# Emotion expression of an affective state space; a humanoid robot displaying a dynamic emotional state during a soccer game

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# Emotion Expression of an Affective State Space;
## a humanoid robot displaying a dynamic emotional state during a soccer game

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### Introduction

A robot collaborating with a person can improve the interaction with that human by showing emotional expressions [1]. The expressions don't have to be realistic; iconic or caricature expressions are enough for a human, with its social intelligence, to instinctively interpret the intention [2]. The Nao, with its humanoid shape, is a robot whose emotional state is relatively easy to be interpreted by a human, although this is mainly based on its posture and gestures. With this robot, we like to demonstrate a dynamic emotional scenario; a robot following a soccer match and react appropriately to these events by showing emotional expressions.

### Platform

The Nao is a humanoid robot[1] whose internal functions are accessible by multiple programming languages. The Python interface was selected, which gives remote access to all methods from the native Naoqi library (version 1.6.13). In this study the standard Naoqi library is extended with an experimental library of emotional expressions, kindly provided by the developers of Aldebaran [2]. The Nao robot has limited expression in its face, so the emotions are mainly expressed by body language. The emotional expression library provides a variety of animations, but doesn't provide the logic when to activate the emotions.


Figure 1. The basic emotions [3] expressed by the Nao robot.

This study has designed the logic for an emotional system for a single scenario which was selected because this scenario typically initiates high arousals and clear emotions.

### Affective State

The chosen scenario is to follow a soccer match, and based on particular events in the match, we would like the Nao to respond appropriately. In order to do so, events must be associated with an emotional response. However, the coupling between events and response is not direct, but also driven by internal factors. The response depends on the team the robot is supporting, and on how the previous events affected the emotional system of the robot. This multi-step approach is not uncommon in other computational emotional processes; see for instance the framework described in [4].

Inside the scenario, six typical events are identified which are strong stimuli. Each event is tagged which an estimated intensity change of the affective state space of Mehrabian [5]. The affective space is represented with three factors [6]: stance, valence and arousal (inspired by [1]). Each factor has a positive and negative scale, respectively open/closed

[1] The Nao robot (v3plus) is a product of Aldebaran Robotics (http://www.aldebaran-robotics.com).

towards new experiences, optimistic/pessimistic feelings and assertive/passive attitude. All factors are normalized on a range between -100 and +100. Both **goal** and **attempt missed** influence the arousal in the positive direction. In contrast, **attempt saved** influence arousal in the negative direction; it is soothing when a keeper intercepts a shot.

| | **Our team** | | | **Their team** | | |
|---|---|---|---|---|---|---|
| | *Stance* S | *Valence* V | *Arousal* A | *Stance* S | *Valence* V | *Arousal* A |
| **Attempt missed** | $F_{-}(b_{game})$ | V - 20 | A + 20 | $F_{+}(b_{game})$ | V + 10 | A - 10 |
| | 'Annoyed'-direction | | | 'Calm'-direction | | |
| **Attempt saved** | $F_{-}(b_{game})$ | V – 15 | A – 5 | $F_{+}(b_{game})$ | V + 15 | A - 5 |
| | 'Sad'-direction | | | 'Content'-direction | | |
| **Goal** | $F_{+}(b_{game})$ | $F_{+}(b_{goal})$ | $F_{+}(b_{goal})$ | $F_{-}(b_{game})$ | $F_{-}(b_{goal})$ | $F_{+}(b_{goal})$ |
| | 'Joy'-direction | | | 'Angry'-direction | | |

The Stance *S* is influenced by the game balance $b_{game}$. During the game the numbers of positive and negative events are weighted and aggregated. If the weights of positive and negative events are nearly equal, the game is in balance. When the balance is in favor of our team, the game is even more interesting to watch. Notice that when no events take place, the values of stance, valence and arousal fade away. The value of arousal decreases stronger than the other values, and can become negative. When multiple events occur in a short time, in most cases the effects are combined, although in some case (**Goal!**) an event can be dominant. The values in this table are validated with a questionnaire with 22 participants[2]. The same questionnaire provided the shape of the dependence of valence and arousal as function of the goal-balance $F(b_{goal})$.

This scheme has been tested on reports of recent games of the Dutch team during the World Championships in South Africa[3]. The trace of the affective state of the exhibition match against Ghana is illustrated in Figure 2.

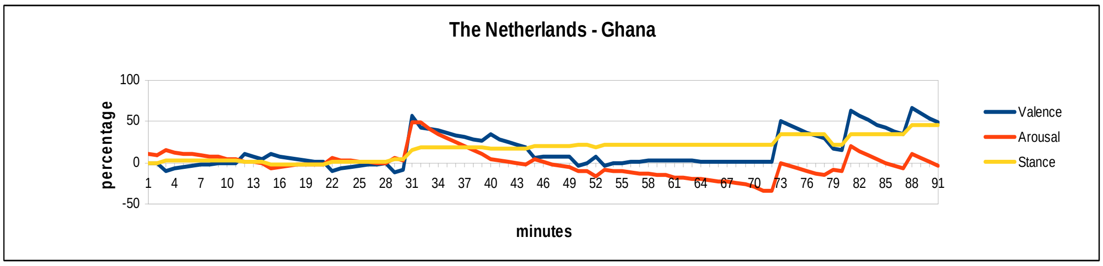


Figure 2. Trace through the affective space based on the emotional system designed for the Nao.

As shown in Figure 2, the valence is mainly influenced by the goals (4 goals for the Netherlands), but the feelings fade away gradually. The stance is mainly influenced by the goal balance (with only a small decline when Ghana scored 2-1). The arousal is mainly influenced by the number of events, and can become negative.

## Robot emotional expressions

The wide variety of emotions generated by the emotional system should be mapped to the animations available for the Nao robot. 9 of the 50 animations are used to express the emotions encountered during the game. There are 14 animations available for neutral valence. Only two are used; both variants of *meditation*. If the arousal is positive, *meditation* is displayed standing, when the arousal is negative is performed sitting.

There are 17 animations with a positive valence. The joy-direction of the emotional trace correlates with four different variants of *Happy*, each used to express a different level of valence, as illustrated in Figure 3.

For negative valences, 19 animations are available. Those animations are mainly different in relation of stance (assertive / passive) and not on the intensity of the valence. Two animations are used to express the emotions found in the anger branch (*sad* and *shortAngry*).

[2] See for more details the survey report at http://dev.midnightcoding.org/redmine/projects/uva-nao/files.
[3] Reports are available at http://soccernet.espn.go.com. The reports are parsed with a SGML parser.

Figure 3. Sequence of animations with increasing valence (**aBitHappy** → **veryHappy**).

In Figure 4 the locations in the affective space are given for the 9 selected emotional expressions.

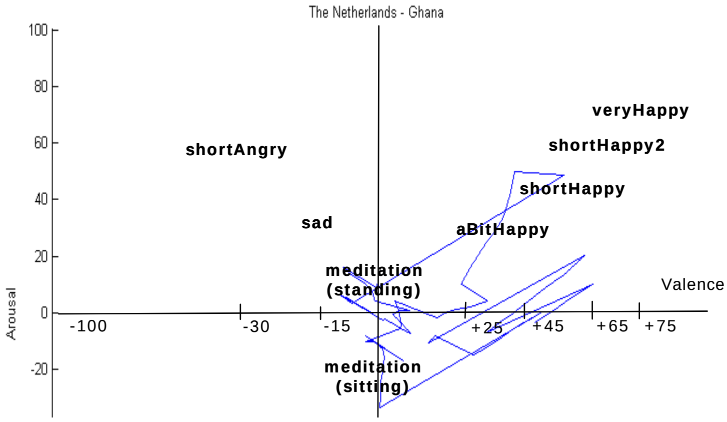


Figure 4. Mapping of Nao's emotional expressions to the affective space (arousal and valence only). The blue line indicates the arousal and valence values encountered during the quarter final.

## Demonstration

The affective state of the Nao can be stimulated in several ways. The stimuli can come from a live report of a soccer match; it can be based on an archived report of a match or can be generated by artificial sequence of events by clicking in an emotional simulator built for this study. Dependant on the timing and order of the events, a different affective state of the Nao is generated. This results in a Nao who follows the game sitting when the game is uneventful. As soon as the game becomes attractive, the Nao stands up, and shows his pleasure or displeasure. Video recordings of this demonstration are available[4].

## Conclusion

Following a soccer game is an example where clear emotions are displayed. This example is worked out for a humanoid robot which can express emotions with body language. The emotions expressed by the robot are not just stimuli-response, but are based on an affective state which shows dynamic behavior during the game. This emotional system can be extended towards other robots, with other means (such as voice or facial expressions) to express emotion.

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[4] The videos are available for download at http://dev.midnightcoding.org/redmine/projects/uva-nao/wiki