Bold Hearts Team Software Description for RoboCup 2020 (Humanoid Kid Size League)

Alessandra Rossi, Rebecca Miko, Sander van Dijk, and Marcus M. Scheunemann

School of Engineering and Computer Science
University of Hertfordshire, Hatfield AL10 9AB, UK
email: boldheartsuh@gmail.com
https://robocup.herts.ac.uk

1 Walking

Since 2013 the team developed and adopted a customised framework, except for some modules that were provided as open-source by the Darwin-OP platform[1], including the walking algorithm. Consequently to the required changes of the hardware and use of ROS 2 as middleware, we needed a suitable and more stable walking algorithm that allows our robots to walk on artificial grass. We decided to integrate in our ROS 2 system the open loop walk engine for humanoid robots developed by the Robocup team Rhoban[2].

2 Vision

In previous years our vision system relied on simple pixel classificaction based on thresholding in HSV colour space. In 2018 we developed a Convolutional Neural Network (CNN) based segmentation approach as a drop-in replacement for this outdated method. The next year, in 2019, we integrated this CNN framework into ROS 2 [1]. We have open-sources this implementation based on Tensorflow Lite[3], and are currently working to release it into the ROS 2 build farm and repositories.

Currently, our focus is on further optimising the runtime overhead of this system, to enable using more complex models. This is based on utilising Tensorflow Lite's model discretisation methods to boot performance on our robot's ARM based CPUs, and applying further optimised operators that obtain good performance at lower computational cost.

[1] Darwin-OP platform open-source code can be found at https://github.com/Fastcode/NUClear.
[2] The Rhoban's IKWalk library can be found at https://github.com/Rhoban/IKWalk
[3] The ROS 2 tflite package: https://gitlab.com/boldhearts/ros2_tflite.

3 Localisation

Developing a new framework from scratch requires time and dedication. In order to participate in the RoboCup competition we started to develop the key behaviours that will allow us to play. However, several approaches to localisation on the RoboCup field are already used, and we are investigating the relatively most robust and reliable at runtime to use. We are particularly interested in a localisation mechanism that can be done using team communication and a vision-based approach to determine which direction to play at. In this direction, we are looking at a vision-based Monte-Carlo localization that uses goalie and other players' relative positions and knowledge of the goalpost and ball's position to determine a global model of the environment to enhance decision making.

4 Behaviours

In RoboCup 2019 we started to move to ROS 2, which is based on Data Distribution Services (DDS) for real-time systems. This connectivity framework aims to enable scalability and real-time data exchange using a publisher-subscriber architecture. ROS 2 sits on top of that, providing standard messages and tools to adapt DDS for robotic needs. Our team has focused most of its efforts on this new framework. As a result, we have developed the basic behaviours so far that are required for the competition.

The robots are able to stand-up, and the walking behaviour is currently being improved upon (details on the software used for the walking can be found in the walking section). Additionally, we are currently working on the positioning of the goalkeeper, allowing the robot to position itself for the game. When the goalie is positioned close to the goal, the field robots can use localisation to determine the direction they are playing. Our robots share information with the teammates about the ball's relative position to themselves.

In previous years we had a hierarchical finite state machine system, which was used to determine which behaviour the robots should have used. We believe this is a simple and good mechanism, and we are currently working to port this over to the new system.

5 Communication

ROS 2 supports the quality of service (QoS) policy that allows you to tune communication between nodes. ROS 2 has an efficient non–blocking 'best-effort', 'UDP-like' and 'TCP-like' policy [2]. We want to incorporate this standard of communication between our robots.

Therefore, the robots will be reliably transmit information about their current location and orientation relative to the global coordinate frame, observations made relative to the robot's local frame, the role in the team including confidence in those values and much more.

6 Contribution

Bold Hearts first RoboCup competion was in 2003 in the Simulation league. Then, the team decided to start a new challenge moving to the Humanoid Kid-Size League in 2013. We hope to consecutively participate for the eighth year in 2020.

The main achievements of the Bold Hearts in the Humanoid League over the last few years are the following:

- Quarter-finalist RoboCup World Championchip 2017 (1st in group)
- 2nd round RoboCup World Championship 2016 (1st in group)
- 1st Iran Open 2016
- 2nd round RoboCup World Championship 2015 (1st in group)
- 3rd German Open 2015
- 2nd RoboCup World Championship 2014

The team is quite active within the RoboCup community. We contributed to the collaborative online tool for labeling image data created by the BitBots team[4] sharing datasets built during RoboCup games. The two datasets released include: goalposts annotated to train goal detection; and ball annotations created and used also during the RoboCup 2018 competition in Montreal. Additionally, we started to share our code based on ROS 2[5] to be used by the community. At the moment, the team shared vision related packages (camera driver using Video4Linux2, Tensorflow Lite based vision and vision algorithms), suite of packages to work with the CM-730 sub controller, and Dynamixel motors, packages for computing and visualizing the orientation of a robot, tools to work with a RoboCup 3D Simulation Server, and to work with the RoboCup Humanoid League Game Controller.

7 Publication

The following RoboCup-related works were published in 2019:

- Marcus M. Scheunemann and Sander G. van Dijk. ROS 2 for RoboCup. 2019. in RoboCup 2019: RobotWorld Cup XXIII. arXiv:1907.00282.
- Sander G. van Dijk and Marcus M. Scheunemann. Deep Learning for Semantic Segmentation on Minimal Hardware. In Dirk Holz, Katie Genter, Maarouf Saad, and Oskar von Stryk, editors, RoboCup 2018: Robot World Cup XXII, volume 11374 of Lecture Notes in Computer Science, 349–361. Springer International Publishing, August 2019. arXiv:1807.05597, doi:10.1007/978-3-030-27544-0_29.

[4] Bit Bots team's online tool for labeling image data can be found at https://github.com/bit-bots/imagetagger

[5] The open source code of Bold Hearts team can be found at https://gitlab.com/boldhearts

References

1. van Dijk, S.G., Scheunemann, M.M.: Deep Learning for Semantic Segmentation on Minimal Hardware. In: Holz, D., Genter, K., Saad, M., von Stryk, O. (eds.) RoboCup 2018: Robot World Cup XXII. Lecture Notes in Computer Science, vol. 11374, pp. 349–361. Springer International Publishing (Aug 2019). https://doi.org/10.1007/978-3-030-27544-$0_2$9
2. Scheunemann, M.M., van Dijk, S.G.: ROS 2 for RoboCup. In: Chalup, S., Niemueller, T., Suthakorn, J., Williams, M.A. (eds.) RoboCup 2019: Robot World Cup XXIII. Lecture Notes in Artificial Intelligence, vol. 11531. Springer International Publishing (2020)