Rhoban Football Club – Extended abstract
Humanoid Kid-Size League, Robocup 2023 France

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Abstract. This paper presents some of the experience acquired by Rhoban during RoboCup 2022, some of the modifications made since and our future plans. It focuses on three points: image recognition using yolo, changes on the robot hardware and a rework on walk.

1 Introduction

Team Rhoban FC has been involved in RoboCup since 2011. It has won the KidSize league four times and finishes second last year.

In this document, we present the following elements: image recognition using yolo, the changes we made on the hardware of the robot, rework on the walk using reinforcement learning and model predictiv control.

2 Image recognition with Yolo

We continued the development of a solution based on the HTC Vive. Indeed, we improved the automatic pre-labelling using a Vive Tracker set on the head of the robot. Yolo V5 [3], a new algorithm of object detection , was implemented in order to compute the weights of the new neural network. To be trained, it uses the pre-labelled images given by the HTC Vive process or by a previous neural network. To be sure that there is no error, a human checking is still required. He quickly verifies pre-labelled frames and can edit them with Label Studio[2], an open source data labeling tool. On a pratical point of view, running Yolo in real-time require computation power thus we use OpenVINO [1] to take advantage of our hardware.

3 Changes in the robot hardware

As most kid size teams, our robots use Robotis Dynamixel. We experiment a lot of failures like gear toth breaking with these motors (mostly with MX106 on legs) due to extensive conditions of walking, shooting and falling. To reduce stress on motor, we design an aluminum cover in replacement of original plastic cover of the motor and we use a classical stack of thrust bearing, ball bearing, thrust bearing to manage the free rotation part (see drawing). The purpose of such upgrade is to stiffen the structure such that efforts on the motor axis are exclusively radial. This result in a novel mechanical design of Sigmaban named MetaBan.

In addition, we also rework hip yaw linkage as the motor in charge of this DOF is particularly exposed to axial forces. The design involves an axis held by bearing, rotation is ensured by steel keys.

4 Robot walk algorithm

During the previous RoboCup editions, the trajectories followed by the feet and the trunk of the robot during the walk were successions of (cubic) task-space splines, crafted programmatically from the target footstep to take and multiple hand-tuned parameters. We then used analytical inverse kinematics model of the legs to produce joint-space targets to be followed by the actuators. This approach, even if leading to a robust walk in practice, has several shortcomings. Mostly, the fact that we don't use any kind of planning and can't control the center of mass of the robot, makes it necessary to fine tune many parameters to ensure the robot stability. We are currently working on a new architecture for the walk algorithm, relying on three phases:

1. **Footstep planning:** we first plan the location of the footsteps, depending on the robot current objectives. To tackle this problem, we developed a method based on deep reinforcement learning, which was already deployed in RoboCup 2019.
2. **Center of mass trajectory planning:** we formulate a linear MPC problem to plan a minimum jerk trajectory for the center of mass, subject to constraints on the LIPM-based ZMP approximation that should remain in support polygons.
3. **Whole body control:** based on those trajectories, we then use a whole-body inverse kinematics hierarchical controller, based on the formulation of a QP (Quadratic Programming) optimization problem to produce joint-space trajectories from task-space specifications subject to inequality constraints such as the joint position and velocity limits.

References

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