



Machine Learning, Team Strategy and Large Data Set logging

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Cooperative Autonomous Mobile roBots with Advanced Distributed Architecture



- Motivation???
- Machine learning (what and where)
- Team Strategy:
 - Related Work
 - Building an Utility Map
 - Strategic Positioning:
 - defensive situations
 - offensive situations
 - free-play
- Large Data Set logging (*CameLog*)

Motivation???



- Some years ago, CAMBADA “actually” made an incursion into the use of machine learning for specific behaviors.
- Experimental tests has allowed as to conclude that machine learning may be well suited to particular low level actions/behaviors such as:
 - Dribbling
 - Holding the ball
 - Engaging the ball
 - Shooting
 - ...

- On the other hand, our perception is also that, for high level decisions and strategy specification, learning will be:
 - Hard to tackle
 - Inefficient, due the natural dynamic reality faced by teams within the games.
- In the following (very old) videos, you can see the result of the use of reinforcement learning for teaching a robot to get the ball and dribble it while turning fast towards the opponent goal

- Trial 1 – *“Go man, turn around the ball and shoot!”*



- Trial N+K – “*COME ON! do it properly...*”







- Today, there are 2+ key factors to win a match (in MSL?):
 - Team Coordination
 - Strategic Positioning
 - Others...
- Doing it effectively and efficiently is halfway to attain this goal.



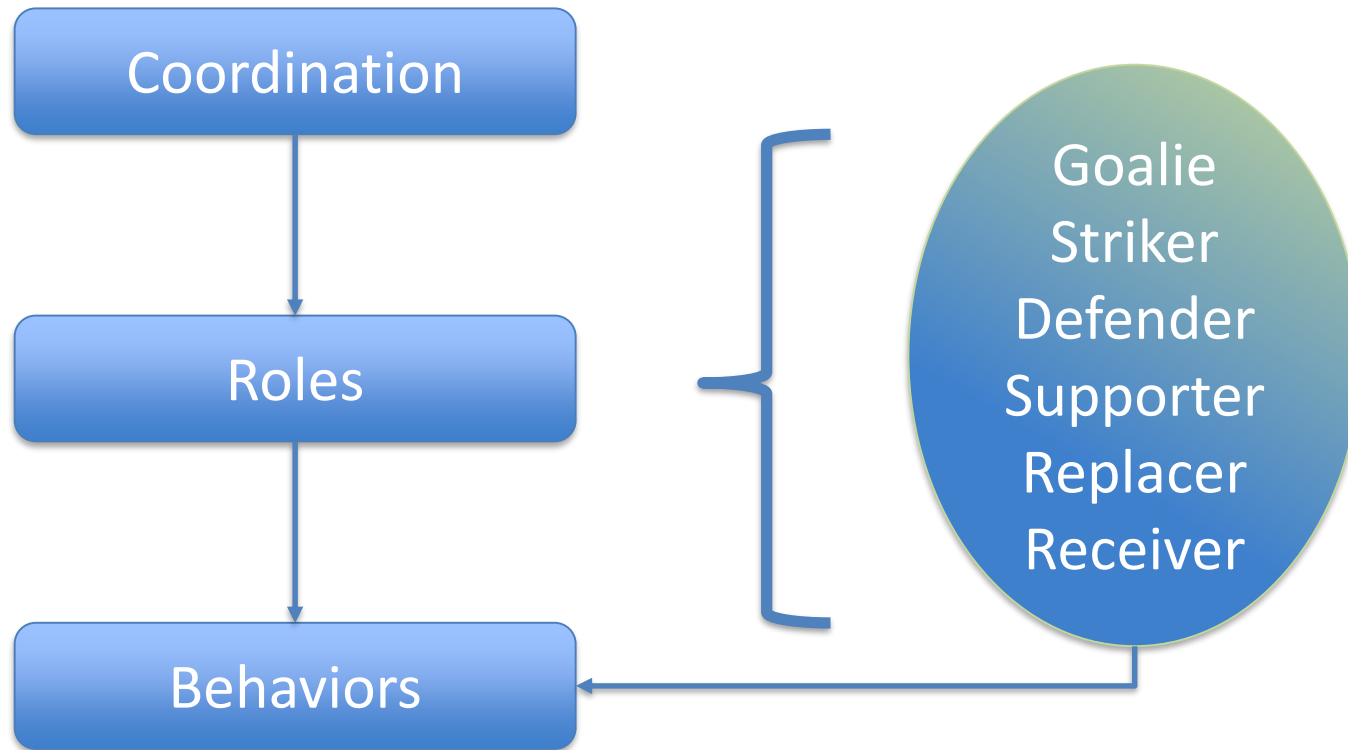
- [2000] SPAR (Stone, P)
Strategic Positioning with Attraction and Repulsion
- [2001] SBSP (Reis, L.P. et al.)
Situation Based Strategic Positioning
- [2005] DPVC (Dashti, H.A.T. et al.)
Dynamic Positioning based on Voronoi Cells
- [2007] DT (Akiyama et al.)
Delaunay Triangulation



- Spatial Representation using grid-cells
 - Simplified world state modelling
- Utility functions have been used before to select the role within multi-agent systems
 - [2004] (Chaimowicz et al.)
- These utility functions stands out as a paradigm for dynamic coordination of multiple robots.
- Taking into account the successful use of this approach, a similar idea was applied to the CAMBADA agents by creating: Utility Maps

Team Coordination and Strategy

CAMBADA hierarchy structure



- Collection of Occupancy Maps, that can include:
 - Opponents
 - Team mates
 - Ball
- Field Of Vision (FOV) from a certain point, usually:
 - Ball position
 - Robot own position
 - Goal
- Specific conditions
 - A set of conditions are used to select which Occupancy Maps and FOVs to include in a Utility Map

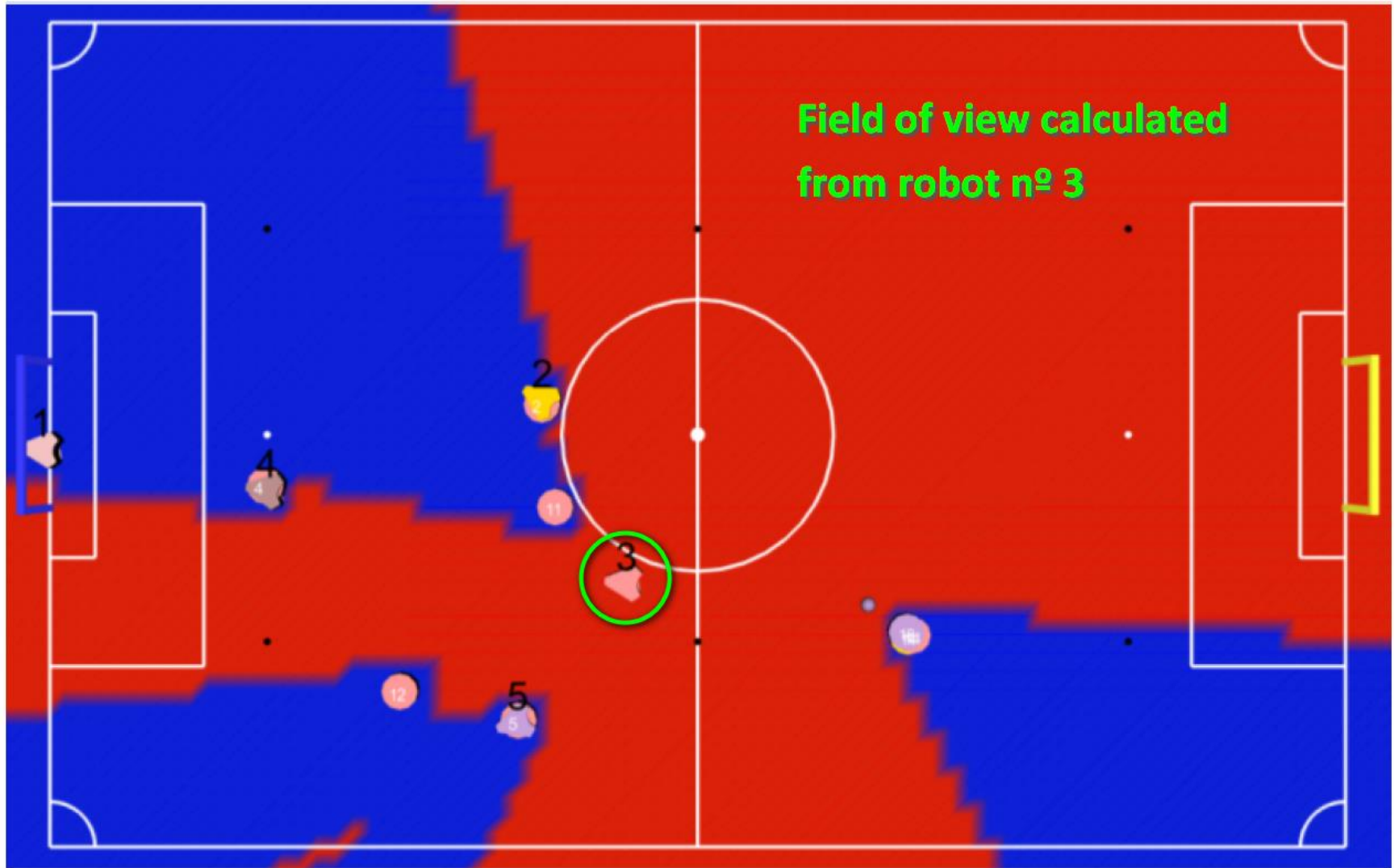


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An occupancy map gives the robot a global idea about the state of the world around it.

Team Coordination and Strategy

Field of View Maps



Team Coordination and Strategy

Positioning in Defensive Set-Pieces



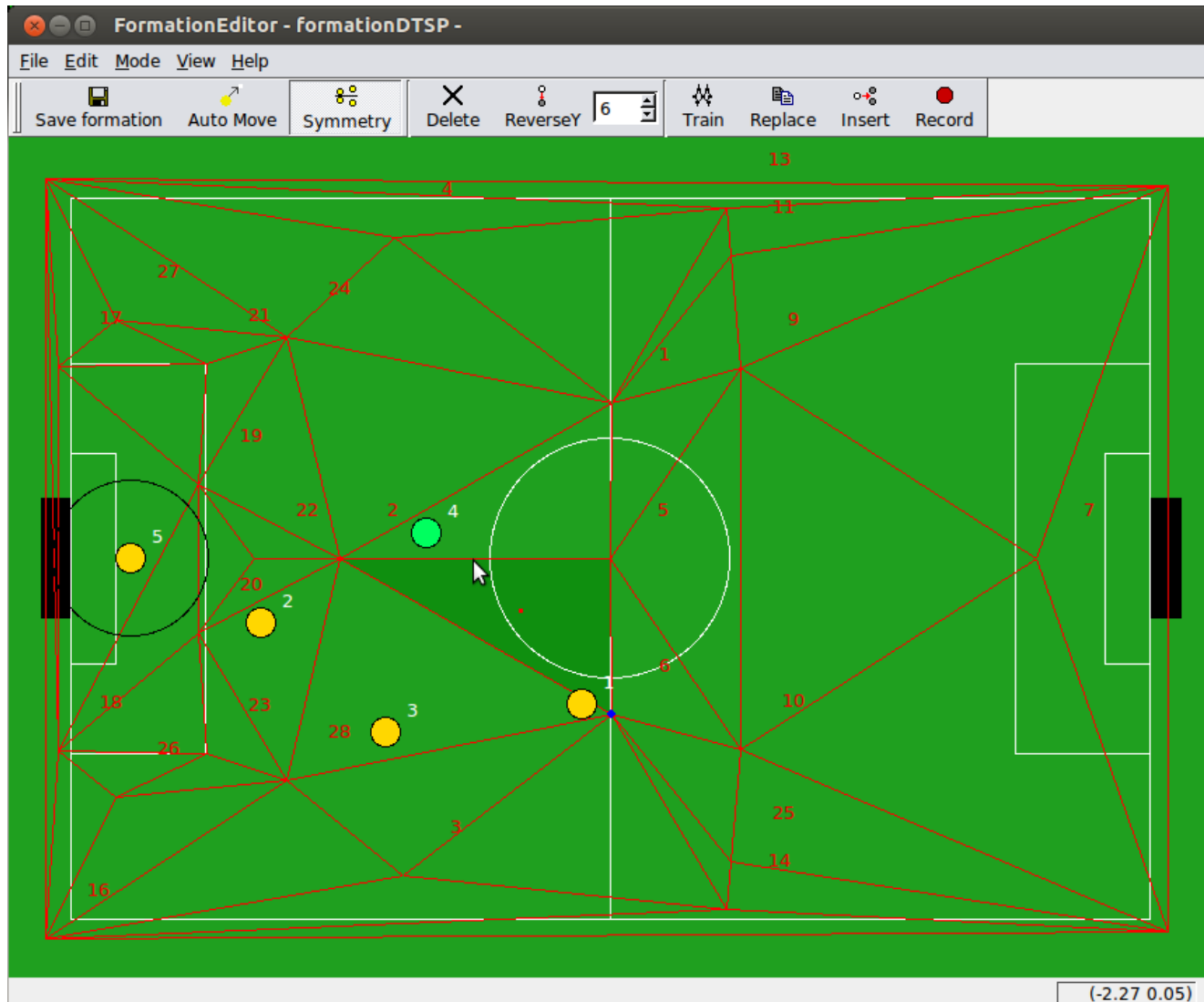
Main objective

Prevent the opponent from performing a pass

- Start with DT (next slide), and on top of that, add some rules:
 - Minimum 3m away from the ball
 - Only 1 player inside penalty area
 - Add an utility between the ball and the obstacles to **cover** line of passes.

Team Coordination and Strategy

Positioning in Defensive Set-Pieces (DT)

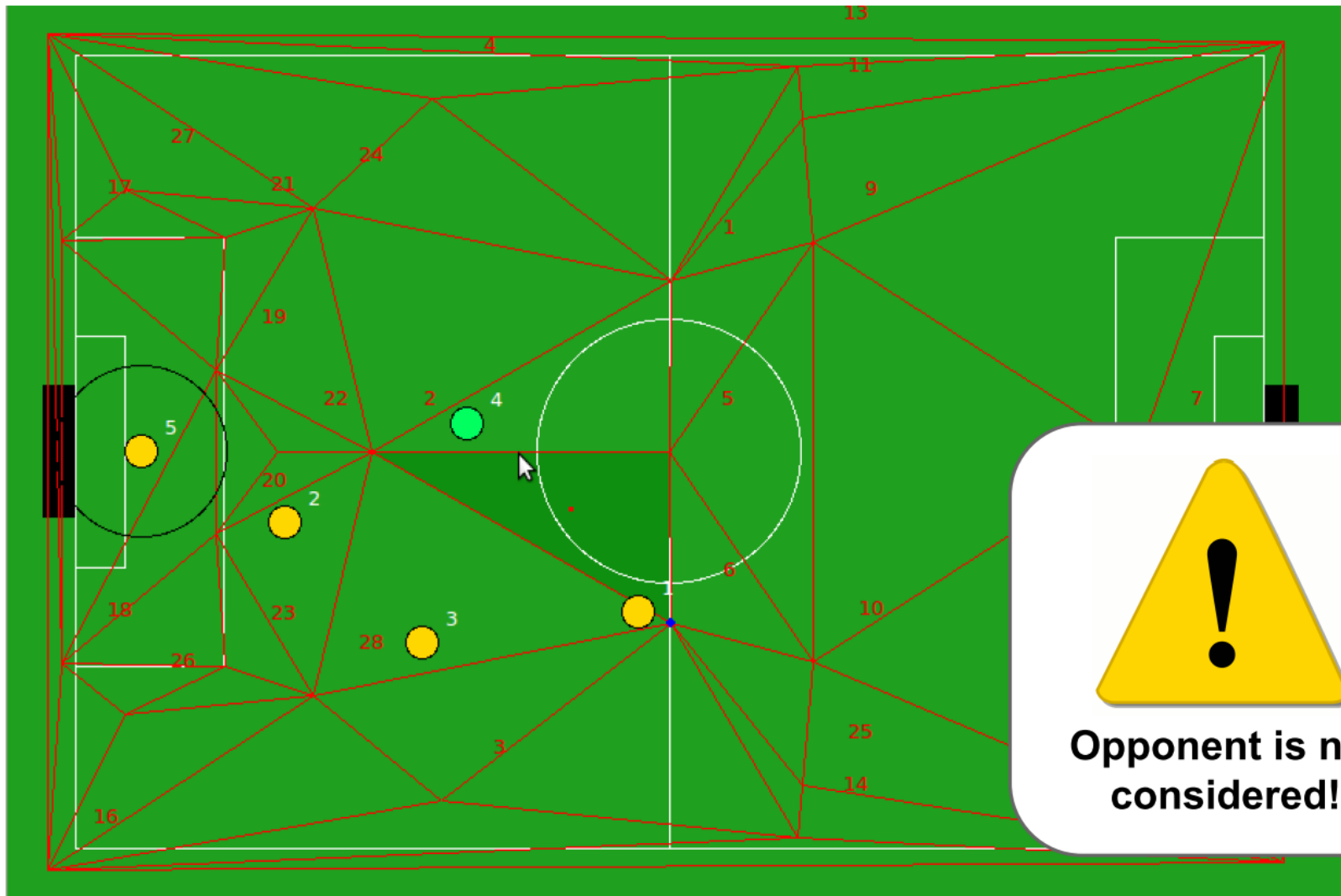


**Delaunay
Triangulation
tool**

- The Delaunay Triangulation formations divide the soccer pitch into several triangles based on given training data.
- Each training datum affects only the divided region to which it belongs. A map is built from a focal point, such as ball position, to the positioning of the agents.
- Delaunay Triangulation is used to interpolate all possible robots positions, depending on the any ball position on the field

Team Coordination and Strategy

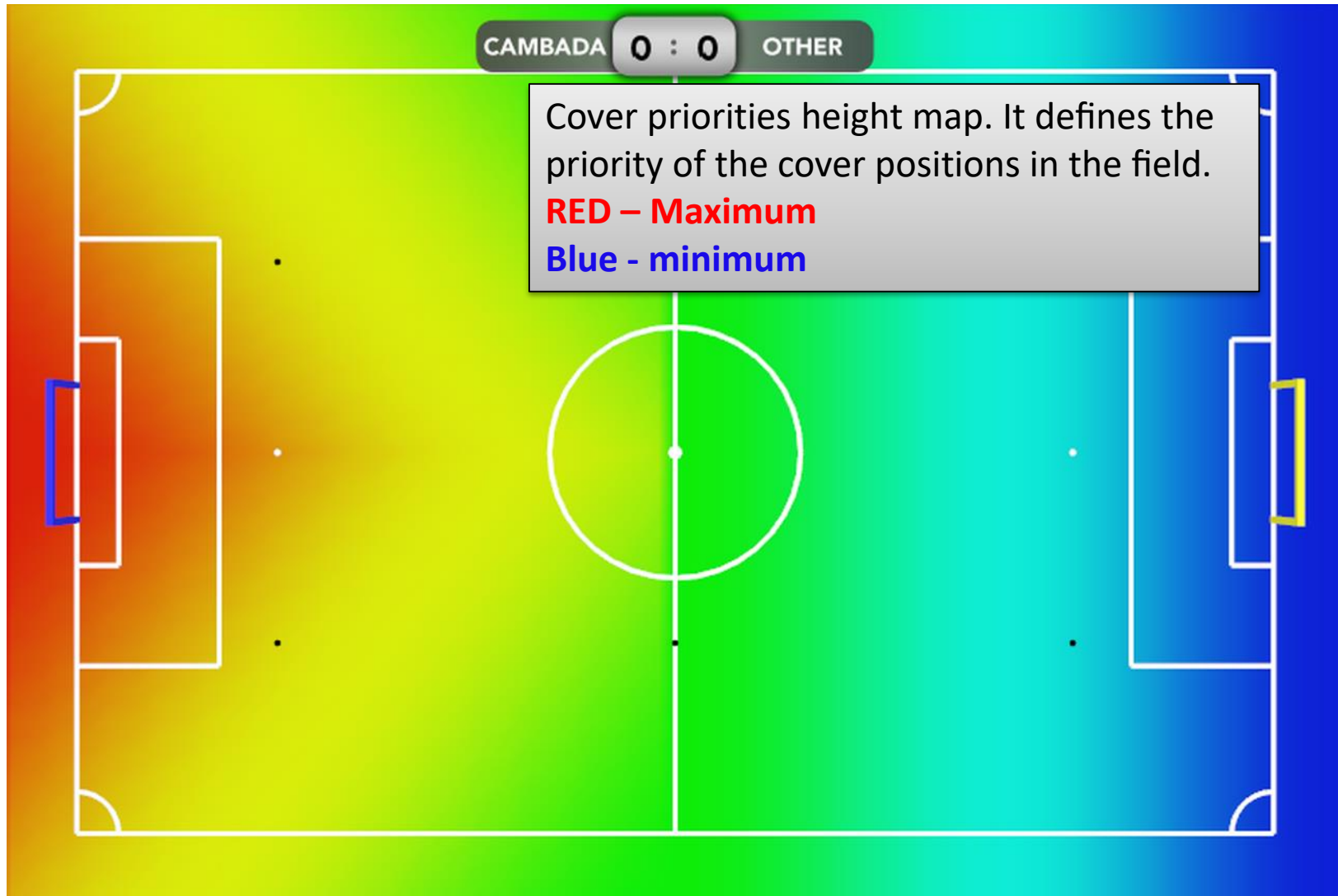
Positioning in Defensive Set-Pieces (DT)



Opponent is not considered!

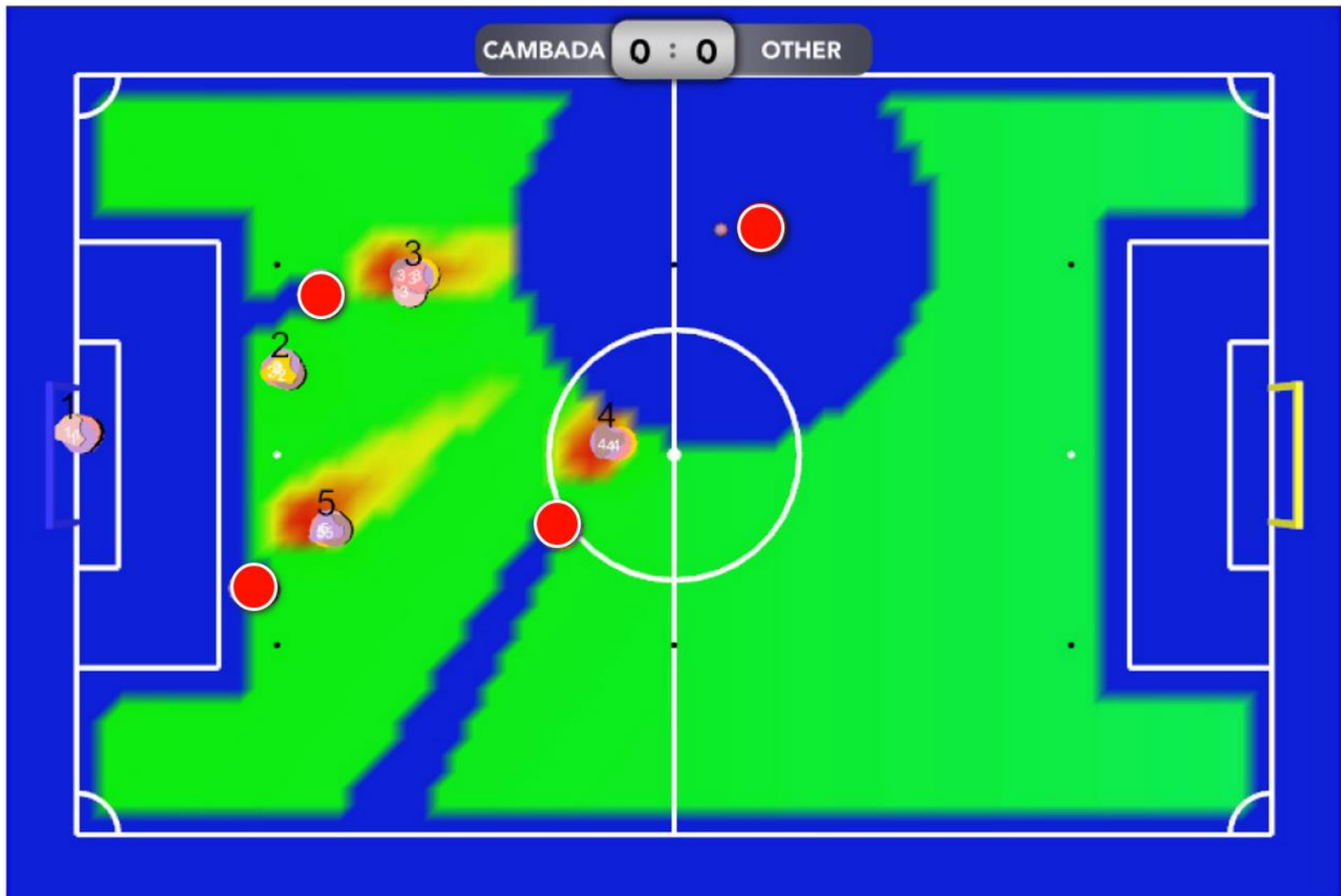
Team Coordination and Strategy

Defensive Set-Pieces Cover Height map



Team Coordination and Strategy

Defensive Set-Pieces Cover Utility map



Team Coordination and Strategy

Positioning in Offensive Set-Pieces



Main objective

Get in a “good” position to receive the ball

- Set pieces are set with a graphical tool that implements an SBSP algorithm.
- The field is divided into 10 zones. Each zone defines a set of positions for the Replacer and Receivers
- The position of the Receivers can be absolute or relative to the ball.
- For the Receivers, the need for a clear line between its position and the ball can also be defined.
- Receivers can also be forced to be aligned with the goal

Team Coordination and Strategy

Positioning in Offensive Set-Pieces



- SBSP

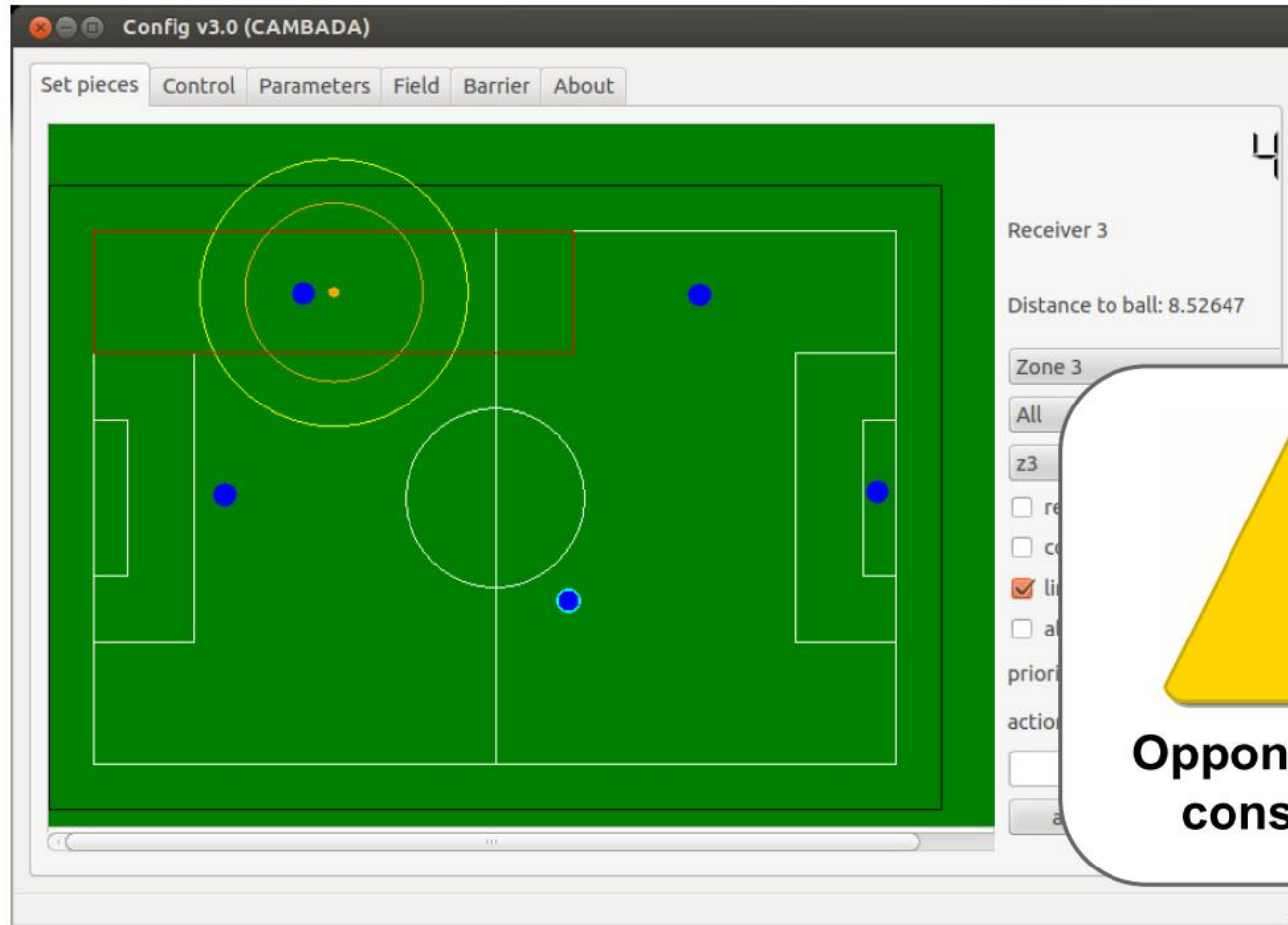


Team Coordination and Strategy

Positioning in Offensive Set-Pieces



- SBSP



- When a receiver has no clear line of sight (and is on the opponent side of the field) an alternative position is selected based on an averaged criteria of:
 - distance between pass line and closest obstacle
 - distance to the ball
 - distance to opponent goal
 - rotation angle for a shoot on target
 - distance from the predefined position
- Constraints are also imposed by the rules:
 - Minimum of 2m distance to receive the ball
 - Not entering in goal areas

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Combination of criteria and constraints result in an Utility Map for each receiver



- Each receiver is also assigned a priority level.
- This priority is defined by a Leader, dynamically elected among the BaseStation and the active robots on the field.
- If the Leader fails, a new election is performed.
- In the following slide, robot 2 has used its Utility Map to define an alternative position for reception while the Replacer has also decided to take the pass to that target.
- Robot number 2 will move to that position to receive the ball only after the Start signal is given.

Team Coordination and Strategy

Positioning in Offensive Set-Pieces



Team Coordination and Strategy

Positioning in Free Play



Striker objective

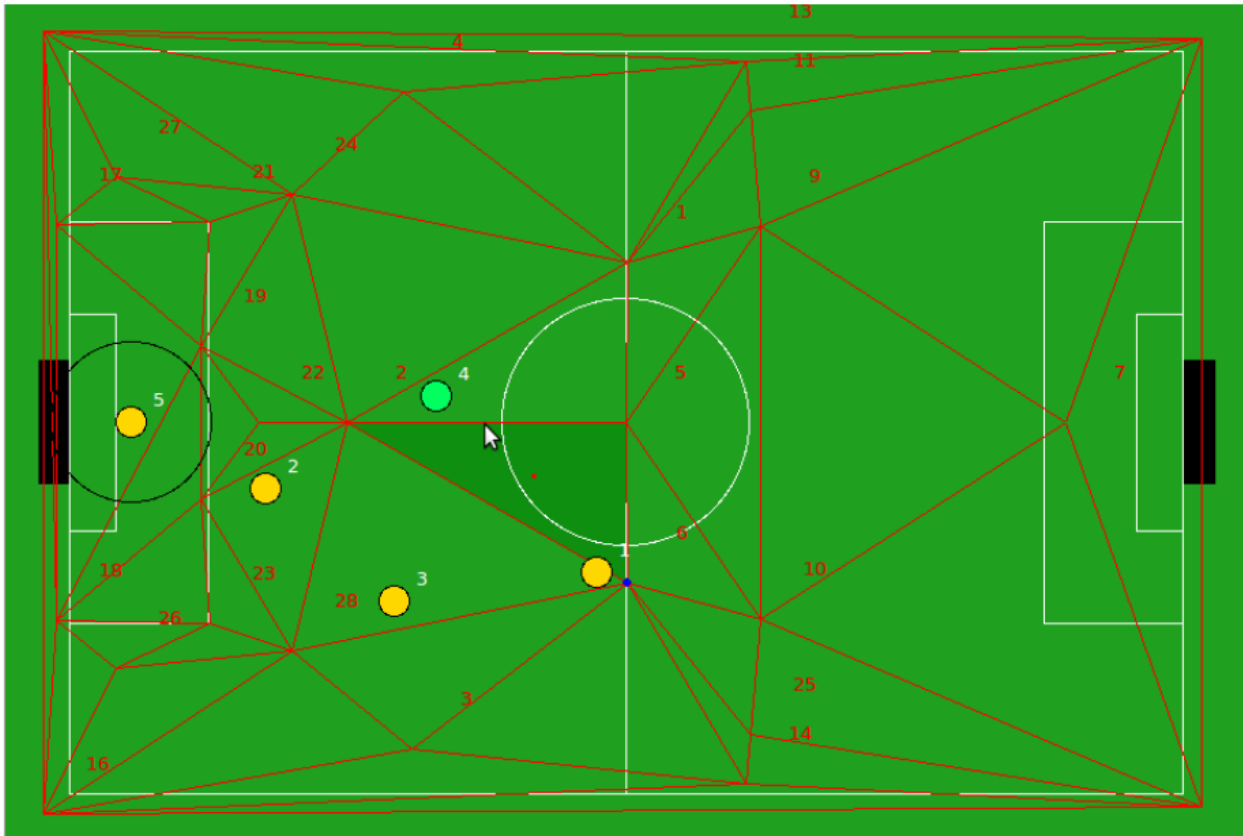
Get in a “good” position to kick towards the goal or make a pass to a team mate

Supporter objective

Get in a “good” position to receive the ball from a pass

- Rules state that:
 - A valid goal is awarded only if a pass between robots occurs before the goal
 - Striker dribbling is limited by a 3m-radius circle

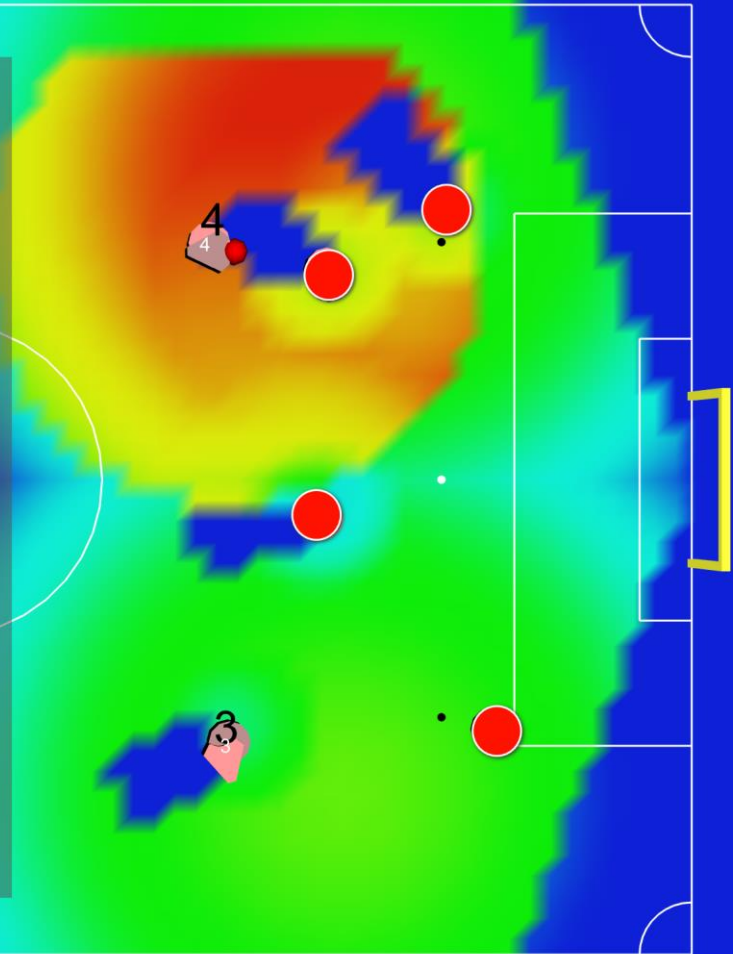
- Starts with a DT formation



- Rules are applied (eg. goal areas avoidance)

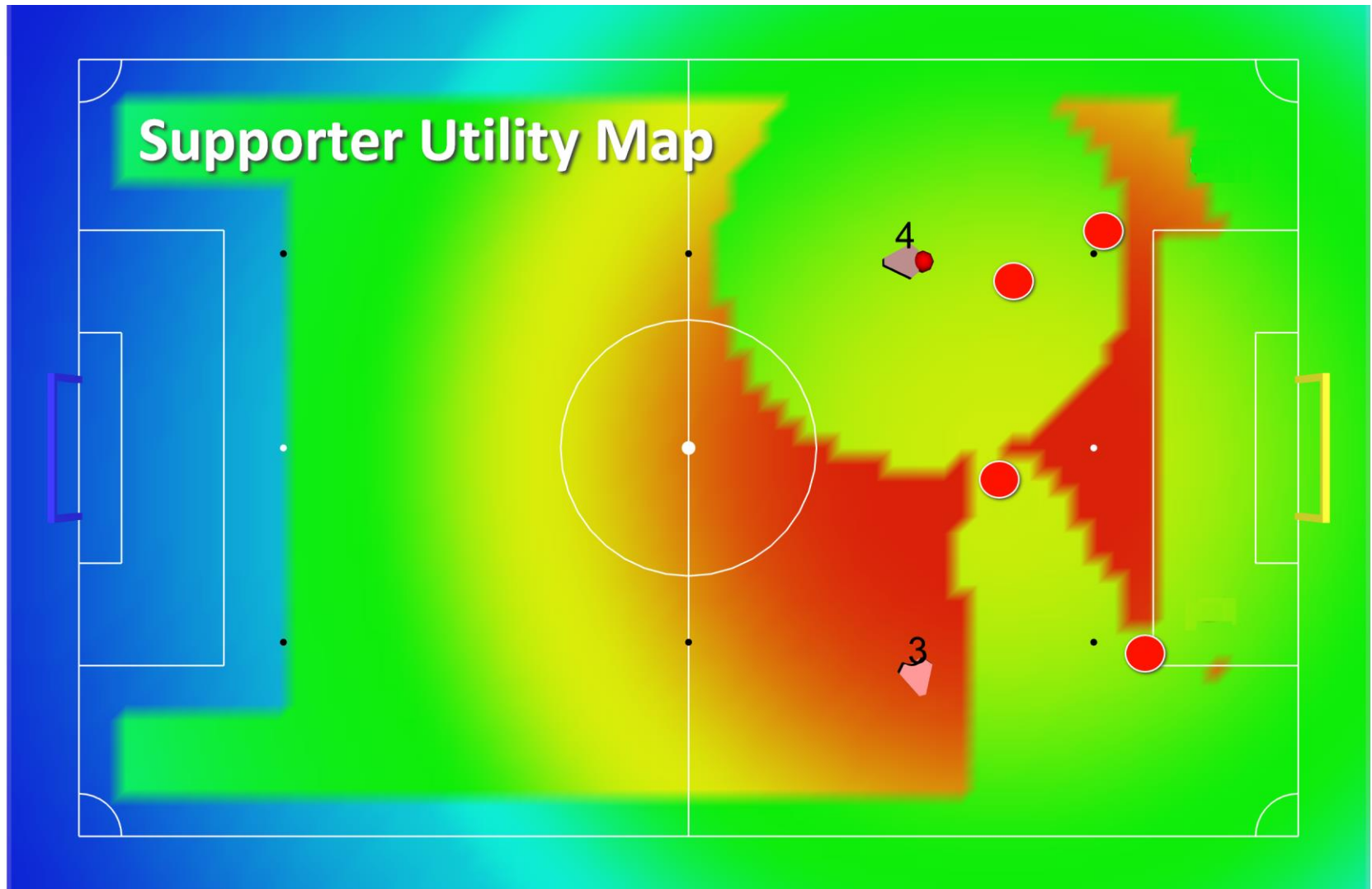
Striker Utility Map

- 3 meter rule applies;
- Priority depends on current condition:
 1. if kick is allowed higher priority is given to the areas close the limits of the field since statistically we get a better chance to score from there.
 2. if pass is required, higher priority will drive striker to get an open line of pass to the supporter.



Team Coordination and Strategy

Positioning in Free Play



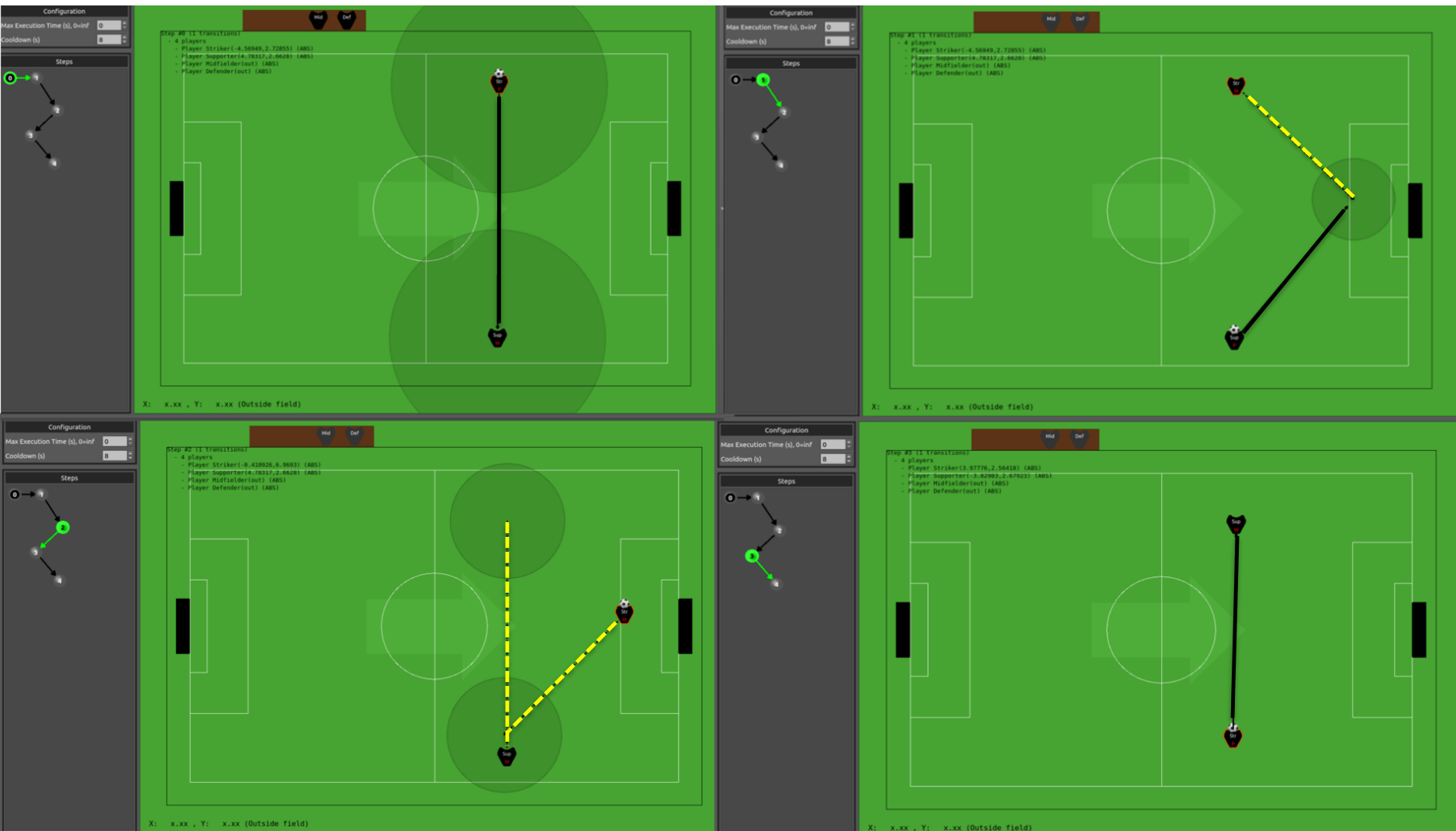
Team Coordination and Strategy

Rehearsed set-plays



Team Coordination and Strategy

Rehearsed set-plays



Team Coordination and Strategy

Rehearsed set-plays



Activities ☒ basestation qui 21:19 CAMBADA Basestation

File Field Debug Points Obstacles Robots Info RefereeBox Video Player Demo Calibration Robot Debug

CAMBADA 0 : 0 OTHER

01:51

Coach Comm Logger

CAMBADA

CAMBADA Simulator

Simulation World

Respawn at (4.62,-1.21)R 1.9 (min) S 1.9 (min) [1.00x]

Penalty Parking Penalty

State: **SIGstart**

Team

All Run All Stop

Blue Cyan

Auto

Manual Formation Alternative Ball

attack

Robot 1

NA	Stop	M
Blue	Cyan	
Supporter		
74.0	0	-1
LineClear		
TryPass0		
Auto	Reloc	

Robot 2

OK	Stop	M
Blue	Cyan	
Supporter		
74.0	0	-1
LineClear		
TryPass0		
Auto	Reloc	

Robot 3

OK	Stop	M
Blue	Cyan	
Striker		
74.0	0	-1
BallPassed1		
None		
Auto	Reloc	

Robot 4

NA	Stop	M
Blue	Cyan	
Auto		
Auto	Reloc	

Robot 5

NA	Stop	M
Blue	Cyan	
Auto		
Auto	Reloc	

Robot 6

NA	Stop	M
Blue	Cyan	
Auto		
Auto	Reloc	

Running setplay: mslWorkshop Step 0



Large Data Set logging On the “road” towards the future

- **INTENT:**

- Make local log, on each robot, of all data on RTDB with adequate local time stamps
- Allow pre-selection, if needed, of selected items
- Use of large circular buffers (e.g. 1 or 2 hours) in a Camelog daemon process running on all agents (robots and coach)

- **Objective:**

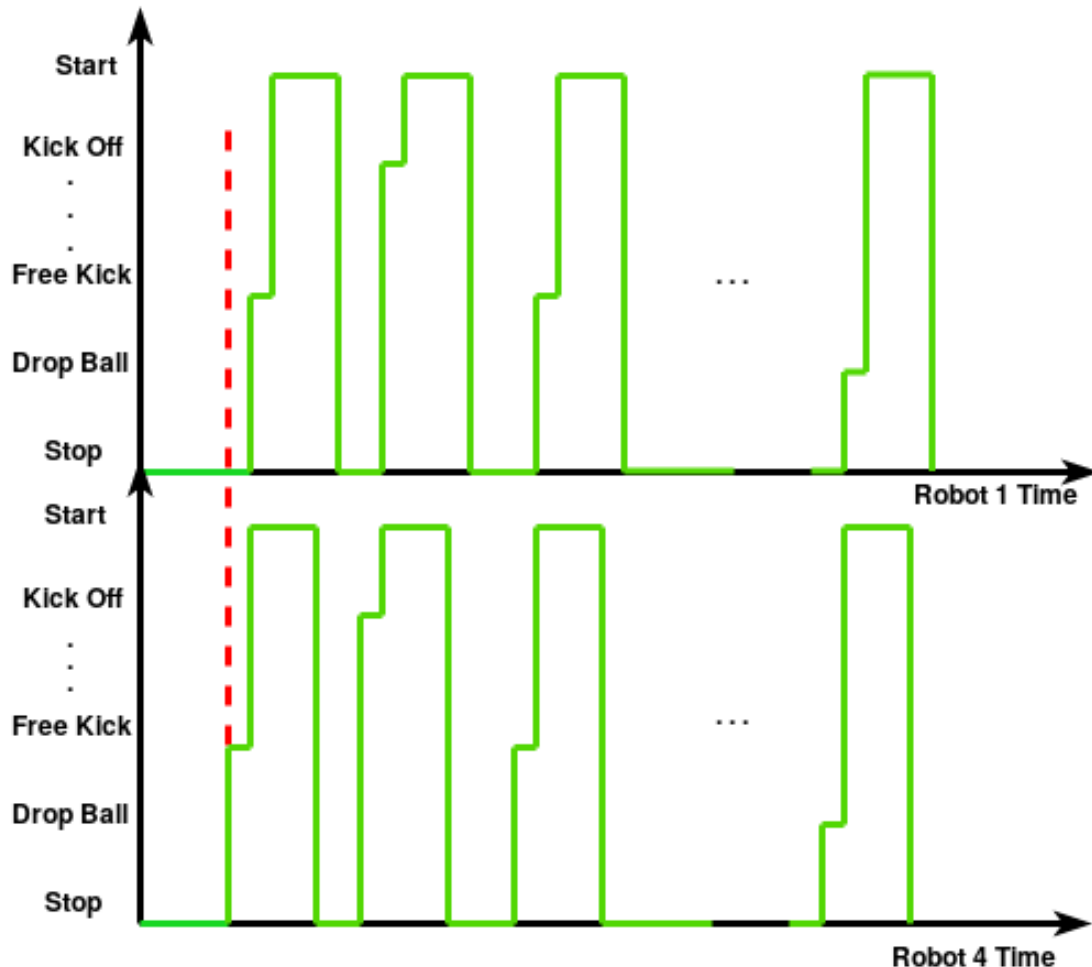
- Gather all possible piece of data, in an off-line state, by downloading every agent CameLog files to a server
- Time synchronize all data among agents
- Register synchronized outcome in large data bases
- Pos-process gathered data



- **Approach:**

1. Clock synchronization among all agents using NTP or Chrony over WiFi using the basestation as NTP server
2. Record timestamped “*game status evolution*” on every agent and post synchronize data among them

- Solution 2 (e.g. for two agents):



- Using one agent as global reference, all “game status evolution” functions are cross-correlated.
- Best correlation output will provide a time offset for correction and time alignment among all agents data.

- FUTURE WORK:
 - Develop new tools for analysis of gathered data for, e.g.:
 - Debug
 - Game analysis
 - Strategy outcome analysis
 - ...
 - Why not, learning tools for global team strategy, efficient role change, dynamic tactics, ...

- António J. R. Neves, Filipe Amaral, Ricardo Dias, João Silva and Nuno Lau, A New Approach for Dynamic Strategic Positioning in RoboCup Middle-Size League, Progress in Artificial Intelligence: 17th Portuguese Conference on Artificial Intelligence, EPIA 2015, Coimbra, Portugal, September 8-11, 2015. Proceedings, Springer International Publishing, 433-444, 2015
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- Joao Cunha, Rui Serra, Nuno Lau, Luis Seabra Lopes, Antonio J. R. Neves, Learning robotic soccer controllers with the Q-Batch update-rule, 2014 IEEE International Conference on Autonomous Robot Systems and Competitions (ICARSC), Espinho, Portugal, p. 134-139, May 2014.
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- Joao Silva, Nuno Lau, Antonio J.R. Neves, Joao Rodrigues, Jose Luis Azevedo, World modeling on an MSL robotic soccer team, Mechatronics, Vol. 21, Issue 2, Special Issue on Advances in intelligent robot design for the Robocup Middle Size League, pp. 411-422, Elsevier, March 2011, ISSN 0957-4158, DOI:10.1016/j.mechatronics.2010.05.011
- Nuno Lau, Luis Seabra Lopes, Gustavo Corrente, Nelson Filipe, Ricardo Sequeira, Robot team coordination using dynamic role and positioning assignment and role based setplays, Mechatronics, Elsevier, vol. 21, no. 2, p. 445-454, March 2011.



Thanks for your attention!



/cambadamsl



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<https://robotica.ua.pt>



Print4fun3D



SKF



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