Team Qualification Document for RoboCup 2017 Nagoya, Japan - Dutch Nao Team

Lagrand, C.; Negrijn, S.; de Kok, P.; van der Meer, M.; van der Wal, D.; Kronemeijer, P.; Visser, A.

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http://www.dutchnaoteam.nl

Caitlin Lagrand, Sébastien Negrijn, Patrick de Kok, Michiel van der Meer,
Douwe van der Wal, Pieter Kronemeijer, and Arnoud Visser
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1 Team Information

This is the qualification document for the Dutch Nao Team with Caitlin Lagrand as its team leader. The team consists of two master students, nine bachelor students and one staff member from the University of Amsterdam and Maastricht University, The Netherlands. The qualification video is available at our YouTube channel[1]. A research report [1], describing the technical details of the team's work for RoboCup 2016, is earlier published on the website[2].

2 Mixed Teams

The Dutch Nao Team is already a cooperation between two Dutch universities. Both teams have invested in the infrastructure of their robotics lab and have an access to in total 15 Nao robots[3]. The Dutch Nao Team has no need to participate in the Mixed Team tournament.

3 Code Usage

Before 2013, the team developed their code in Python. In 2013, the team switched to use Berlin United's code base (then called NaoTH). Because of the lack of documentation, the team decided to use B-Human's framework in 2014 and 2015 during the soccer competitions.

[1] Available at: https://www.youtube.com/watch?v=FqzGRQzBJwo

[2] See http://www.dutchnaoteam.nl/publicaties/

[3] See https://project.dke.maastrichtuniversity.nl/robotlab/ and http://www.intelligentroboticslab.nl/robots/

While our previous qualification document mentions the creation of a custom framework based on ROS [2], we later did not enter the competition with this framework. Later experiments showed that running a ROS core node and image publishing nodelet resulted in a frame rate of approximately 5 Hz even without any further processing, which we deemed too low for usage in RoboCup competitions. For this competition, we used B-Human's 2015 code release[4], and plan to continue using this as our base and include no new releases from the B-Human team.

Advancements made by our team include the creation of a new behavior engine and a detection method for the black and white ball which matches candidates by means of regular expressions of which a more complete overview can be found in the recent technical report[1]. For the upcoming RoboCup research into a complete vision overhaul and a different localization method are being developed.

3.1 Behavior Engine

The framework of B-Human has as behavior engine CABSL, the C++ macro implementation of XABSL [3]. CABSL is based on the instantaneous evaluated preconditions for it's Finite State Machine approach. The new Behavior Engine of the Dutch Nao Team uses decisions, called axes, which gradually gain score depending on environmental factors. The environmental factors that an axis is based on can be any method that is available in the system. Various frequently used methods are wrapped into a small library, simplifying the search for suitable functions[5]. Each axis thus depends on a number of environmental factors, we call these factors considerations. Considerations are paired into a graph structure, the root of the graph determines the value of the scoring axis. The final score of a consideration could be a non-linear combination of scores returned by the environmental functions and enables us to describe complex relations intuitively. These environmental functions are collectively called the utility function $u(d)$ of the consideration. All consideration scores $C(d)$ are multiplied and normalized into score $s(a)$ and the action of the decision d with the highest score, chosen with Equation 1, is executed.

$$d = \arg\max_{d \in D} u(d) \prod_{a \in C(d)} \sigma(a) \tag{1}$$

This new Behavior Engine has proven to be a versatile tool to create new behaviors, including specifying under which specific circumstances they should be applied.

3.2 Ball detection

The team's ball detection is based around regular expressions, for which we require that each pixel value is assigned a color based on the color calibration, the available colors being black, green, white, or null. A hand-crafted regular expression is applied to each of the image's columns to match patterns which are ball candidates. To speed up this process, we use BHuman's ScanLines, which eliminate some of the columns. The resulting ball candidates are then filtered by (1) checking for a minimum size, (2) checking if it has a realistic radius, (3) checking if the ball is actually on the field and (4) is not inside a robot. This method is currently being improved by learning the regular

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

[5] Public available at: https://github.com/pkok/behavior-engine

expression from a labeled dataset using evolutionary methods, and automatic color calibration based on previous research [4].

There is also work in progress on a ball detection method that is independent of any form of color calibration to counter the realistic lightning introduced in the RoboCup this year. The method is based on the Canny Edge detector [5] which shows all the lines on an image where a strong color change is present. On these lines an attempt is made to fit circles using the Hough transform [6]. This gives a fair amount of false positives, but by checking whether the circle is placed on an area which contains very little color (low saturation in the HSV spectrum) most false positives can be eliminated. Based on the joint values of the Nao robot it is also possible to calculate the size of the ball on a certain place in an image, which can be used to eliminate even more false positives.

3.3 Deep Neural nets

Based on the recent enhancements in the speed up of (convolutional) neural networks, the Dutch Nao Team is working to replace the current vision methods by a single neural network. Similar to other research in the field of object segmentation [7] this network outputs a probability for each pixel in the image of belonging to an object class (ball, goal, field, robot, etc.). As typical networks proposed in these applications are very deep, we combine the results from recent papers [8] that provide significant speed up by only using binary values in most layers solving the limitations of the Nao robot.

3.4 Localization

Besides the vision modules, the localization method currently being used is replaced with a method that detects points at line segments in the image and match those points with the classic Iterative Closest Point algorithm [9] to the known dimensions of the field. First the internal sensors of the Nao are used to predict the next pose of the robot (motion model), followed by a sensor update based on the estimate of the Iterative Closest Point algorithm (sensor model). Both the pose estimates of the motion model and the sensor model are combined on the confidence in both estimates, resulting in an implementation of an Extended Kalman Filter for localization [10].

3.5 Team Communication

As of now, the robots from the Dutch Nao Team do not share information about their intentions and perception except for the drop-in challenge. Similar to how the decision engine works for a single robot, a same approach is being developed to determine a team strategy using shared information. The shared information is modeled with an uncertainty after which the best role (defender, striker, etc.) is assigned to each robot.

4 Past History

The predecessor of the Dutch Nao Team was the Dutch Aibo Team [11]. The Dutch Nao Team debuted in the Standard Platform League (SPL) competition at the German Open 2010 [12]. Since their founding, the Dutch Nao Team has been qualified for the world cup competitions in Istanbul [13], Mexico City [14], Eindhoven [15], João Pessoa [16] and Leipzig [2]. 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[6], the European Open 2016, the Robotic Hamburg Open Workshop 2016, and the Benelux Conference on Artificial Intelligence, where the team received the award for best demonstration [17].

As requested, only results from 2015 onward are published. Because the team did not apply for qualification for the competition in Hefei, only results for the world cup competition in Leipzig are presented in Table 1a. After a penalty shoot-out, we ended third in our first round-robin pool. We were eliminated in the play-in round with a penalty shoot-out. The team did not participate in the technical challenges.

Table 1b shows the scores for the open competitions. The scores during the open competitions are not very representative for the potential of our team. The Dutch Nao Team uses these games to test their latest developments in preparation of the world championships.

Round	**Opponent**	**Score**
Round Robin	UT Austin Villa	0:6
	Linköping Humanoids	0:0
	SPQR	0:0 [0:1]
Play-in	DAInamite	0:0 [2:3]

(a) Game scores for RoboCup 2016.

Year	**Competition**	**Opponent**	**Score**
2015	IranOpen	HTWK Leipzig	0:6
		MRL	1:3
		ETH Z-Knipsers	3:2
		Berlin United	0:5
2016	European Open	B-Human	0:7
		Nao Devils	0:2
		HULKs	0:0

(b) Game scores for open competitions since 2015.

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

The Dutch Nao Team will come well prepared to the competition in Nagoya: in November 2016 the Dutch Nao Team has attended the RoHOW[7]; on this event the team has made plans to play friendly matches with the newly-started SPL team Luxembourg United[8], and will participate either at the IranOpen or the GermanOpen 2017.

5 Impact

In the past two years the Dutch Nao Team has provided its support or resources in four publications and projects that lead to a publication ranging from a large variety of topics. Using the Optitrack[9] camera tracking system, which is usually used to track our Nao robots for ground truth localization information, a worm from the Open Worm project [18] was followed with an aerial drone [19]. The Dutch Nao Team also extends its applications of the Nao robot to the @Home league of the RoboCup: in another project the Nao robot was used to help in a kitchen environment by

[6] Techfest is Asia's largest science and technology fair with more than 165,000 people in attendance: http://techfest.org/. The Shaastra event mentioned in the previous qualification document [2] was cancelled due to floods killing more than 500 people and displacing more than 1.8 million people.

[7] See ttps://rohow.de/2016/en/teams.php

[8] Luxembourg United's website: https://luxembourg-united.uni.lu/

[9] http://optitrack.com/

finding a tomato and grabbing it from a table [20]. Finally, the Dutch Nao Team has made the penalty shootout situation into a standalone demonstration[17] which it premiered at the Benelux Conference on Artificial Intelligence and won the first prize for best demonstration.

Earlier the Dutch Nao Team have published papers in the International Conference on Advanced Robotics [21], the Performance Metrics for Intelligent Systems Workshop [22], the RoboCup IranOpen Symposium [23] and the RoboCup Symposium [24].

The Dutch Nao Team is not the only team of the Intelligent Robotics Lab; students and experience are shared with teams participating in the RoCKIn@Work camp [25], the HumaBot competition [26] and the RoboCup@Rescue [27].

6 Other

The Intelligent Robotics Lab has submitted a proposal to compete in the standard platform competition of the @Home league with a SoftBank Robotics Pepper robot [28]. Two former members of the Dutch Nao Team will focus their research on Pepper. Both teams will work closely together, exchanging their insights and experiences on humanoid robots.

In addition, the Dutch Nao Team has been active to promote robotics research to a broad audience, for instance with a performance on the stage of the National Theatre at the Science Gala.

7 Conclusion

The Dutch Nao Team is looking forward to compete in the RoboCup competition in Nagoya. The team has established a foundation dedicated to the team to make crowd funding possible. With this sort of sponsoring and support it will be possible to travel with 12 team members to Japan.

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