WF Wolves & Taura Bots – Humanoid Kid Size Team Description for RoboCup 2016

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Abstract. This paper describes the joint team WF Wolves & Taura Bots, their robots and current research status. The robot hardware is specified in detail, separating out the mechanical platforms from the electrical systems. Also the fields of research, the developed software and planned revisions are illustrated. Hereby WF Wolves & Taura Bots applies for participation at the RoboCup 2016 competition in Leipzig.

1 Introduction

WF Wolves & Taura Bots is a joined RoboCup Soccer Team founded in 2014. The team integrates WF Wolves from Germany and Taura Bots from Brazil. While WF Wolves have some years of experience in RoboCup competitions, Taura Bots is a more recently formed team that started participation in RoboCup from 2015 in collaboration with the WF Wolves. WF Wolves won the world championship in the Mixed Reality League twice. In Humanoid League they modified their robot platform over the years. Since 2013 they use a DARwIn-OP based platform and a new software framework. With the new hardware and software they won the German Open 2013 and in their Kid Size team got a good ranking in world championship in Eindhoven. There they had some Brazilian supporters, who founded the team Taura Bots afterwards. With this new team the mixed team WF Wolves & Taura Bots was formed and lined up first in Hefei 2015. Together they want to concentrate manpower at the research of humanoid robots.

2 Research Overview

2.1 Robustness

The artificial grass was more challenging than expected in 2015. Therefore, the stabilization of our robots was not convincing in the last competitions. For this reason we focused on improving the robustness of walking and kicking. On the one hand we tested cleats for the feet of the robots to get more grip. On the other hand we improved the sequences and the closed-loop controllers. Thereby we could reduce the falls during the kick motions and stabilize the walking. Furthermore, we have plans for weight cells in the feet to get more information of the effective forces. It was developed a walking algorithm based on Capture Step also.

2.2 New Bodyboard

Our team is developing a new Bodyboard for all real time tasks: Controlling the servo motors, reading sensor data and execution of closed-loop controllers. A developer board with an ARM processor is the basis and is connected to an own created shield board. This includes voltage regulators, user interfaces and servo connectors. The first prototypes were build and tested, but showed some improvement opportunities. Our software was adapted to the new hardware and works properly. We expect to use these new boards for the next competitions.

2.3 Stereo Vision

In addition to the standard mono vision approaches, we tested the Bumblebee stereo camera. The detection rate, distance estimation and processing times were compared to the standard approach. [7]

3 Mechanical Hardware

3.1 Da-v1n

The mechanical platform of our small robots is based on the DARwIn-OP, but the design was changed to fit our custom electronic components. The aluminum parts were built in our university's mechanical workshop, Dynamixel RX-28 and MX-28 are used as servo motors.

3.2 Detlef

We have constructed a bigger robot based on the NimbRo-OP which size is valid for the KidSize and the TeenSize. It uses Dynamixel MX-106 in the legs and MX-64 for the arms and head. The aluminum and carbon parts were milled in our university's mechanical workshop. Plastic parts like the head were created with a 3D printer from ABS.

3.3 Series Elastic Actuator

The design of the robot actuators used so far is very static and servos can be destroyed by strong jerks. So we researched actuators that are more elastic and offer advantages in humanoid movements. We tested actuators modified with springs, which could improve walking. [5] [9] [10] [11]

4 Electrical Hardware

The electrical system is custom made and designed specifically for our humanoid robots. Two of the three different boards were particularly designed. A mini PC board with a standard x86 processor is used for high-level control, vision and behavior. Besides the robots have a body board for controlling the servos and generating the movements. For power management and user control our third board is integrated in the system. All the boards are located in the torso of the robots.

4.1 Main Board

For the small robots we use an Intel Atom running at 1.6 or 2.0 GHz as main processor. The mini PC boards have up to 2 GB DDR2 RAM as well as USB 2.0, RS-232 and wireless LAN on board. Our big robots have Intel NUC computers with Core i5 in addition to 4 GB DDR3 RAM, USB 3.0 and wireless LAN.

4.2 Body Board

The core of our body board is an Atmel AT91SAM7 microprocessor which runs at 96 MHz. It controls the movement of the servos and generates motion patterns for walking and kicking or plays prepared key-frame motions, e.g. for getting up. To stabilize the robot the motions can be parameterized by inertial measurement data. The body controller communicates with the main board via an USB connection.

4.3 Inertial Measurement Unit

The body boards are equipped with a 9 degrees of freedom inertial measurement unit consisting of gyroscope, accelerometer and magnetometer each with 3 axis. While gyroscope and accelerometer provide sensor data for stabilizing the motions, the magnetometer is not used.

4.4 Visual Sensor

Up to now we use a Microsoft LifeCam HD-3000 as visual sensor. The camera runs up to a 1280 x 720 resolution at 30 FPS and supplies YCbCr422 format images.

4.5 Power Supply

The power for the robots is supplied by lithium polymer batteries. The small robots have batteries with 3 cells and 2500 mAh, the big robots 4 cells and 5200 mAh. To provide different required voltages, we use a separate board with voltage regulators, which can be powered additionally by an external supply. This board can also switch the power for the servos via transistors, so the servo power can be controlled by the body controller. Additionally, the main board and body board have their own local regulators.

5 Software

5.1 Framework Architecture

Our high-level architecture was inspired by the framework published by the team FUmanoids. It is a blackboard based structure and divides the system into modules and representations. A thread pool is used in combination with a scheduler to automatically determine the module execution order on the basis of the dependencies. More recently we have initiated the design of a ROS based framework.

5.2 Vision

Our vision system is separated into several modules declaring all dependencies and the provided output. In combination with probabilistic algorithms this results in speed optimization [2]. With specific filters and the modularity we achieved a robust object detection with less false detections [3]. Furthermore we work with automated tests in vision validation, which has greatly increased the performance making our vision system well tested and reliably working.

5.3 Behavior and Communication

Our behavior is dynamical and can change its role while playing. Until now we have implemented four fundamental roles: Goal keeper, defender, supporter and striker. Furthermore, we integrated communication between our robots based on the *Mixed team communication protocol* developed by the team FUmanoids [6]. Therefore, the robots can exchange their data and agree on the roles.

5.4 Key-frame Motions

Even though static motions prove to be the inferior control method, some motions are too complex to be easily generated. Our robots therefore use predefined key-frame motions e.g. for goalkeeper motions and getting up.

5.5 Walk Engine

For locomotion, such as walking forward, backwards, sideways and turning, an omnidirectional walk engine is used, calculating the servo positions in real time. This allows controlling the body using high level commands instead of combining a predefined set of key-frame motions. It also allows incorporating sensor data for stabilization. Besides this, it is sufficiently abstract to allow running the same behavior on different robots without the need of sophisticated calibration. [1] The stability was improved with a new closed-loop control based on the IMU data.

5.6 Capture Step

The team also implemented its version of the Capture Step algorithm to walk developed by Missura [12], which makes the robot identifies the position in which to put foot in the act of walking to keep your balance.

5.7 Kick Engine

We use a kick motion generator that was developed by us [4]. This allows the robots to kick in nearly every direction depending on the ball position. With two vectors, one for the current ball and one for the target position, the engine calculates the required movements in real time. For more stabilization a closed-loop control was added and the sequence was improved. [8]

6 Conclusions

Our changes in robot hardware and software provide improvements in comparison with previous year. A better robustness for the motions and upgrades for vision and localization show promise results. WF Wolves & Taura Bots is looking forward to participate in the RoboCup 2016 competition in Leipzig.

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