FCPortugal

Recent Scientific Contributions

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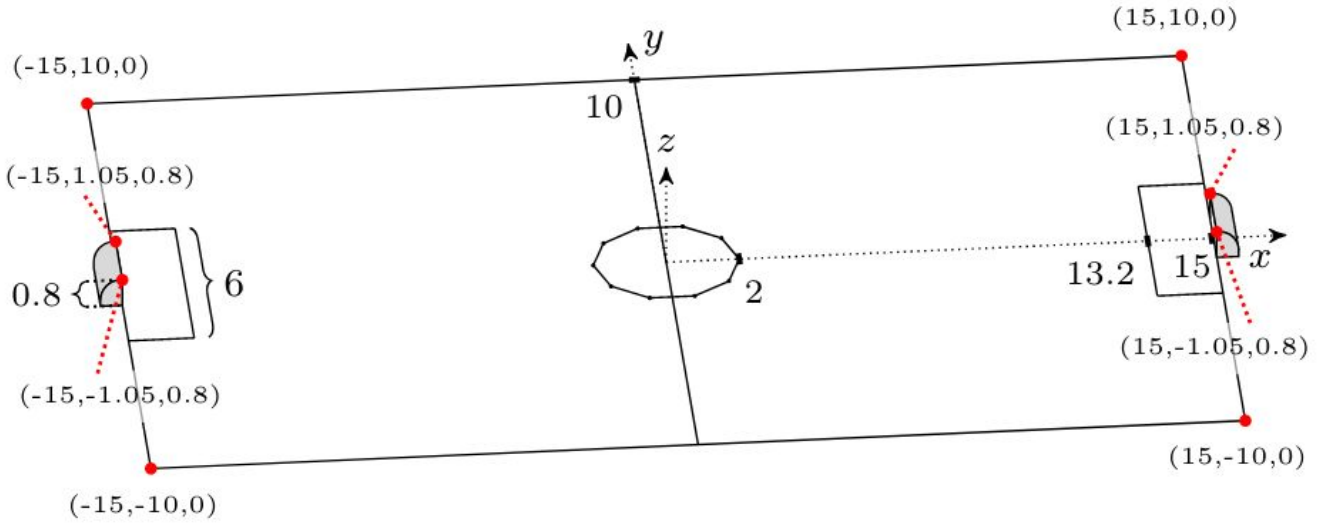
Agenda

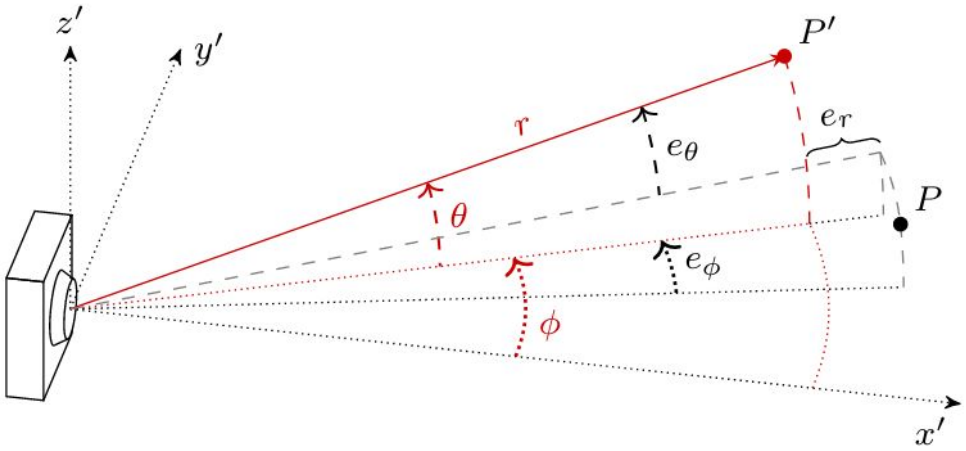
- Self-Localization
- FCP Gym
- Kick in Motion
  - Omnidirectional walk and kick
  - Sprint and kick
- Goalkeeper unified behavior
- Improved Visualization
- Conclusion

Self-Localization

Self-Localization



Self-Localization - Noise



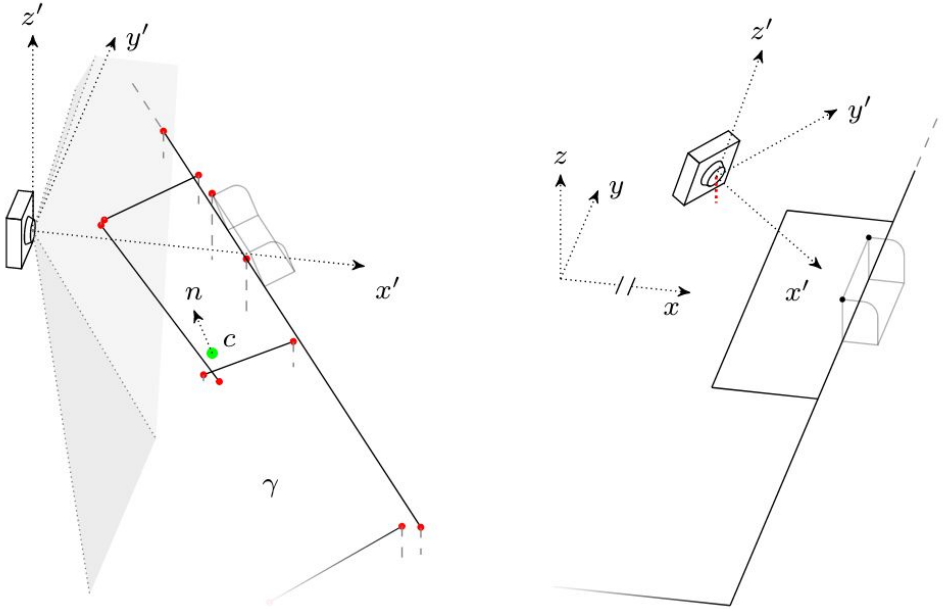
$e_x = [-0.005, 0.005]$ $\quad e_r \sim N(\mu_r, \sigma_r^2),$ $\quad \mu_r = 0,$ $\quad \sigma_r = r \times 9.65 \times 10^{-4}$

$e_y = [-0.005, 0.005]$ $\quad e_\theta \sim N(\mu_\theta, \sigma_\theta^2),$ $\quad \mu_\theta = 0,$ $\quad \sigma_\theta = 0.1480$

$e_z = [-0.005, 0.005]$ $\quad e_\varphi \sim N(\mu_\varphi, \sigma_\varphi^2),$ $\quad \mu_\varphi = 0,$ $\quad \sigma_\varphi = 0.1225$

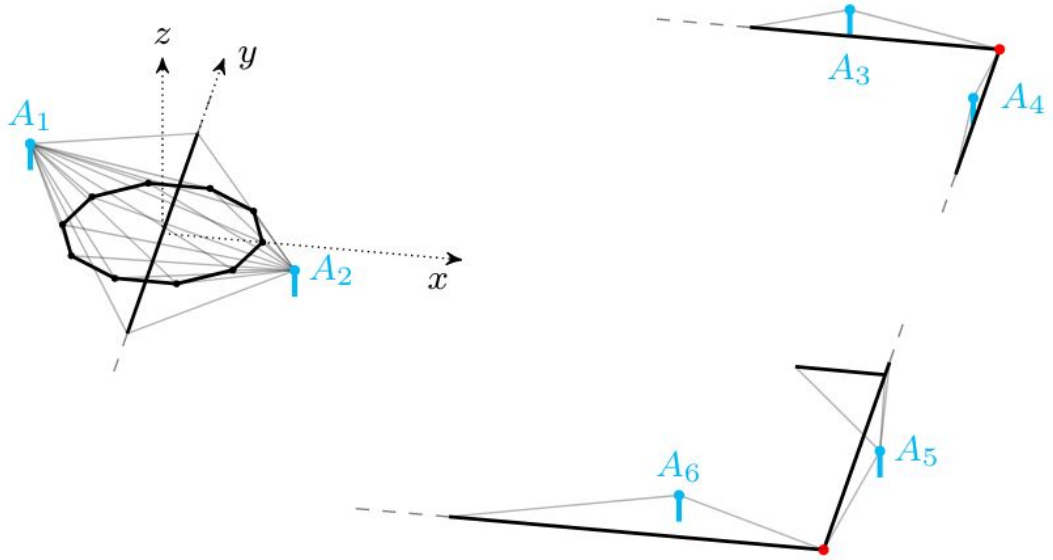
Rounding Error:
$e \sim U(-0.005, 0.005)$

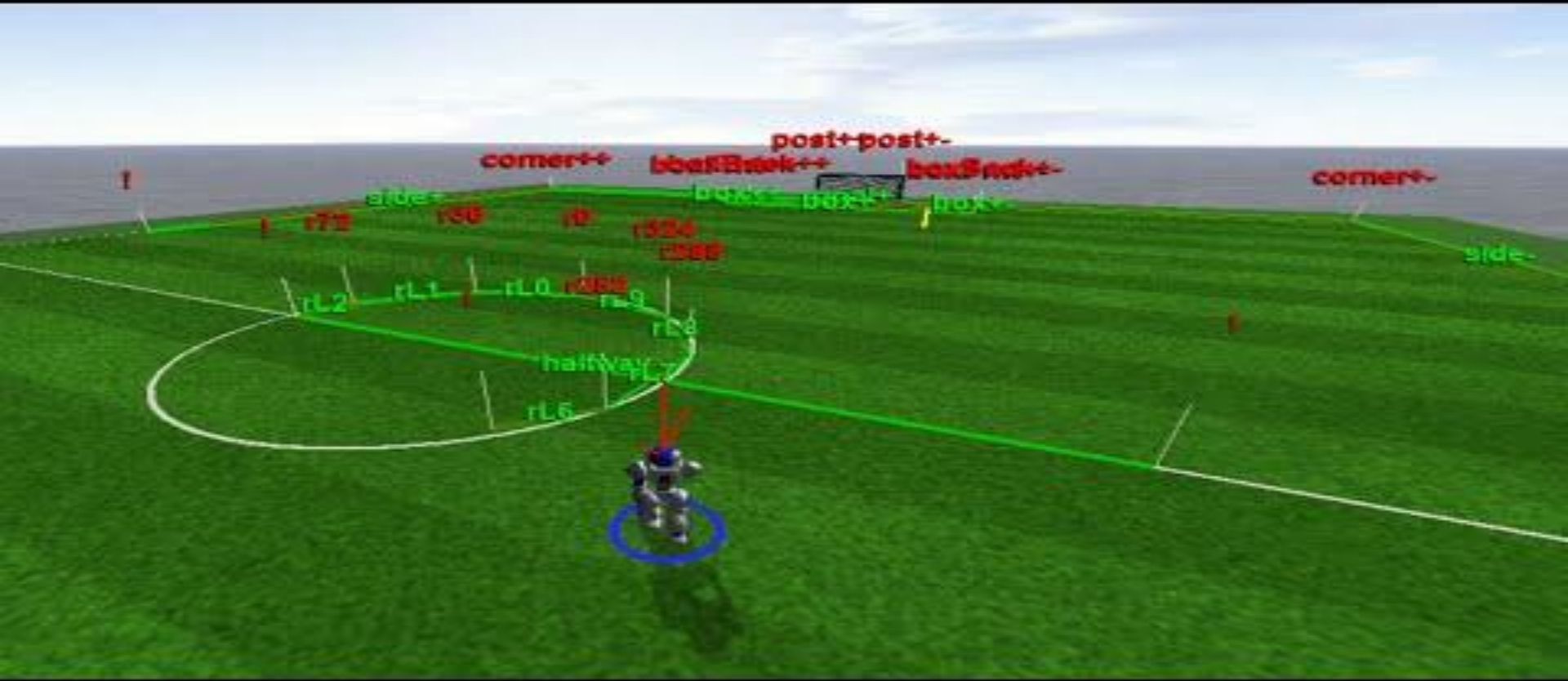
Self-Localization - Mapping Perspectives



Self-Localization - Mapping Issues

Ambiguous locations when no static markers are visible




post++post+-
corner++
goalBack++
goalBack+-
corner+-
side+
side-
rB
rL2
rL1
rL0
rL6

Self-Localization

	2D Mean Abs. Error (MAE)		3D Mean Abs. Error (MAE)	
	Before	After	Before	After
Agent Position	39mm	5mm	262mm	6mm
Ball Position	52mm	28mm	85mm	39mm

FCP Gym

FCP Gym

- Compliant with OpenAI Gym's API.
- Built on top of our codebase, so we can use our agent code when training models (e.g. kicks, walking engines, strategies, etc...)
- Sharing training environments and implementing trained models into production is straightforward.
- Compiles into a shared library, so sharing and setting up the framework itself is also easy.

Kick in Motion

Based on omnidirectional walking skill

Kick in motion

- Current kicks were very slow, requiring precise positioning and long preparations.
- Training was conducted using **S**oft **A**ctor **C**ritic, an Entropy-Regularized RL algorithm.
- Requires very little hyperparameter tuning.
- Based on the Stable-Baselines 3 implementation.

$$J(\pi) = \mathbb{E}_{\pi}\left[\sum_{t} r(s_t, a_t) + \alpha H(\pi(\cdot|s_t))\right]$$

Kick in motion (results)

Distance (m)	Percentage (%)	Mean (m)	Std. Deviation (m)
< 1 (failure)	5.4	N/A	N/A
< 3	9.6	2.20	0.52
< 5	21.8	4.29	0.56
>= 5	63.2	6.28	0.89

Results measured over 1,000 episodes.


localhost - RoboViz 1.6.1
FCPortugal 0:0 <Right> 00:48
FCPortugal : 1
<Right> : 0


localhost - RoboViz 1.6.1
Connection Server View Capture
FCPortugal 0:0 <Right> 15:06
Playmode: PlayOn Server Speed: 100%
FCPortugal : 1
<Right> : 0

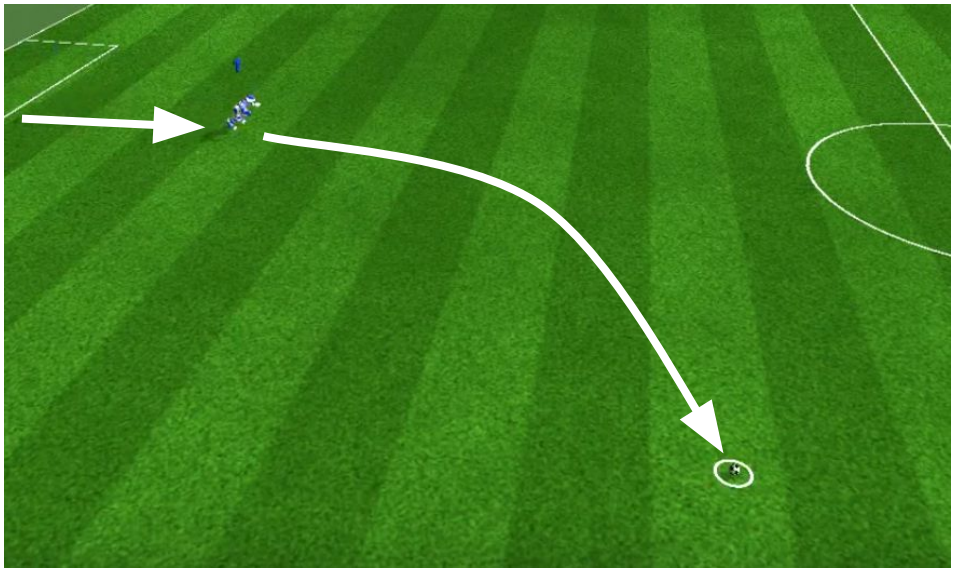
Kick in Motion

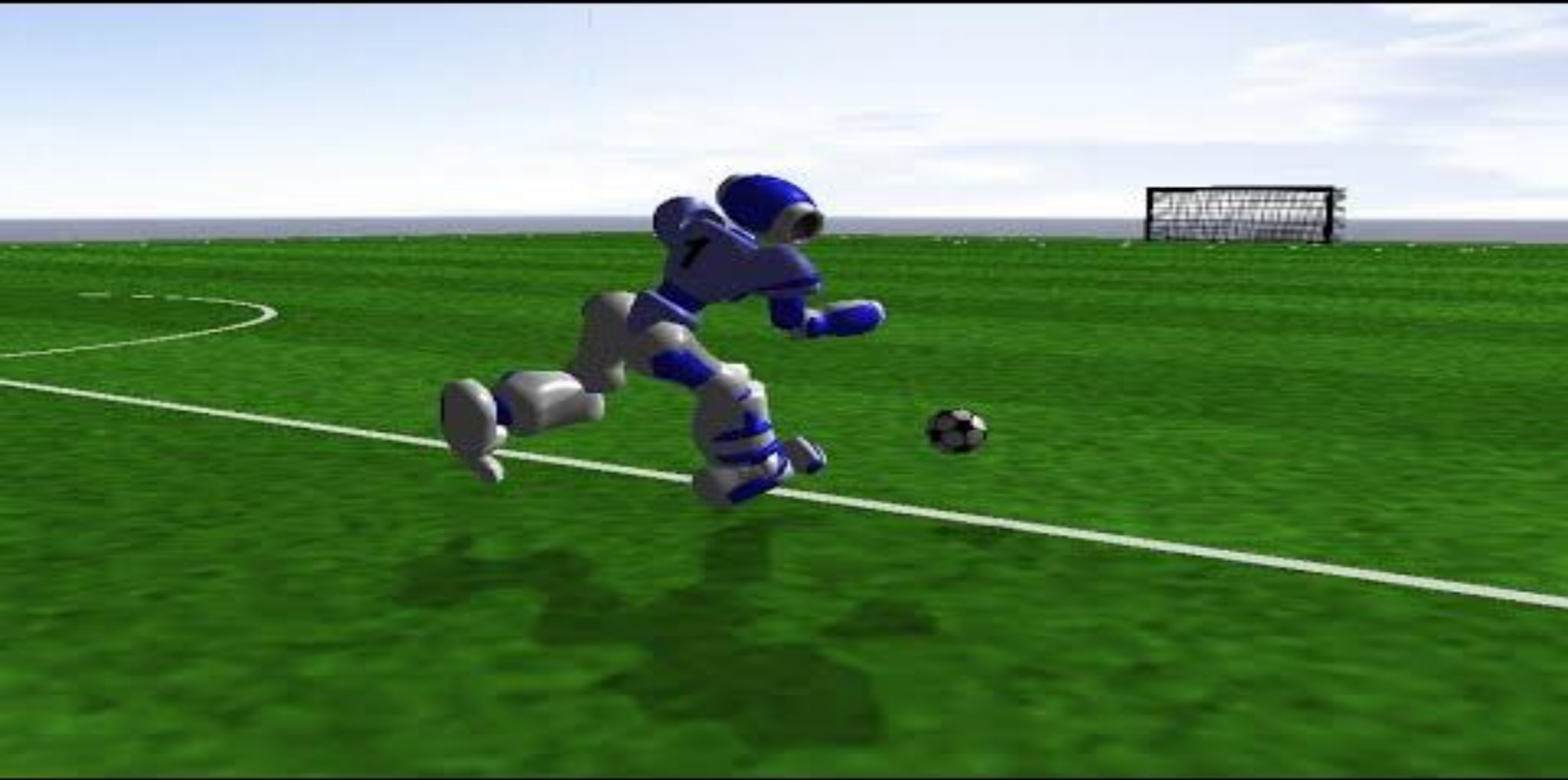
Based on sprint skill

Sprint and Kick

Composite behavior:

- Straightforward sprint
- Rotation
- Kick





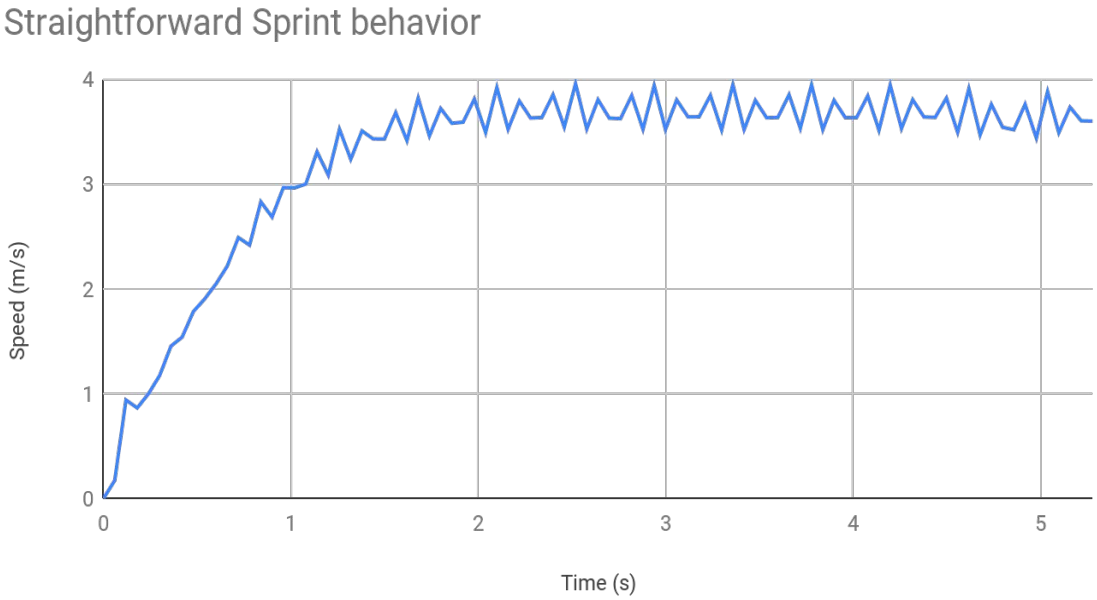
Sprint and Kick

Robot Type 4:

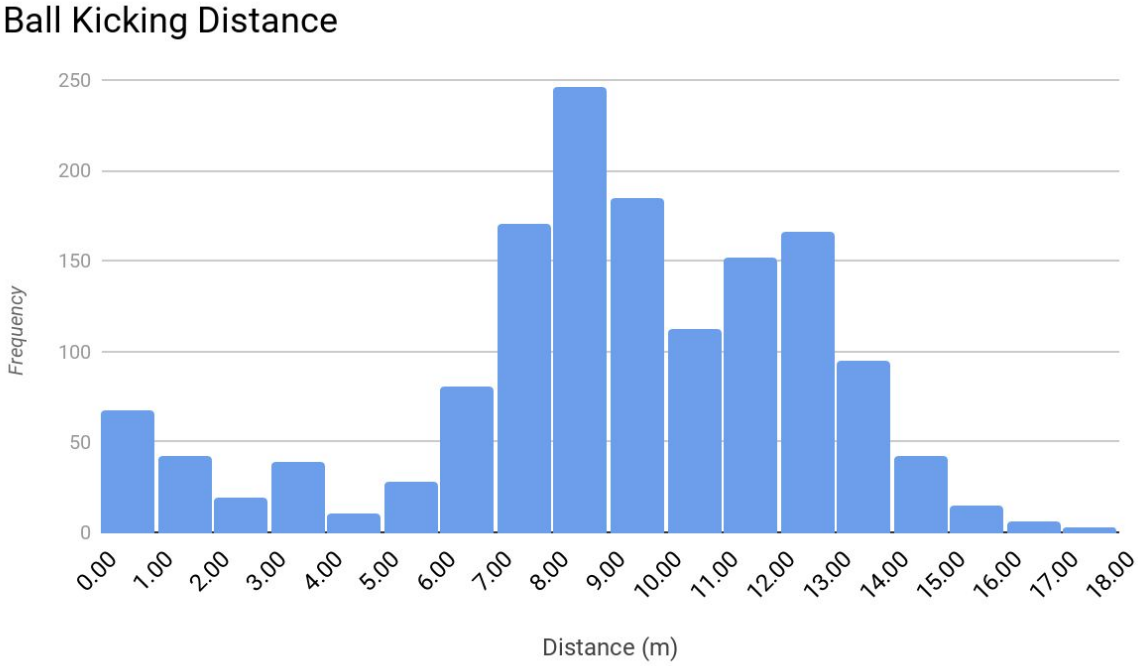
	Max. Speed	Turning Radius
Straightforward Sprint	3.69m/s	-
Rotation	3.44m/s	6.02m

	Avg. Ball kicking distance
Kick	9.07m

Sprint and Kick



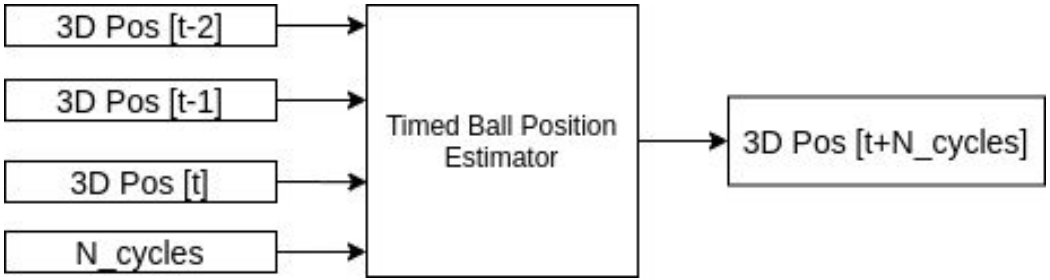
Sprint and Kick



Goalkeeper unified behavior

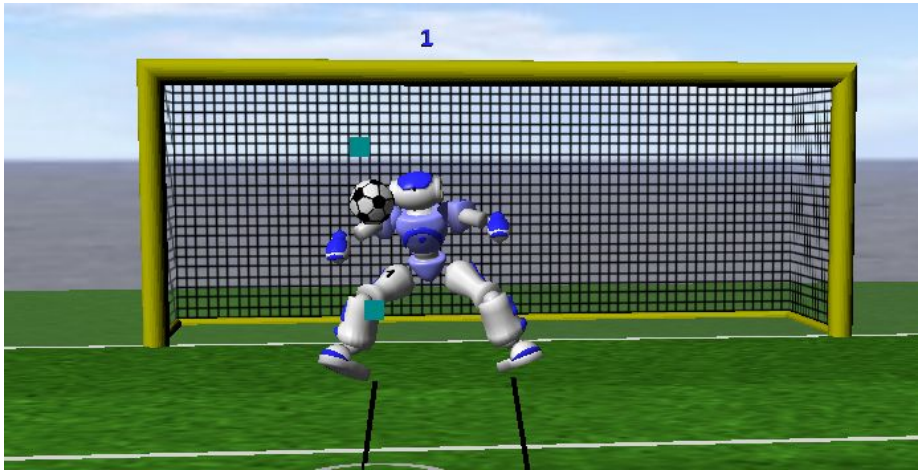
Ball Estimator

- The current ball estimator could not estimate heights and did not handle noisy positions in an appropriate way.
- The new estimator was developed based on a supervised learning approach: Neural Networks with 2 fully-connected hidden layers and ReLU activation.
- More ball positions in the input reduce the noise impact.



Goalkeeper save behavior

- Generic behavior, capable of saving diverse shots.
- Deep Reinforcement Learning approach: PPO algorithm (used the PPO2 implementation from Stable-Baselines2).
- NAO robot type 3: longest legs and arms and wider hip.



Improved Visualization

Improved Visualization

Dangerous plays have dynamic camera emphasis

Improved Visualization

Foul count trigger on close contact caught on camera and shot angle

Improved Visualization

Possession graph and camera follow

Conclusion

- Realistic Simulation
  - Immersive Simulation / Realistic Broadcast
- Self-Localization and Orientation
  - Agent position: ~8x less error (2D) ~41x less error (3D)
  - Ball position: ~2x less error (2D/3D)
- FCP Gym
  - Skill optimization is abstracted from implementation details
- Kick in Motion
  - Mitigates preparation time
  - Improves competitiveness and game fluidity
- Goalkeeper unified behavior
  - Generalized behavior
  - Seamless transitions

Questions?

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