SELECTIVELY REACTIVE COORDINATION FOR A TEAM OF ROBOT SOCCER CHAMPIONS

J. P. Mendoza, J. Biswas, P. Cooksey, R. Wang, S. Klee, D. Zhu & M. Veloso
Carnegie Mellon University

Dimitris Mouris

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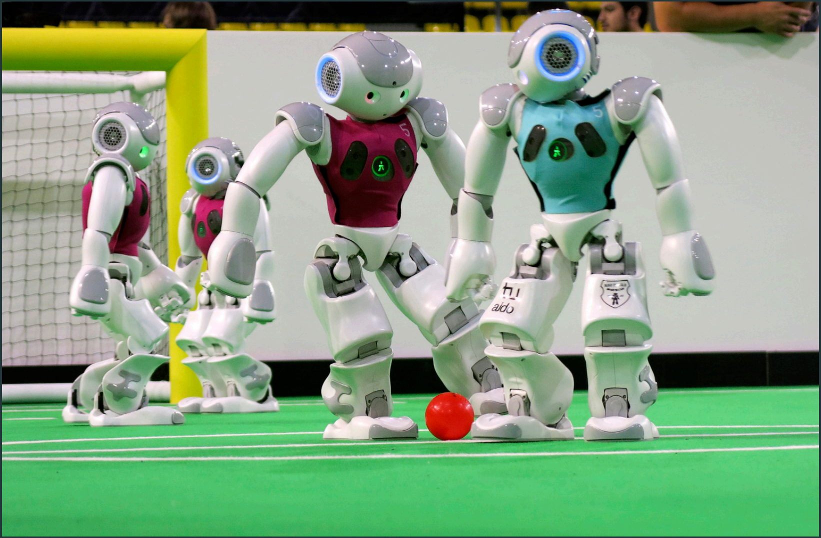
Department of Informatics and Telecommunications,
National Kapodistrian University of Athens

ROBOT WORLD CUP INITIATIVE: ROBOCUP



SMALL SIZE LEAGUE CHAMPIONS: CMDRAGONS 2015

Composed of the same robot hardware for the last 10 years, won the competition, scoring 48 goals and suffering 0 goals in 6 games

OPPONENT REACTIVITY

- Purely Reactive Team
  - Positions the robots completely in reaction to the adversary.
  - Unable to carry out plans of its own.
  - Susceptible to coercion.
- Open Loop Team
  - Positions the robots ignoring the opponent's state.
  - Unable to appropriately react to opponent behaviour.

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- **Purely Reactive Team** (Probabilities)
  - Positions the robots completely in reaction to the adversary.
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- **Open Loop Team** (Offline plans)
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OFFENCIVE ROLES

In offence, there are two types of roles:

- 1 Primary Attacker (PA)
  - Completely opponent and situation driven.
- (n-1) Support Attackers (SAs).
  - Moving to maximize the estimated probability of the team scoring.

MULTI-ROBOT OFFENSE COORDINATION (1)

- Coordination via Zones and Guard Locations
    - Plan P = Set of roles R = $\{r_1, \ldots, r_n\}$ (what & how)
    - Bound each SA in a zone z_i and assign it a default guard location p_i.
    - Offline search for effective plans. (extensive data & human knowledge)
- Individual Action Selection
    - Passive: move(p).
    - Active: getBall, shoot, pass(p), dribble.
    - All actions provide a possibility after the action to score.
    - PA selects the optimal action among the set of possible active actions.

- Complete Overview of SRC algorithm

Algorithm 1 PlanAction

1:	Instantiate roles r_i with zones z_i	$O(n)$
2:	Optimally assign roles	$O(n^3)$
3:	Choose actions individually	$O(n+m)$

In Algorithm 1, variable n corresponds to team's robots, and m to the number of opponent team's robots.

As the size of the team grows, step 2 might need to be modified to maintain real–time planning.

ROLE ASSIGNMENT TO ZONES (1)

- Coverage–zone Selection
  - Offline definition of zone sets each of which covers half of the field.
  - On-line the team chooses the right coverage set Z based on features of the state of the game. (e.g. ball possession/position)
- Dynamic–zone Selection
  - Coordinated zone selection to determine the flow of actions. (little individual positioning choice)
  - Each zone of a smaller size than the coverage–zones.
  - Select plan P from a set of possible plans. (generated by extensive simulation tests)
- Optimal role assignment

ROLE ASSIGNMENT TO ZONES (2)

Coordinated zone assignments for Support Attacker robots.

(a) Coverage-zones for 3 SAs (b) Dynamic-zone assignment, step i (c) Dynamic-zone assignment, step $i + 1$

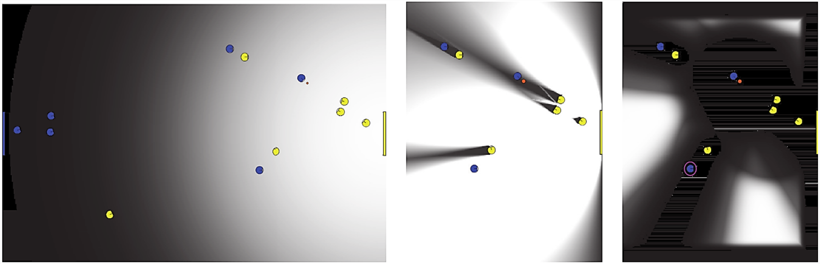
White dashed lines show the zone boundaries; white and orange circles show SAs and PA respectively.

A pass from the PA in (b) triggers a change in zones to those in (c).

PRIMARY ATTACKER (PA)

- Individual Dribbling
  - The goal of the PA is to manipulate the ball to maximize the probability of scoring a goal & drives with the ball to keep it away from opponents.
  - Uses a rotation dribbler bar that imparts back–spin on the ball.
- Primary Attacker Algorithm
  - e.g. The probability of scoring a goal by shooting, is estimated as the probability that the ball is close enough to the opponent's goal for the shoot and that the robot has a wide angle on the goal.
  - $P(goal|shoot, p, x) = P(near|p) * P(open|p, x)$, where p is the location of the ball, and x the state of the world

PROBABILITIES



(a) $P(\text{near}\,|\boldsymbol{p})$ (b) $P(\text{open}\,|\boldsymbol{p},\boldsymbol{x})$ (c) $P(\text{receive}\,|\boldsymbol{p},\boldsymbol{x})$

Lighter gray indicates higher probability points.

(a) is near enough to the yellow goal, (b) has a wide enough angle to shoot and score, (c) the highlighted SA can receive a pass at different locations p from the PA holding the ball.

SUPPORT ATTACKERS (SA)

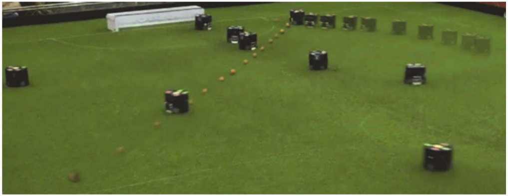
The task of each SA, is to maximize the probability of the team scoring by supporting the PA from within its assigned zone.

- Optimal Pass Location Search
  - $P(\text{receive}|p, x)$
  - $P(\text{goal}|\text{shoot}, p, x') = P(\text{near}|p) * P(\text{open}|p, x')$
- Pass-ahead Computation
- Secondary Attacker Algorithm

PASS CONFIGURATION

Pass–ahead maneuver leading to a goal in RoboCup 2015.

(a) Pass initial configuration



(b) Pass final configuration, immediately preceding a goal

CMDRAGONS PERFORMANCE IN ROBOCUP 2015

- Average 32.3 passes completed per game. (79%)
- Average 8 goals per game. (32.4%)
- Most of the team's goals were collective efforts:
    - 22 were scored after 1 pass.
    - 11 were scored after 2 passes.
    - 1 was scored after 3 passes.

Questions?