WF Wolves – Humanoid KidSize System Description Paper for RoboCup 2023

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Abstract. In this system description paper, the currently used algorithms are described. Additionally, the fields of research, the developed software and future work are illustrated. Hereby WF Wolves apply for participation at the RoboCup 2023 for **Team Competition** in Bordeaux, France.

1 Introduction

Since we weren't able to participate in lasts years RoboCup, we continued working on our old monolithic walker and servo control loop. Further we took the chance to use state-of-the-art walking algorithms (see Walking) without having the pressure to stay competitive in last years RoboCup, allowing for a more in depth and fundamental adjustment.

2 Software Description

Since 2016 the WF Wolves are using the Robot Operating System (ROS)[1] based framework for our software architecture. In 2017, the framework was revised together with the Hamburg Bit-Bots to strengthen a team spreading cooperation. This modularity of the framework which enables code exchanges in an easier way among the teams is also one of the biggest advantages. Since ROS is used by more and more teams each year in RoboCup, it is easier to exchange software modules [3]. Since parts of our software stack was heavily relying on legacy code we adapted our software closer to ROS standards and had the chance test and evaluate new algorithms.

2.1 Walking

Our old Walker consisted of basic walking loops using inverse kinematics, supported by a PID-controllers it was unstable and inflexible to change. While refactoring our outdated walking and body routines into a ROS-conform state, we decided to overhaul our core walking algorithms as well. We introduced Central

[1] https://ros.org/

Pattern Generators (CPGs) [15,9,2] as basis for our walking. CPGs use a natural approach found in biology in essential neuronal cells. Further, these neurons create a pattern that is usually applied subconsciously and is used for motions, e.g. walking, flying, or swimming. These patterns are found in birds, fish, mammals, or humans and range from simple, to complex states. Patterns are created via a Hopf Oscillator including ordinary differtial equations (ODE). Further, a phase shift is implemented, to achieve alternating leg movement. Subsequently, our developed kick motion generator [10] was ported, allowing the robots to kick in nearly every direction depending on the ball position. Utilizing vector calculus, the kick-engine calculates required movements in real time in every direction.

2.2 Vision

Since 2017 we are working with Tensorflow [1] and neural networks like AlexNet [11] to detect balls [7], later approaches for field lines and goal posts were added, but have to be improved. For classification, the Bit-Bots Imagetagger is used [6]. While currently using MobileNet[8,16] as good performing solution, evaluations with other CNNs like YOLO [17] are currently in development and have to be decided on premise. All in all the built-in Jetson improves ball classification and calculation time by a lot, rendering classical computer visual approaches, as well as previously used cascade classifiers obsolete.

2.3 Localization

Since first approaches using a visual compass weren't as robust and were computationally intense, further difficulty increased by adding natural light scenarios last year. With the introduction of natural light, existing reflections on the artificial grass appeared. Adaptions in current implementations to determine correct field colors and detect field-lines for basic localization were made.
While trying to emphasize ROS capabilites we developed early prototypes using Monte Carlo based localization. Since this approach normally relies on odometry and laser scan data, we extended these approaches to fit with visual features feedback e.g. lines [12]. Different features, could be used as well, but weren't evaluated yet and neglected to further improve a stable base. Moreover this approach can be further improved due to the lack of a sufficient odometry. Using load cells will lead to better odometry but it's still not certain if the will be implemented until this years competition.

2.4 Team Communication

The team communication is solved via the official Mixed Team Communication protocol (MiteCom) [2]. While we use it to transfer basic information and use it for simple error correction, not much tactical gameplay is embraced yet.

[2] https://github.com/RoboCup-Humanoid-TC/mitecom

2.5 Behavior

Our robot behavior is based on a state machine using FlexBE [3]. The role of the robot is configurable, therefore actions are dependent on the current role and situation. Current existing roles are striker and goalie, while defender behavior is still in development. FlexBE allows us to design complex robot workflows also used in DARPA and ARGOS challenges. Thus we are able to build, analyze and adapt our robot behavior more easily, while mainting ROS standards and lowering the entry barrier for new members of the team.

3 Contributions to the RoboCup community

Since our team mostly consists of students, publications mostly rely on theses. Early work included walking of robots including a dynamic kick engine allowing for a target direction to kick without having to rotate behind the ball and kicking forward. [10] Further early localization utilizing the ROS Framework approaches were evaluated [12] as well as the use and benefits of security enhanced ROS (SROS) [4] and early ROS2 in [13]. We further improved our Robot control in [14].
Besides student theses a close interaction with the Hamburg Bit-Bots [5] exists. We helped designing a common ROS architecture for the Humanoid League resulting in a master thesis [3]. Combined knowledge was used to test new hardware e.g. Jetson and implement CNNs for Ball Detections [7]. Subsequently, due to the similarity in hardware, we participated as a joint team in RoboCup 2018 [5] & 2019 [4] to more easily evaluate different software approaches.

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[3] https://github.com/FlexBE/flexbe_behavior_engine
[4] https://wiki.ros.org/SROS
[5] https://robocup.informatik.uni-hamburg.de/en/

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