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### Team Qualification Document for RoboCup 2018, Montreal, Canada: Dutch Nao Team

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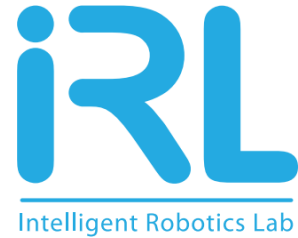
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TEAM QUALIFICATION DOCUMENT FOR ROBOCUP 2018  
MONTREAL, CANADA

# DUTCH NAO TEAM

<http://www.dutchnaoteam.nl>



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January 31, 2018

## 1 Team Information

This is the qualification document for the Dutch Nao Team with Caitlin Lagrand as its team leader. The team consists of eight master students, six bachelor students and one staff member from the University of Amsterdam in The Netherlands. In the last eight years the team has bought 17 Nao robots, although not all those robots are operational anymore. If the Nao V6 will be allowed in the competition, the Dutch Nao Team has the intention to buy this version to replace the no longer serviced Nao V3 robots. The qualification video is available at our YouTube channel<sup>1</sup>. A research report [1], describing the technical details of the team's work for RoboCup 2017, has previously been published on our website<sup>2</sup>.

## 2 Mixed Teams

For this year, the team is focusing on developing the basic modules of its framework, such as localization and team communication, which are necessary to play football with other teams. Therefore, the Dutch Nao Team is not interested in participating in the Mixed Team competition this year. In future RoboCup events however, the team is interested in joining the Mixed Team competition.

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<sup>1</sup> <https://www.youtube.com/watch?v=-6J7s3rnm1E>

<sup>2</sup> <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 in 2014 and 2015 for the soccer competitions.

In 2016, the team started with a custom framework based on ROS [2], however, we did not enter the competition with this framework as experiments showed that running a ROS <sup>3</sup> core node and image publishing nodelet resulted in a frame rate of approximately 5 Hz, even without any further processing. We deemed this too low for usage in RoboCup competitions. In the 2016 RoboCup competitions, we used B-Human's 2015 code release<sup>4</sup>, extended with our own behavior engine [3] and ball detector [1].

Starting from April 2017, the team has been using its own framework. The decision to start a new framework was made because the complexity of other frameworks was cumbersome, hampering the educational value of participating in the RoboCup. Furthermore, a custom framework allows for more opportunity to contribute to the goal of the RoboCup. The team members indicated that their lack of knowledge on numerous aspects of foreign frameworks caused frustrations during the development of new modules. To solve this problem the team's framework should be simple, properly documented and supplied with examples, allowing it to be expanded upon by future iterations of the team. Ultimately, every team member should be able to largely understand its inner workings and feel comfortable with it.

So far, the team has noticed that despite the obvious drawbacks of having to redo 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.

#### 3.1 DNT-framework

The main goal of our framework is to make it easy enough for new team members to implement their algorithms while still being powerful enough to offer good scalability and performance, possibly for future robotic platforms. Our new framework is based on messages sent between modules, where each module represents one algorithm handling a task in the soccer 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.

In contrast to ROS, our system does not need to use the TCP/IP stack to deliver messages between modules. Instead the framework has four important components: modules, module groups, topics and messages. The base class of every module can create a publisher to send messages and a subscriber for receiving messages. The subscriber class has a queue of messages which allows for interpolation between messages or filtering while mainly being beneficial for async-messages.

The second component is a topic, which receives a representation from a publisher and sends it to all subscribed subscribers. The use of a wrapped Message class eliminates the need for making a copy of the data.

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<sup>3</sup> <http://www.ros.org/>

<sup>4</sup> 2015 Release: <https://github.com/bhuman/BHumanCodeRelease/tree/1fd87519e2bbb3cbb5f288980438b692629f7c1>

Thirdly, the module master uses topological ordering of module update calls for scheduling where modules are nodes and edges are represented by either publishers or subscribers for each topic. The cycles in the graph are removed by running minimal spanning tree based on edge weight.

Finally, the module group which is run by a module master represents a set of modules which run in their own thread while the framework handles the communication across threads. By centralizing the topics, error logging, serialization and communication with a PC over TCP/IP could be easily implemented.

The whole framework is implemented in modern C++14 with a fully templated API for type safety reasons. It also uses static asserts, exceptions and tests to make the API as reliable as possible.

### 3.2 Localization

As the basics of the framework have been made last year, which enabled walking and seeing the ball, more advanced cognitive functions can be added to the framework, such as localization. To enable this crucial element we approached the problem in several steps. We started by detecting lines in an image. However when testing we realized the lack of adequate data-sets available to determine whether our parameter tuning was effective. We built a tool for annotating lines in images obtained on the robot in order to create a validation and test data-set which we could use for evaluating our line detection models. The result of such manual labeling can be shown below in Figure 1. The result of this labelling is a list of  $x, y$  coordinates describing lines in every labelled image. This allows us to test for accuracy of our line detection algorithms and leads to better fine tuning on our part.

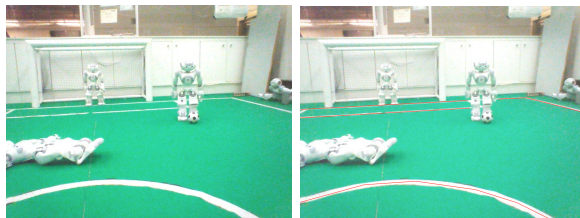


Figure 1: Before and after manual line labelling

For line detection some pre-processing is done. First a background mask which eliminates everything outside the field by detecting green. Afterwards the image is converted to a binary image. Finally a simple cluster assignment algorithm, based in Euclidean distance, captures pixels which are likely to belong together to form a certain object. Additionally a real distance transformation will be implemented which would make the clustering algorithm more accurate in it's estimations.

The technique used for our localization module is based on Unscented FastSLAM [4] which is derived from an Unscented Kalman Filter (UKF) [5]. In conjunction with the currently implemented modules, line detection and localization are the most valuable features to enhance the Nao's ability to compete.



Figure 2: Cluster assignment algorithm

### 3.3 Interface

In order to have a more user friendly way to visualize the different representations, the team is currently building a graphical interface, using the library NanoGui<sup>5</sup>. Each representation has its own widget that displays the contents in an appropriate way. For example, the widget associated with the Camera module shows the image as currently seen by the robot and highlights the ball according to the ball detector while the widgets associated with the sensors show either numerical values (i.e. for the battery level) or simple check-boxes for binary values (i.e. the currently pressed buttons). In addition, a graphing feature is planned which allows for live examination of numerical values.

### 3.4 Whistle Detection

At the start of the game, robots are supposed to start moving after hearing the whistle, which becomes an event driven activity, achieved using a whistle detector. Although an initial study indicated the possibilities for such detector [6], we did not have a whistle detector module integrated in our framework. This gives the other team, if they have a whistle detector, an 15 second advantage. Besides giving the other team more time, it also looks more interesting to the public if the robots react to a whistle, compared to randomly starting to move. Therefore we decided to integrate a whistle detector module into our framework this year. The whistle detector module uses the audio data in the audio buffer that is updated continuously by the microphone module of our framework. The whistle threshold and frequencies are pre-configured in a configuration file, which is used for comparison. The whistle detector uses the Short Time Fourier Transform library, developed by Austrian Kangaroos which was released as part of their whistle detection module on the RoboCup Standard Platform League open source resources page<sup>6</sup>.

## 4 Past History

The predecessor of the Dutch Nao Team was the Dutch Aibo Team [7]. The Dutch Nao Team debuted in the Standard Platform League (SPL) competition at the German Open 2010 [8]. Since

<sup>5</sup> <https://github.com/wjakob/nanogui>

<sup>6</sup> RoboCup Standard Platform League open source resources: <http://spl.robocup.org/open-source/>

their founding, the Dutch Nao Team has been qualified for the world cup competitions in Istanbul [9], Mexico City [10], Eindhoven [11], João Pessoa [12], Leipzig [2] and Nagoya [13].

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<sup>7</sup>, the European Open 2016, the Robotic Hamburg Open Workshop 2016 and 2017. At the Benelux Conference on Artificial Intelligence 2016 the team received the award for best demonstration [14], at the Iran Open 2017 the team received the Award in the Open Challenge with a presentation on our behavior engine.

The results from 2016 onward are presented in Table 1. In Nagoya, we ended second in our first round robin pool and third in our second round robin pool.

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.

Year	Round	Opponent	Score	Year	Competition	Opponent	Score
2016	Round Robin	UT Austin Villa	0:6	2016	European Open	B-Human	0:7
		Linköping Humanoids	0:0			Nao Devils	0:2
		SPQR	0:0 [0:1]			HULKs	0:0
	Play-in	DAInamite	0:0 [2:3]		2017	Iran Open	HTWK
Round Robin	Luxembourg United	0:0	MRL	0:2			
	Aztlan	0:0	HULKs	0:0			
	Second round	Nomadz	0:1	SRC			0:0
		JoiTech	1:1				

(a) Game scores for RoboCup 2016 and 2017.

(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 Montreal: in December 2017 the Dutch Nao Team has attended the RoHOW<sup>8</sup>, and we are planning to participate in the IranOpen 2018<sup>9</sup>.

## 5 Impact

During the participation in the RoboCup, the Dutch Nao Team has provided its support or resources in bachelor & master theses[15,16] and projects that lead to publications on a large variety of topics. At the Maastricht University, a PhD student published a paper on learning a more stable gait[17], compared to the energy efficient gait from earlier work[18]. In an honours project a comparison was made on ball detection with classical image processing versus modern deep learning techniques[19]. The Dutch Nao Team extended the application of the Nao robot to the @Home league of the

<sup>7</sup> TechFest is Asia’s largest science and technology fair with more than 165,000 people attending: <http://techfest.org/>

<sup>8</sup> See <https://www.rohow.de/2017/en/teams.html>

<sup>9</sup> <http://2018.iranopen.ir/en-gb/home.aspx>

RoboCup: the Nao robot was used to help in a kitchen environment by finding a tomato and grabbing it from a table [20,21]. Finally, the Dutch Nao Team has made the penalty shootout situation into a standalone demonstration [14] which it premiered at the Benelux Conference on Artificial Intelligence 2016<sup>10</sup> and won the first prize for best demonstration.

Earlier the Dutch Nao Team has published papers in the International Conference on Advanced Robotics [22], the Performance Metrics for Intelligent Systems Workshop [23], the RoboCup IranOpen Symposium [24], the RoboCup Symposium [25] and the international conferences as International Conference on Autonomous Robot Systems and Competitions [20].

Besides the Dutch Nao Team, the Intelligent Robotics Lab<sup>11</sup> of the University of Amsterdam also has a team called UvA@Home that competed in the standard platform competition of the @Home league with the SoftBank Robotics Pepper robot [26]. Two members of the UvA@Home team will be helping the Dutch Nao Team with new experience in localization, perception and kinematics. 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.

## 6 Other

Besides working on robot football, the Dutch Nao Team gives many lectures about robotics, 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. All money donated to the foundation is used to educate and inspire the general public and students of information studies to learn about robotics and artificial intelligence.

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