Online Generated Kick Motions for the NAO Balanced Using Inverse Dynamics

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Abstract. One of the major tasks of playing soccer is kicking the ball. Executing such complex motions is often solved by interpolating key-frames of the entire motion or by using predefined trajectories of the limbs of the soccer robot. In this paper we present a method to generate the trajectory of the kick foot online and to move the rest of the robot's body such that it is dynamically balanced. To estimate the balance of the robot, its Zero-Moment Point (ZMP) is calculated from its movement using the solution of the Inverse Dynamics. To move the ZMP, we use either a Linear Quadratic Regulator on the local linearization of the ZMP or the Cart-Table Preview Controller and compare their performances.

1 Introduction

To play humanoid soccer, two essential motion tasks have to be carried out: walking over a soccer field and kicking the ball. Both motions have to be both flexible and robust, i.e. the robot has to be able to walk in different directions at different speeds and kick the ball in different directions with different strengths, all while maintaining its balance to prevent falling over.

To design and execute motions to kick the ball, different methods have been developed. A seemingly obvious approach to motion design is to manually set up some configurations, i.e. sets of joint angles called key-frames, which the robot shall assume during the motion, and then interpolate between these key-frames while the motion is executed. This quite popular method has been used to design kick motions by a number of RoboCup Standard Platform League (SPL) teams including B-Human [12] and Nao Team HTWK [13].

Because it completely determines the robot's motion, the interpolation between fixed sets of joint angles precludes any reaction to changing demands or to external disturbances. Therefore, Czarnetzki *et al.* [3] specify key-frames of the motion of the robot's limbs in Cartesian space instead of joint space. This leaves the movement of the robot under-determined, so the Cartesian key-frame approach can be combined with a controller to maintain balance.