Deep Reinforcement Multi-Directional Kick-Learning of a Simulated Robot with Toes

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Deep Reinforcement Learning has gained increasing interest in robotics and was first introduced into the simspark domain with the work of Abreu et al. [1] to learn a walking or rather running behavior using Proximal Policy Optimization (PPO) and was improved uppon in later work [2]. We apply this approach to the kick task using a toed robot and show that compared to an exisiting kick learned with genetic algorithms [3], the new kick improves the reliability with respect to kickable area and avoidance of falls.

We further show that a toed robot outperforms a robot without toes on long kick distances which is of higher value for game playing.

In addition we extend the observation space as inspired by [1] with desired distance and direction as input to the deep network. This so learned *multi-directional kick* allows for precise ball passing in varying gameplay situations and can be seamlessly integrated into soccer games resulting in faster, more natural and overall better gameplay. The improvement in gameplay was shown in a series of 200 games of two identical teams of eleven robots where the team using the new kick without parametrization (i.e. a straight kick) scored an average of 0.656 goals compared to 0.385 goals of the team using the old kick learned using genetic algorithms. In another series of 200 games the team using the new multi-directional kick outperformed (0.695 goals vs. 0.460 goals on average) the other team that was using the new kick without parametrization.

References

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2. Melo L and Maximo M (2019). Learning Humanoid Robot Running Skills through Proximal Policy Optimization. arXiv:1910.10620.
3. Dorer K (2017). Learning to Use Toes in a Humanoid Robot. In Akiyama H, Obst O, Sammut C, Tonidandel F: RoboCup 2017: Robot World Cup XXI, Nagoya, Japan, Springer Verlag.

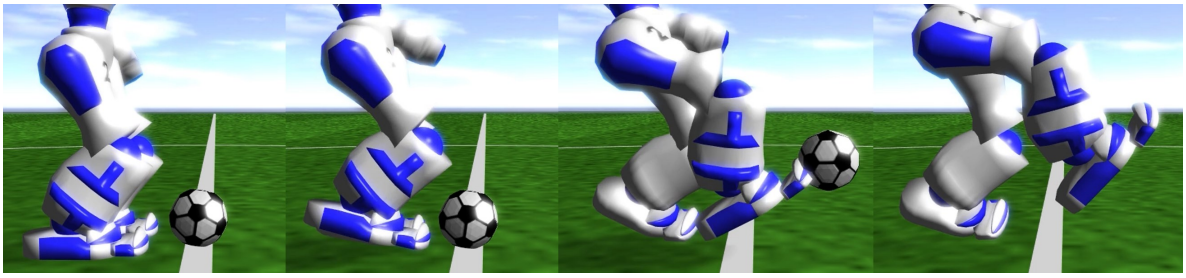

Fig. 1. Visualization of the kick phases of a straight kick.