Team Qualification Document for RoboCup 2019, Sydney, Australia

Dutch Nao Team

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1 Team Information

This is the qualification document for the Dutch Nao Team with Pieter Kronemeijer and Caitlin Lagrand as its team leaders. The team consists of twelve master students, two bachelor students, one alumnus and one staff member from the University of Amsterdam, The Netherlands. In the last nine years the team has bought 19 Nao robots, although not all of them are operational anymore. The team currently has two `V6` robots, but has the intention to buy at least two more before the upcoming RoboCup. The qualification video is available on our YouTube channel[1]. A research report [1] describing the technical details of the team's work for RoboCup 2018, has previously been published on our website[2].

2 Mixed Teams

For this year, the team still wants to focus on extending its framework with modules such as localisation and team communication, which are necessary to play football with the other teams. Therefore, the Dutch Nao Team is not interested in participating in the Mixed Team competition this year. However, the team is interested in joining the Mixed Team competition in future RoboCup events.

[1] https://youtu.be/dOELK0FmX90

[2] http://www.dutchnaoteam.nl/en/publications

3 Code Usage

Before 2013, the team maintained their own framework in `Python`. In 2013, the team switched to use *Berlin United*'s code base (then called *NaoTH*). Due to the lack of documentation provided with the framework, the team decided to use *B-Human*'s framework for the competitions in 2014 and 2015.

In 2016, the team started implementing a custom framework based on ROS[3] [2]. However, the team did not enter the competition with this framework since experiments showed that running a ROS core node and image publishing nodelet results in a frame rate of approximately 5 Hz, without any further processing. This was deemed too low for usage in RoboCup competition, so in the 2016 RoboCup competitions *B-Human*'s 2015 code release[4] was used, extended with our own behaviour engine [3] and ball detector [4].

From April 2017 onward, the team has been using its own framework. The decision to start a new framework was made to provide the team with a codebase it fully understands and is documented in a way that is understandable for all members of the team, new and old. By creating an own framework, the team has gotten a better understanding of all components required to go from sensor values to high level actions. Ultimately, every team member should be able to largely understand its inner workings and feel comfortable with it. Our new framework is based on messages sent between modules, where each module represents one algorithm handling a task in the football playing robot. Each message shared between modules contains a representation. The system uses a message naming convention comparable to the ROS messaging system, which makes it easy to use for developers that have some experience with ROS.

So far, the team has noticed that despite the obvious drawbacks of having to recreate basic functionality, the educational value of our new framework has increased the motivation of (newer) team members and has had a positive impact on the overall productivity. A code release is planned when all basic functionality has been implemented and tested thoroughly.

Due to the large impact of the walking performance, the walking engine of BHuman[5] based on rUNSWift's walking engine[6] has been fully integrated into the framework because of its proven stability.

4 History

The predecessor of the Dutch Nao Team was the Dutch Aibo Team [5]. The Dutch Nao Team debuted in the Standard Platform League (SPL) competition at the German Open 2010 [6]. Since their founding, the Dutch Nao Team has been qualified for the world cup competitions in Istanbul [7], Mexico City [8], Eindhoven [9], João Pessoa [10], Leipzig [2], Nagoya [11] and Montreal [12].

Besides the major RoboCup events, we have attended multiple GermanOpens, IranOpens, the Humanoid Soccer School 2013, the Mediterranean Open 2011, the Colombia Robotics week, TechFest 2015[7], the European Open 2016, the Robotic Hamburg Open Workshop 2016, 2017 and 2018. At the Benelux Conference on Artificial Intelligence 2016 the team received the award for best

[3] http://www.ros.org

[4] 2015 release: https://github.com/bhuman/BHumanCodeRelease/tree/1fd87519e2bbb3ccbb5f288980438b692629f7c1

[5] https://github.com/bhuman/BHumanCodeRelease/tree/coderelease2017

[6] https://github.com/UNSWComputing/rUNSWift-2016-release

[7] TechFest is Asia's largest science and technology fair with more than 165,000 people attending: http://techfest.org

demonstration [13], at the Iran Open 2017 the team received the Award in the Open Challenge with a presentation on our behaviour engine.

The results from 2017 onward in major RoboCup competitions are presented in Table 1a. In Montreal, we ended second in our first round robin pool and fourth in our second round robin pool. Table 1b shows the scores for the open competitions.

Year	Round	Opponent	Score
2017	Round Robin	Luxembourg United	0:0
		Aztlan	0:0
	Second round	Nomadz	0:1
		JoiTech	1:1
2018	Round Robin	Aztlan	0:0
		Naova	0:0
	Second round	NTU RoboPAL	0:2
		Naova	0:2
		Unbeatables	0:0

(a) Game scores for RoboCup 2017 and 2018.

Year	Competition	Opponent	Score
2017	Iran Open	HTWK	0:7
		MRL	0:3
		HULKs	0:0
		SRC	0:0
2018	Iran Open	HTWK	0:7
		MRL	0:0
		HULKs	0:5

(b) Game scores for open competitions since 2017.

Table 1: Game scores for the Dutch Nao Team in different competitions.

Although not visible in the scores, the field play has improved a lot, resulting in games with a lot of ball possession. Yet, without localisation scoring is difficult. The Dutch Nao Team will come well prepared to the competition in Sydney: in December 2018 the Dutch Nao Team attended the RoHOW[8], and we are planning to participate in RoDeo 2019[9].

5 Impact

During the participation in the RoboCup, the Dutch Nao Team has provided its support or resources in a number of bachelor & master theses [14,15,16,17] and projects that lead to publications on a large variety of topics [18,19]. At the Maastricht University, a PhD thesis is finished [20] based on e.g. a paper on learning a more stable gait [21], compared to the energy efficient gait from earlier work [22]. In an honours project a comparison was made on ball detection with classical image processing versus modern deep learning techniques [23]. The Dutch Nao Team extended the application of the Nao robot to the @Home league of the RoboCup: the Nao robot was used to help in a kitchen environment by finding a tomato and grabbing it from a table [24,18]. Finally, the Dutch Nao Team has made the penalty shootout situation into a standalone demonstration [13] which it premiered at the Benelux Conference on Artificial Intelligence 2016[10] and won the first prize for best demonstration.

Earlier the Dutch Nao Team has published papers in the International Conference on Advanced Robotics [25], the Performance Metrics for Intelligent Systems Workshop [26], the RoboCup

[8] See https://www.rohow.de/2018/en/teams.html

[9] https://naodevils.de/rodeo

[10] http://bnaic2016.cs.vu.nl

IranOpen Symposium [27], the RoboCup Symposium [28] and the international conferences as International Conference on Autonomous Robot Systems and Competitions [24].

Besides the Dutch Nao Team, the Intelligent Robotics Lab[11] of the University of Amsterdam also had a team called *UvA@Home* that competed in the Standard Platform League of the @Home league with the SoftBank Robotics Pepper robot [29]. Both the Pepper and the Nao robots work with the same operating system, allowing both teams to exchange knowledge in order to benefit each other. The Dutch Nao Team also proposed and supervised RoboCup related projects for a course of the Artificial Intelligence bachelor at the University of Amsterdam.

Furthermore, the last year the team has been working on the following techniques:

5.1 Line Detection

To detect lines, grayscale images are scaled down and thresholded to a binary image. Edges are found in the binary image using a fast approximation of the canny edge filter. Finally lines are found using an OpenCV implementation of a fast line detector [30]. This method has proven fast enough for the framework, but requires calibration at each venue. The Dutch Nao Team therefore plans to implement a method based on the adaptive field detection to achieve lighting invariant line detection [31].

5.2 Localisation

To determine the position of the robot on the field, a particle filter [32] has been implemented. By updating the position of the particles based on the supposed sensed movement of the robot, and scoring the particles based on the visual cues from lines our robots are now able take action based on their position. By resampling particles with a low score and using a-priori knowledge about the game, our method to localise the robot is able to recover from lost positions over time.

5.3 Interface

The newly added interface allows for high-level interaction with the DNT framework. The interface includes the results from ball detection, current position estimates from the localisation module, lines detected and will soon include behaviour states. The interface has shown to be very beneficial in debugging, testing and optimising modules.

5.4 Forward Kinematics

Before the RoboCup 2018 the team did not make use of forward kinematics while playing football. This year, the team created its own forward kinematics module, inspired by [33]. This module is currently used to determine the position of the camera in world coordinates in real time. With a known camera position, visual game elements such as lines and balls are converted from image coordinates to world coordinates to aid the localisation and behaviour methods.

[11] http://www.intelligentroboticslab.nl

5.5 Nao version 6

The University of Amsterdam has given the Dutch Nao Team access to two Nao V6 robots. This robot has multiple changes compared to the older versions, such as different hardware and changes to the NAOqi framework. Our framework has been made compatible with these changes and can be run on both V5 and V6 systems. Before the RoboCup, we hope to be able to exploit the faster hardware of the Nao V6 robot to improve the performance of existing modules. One such improvement would be the use of deep learning in perception modules.

6 Other

Besides working on robot football, the Dutch Nao Team gives many lectures about robotics and AI, and demonstrations of autonomous football at companies and schools throughout the year. This spreads knowledge about robotics and AI and is a way for the Dutch Nao Team to fund the trip to the RoboCup. After RoboCup 2016 a foundation was started to allow for transparent financial communication.

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