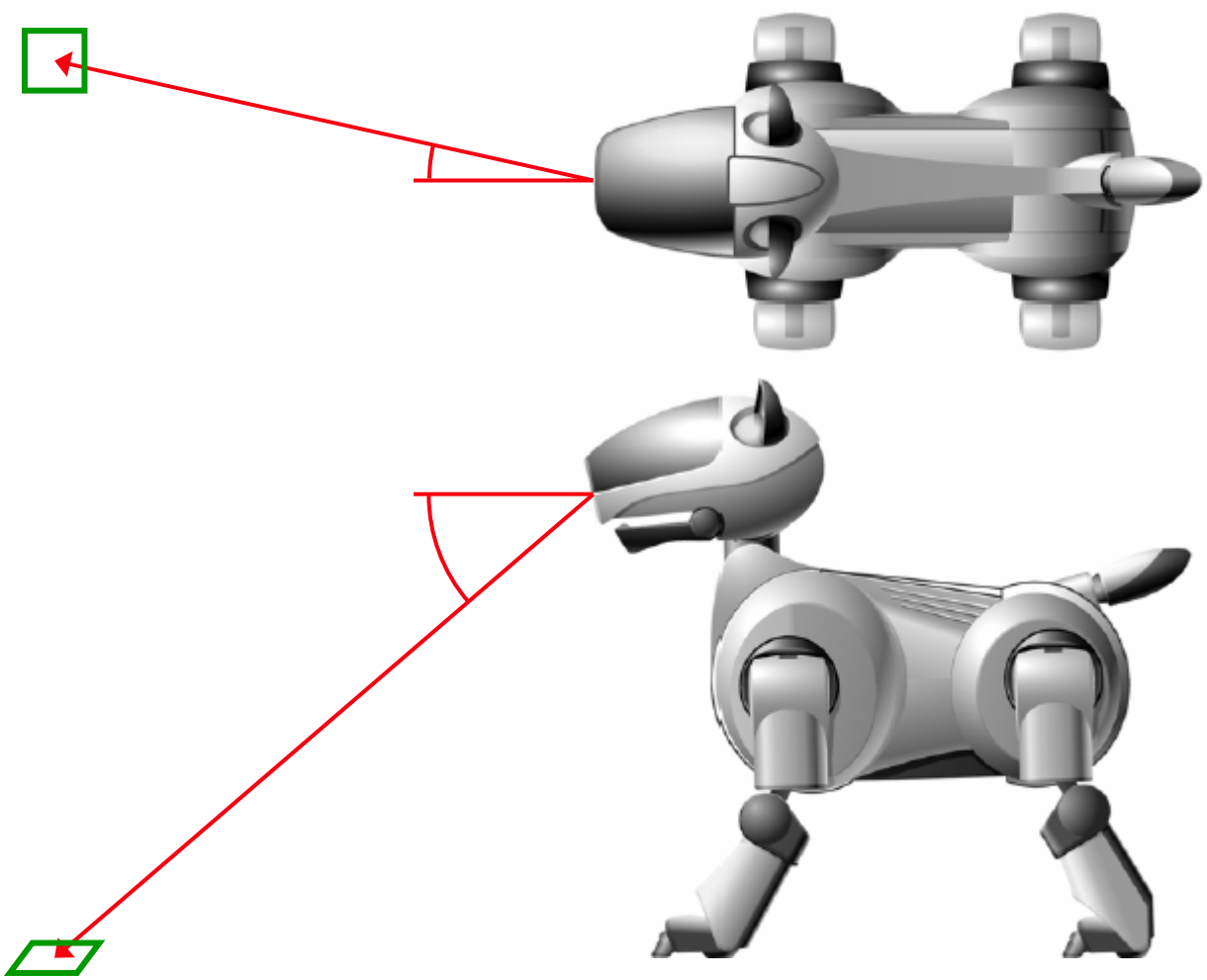
- Size: 2,70m x 4,20m
- Landmarks and goals
- 4 robots per team

Detecting Edges

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



Projection on the Field



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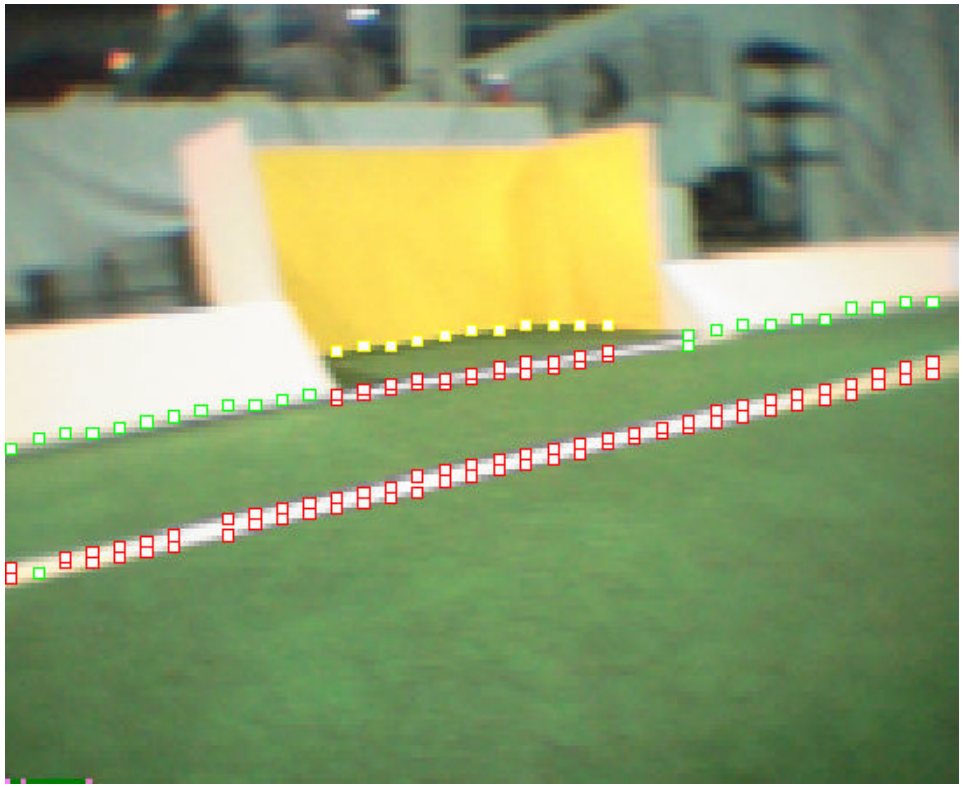
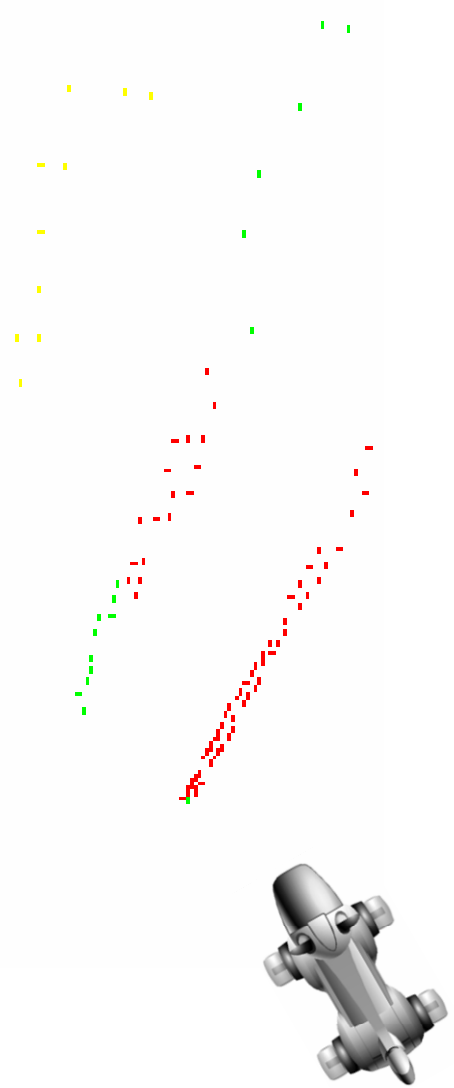
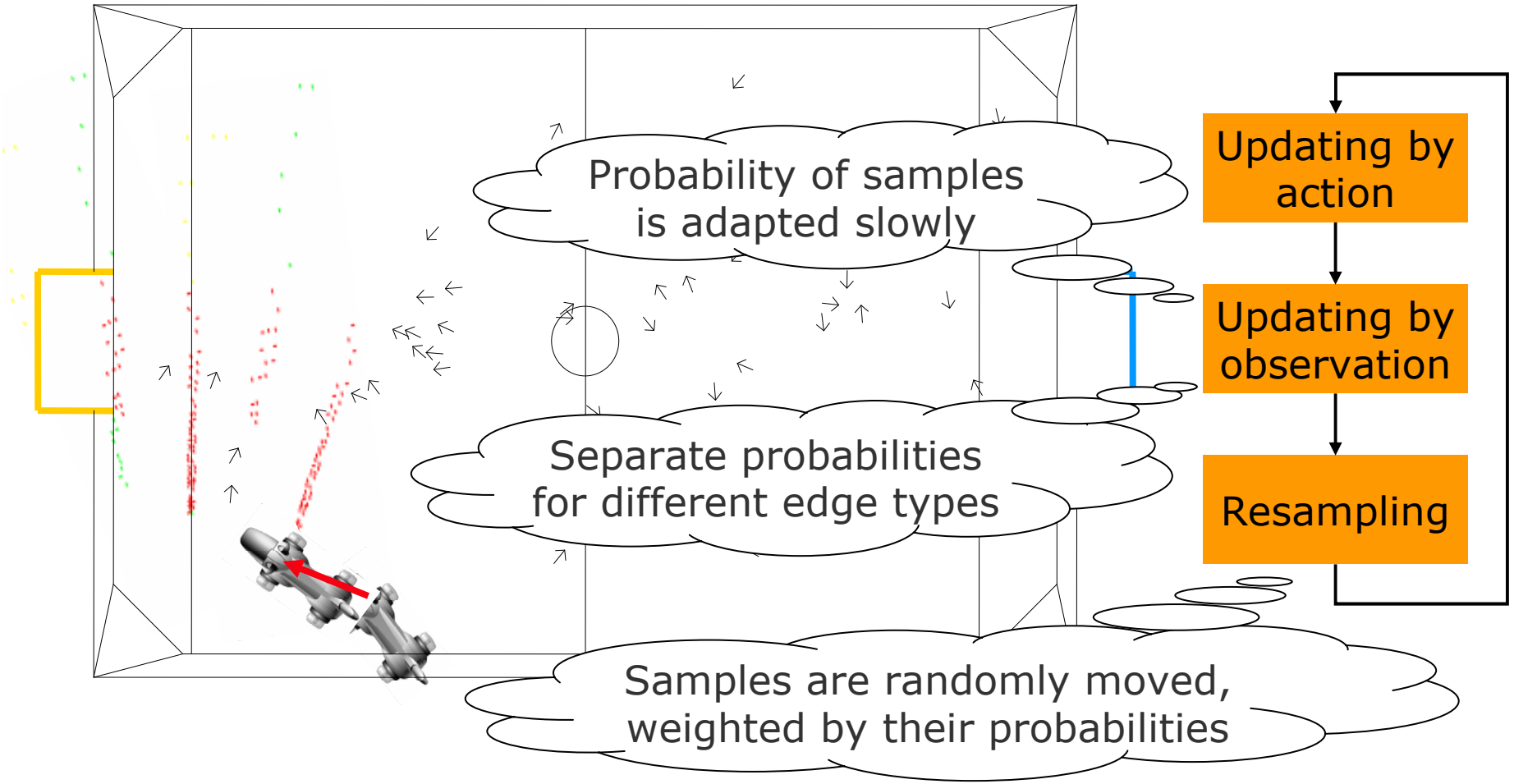
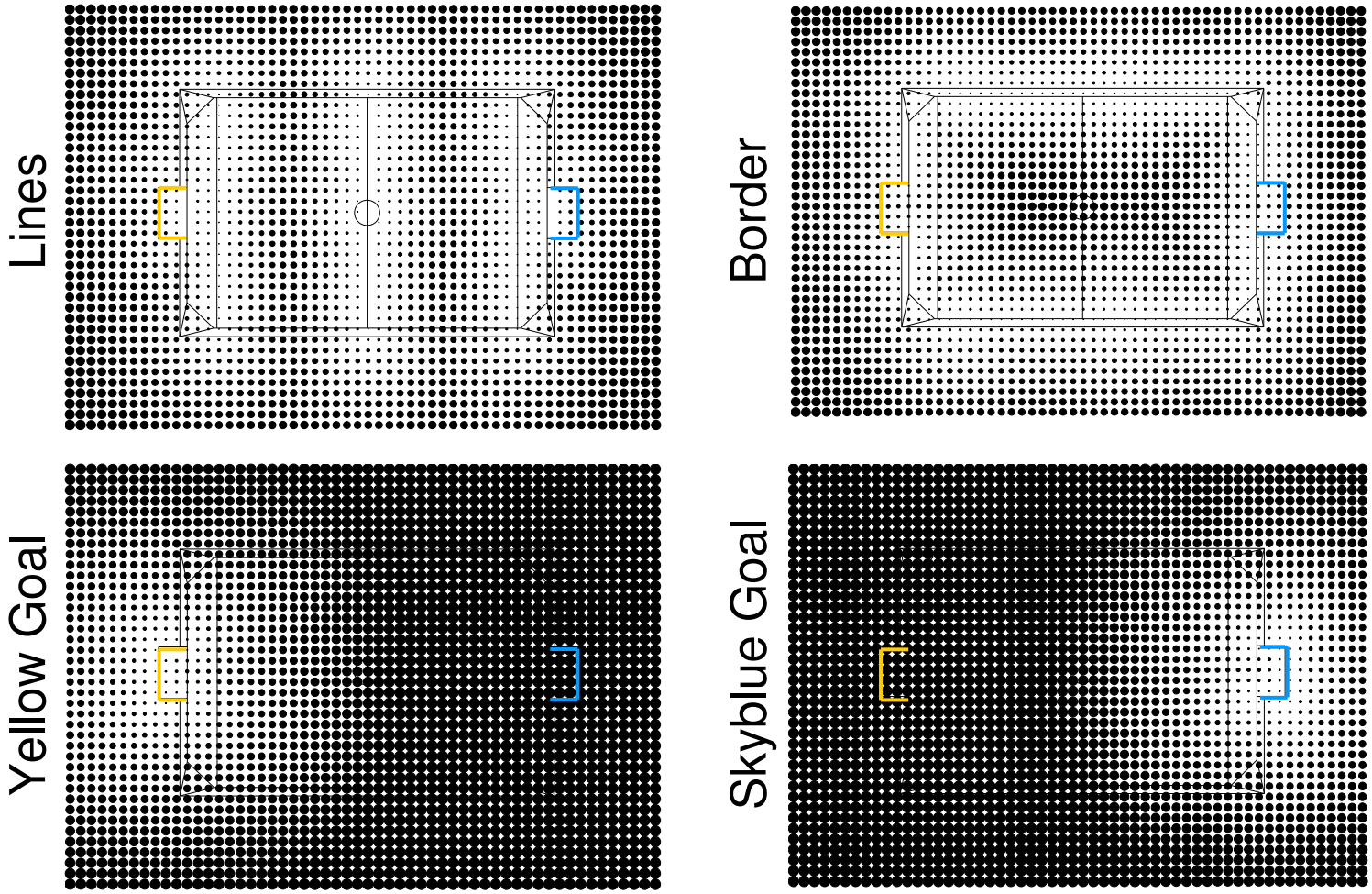




Approach

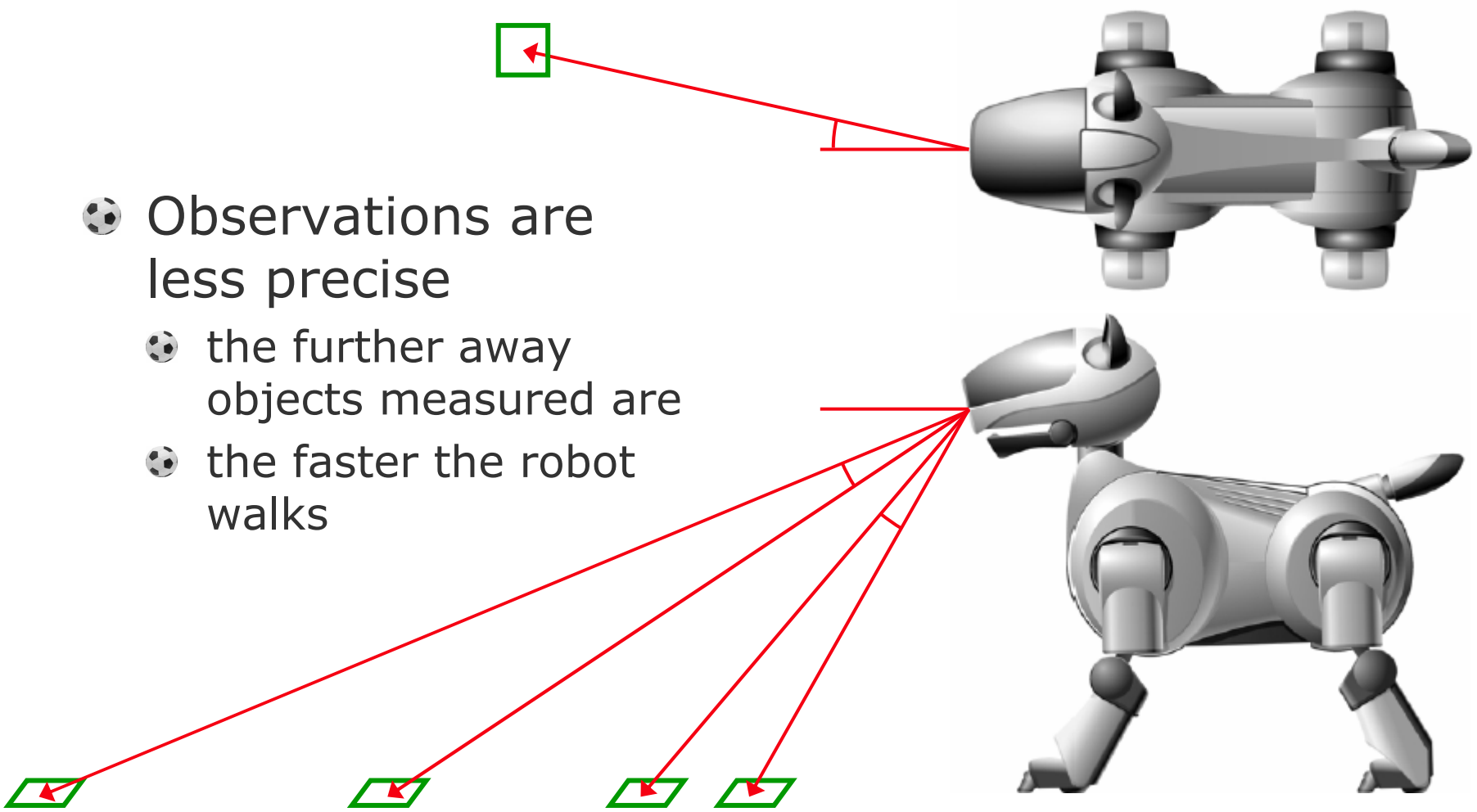

Probability of samples is adapted slowly
Separate probabilities for different edge types
Samples are randomly moved, weighted by their probabilities
Updating by action
Updating by observation
Resampling

Assigning Observations to Field Model



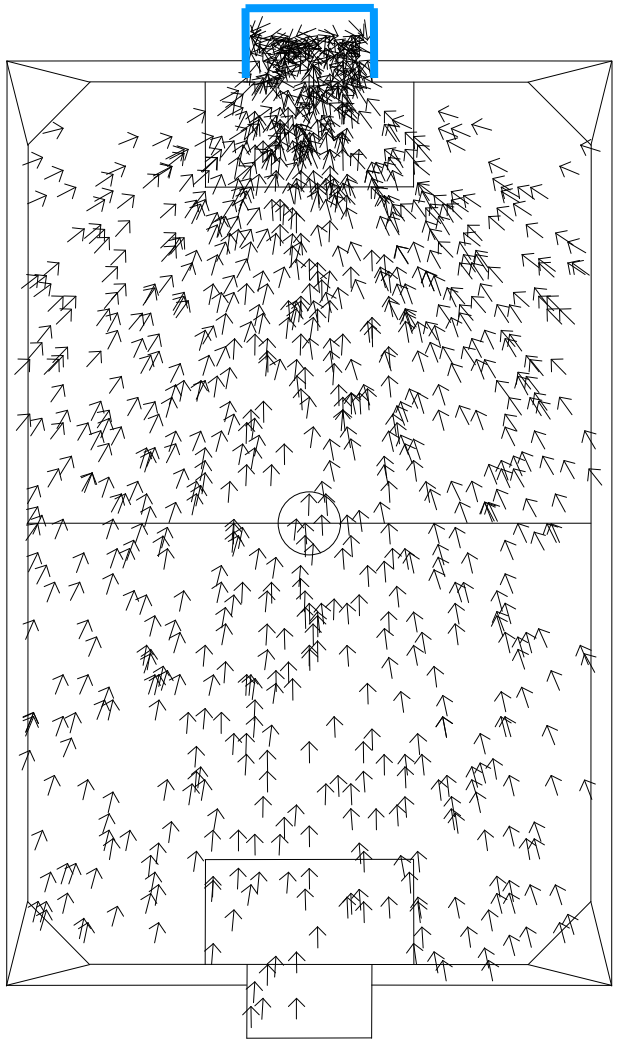
Sensor Model

- Observations are less precise
  - the further away objects measured are
  - the faster the robot walks

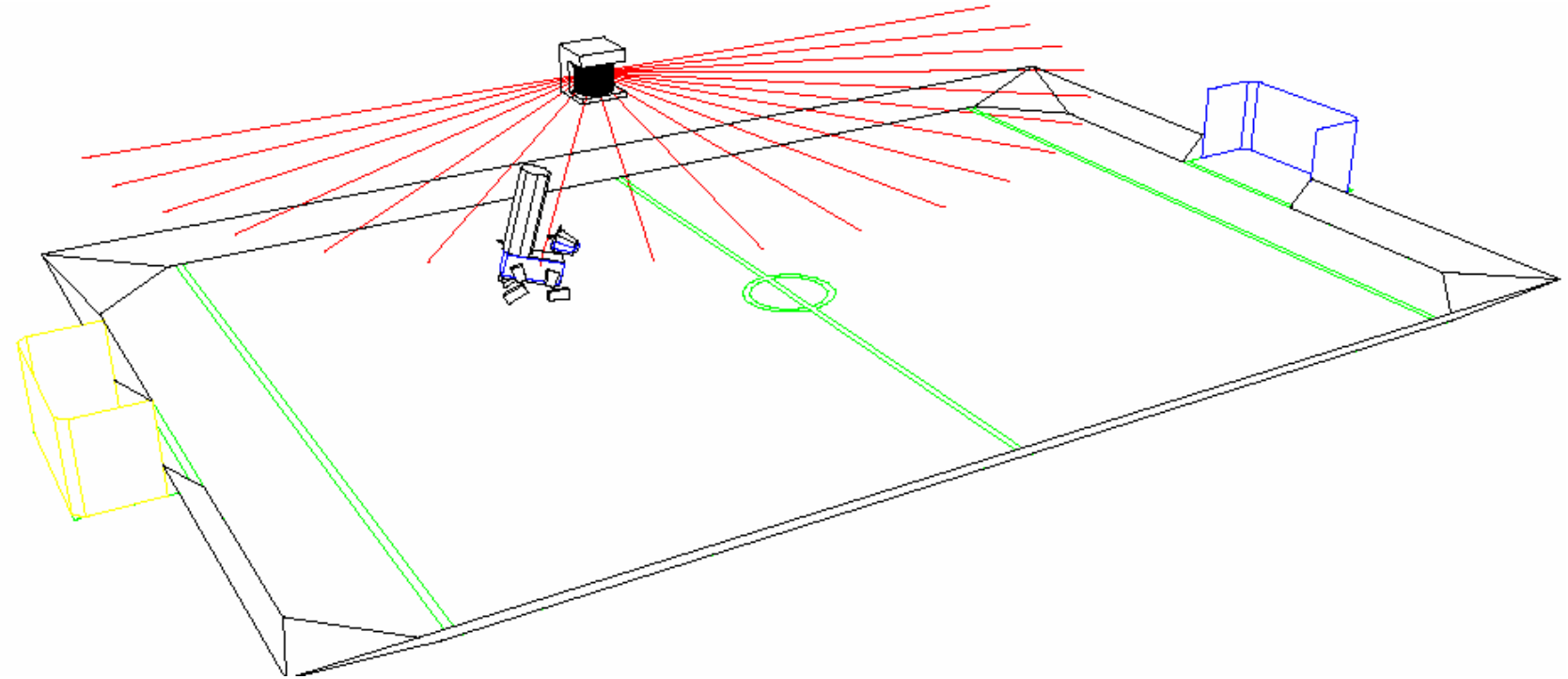


Drawing from Observations

- 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 of goals
- 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

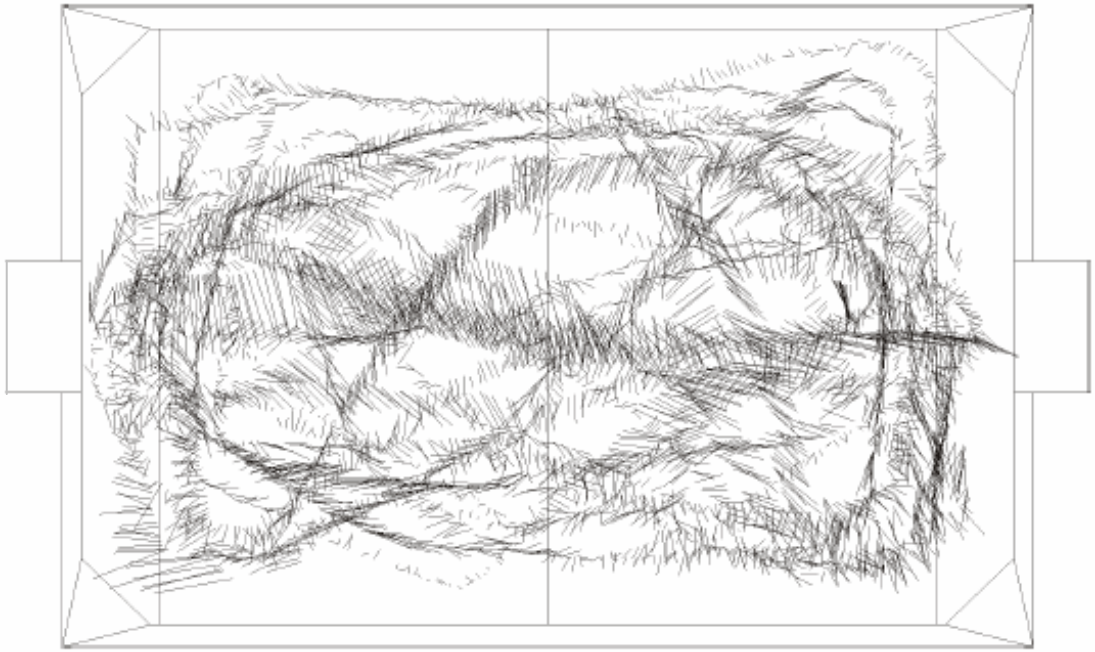


Experimental Setup



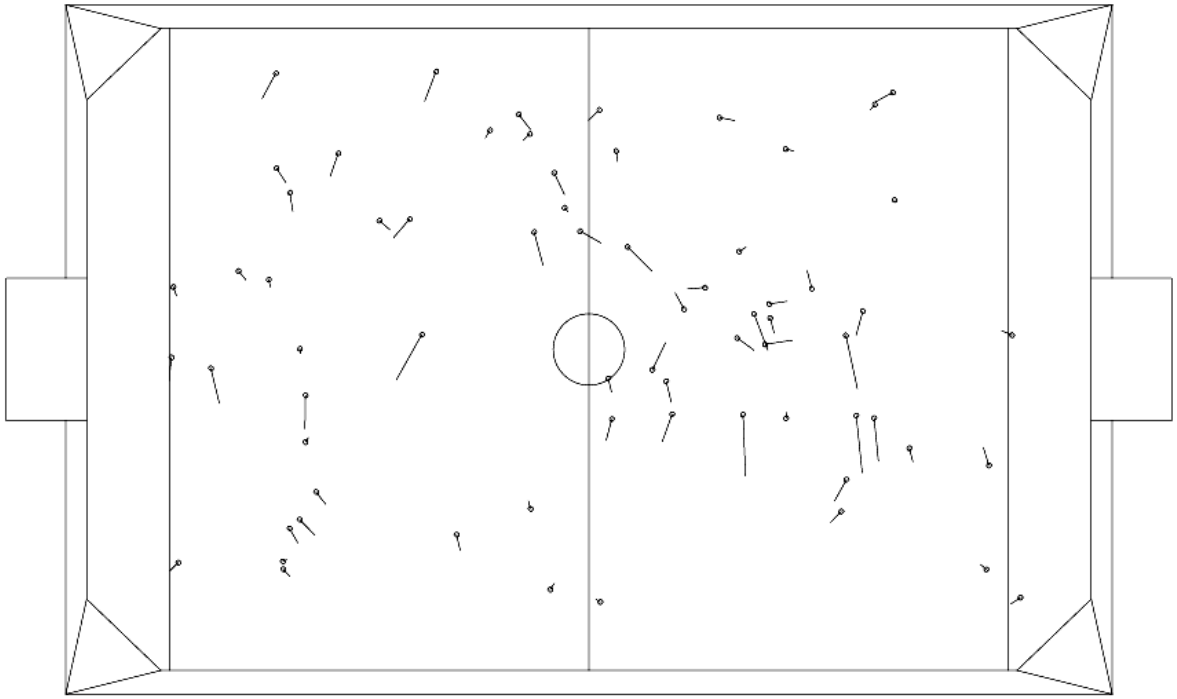
Experiment 1

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

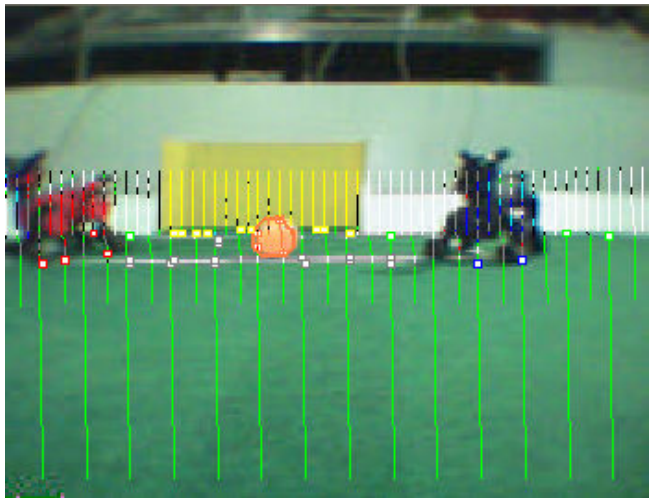


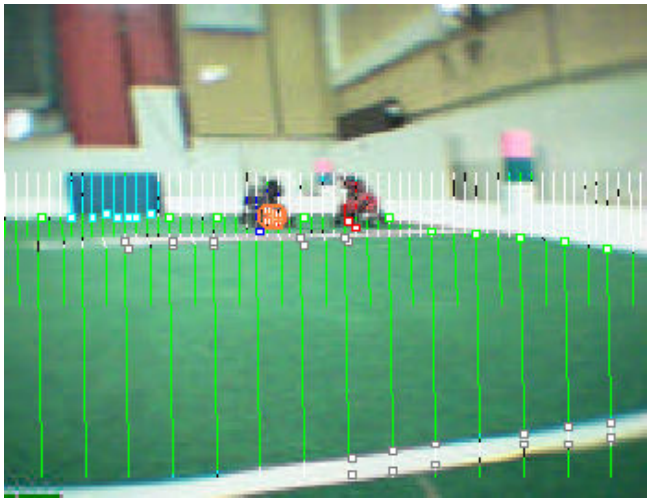
Experiment 2

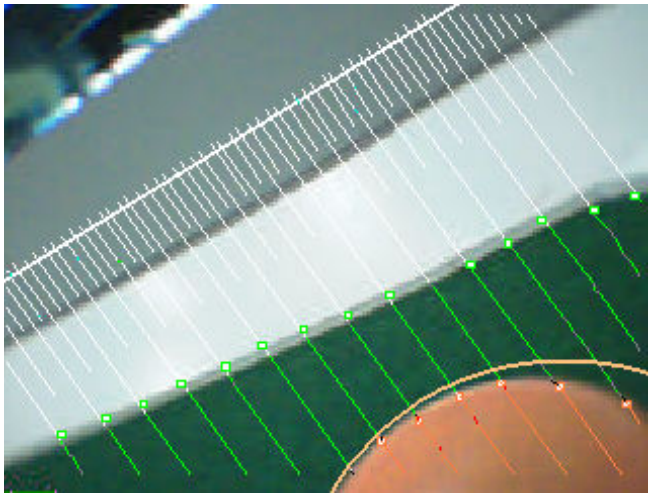
- Robot walks to random positions (approx. 70)
- Average error in positioning < 9.5 cm
- Average error in localization < 8.5 cm



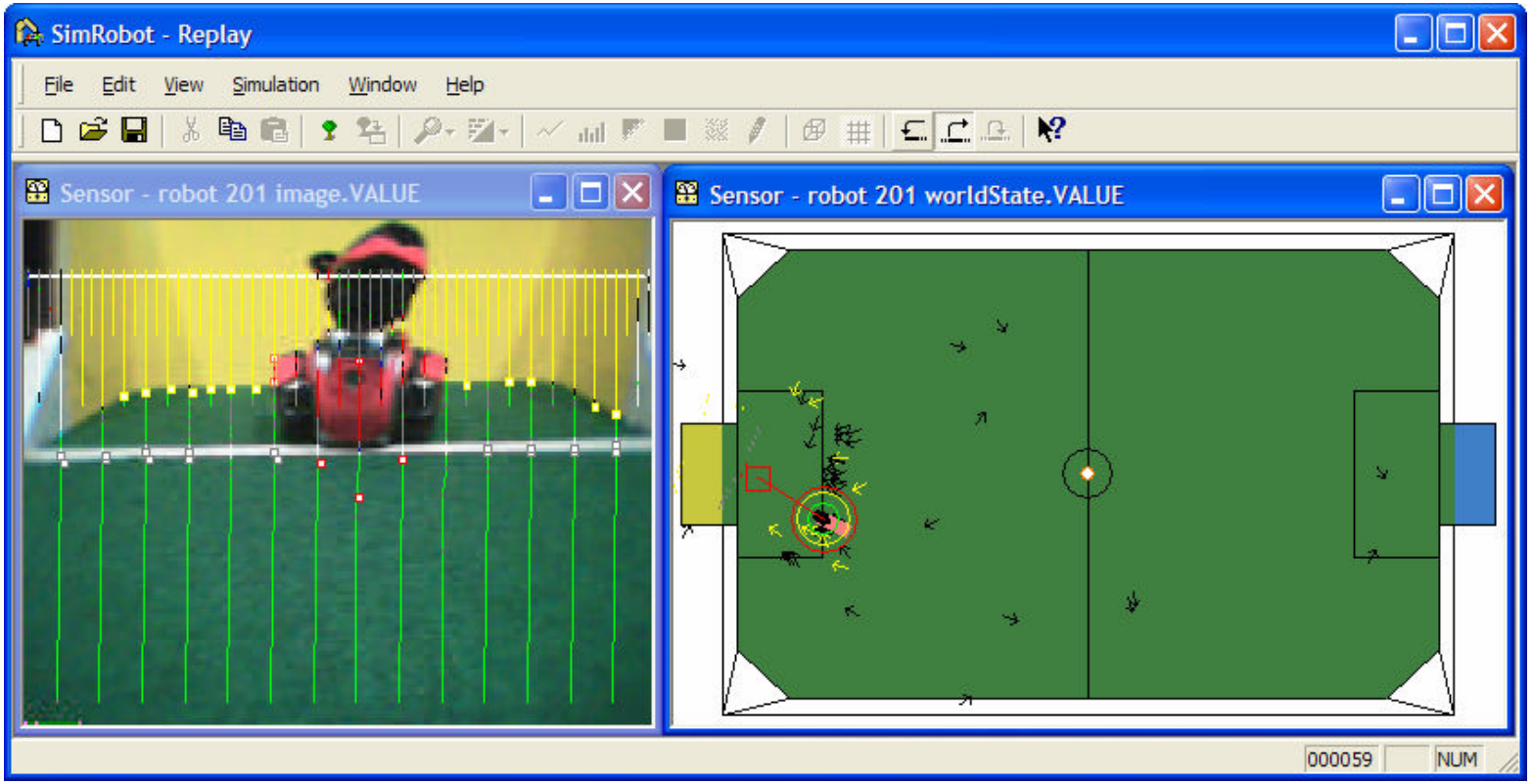
Edge-based Localization in Real Games







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?