WF Wolves & Hamburg Bit-Bots Team Description for RoboCup 2018 – Humanoid KidSize –

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Abstract. In this team description paper the joint team WF Wolves & Hamburg Bit-Bots, their robots, and current research status are introduced. With the collaborative work for a standardized software framework for humanoid robots based on a ROS framework, a joint team should show advantages of using this framework. As a new research topic, the Bit-Bots focused on Neural Networks for bio-inspired image processing which was adopted by the WF Wolves. Additionally, the hardware and software of the robots are specified in detail for the robots. Hereby the joint team Bit-Bots and WF Wolves apply for participation at the RoboCup 2018 for **Team Competition** in Montreal, Canada.

1 Introduction

WF Wolves & Hamburg Bit-Bots want to participate as a joint robot team. The team integrates WF Wolves from Germany, Wolfenbüttel and Bit-Bots from Germany, Hamburg. The Hamburg Bit-Bots is supported by the Department of Informatics at the University of Hamburg. They are an independent working group and Bachelor, Master and Ph.D. students are part of the group. Their robot platform Minibot will participate in the KidSize competition, whereas their two new Nimbro-based robots are allowed to participate in KidSize and TeenSize competitions. The WF Wolves are located at the Faculty of Computer Science at the Ostfalia - University of Applied Sciences. Besides computer science students also students from electrical and mechanical engineering are part of the team. Like the Bit-Bots the team is an independent working group, financially supported by the University. While WF Wolves changed to a NimbRo-OP based platform (usable in Kid- and TeenSize) in 2014, they already have some years of experience in TeenSize RoboCup competitions, the Hamburg Bit-Bots concentrate on playing with a self-designed KidSize platform called "Minibot" . Since the WF Wolves robots are also valid for KidSize, we are concentrating on a common framework platform. Together we want to concentrate manpower at the research of humanoid robots. The teams started working together in 2017 building a common ROS framework. At the Iran Open 2017, the teams first participated as a joint team and got the 5th place in the TeenSize competition.

In Hefei (KidSize/TeenSize) and in Leipzig (TeenSize) WF Wolves made the second place in the category Technical Challenge. In 2017 they won the third prize at the German Open, Magdeburg and the second prize in the new category Drop-In Challenge at the RoboCup World Championship in Nagoya, Japan.

Besides, the Hamburg Bit-Bots have some further projects for a better interconnectedness between humanoid robot teams and to support a more general public presence and availability. Since 2014, the Bit-Bots are actively part of the RoboCup Federation supporting the organization of the RoboCup world championship and participating in the enhancement of the rules. For this year, we want to adapt the GameController to support the new rule changes. Apart from that, the annual RoHOW[3] is hosted by us together with another RoboCup Team (SPL league) from Hamburg.

2 Research Overview

This section gives an overview of the focused research topics for the following RoboCup competition.

2.1 Motion Robustness

Although the artificial grass is used for two years now it is still a hard challenge for stabilization and robustness of the robots motions. Therefore we worked on weight cells under the foot plates. Additionally, we introduced a different kind of studs for a better grip on the field and we continued improving the sequences and the closed-loop controllers. With these techniques we achieved less falls during a kick motion and a more stable walk. Besides the WF Wolves have built a robot with a series knee. That fact improves a faster walk and a higher kick range. With those aspects, we improve the robustness of walking and kicking of the robots. The Hamburg Bit-Bots are currently working on using a neural network to learn the gait based on inputs from the new weight cells and the information about the current efforts and positions in the joints.

2.2 Tensorflow & Convolutional Neural Network

Until now we worked with the haar ball finder to localize the field, the ball, and the goal. Because of an expansion of the football field, the problem of detection

[3] Robotics Hamburg Open Workshop, www.rohow.de/en/

over a longer distance occurred. As an advantage, we are working with Tensorflow and a Convolutional Neural Network (CNN) now to recognize all important parts on the field, especially over a longer distance. This is based on our award-winning publication [13]. As already mentioned, the neural networks can also be used for a lot of things, like operating behavior.

2.3 Interteam Collaboration

We researched and developed tools to accelerate the research and ease collaboration. One result is a common ROS interface and a tool set for the Humanoid League [14]. Another tool, called "Imagetagger" was developed to enable collaborative online labeling and exchange of vision training data sets [16]. This is increasingly important since many teams use deep learning in their object recognition and therefore need large amounts of data. Furthermore, it makes it easy to compare different algorithms with each other.

3 Hardware

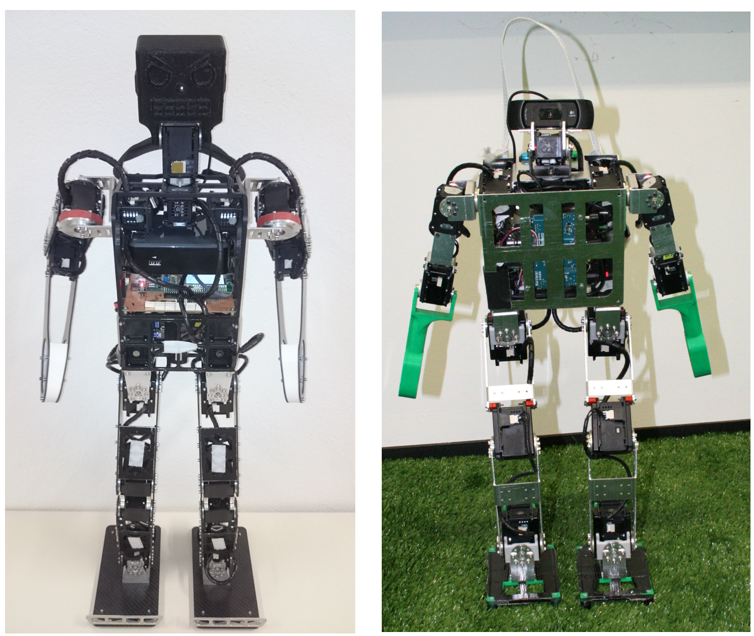

Fig. 1. NimbRo-OP based robot (**left**) and the Minibot (**right**).

3.1 WF Wolves Robots: Detlef & Hans & Gambi

The size of all robots is valid for the TeenSize and KidSize league. They based on the NimbRo-OP platform. In the legs, Dynamixel MX-106 are used. Dynamixel MX-64 are used for the arms and the head. In our university's mechanical workshop we milled the aluminum and carbon parts. With our 3D printer, we can create plastic parts like the head with ABS. Gambi as a refined robot has series knee (see Fig. 3). It is a modified knee with two Dynamixel MX-106 servos in a row. Hans is the robot with weight cells under the foot plates. Every robot has an Intel NUC computer with Core i5 in addition to 4 GB DDR3 RAM, USB 3.0 and wireless LAN. As a new part, we built in a body board from Rhoban, connected to an adaptive shield board. This board also serves power supply for our Jetson boards. The Nvidia Jetson board was added to the robot to be able to get a higher performance in running neural networks which are now used in object detection and motion. The power is supplied by lithium polymer batteries. To regulate the voltage, the robots have a separate board as voltage regulator included. All the parts are located in the torso of the robots. Our software was adapted to the new hardware and works properly. We used these boards for the first time at the competition in Nagoya. The used camera for the WF Wolves robots is the Logitech C920 HD Pro Webcam as a visual sensor. The camera runs up to a 1.920 x 1.080 resolution at 30 FPS.

3.2 Bit-Bots Robots: Minibot

The Hamburg Bit-Bots experimented over a long period of time with different robot platforms in different sizes. The Minibot is a compromise in hight, which ensures stability and low weight, while still being big enough for a fast walk and a strong kick. It is made of simple aluminum sheet metal and uses the Dynamixel MX servos of all sizes. It is controlled via an Odroid XU-4 with an octa-core ARM processor and a CM730 for the servo control.

3.3 Studs & Weight Cells

Since the introduction of the artificial grass, we are printing different kinds of studs with our 3D printer from ABS. By mounting them, we achieve a more stable walk on the field [10]. One of the best working studs is shown in Fig. 3. Additionally, we assumed the weight cells from the Kid Size Team Rhoban from France and integrated them under the foot plates. This integration of the weight cells can is shown in Fig. 2.

4 Software

4.1 Framework Architecture

Since 2016 the WF Wolves are using a ROS based framework for our software architecture which was adopted by the Hamburg Bit-Bots in 2017. Since last

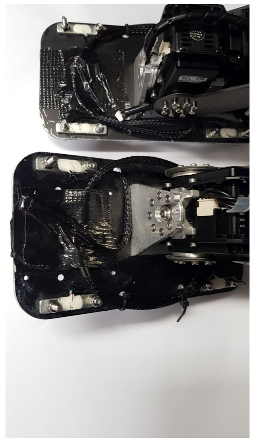

Fig. 2. The Weight Cells

Fig. 3. Studs and Series Knee

year we revised the framework together. The main advantage of the now used framework is the modularity that enables code exchanges in an easier way among each other. Therefore, we (WF Wolves & Hamburg Bit-Bots) can develop software modules independently from each other but still share and compare them. Since ROS is being used more often in RoboCup, cooperation with other teams is also getting easier. Our code is open source and available online [4].

4.2 Team Communication

Communication between robots is getting more important since last years Drop-In challenges. Therefore a shared protocol was developed by team FUmanoids[8].It is the so-called *Mixed team communication protocol* (mitecom). With the use of this protocol, our robots are capable of communication with other robots of the own or another team. Especially in a drop-In challenge where robots from different teams play together, a communication is useful. This was already tested during previous championships. What's more, with this protocol it is much easier for our teams to play together in a joint team.

4.3 Localization

Our vision consists of three parts. We worked on the ball detection using tensorflow and a neural network. With the introduction of artificial grass, the problem of reflections on the field occurred. For that reason, we developed some approaches on finding the right field color and field-lines for basic localization [11]. Additionally, a particle-filter based approach to recognize various features on the field. Finally, we created a goal detection so that the robot kicks the ball in the right direction.

[4] https://github.com/Bit-Bots

4.4 Motions

For movement, such as walking forward, backward, sideways and turning, an omni-directional walk engine is used. Servo positions are calculated in real time. This allows us to control the body via high-level commands instead of using a combination of predefined sets of key-frame motions. Even though the inferior control method proves to be static motions, some are too complex to be generated in an easy way. Therefore the robots use predefined key-frame motions e.g. for goalkeeper motions and getting up. Besides this, it is sufficiently abstract to allow running the same behavior on different robots without the need for sophisticated calibration [2]. A kick motion generator was developed by WF Wolves to allow the robots to kick in nearly every direction [3]. With two vectors, one for the current ball and one for the target position, the required movements are calculated in real time. For more stabilization, a closed-loop control was added and the sequence was improved [10].

The walking is now based on more data than before. The foot pressure force is measured by the weight cells. The effort values are based on the current of the motors and available due to the new firmware version of the MX Dynamixels. These information are used by a neural network, which continuously computes spline points for the motion of both feet. The goal position of the joints is then computed by the spline interpolation. The network uses online learning to update its own weights based on the stability of the robots walking. Therefore manual tuning of parameters is not necessary.

4.5 Vision

The vision is the new part we are working on together to get a common status of the vision software. The WF Wolves used a cascade classifier for ball detection implemented in OpenCV until last year. With the cooperation with the Hamburg Bit-Bots we started to work on ball recognition with the help of neural networks. With the installed Jetson it can be calculated well and the recognition works better. Because of reflections on the artificial gras some new approaches on field colour and field-lines for basic localization [11] were introduced. Additionally to that we try to localize the goal, to be able to kick to the right direction. The Hamburg Bit-Bots started on fundamental research in the field of deep learning. By doing that they contribute bio-inspired neural architectures which enhance the visual perception of complex scenarios. The neural network is able to learn substantial features on the field during a match [13, 15]. This technique should be improved with the cooperation.

4.6 Behaviour

A hierarchical state machine is the base of the behavior framework. Therefore it is necessary that the robot knows it's role, like goal keeper, striker or defender. Depending on the vision and calculations the robot can fulfill tasks like going to the ball, searching the ball, kicking. Attacking or defending are more high-level tasks. For path-finding an offline trained neural network is used [1].

5 Conclusions

Our changes in robot hardware and software provide improvements in comparison to the previous year. A better robustness for the motions and upgrades for vision and localization show promise results. WF Wolves & Hamburg Bit Bots are looking forward to participating in the RoboCup 2018 for the **Team Competition** in Montreal, Canada.

References

1. Poppinga, M.: Intelligente Wegfindung humanoider Roboter am Beispiel des RoboCup. Bachelor thesis, Universität Hamburg, Department of Informatics, Germany (2014)
2. Michalik, S.: Dynamisches Laufen von humanoiden Robotern. Bachelorthesis, Ostfalia - University of applied Sciences, 2010.
3. Krebs, O.; Gerndt, R.: Dynamic Ball Kicking for Humanoid Robots. In: First Brazilian Workshop on Service Robotics, Santa Maria, 2013.
4. Martins, L. T.; Gerndt, R.; Guerra, R. S.: Series Elastic Actuator and Its Application For Humanoid Platform. In: First Brazilian Workshop on Service Robotics, Santa Maria, 2013.
5. Martins, L. T.; de Mendonça Pretto, R.; Gerndt, R.; da Silva Guerra, R.: Design of a modular series elastic upgrade to a robotics actuator. In Robot Soccer World Cup (pp. 701-708). Springer International Publishing, 2014
6. Martins, L. T.; Tatsch, C.; Maciel, E. H.; Henriques, R. V. B.; Gerndt, R.; da Guerra, R. S.: Polyurethane-based modular series elastic upgrade to a robotics actuator. In Robot Soccer World Cup (pp. 347-355). Springer International Publishing, 2015
7. Martins, L. T.; Tatsch, C. A. A.; Maciel, E. H.; Gerndt, R.; da Silva Guerra, R. : A polyurethane-based compliant element for upgrading conventional servos into series elastic actuators. IFAC-PapersOnLine, 48(19), 112-117, 2015
8. FUmanoids, Mixed Team Communication protocol, 2014. Available online at https://github.com/fumanoids/mitecom.
9. Krebs, O.; Bolze, T.; Gerndt, R.: Bumblebee Stereo Camera for Robotic Soccer - A Case Study. In: RoboCup Humanoid Open Workshop, Dresden, 2015.
10. Krebs, O.: Closed-Loop Kinematic Scheme for Kicking Motion of Humanoid Soccer Robots. Bachelorthesis, Ostfalia - University of applied Sciences, 2015.
11. Lorenz, T.: Visuelle Lokalisierung eines humanoiden Roboters anhand von Feldlinien. Bachelorthesis, Ostfalia - University of applied Sciences, 2016.
12. Missura, Marcell, and Sven Behnke.: Balanced walking with capture steps. RoboCup 2014: Robot World Cup XVIII. Springer International Publishing, 2014. 3-15.
13. Speck, D., Barros, P., Weber, C., Wermter, S.: Ball Localization for Robocup Soccer using Convolutional Neural Networks. *20'th RoboCup International Symposium, Leipzig*, 2016
14. Bestmann, Marc.: Towards Using ROS in the RoboCup Humanoid Soccer League. Masterthesis, University Hamburg, 2017.
15. Speck, D.; Balltracking for Robocup Soccer using Deep Neural Networks. Bachelor thesis, University of Hamburg, Department of Informatics, Germany (2016)
16. imagetagger.bit-bots.de