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A novel ball handling mechanism for the RoboCup middle size league

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ABSTRACT

This paper presents the hardware design and control design of a novel ball handling mechanism in the RoboCup Middle Size League used by team Tech United Eindhoven. The ball handling mechanism consist of two levers with two actively driven wheels attached to it, to exert forces on the ball in order to control its position relative to the robot. The proposed design is fully compliant to the rules and regulations imposed by the RoboCup Middle Size League community. The control design consists of a cascaded velocity and position feedback loop in combination with a feedforward controller which compensates for the robots ego motion. The proposed design is validated on a robot used by the Tech United Eindhoven team.

1. Introduction

This article presents a novel ball handling approach for the RoboCup [5] Middle Size League (MSL). In the MSL, where a team of autonomous robots play soccer, it is crucial to have a good ball handling during dribbling motion in order to maneuver fast through the defense of the opponents. Regarding ball manipulation the rules and regulations of the middle size RoboCup league [6] state that:

- The convex hull of the robot may enclose the ball only for one-third of the ball diameter. During catching of the ball it may enclose half the diameter of the ball.
- The ball should rotate in its natural direction of rotation.
- Mechanical devices for ball manipulation, which in this work are referred to as ball handling mechanisms, are allowed provided that they are safe.

Obviously, the goal of ball handling mechanisms is to catch the ball and keep it during a dribbling motion of the robot, while satisfying the rules mentioned above.

Several methods for ball manipulation have been reported, e.g. [9,3]. Many of the methods rely on passive systems in which the ball handling problem is shifted to a trajectory planning problem. In such systems only pushing forces can be exerted on the ball with a component pointing away from the robot. To slow down the ball the robot has to rotate 180° around the vertical axis of the ball, which constraint is included in the trajectory planning. The other type of existing methods use active open-loop mechanisms in which wheels or rollers spin backward in order to pull the ball towards the robot [3]. However, due to small variations in the friction between ball and field, the ball is prone to spinning backward or lying still during a forward movement. Touch sensitive ball handling is investigated in [15], where a combination of four sensors is implemented to give the robot the opportunity to have force and position feedback with respect to the ball. The closed-loop control is still under investigation to improve the ball handling. Future work of [15] will focus on using the force and position measurements to adjust the path planning. However, no results have been presented yet. In [14] a ball handling design is described in which two wheels are used to actively exert forces onto the ball. The control architecture of [14] has two levels. On the low level the velocities of the wheels are controlled. At the high level a supervisory loop is implemented to determine whether or not the ball handling system needs to be activated such that the wheels are driven to match the velocity of the robot. However, there is no position measurement of the ball relative to the robot present to determine if the wheels are actuated correctly. When the ball has a slightly different radius for example the ball might spin backward and/or lies still during movements, which is against the prescribed rules and regulations.

The goal of this work is to present the mechatronic design approach of a novel active ball handling mechanism. The combination of the constructive hardware design and the motion control design have led to a multidisciplinary mechatronic concept which effectively solves the ball handling control problem. The novelty of the design lies in the fact that the presented active ball handling mechanism is closed-loop controlled in a sense that it controls the distance between the ball and the robot. The proposed design is superior to the commonly used ones for multiple reasons. First of all, it creates the opportunity to drive *backwards* while still possessing the ball. Secondly, during a kick the ball can be pulled

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