Introduction to WrightEagle RoboCup Soccer Simulation 2D Team

Aijun Bai
http://home.ustc.edu.cn/~baj/

University of Science and Technology of China

October 9, 2014

Outline

1. Introduction to RoboCup 2D
2. World Champion Team – WrightEagle
3. Summary

Outline

1. Introduction to RoboCup 2D
2. World Champion Team – WrightEagle
3. Summary

The RoboCup 2D domain - introduction

- Simulated soccer game
- Two teams of 11 players
- Independently controlled
- In each cycle (100ms)
  - Receive perception
  - Make decision
  - Send action(s)
- Normally 6,000 cycles

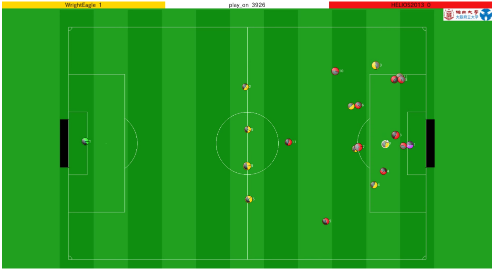

Figure 1 : RoboCup 2D.

The RoboCup 2D domain - model

- State:
  - Ball state, player states and game information
- Observation:
  - Visual information (within field of view):
    - Simulated ball, landmark, and player detections
  - Aural information: msg $(|msg| \leq 10)$
- Action (with parameters):
  - $turn, dash, kick, tackle, say, [catch], \ldots$

The RoboCup 2D domain - model (cont'd)

- Transition model: game rules, physical laws with noise
- Observation model: noise and hidden information
- Key feature:
  - Abstraction made by the simulator
  - High-level planning, learning and cooperation
  - No need to handle robot hardware issues
- Key challenges:
  - Fully distributed multi-agent stochastic system
  - Continuous state, observation and action spaces
- Demonstration - before Q&A session

Outline

1. Introduction to RoboCup 2D
2. World Champion Team – WrightEagle
3. Summary

WrightEagle 2D soccer simulation team

- Have participated in RoboCup 2D, since 2000
- 5 world champions: 2006, 2009, 2011, 2013 and 2014
- Website: `http://www.wrighteagle.org/2d/`
- Key components:
  1. Belief update via particle filtering
  2. Hierarchical online planning
  3. Monte-Carlo planning
  4. Multi-agent decision-making

Belief update via particle filtering

- Particle filter based self-localization and multi-object tracking
- Belief state is useful in:
  1. Information gathering
  2. State estimation
  3. Probability estimation
  4. Future state prediction

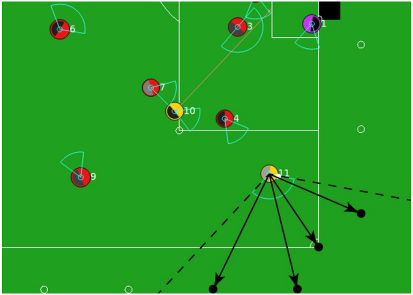

Figure 2 : Local views.

Belief state via particle filtering - example

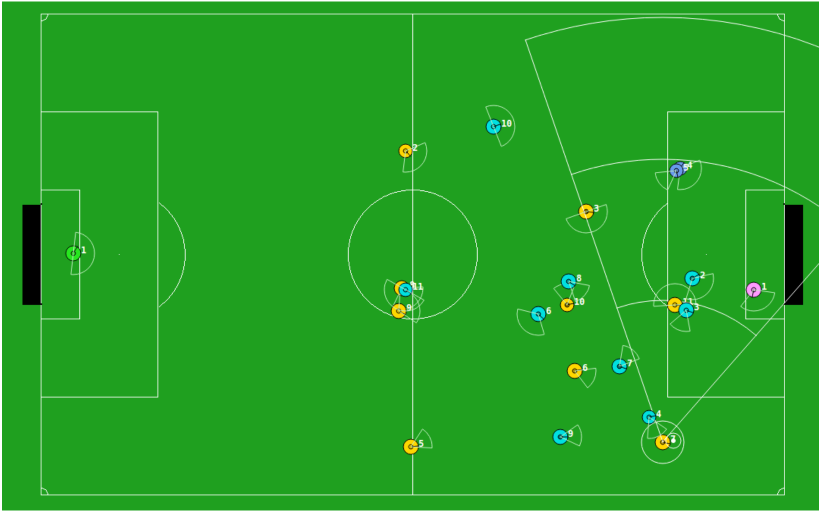

Figure 3 : Unobservable real state.

Belief state via particle filtering - example (cont'd)

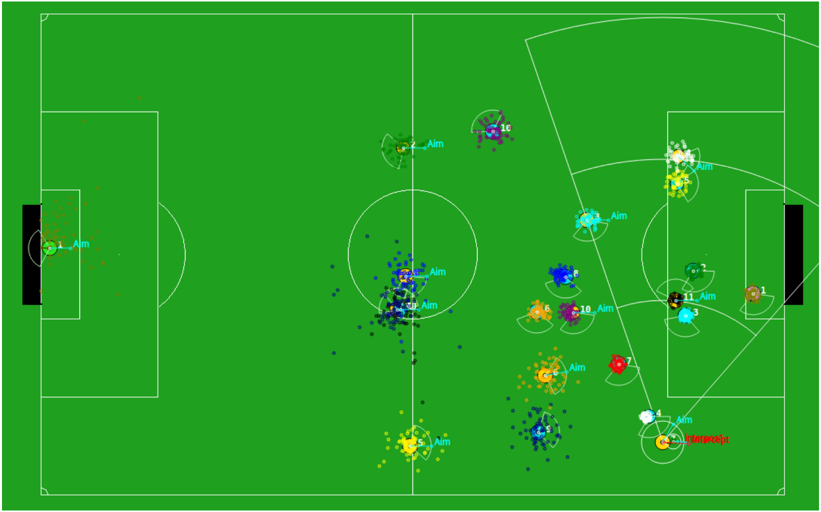

Figure 4 : Updated belief state of player #7.

Hierarchical online planning

- Decision tree:

  PlanAttack() {
  ...
  if *should_shoot* **then**
  ⌊ **return** PlanShoot()
  else if *should_pass* **then**
  ⌊ **return** PlanPass()
  else
  ⌊ **return** PlanDrrible()
  ...
  }

- Hierarchical online planning:

  PlanAttack() {
  ...
  shoot $\leftarrow$ PlanShoot()
  pass $\leftarrow$ PlanPass()
  dribble $\leftarrow$ PlanDrrible()
  ...
  return $\max\{$shoot, pass, dribble, $\ldots\}$
  }

Hierarchical task graph in WrightEagle

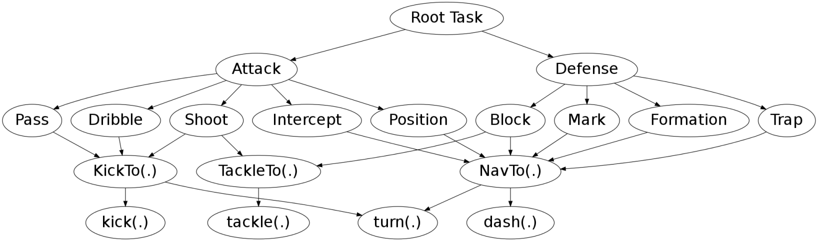

Figure 5 : MAXQ hierarchical structure in WrightEagle.

Hierarchical online planning - an example

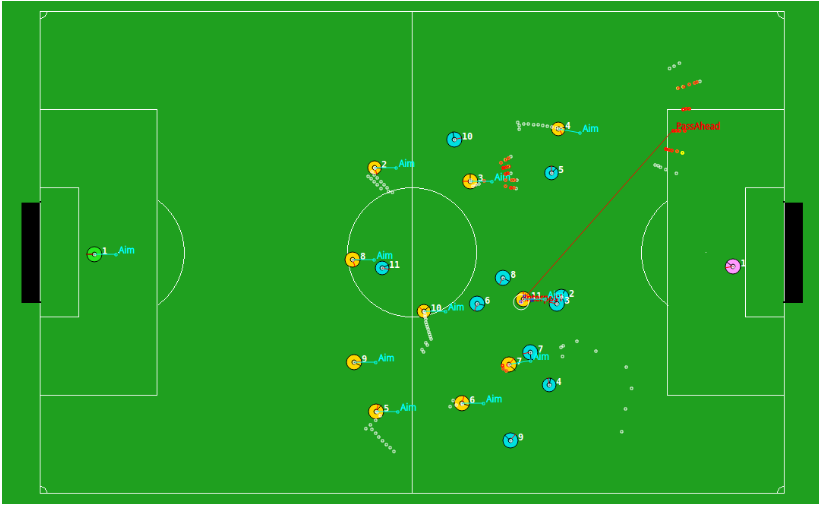

Figure 6 : Hierarchical planning of pass behavior.

Evaluation function - an example

$$V(s) = \max_a Q(s, a) \tag{1}$$

$$Q(s, a) = pV(s') + (1 - p)V(s'') \tag{2}$$

- s is the state
- a is the macro-action
- V is the state value function
- Q is the action value function
- p is the probability of success
- s' and s'' are the predicted states

Heuristic search in action space

- Efficiently search in huge (macro-)action spaces
    - Enumeration is impossible and not necessary
    - Behavior dependent: hill climbing, best-first-search, pruning, . . .

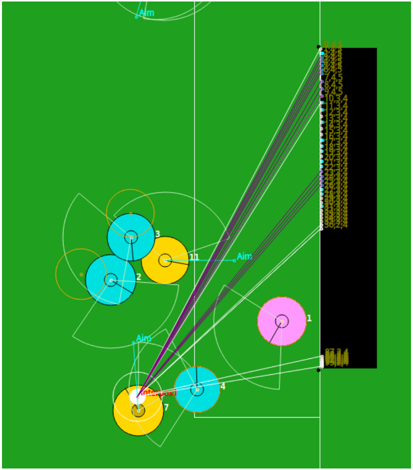

Figure 7 : Search in shoot.

Monte-Carlo planning

- Explicit transition matrix $\Pr(s' \mid s, a)$ is unavailable
- State sampling rules $s' \sim \Pr(s' \mid s, a)$ given by the simulator
- Monte-Carlo tree search
- Low-level skills: $NavTo$, $KickTo$, ...
- Embedded in the overall hierarchical framework

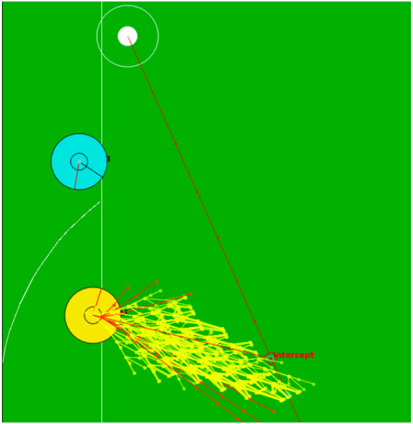

Figure 8 : Search tree in *NavTo*.

Multi-agent decision-making

- Formation and role system
  - Formation: $\Pr(x_1, y_1, \ldots, x_{22}, y_{22} \mid x_b, y_b)$
  - Role classification: forward, midfielder, defender
  - Task allocation (particularly in defense behavior)
- Plan for the team
  1. Pass the ball to teammate t
  2. Recursively plan t's future actions after receiving the ball
  3. Evaluate the pass behavior
- Communicate whenever possible
  1. Share information
  2. Propose future plans
  3. Broadcast emergence

Outline

1. Introduction to RoboCup 2D
2. World Champion Team – WrightEagle
3. Summary

Summary

1. RoboCup soccer simulation 2d domain
   - Fully-distributed multi-agent stochastic system
   - Continuous state, observation and action spaces
2. WrightEagle soccer simulation team
   - Planning and sensing in belief space
   - Utilizing MAXQ hierarchical structure
   - Exploiting heuristic and Monte-Carlo techniques