Z-Knipsers Team Description Paper for RoboCup 2016

Georgios Darivianakis[1], Benjamin Flamm[1], Marc Naumann[1], T.A. Khoa Nguyen[1], Louis Lettry[2], and Alex Locher[2]

[1] Automatic Control Lab
[2] Computer Vision Lab
D-ITET, ETH Zurich, 8092 Zrich, Switzerland

Abstract. This report summarizes the activities of the RoboCup SPL team *Z-Knipsers*. In 2014, we participated at our first open tournament and our main focus has been perception and behavior programming. At the 2016 RoboCup, we will compete in the indoor tournament, the drop-in player event as well as the technical challenges. This paper provides an overview of our activities, detailed reports of the students' works are available on our website http://www.robocup.ethz.ch.

1 The Team

The *Z-Knipsers* started in 2012 at ETH Zurich and are a joint effort of the Computer Vision Lab (CVL) and the Automatic Control Lab (IfA, Institut fr Automatik) at the Department for Information Technology and Electrical Engineering. The letter 'Z' stands for Zurich and 'Knipsers' is a German word meaning something like an efficient goal scorer.

The team consists mainly of students working on semester or master projects to earn credits to their respective degrees. They are supervised by Alex Locher, Louis Lettry and Prof. Luc Van Gool from the Computer Vision Lab as well as Georgios Darivianakis, Benjamin Flamm, Marc Naumann, Khoa Nguyen, and Prof. John Lygeros from the Automatic Control Lab. In the spring term 2016, eight students are working together on semester projects. They have been working in the fields of perception, motor control to behavior. Figure 1 shows the team at the European Open 2016.

Team members Besides the supervisors, these students joined us for the 2015-2016 season: Quentin Censier, Simon Flckiger, Rafael Gomez-Jordana, Matej Kastelic, Dany Manickathu, Gautham Manoharan, Simon Maurer, Silvan Plsch, Adam Radomski, Ralph Stadler, Orhan Sylejmani, Maximilian Wulf, Pierre-Emmanuel Wulfmann, Yupeng Zhao, Yue Zhou.

2 Robot Hardware

We have currently four V5, one V4, and three V3.3 NAOs (all H21). All robots are used for developing, testing, competition and exhibition (e. g., public relations events). We will use the V4 and V5 robots at the RoboCup 2016.

Fig. 1. The Z-Knipsers team at the 2016 European Open in Eindhoven.

3 Robot Software and 2016 SPL contributions

We have based our code on the 2013 code release of B-Human and have focused our activities on perception, behavior programming and to a limited extent also motor control.

3.1 Perception

Two main tracks of research have been followed with the help of nine students over the last year.

The first one meant to adapt the different algorithms to fit the new rules: white goals on both sides of the pitch and a white soccer ball. Both challenges proved to be difficult as the elements of interest on the field have seen their difference in color reduced to become white. The goal detection has been improved to a robust version of the yellow goal detection to account for situations where "ghost" goals appear (i. e., two robots standing under a white line). The ball detection uses the main geometric, color and motion constraint present on the ball, respectively, its spherical shape, the black dots and the planar motion. A sliding window approach looks for spherical objects of a certain size and containing a certain percentage of dark pixels has proven to be reliable for the ball detection. We are still working on rendering this method more robust to reduce the number of false positives (e. g., robot feet, shoulders, goals with black nets).

The second track's objective is to improve the self-localization of the robots as landmarks (i. e., goals) get harder to detect reliably. Simultaneous Localization And Mapping (SLAM) methods have proven in the past to perform well even given high constraint such as low computational power. In this regard, we

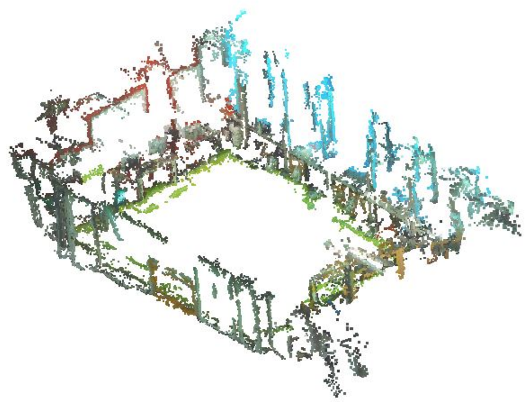

Fig. 2. Example of background reconstruction shared across the different robots which is used for self-localization.

allocated a lot of energy to producing a localization system based on state-of-the-art techniques applied to our particular situation. We mainly incorporated the reduced dimensionality of the robot motion in the pose estimation and the relative constant background as a map shared across robots (example Fig 2). The students' report will be released by the end of summer 2016.

3.2 Behavior Programming

In terms of behavior programming, we have added the skill of dribbling and have been working on small details such as path planning and opponent detection.

Ralph Stadler implemented the dribbling skill with a focus on simplicity, robustness and configurability. Specifically, he implemented an algorithm for the skill that computes on which trajectory the robot should approach the ball to improve alignment with the subsequent target (Fig. 3) and files for configuration parameters that determine for instance how much the ball should be pushed in front of the robot. This skill was extensively tested with the former red ball, but has been more difficult with the new white ball due to unstable detection.

Zhao Yupeng has recently started working on robot detection and location as we are pursuing a more general framework for decision making to determine whether the robot should shoot, pass or dribble. The robot detection is based on the module of B-Human's 2015 code release and has been modified to fit into our code base. In particular, detection and location are solely based on images and use our superpixel method described previously. We do not rely on ultrasound. Detected robots are shared and converged to feed into the team's combined world model. We believe that this information will be important for future calculations for decision making and may also improve self-localization.

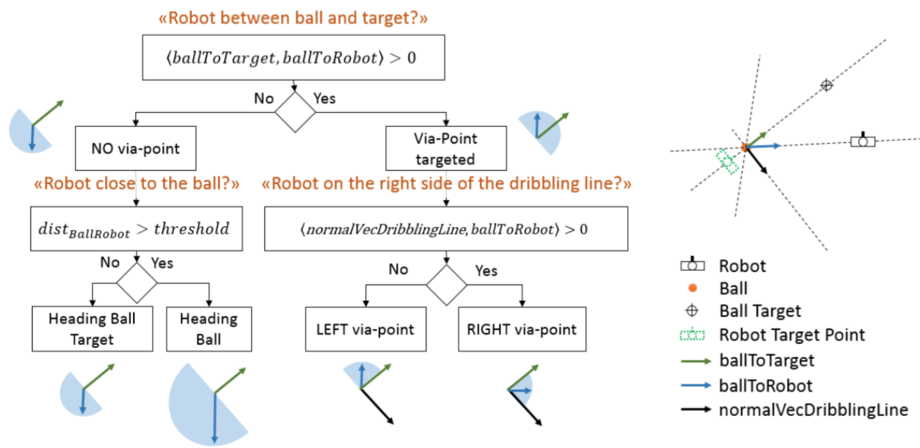

Fig. 3. Decision tree of walkToBall, part of the Z-Knipsers' dribbling skill. This tree determines based on the locations of robot, ball and target, how the robot approaches the ball.

Rafael Gomez-Jordana has also recently started working on path planning with the objective to accelerate our time to the ball. This project has been inspired by rUNSWift's impressive walking and action speed at the RoboCup 2015. Several avenues will be studied: reducing the 'randomness' of the rapidly exploring random tree, field potential methods and Bezier curves. A report will be published towards the end of the year.

Additionally, we would like to introduce dynamic role assignment and passing, two previous projects from 2014-2015 that have been tested in the simulator. However, we have been plagued by unstable and inaccurate self-localization that rendered these algorithms non-effective for the time being.

3.3 Motor Control and Improved Walking Engine

Silvan Pluess has been working on analyzing and improving the current walking engine, with an initial goal of increasing the speed and robustness of straight-line walking. Although our walking has become more stable compared to the German Open in 2014, there is still ample space for improvement both on planning and tracking of a reference walking trajectory. The inverted pendulum model, currently in use in the B-Human 2013 release, is kept, but the control scheme was considerably improved. Instead of relying on an iterative algorithm which solves a set of nonlinear motion equations to compute the motor commands, Silvan has devised a control scheme based on a linear quadratic regulator (LQR) which uses a hybrid discrete-time state-space representation. This method exhibits improved trajectory tracking capabilities compared to the previous implementation.

3.4 Drop-in Player

We adapted our code to incorporate the SPL standard message with intentions and suggestions. We categorize our teammates into five reliability states (from unreliable to reliable) based on possibly conflicting information in their sent messages and thus weight their intentions and suggestions accordingly.

3.5 Challenges

Pierre-Emmanuel Wulfmann is implementing the 'No Wi-Fi Challenge'. Our idea is to encode positions and bits through acoustic sinusoidal tones where the frequency of the sinusoid denote a position or a value for two or three bits.

Regarding the 'Outdoor Challenge' our strategy will be to improve the carpet challenge code from 2015 and also test some adaptive color calibration that one student worked on in 2014 to be able to detect the ball and/ or goals in an outdoor environment. However, the adaptive calibration has not been rigorously tested previously.

4 Conclusions

The Z-Knipsers are participating for the first time at the team event of the RoboCup. We are advancing steadily and our long-term objective is to leverage our labs' solid expertise in control and computer vision for action planning, decision making and self-localization, respectively.

5 Acknowledgments

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