Hamburg Bit-Bots Extended Abstract 2024

Jasper Güldenstein and Jan-Niklas Feldhusen

Universität Hamburg, Hamburg, Germany
info@bit-bots.de

1 Lessons learned in previous RoboCup competitions

Between 2021 and 2022, we switched from using ROS 1 to using ROS 2 [1] as the framework for our robot software. Our team improved the framework with several contributions and achieved a stable system. This allows us to spend more time on the development of the robot software.

We contributed significantly to the ROS Sports[1] working group. This group focuses on developing generalized software, such as inverse perspective mapping (IPM). The solutions developed in this group are applicable not only to the RoboCup Humanoid domain but also to robotics in general. We believe that this investment has already paid off, as we can rely on the stable and proven software in this project.

We experienced significant problems with the stiffness of our robots' mechanical links during the RoboCup 2023. This caused our robot to fall many times and inflicted damage to other components. We identified the issue in several 3D-printed parts of the robot, which experienced fatigue.

As our team is mostly comprised of students, we have significant changes in team members. We are anticipating and counteracting this expected loss of expertise by focusing on recruiting and training new members.

2 Major problems to solve for RoboCup 2024

RoboCup 2024 will introduce the requirement for whistle recognition. We are solving this problem by adapting approaches proven to work in the Standard Platform League. However, as our robots have significantly increased computing performance, we are able to use more complex neural networks for this task. This will hopefully increase the accuracy of the detection.

Further, we want to achieve increased stiffness of the robots' links by replacing several 3D-printed parts with aluminum alternatives. This should reduce the number of falls.

3 Major Changes for RoboCup 2024

Our navigation relies on commanding the velocity of the robot to reach a goal pose. This approach is adapted from path and motion planning for wheeled

[1] https://github.com/ros-sports

robots. However, we want to utilize the humanoids' capabilities more extensively by planning the individual footsteps. This has the potential to increase not only the performance in terms of time to reach a goal but also robustness to falls by performing steps to mitigate disturbances.

The robots' current inertial measurement unit has mostly worked well. However, we have noted problems with the calibration. We plan on using a new sensor, which is factory calibrated, and implementing methods to calibrate the mounting offset using the robots' camera.

Our localization method is based on a particle filter. It evaluates line matching of the inverse perspective mapped lines and heavily relies on an accurate measurement from and calibration of the IMU. In addition to this, we are also pursuing research in localization directly from images using machine learning.

Additionally, we want to introduce machine learning methods for improving the odometry of our robots by extending an approach by Rouxel et al. [2] and increasing the walking's stability by adapting an approach proposed at the RoboCup 2023 symposium[3].

To increase the robots' robustness to falls even further we are looking to increase the number of 3D-printed shock absorbers on the robot. These will be produced in the team colors to reduce the need for additional team markers.

4 Implementation status of the planned changes at the time of submitting

The footstep planning has been developed in a master thesis. However, it has only been developed in simulation and must be transferred to work in the real world and in real-time conditions.

A prototype of the the PCB with the new IMU has been manufactured, and the software is currently being adapted.

The aluminum parts that we are using to increase the stiffness of the robots' links have been designed and simulated using finite element analysis.

The other mentioned projects are in the prototype phase.

References

[1] Steven Macenski et al. "Robot Operating System 2: Design, architecture, and uses in the wild". In: *Science Robotics* 7.66 (2022), eabm6074.

[2] Quentin Rouxel et al. "Learning the odometry on a small humanoid robot". In: *2016 IEEE International Conference on Robotics and Automation (ICRA)*. 2016, pp. 1810–1816.

[3] Eunsoo Chung et al. "Swing foot Pose Control Disturbance Overcoming Algorithm Based on Reference ZMP Preview Controller for Improving Humanoid Walking Stability". In: *RoboCup 2023:* (to appear). Springer International Publishing, 2024.