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### Dutch Nao Team - Team Description for Robocup 2014 - João Pessoa, Brasil

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**Publication date**

2013

**Document Version**

Author accepted manuscript

[Link to publication](#)

**Citation for published version (APA):**

de Kok, P., Negrijn, S., Bargiacchi, E., Gudi, A., Kooijman, C., van der Linden, I., Methenitis, G., Nugteren, S., Steenbergen, N., ten Velthuis, D., Verschoor, C., Wiggers, A., Thomas, J., Delgado Lopes, G., Roos, N., & Visser, A. (2013). *Dutch Nao Team - Team Description for Robocup 2014 - João Pessoa, Brasil*. Universiteit Amsterdam, TU Delft & Maastricht University. <http://www.dutchnaoteam.nl/index.php/publications/>

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TEAM DESCRIPTION FOR ROBOCUP 2014  
JOAO PESSOA, BRASIL

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## DUTCH NAO TEAM



<http://www.dutchnaoteam.nl>



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December 4, 2013



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## 1 Introduction

The Dutch Nao Team consists of students and staff members from three Dutch universities. The Dutch Nao Team debuted in the Standard Platform League (SPL) competition at the German Open 2010 [1]. Since their founding the Dutch Nao Team has been qualified for the world-cup competitions in Istanbul [2], Mexico City [3] and Eindhoven [4].

The Dutch Nao Team intends to participate in the main SPL soccer challenge, the drop-in challenge and the technical challenges, with a strong preference for the sound recognition and autonomous refereeing challenge, on one condition. As of now the Dutch Nao Team lacks the funding to send its undergraduate students to the event. Without sponsoring or travel support the Dutch Nao Team will not be able to attend the RoboCup. In table 1 can be seen that the current deficit is 4080 euro with a limited team representation of four members. In previous years the sponsorship, for instance earned by demonstrations, was in the order of 1000 euro.

	Expenses	Income
Flight	€4400,00	
Transit from airport to venue location	€400,00	
Hotel	€840,00	
Daily spending	€840,00	
Team-member contribution		€2400,00
Registration fee	€1600,00	
Universities registration contribution		€1600,00
Total	€4080,00	

Table 1: An overview of the Dutch Nao Team budget for sending four students to the RoboCup in Brazil. It shows a deficit of 4080,00 euro.

## 2 Relevant achievements and publications

The Dutch Nao Team was founded in 2010. Since that time, it has participated in several workshops, regional competitions and world cups. When possible, participation in the competition was combined with a symposium publication [5,6]. In the 2011 World Championships in Istanbul [2], a top 16 position was achieved. At the 2012 World Championships in Mexico [3] the team was eliminated during the intermediate round. In the 2013 World Championships in Eindhoven [4], again a top 16 position was achieved again.

The Dutch Nao Team, and its predecessor the Dutch AIBO Team, has an extensive publication list<sup>1</sup>. The list contains for instance 1 journal article, 3 book chapters, 10 conference papers, 7 master theses and 5 bachelor theses. More details about current research can be found in section 3.

### 2.1 Support

The Universiteit van Amsterdam has been active in the RoboCup since Paris 1998. The Universiteit van Amsterdam has cooperated in several leagues with other universities, for instance,

<sup>1</sup> See for an overview <http://www.dutchnaoteam.nl/index.php/publications/>

with the TU Delft (Windmill Wanderers, Clockwork Orange, Dutch Nao Team). This year also a RoboCup@Work team has been initiated [7]. The Universiteit van Amsterdam's Informatics Institute and TU Delft support the team with a fully equipped robot lab and the usage of two H25 v3.2 Nao robots, five H21 v3.3 Nao robots equipped with v4.0 heads, four H21 v4.0 Nao robots and two H25 v4.0 Nao robots. Maastricht University has three v3.2 H25 robots and recently ordered a H25 v4.0 Nao robot. When qualified, the Maastricht University intends to buy two additional H25 v4.0 Nao robots.

### 3 Research

The main focus of the Dutch Nao Team is the combination of Artificial Intelligence and Robotics. The RoboCup initiative gives the team the opportunity to work with various aspects of Robotics.

Since early 2012 the Dutch Nao Team has chosen Nao Team Humboldt's (NaoTH) code<sup>2</sup> as framework for their code. Its modular design gives the Dutch Nao Team the opportunity to focus on high level programming by giving a more solid low level foundation. With the NaoTH framework the team can focus more on bringing the newest AI techniques to the code.

The code our team uses, is forked right before NaoTH joined the Berlin United research group. By forking this framework, we hope to bring diversity among the SPL teams. The research goals of the Berlin United group differ from ours, and we expect to diverge considerably in the future.

Examples of previous, current and future research [8,9,10,11,12,13,14] are presented in the sections 3.1 – 3.10. Other examples [5,6,15] are described in our previous team description papers [2,3,4].

#### 3.1 Orientation on the field

The symmetrical field triggered our interest in finding a robust method of overcoming related mistakes in localization. In our recent publication [10], we present an approach to orientate accurately on the field. The visual compass that inspired our approach [11,13] assumes a static environment, infinite distance from the color features, and only a single initialization phase before the actual query phase of the model; assumptions that make this approach weak in dynamic environments such as the one we are interested in.

To overcome these issues, we came up with an extension to the work discussed before [11,13]. To reduce the error that arises by moving from the initialization point, our method [10] constantly builds up a model for several visual compasses, distributed over the field in a grid. Updates can be added even during the query phase, dealing like this with the dynamic environment. The query phase of this model combines information from several cells and features depending on the location and the orientation of the particles from the underlying localization module.

This framework can be extended to a multi-agent setting. Robots can benefit from each other's observations by sharing feature vectors to achieve a faster adaptation to the environment.

#### 3.2 Position on the field

We do not only strive to improve the orientational accuracy, but also the positional accuracy. As for previous years, this part of the localisation module is subject to change again. Currently we use

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<sup>2</sup> See for more information <http://www.naoteamhumboldt.de/en/publications/>

a method based on the augmented Monte Carlo localization, such as described in [16]. However, more advanced techniques have been developed.

The marginalized particle filter is one of the possible approaches we are considering. This filter is known to be computationally intensive [17]. The error in computed and true location will be investigated. When comparing this with the error of comparable localization modules, we hope to get insight in the performance of our visual feature detectors in game situations.

### **3.3 Player recognition**

Recognizing opponent robots on the field enables the application of advanced attack and defense strategies. A straight-forward method for robot recognition could be based on color segmentation of the Nao's cyan and magenta jerseys. To perform this recognition for unknown lighting conditions requires a learning approach, comparable with the approach described in Section 3.7. Yet, it can be foreseen that conflicts will be arrive between the magenta of the jersey and the red of the ball.

The robustness of the color segmentation based approach will be compared with a method based on a curvature based shape representation [18]. Both techniques will be evaluated under typical soccer circumstances (involving frequent occlusions).

### **3.4 An effective “pushing” strategy for the Nao robot**

As application to the open challenge, the Delft Center for Systems Control has decided to work on something that can be advantageous to the field of humanoid robotics in general. Pushing obstacles is a task that human beings come across quite often. Humanoid Robotics will reach a stage in the future when robots will be executing exploration missions, rescue missions and other types of missions where the task of pushing obstacles will have to be handled efficiently. Hence I have narrowed down my objective for the open challenge to enabling the NAO to effectively and if possible, dynamically as well as stably push objects.

Much work has already been done in the field of ‘static pushing’ using humanoids. The most interesting work in recent literature being the work done on humanoid robot HUBO+ [19]. Different postures that humans use for pushing, namely the ‘feet together’ and ‘feet apart’ stance were implemented and studied. An articulation in the waist enabled the Zero Moment Point (ZMP) to be moved forward in the pre-pushing stance, in both the postures described earlier. This forward movement of ZMP played a crucial role in helping the humanoid robot exert more force on the object being pushed. But it is understood that usually the ‘feet apart’ stance is more advantageous while pushing an object, since the robot would not have to rely on the object for stability. For the Nao robot we will concentrate on dynamic pushing in the ‘feet apart’ stance.

### **3.5 Discovering reoccurring motifs to predict opponent behavior**

In contrast to human soccer players, autonomous robot soccer players often move according to a limited set of predefined behavioral rules. This knowledge can be used advantageously: If the opponent's behavioral rules are learned, it will be possible to detect these during a match and react accordingly. A method for autonomous activity mining in videos, called Probabilistic Latent Sequential Motifs, is used to discover optical flow patterns in videos of a robot soccer player during a penalty shootout [8].

The discovered patterns are used by the goalkeeper to predict and anticipate opponent behavior. Effectiveness of the method is tested by comparing the performance of this goalkeeper with predictive behavior to that of an existing goalkeeper that only reacts when the ball approaches at sufficient speed. The performance is measured based on the ratio of number of goals to number of goals prevented. Results show that the goalkeeper with predictive behavior could prevent a fair amount of goals, but that it loses in performance to the existing goalkeeper.

### 3.6 Visual terrain classification

The use of evolutionary algorithms to optimize walking parameters for an existing walking framework has proven to be reasonably successful [9]. After setting reasonable bounds on the parameters and sufficient iterations in simulation, a gait was found that performed well for omnidirectional walking tasks. If several similar gaits are found for a discrete set of ground types, ranging from flat carpet to uneven, rough terrain, the Nao can adapt by classifying the ground type and adjust its gait accordingly by switching to a corresponding set of parameters.

Classification of terrain requires a discretization of possible terrain types. Attributes that are likely to be important are friction, slope and if the ground is uneven. All of these can be perceived, although some attributes are harder to measure accurately than others. The amount of friction the terrain offers can be classified by comparing the robot's displacement to expected displacement based on kinematics. Less displacement, possibly due to slipping, indicates low friction; no or negative displacement, possibly due to a stuck foot, indicates high friction. Slope is measured by looking at gyroscope data and comparing it to expected values for flat ground, and could be computed analytically when the terrain is even. Unevenness in the ground can be detected through the foot sensors, although there are only four sensors per foot, and the effectiveness of this method has yet to be shown. Training of the model will be time consuming, but once learned efficient methods for confirming or rejecting the current ground model can be devised, based on the expected pressure.

### 3.7 Automatic color calibration

To be successful in the Any Place Challenge several nontrivial problems have to be solved. For instance, the Nao has to walk on a surface which is not known in advance. Another issue will be that there will be no fieldlines, which requires a graceful degradation of the localization module. Further, the Nao has to make its decisions based on only two percepts: the goal detection and the ball detection. During the challenge, we may assume that the largest yellow object consisting of three lines and circular, orange objects are the goal and the ball respectively. However, these colors must be recognized under unknown lighting conditions.

A previous study [14] researched this lighting issue, and it was found that the absolute position of the colors can dramatically shift with the lighting conditions, but that the relative position can be used to classify color cluster correctly.

A subset of the results is shown in Fig. 1. The algorithm, developed in [20], proved to be highly robust against lighting conditions. Still, there are many open issues. For instance, the location of the white cluster in the color space is a good indication of the color of the light source and gives an indication where the search for the orange and yellow clusters can start. Another challenge is distinguishing candidate ball and goal objects from the background.

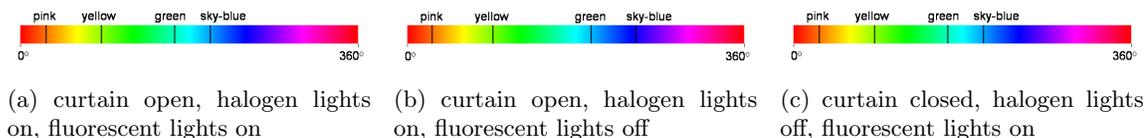


Fig. 1: Hue value of the cluster centers  $H_s$  under a variety of lighting conditions

### 3.8 Fisheye camera for robot detection

Localizing a humanoid robot, such as a Nao, with the use of external cameras is often done with multiple overhead cameras. A single fisheye camera creates the wide, panoramic images that enable view of the whole soccer field, such that it can be captured by a single camera. When Nao robots are localized using the overhead fisheye camera in our developed system [21], quite accurate coordinates will be available. These coordinates can be used as ground truth to verify a Nao’s location belief, or as input for an autonomous refereeing system. With tracking techniques of an earlier project [12], the system will be able to observe events, such as specific robots crossing a certain line.

### 3.9 Acoustic signal recognition

Since teams will use their own whistles and are supplied by the sounds to be recognized in advance, these signals can be analyzed in terms of frequencies contained in the signals. Since these signals are a compound of a priori known frequencies, our method will first compute a Fourier transform and filter out frequencies that are not part of the signal to be recognized, such as ambient noise. One method for removing transient noise is to smooth the transformed and filtered signal over time. A simple detection algorithm would be realized through detecting energy in those specified frequency bands with a given time threshold. If a stable signal is recognized for a sufficient time span it can be classified as the whistle. We expect the duration of the noise to be shorter than the whistle signal.

An extension to this is to construct a “template” for the input sound, and classify the sound according to an “input template” distance threshold. This could either be realized in pure frequency space, or alternatively through algorithms, such as mentioned by [22] that compute timbre features of the input sound.

### 3.10 Drop-in challenge

The drop-in challenge of last year is now scheduled as a full competition. This is a great opportunity to study multi-agent cooperation. During the challenge in Eindhoven, the teams that used static role assignment for the player roles did not perform too well. We intend to assign roles dynamically to our player in the drop-in challenge, as happens as well when playing in the regular league. The roles will dynamically changes depending on the position of other agents and the position of the ball. Furthermore, we will investigate the possibilities to learn more information about the capabilities of our team-mates, for instance, with the method mentioned in section 3.5.

## 4 Activities

As part of the Intelligent Robotics Lab, the Dutch Nao team is involved in activities that focus on outreach and on education of both high school students as well as our own students.

#### 4.1 Demonstrations and media attention

The last year, the Dutch Nao Team has focused on promoting the RoboCup and Artificial Intelligence at several locations in the Netherlands. This was accomplished by giving demonstrations at relevant events and through the use of media<sup>3</sup>. A monthly demonstration of robot soccer is given in the lab for the general public, where changes in code are explained.

#### 4.2 Education and promotion for highschool students

The team is involved in several projects targeting high school students. For one, the annual summerschool has been transformed into a masterclass. With the support of the Universiteit van Amsterdam, this will be held twice a year. Students will learn the basics of robotics in an assignment to walk through a maze. As a second project, the Universiteit van Amsterdam organizes an annual event where senior high school students study and work on a subject of the bachelor studies of their choice. For the Bachelor in Artificial Intelligence, the practical assignment is to program a Nao to dance, based on a Dutch translation of 'An introduction to robotics with NAO' [23]. As third project, to finish the highest level of high school on a heavily STEM oriented track, a student is creating an interactive version of the assignments in [23].

#### 4.3 Teaching at undergraduate and graduate level

The team has organized a C++ programming course to educate future members and other interested students. This has encouraged freshmen to join the Dutch Nao Team or other teams encompassed by the Intelligent Robotics Lab. By offering projects, students are able to conduct research relevant to the RoboCup for course credits. Workshops and lectures held by peers and local companies are well-attended. Members of the team have attended several RoBOW workshops and the Humanoid Soccer Summer School in Bonn.

### 5 Conclusion

The Dutch Nao Team has become an experienced team. It will continue its research, especially in the field of probabilistic robotics and autonomy. By joining forces with Maastricht University and cooperation with the teams participating in other robotic competitions, it will become possible to apply state-of-the-art techniques in a much broader field than before. It will also continue to educate students interested in Robotics, as well as promotion of AI research in general.

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<sup>3</sup> See for a list of activities <http://www.dutchnaoteam.nl/index.php/irolab/>

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