Learning a Humanoid Kick For Different Ball positions with Respect to the Robot

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Abstract. We investigate the learning of a flexible humanoid robot kick controller such that the controller may be applicable for different (close enough) ball position with respect to the robot torso once robot decides to kick the ball. The goal is to find a parametric function that given a ball position, with respect to the robot torso, outputs the (near) optimal kick controller parameters.

1 Problem Statement

We want that, when robot is close enough to the ball and decides to kick the ball, it reads the relative position of the ball (X, Y) with respect to its torso and after that it sets the parameters $\boldsymbol{\theta}$ of our kick controller such that it kicks the ball as far as possible in a direct line with respect to its torso.

2 Our Method

We have a parametrized kick controller with parameters $\boldsymbol{\theta}$ and we also have stability module that stabilize the robot during performing the kick movement(see [1] for more information). Our goal is to find a function in form of $\mu(\boldsymbol{s}) = \boldsymbol{A}^T\varphi(\boldsymbol{s})$, that given a context vector $\boldsymbol{s}$ with dimension d_s, outputs a optimal parameter vector $\boldsymbol{\theta}$ with dimension $d_{\boldsymbol{\theta}}$ such that it maximise our objective function $R(\boldsymbol{\theta}, \boldsymbol{s}) : \{\mathbb{R}^{d_s}, \mathbb{R}^{d_{\boldsymbol{\theta}}}\} \rightarrow \mathbb{R}$. Where $\varphi(\boldsymbol{s})$ is an arbitrary feature function of context $\boldsymbol{s}$ that outputs a feature vector with dimension d_φ and the gain matrix A_π is a $d_{\boldsymbol{\theta}} \times d_\varphi$ matrix. Typically $\varphi(\boldsymbol{s}) = [1 \ \boldsymbol{s}]$, which results in linear generalization over contexts. In our problem context vector $\boldsymbol{s}$ is a 2 dimensional vector which is the position (X, Y) of the ball with respect to the robot torso. Our objective function is the distance that ball travels with respect to the robot torso. Now the task is to learn the optimal gain matrix A such that robot kick the ball as far as possible for any given ball position (X, Y). As we don't have the labelled data to fit A, we need to use a reinforcement learning method. In order to do that we use the same method as we used in our previous research where we could learn a controller for different distances [1]. We will show that using our proposed learning algorithm in [1] robot learns to kick the ball with average of 12 meters for different positions of the ball with respect to the robot.

References

1. Abbas Abdolmaleki, David Simoes, Nuno Lau, Luis Paulo Reis, and Gerhard Neumann. Learning a humanoid kick with controlled distance. In *RoboCup International Symposium 2016: Robot World Cup XVIII*. Springer, 2016.