

Postural Expressions of Emotions in a Humanoid Robot for Assistive Applications

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Abstract—In this paper, we present the development of postural expressions of emotions for the humanoid robot Nao in an assistive context. The approach is based on the adaptation of human body postures to the case of the Nao robot. In our paper, the association between the joints of human body and the joints of Nao robot are described. The postural expressions are studied for three emotions - anger, sadness, and happiness. In our experimental design, we generated 32 postural expressions for each emotion and based on the questionnaire-based interview of ten external observers, we selected the best five postural expressions for each emotion. The results of this work will be integrated in a study designed for children with autism.

Keywords-human-robot interaction, social behavior, emotions.

I. INTRODUCTION

In the past few years, many studies have tried to equip robots with emotional expressiveness [1, 3, 4]. Having robots with naturally social behaviors in interaction with humans is a challenge in the human-robot interaction field. Postural expressions of emotions constitute an important part in the social interaction between the humanoid robot and the human. This study aims at developing emotional postures to be used with Nao robot in an assistive context, designed especially for children with autism.

To the best of our knowledge, a lot of the existing studies that are equipping robots with emotions, are focusing on emotional facial expressions. The Ekman six emotions: happiness, fear, surprise, sadness, anger, and disgust have become to be known as the six basic emotions [2]. Breazeal in [3], describes a social behavior architecture that allow the Kismet robot to express various emotions through the different parts of the facial construct. In [4], the authors, are describing a humanoid robot capable of facially expressing Ekman's six emotions. Compared to facial expressions, body postures are less studied in humanoid robot applications. The authors in [4] used body postures to accompany the facial expressions. However, in their work, a single body posture for each emotion was generated. As far as we know, no extensive research work in robotics concentrates on generating sets of body postures for conveying specific emotions.

Most of the existing studies try to generate human postures in virtual environments by using simplified simulation of

human body [5,6,7]. In these studies various postures are generated and shown to observers on computer screen. The feedback of the observers is used to verify the emotional content of body postures. The work of Coulson [8] is remarkable since it provides not only the visual content but also the quantitative joint angle values for various postures for the six emotions. In this work, we take inspiration from Coulson's work and try to generate postural expressions of emotions with our humanoid robot, Nao.

II. POSTURAL EXPRESSIONS OF EMOTIONS WITH NAO ROBOT

The research question that we would like to address in this paper is whether it is possible to generate postural expressions of emotions with a humanoid-robot. Moreover, our research question can be reduced to whether the postural expressions of emotions of human body convey the same kind of emotions when expressed through a robot body.

In order to answer this question, the human postural expressions of emotions [8] are adapted to the Nao robot. This adaptation requires slight modifications of the postures considering the constraints of the robot's joints which do not exist in human body. The range of joint angles of the Nao robot is not as large as the human body. The number of degrees of freedom of the joints is also less. Another constraint is due to the difference in mass distribution throughout the robot body. In some postures, the human body can stand stably, which is not the case of Nao robot because the ratio of the mass of the head to body is larger in Nao.

Among the six postural expression of Ekman's emotions studied by Coulson [8], we chose to focus on the most successful ones - anger, sadness, and happiness. These three emotions were attributed to a large number of postures with some of them reaching a consensus level of 90% among the participants. The most successful postures, all of which reached a consensus level of more than 90%, are given in Figure 1 for the three emotions (i.e., anger, happiness, and sadness). In our study, we use the 32 postures for each of these three emotions and determine five most successful postures for each emotion for the Nao robot. The data of Coulson [8] is transformed to fit the joint configuration of the Nao robot.

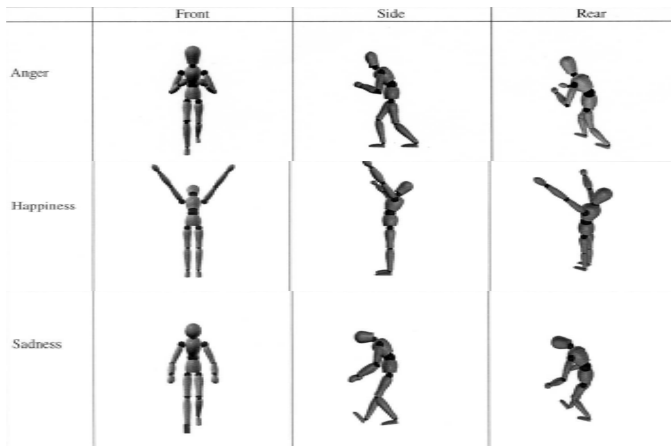


Figure 1. Most successful postures for anger, happiness, and sadness by Coulson, viewed from three different sides. [Adapted from [8].]

III. EXPERIMENTAL RESULTS WITH NAO ROBOT

Our aim is to come up with five successful postures for each of the chosen emotions.

The process of elimination was based on the feedback of ten external observers. A video for each emotion with 32 different postural expressions was generated. The participants watched the three videos of postural expressions of the chosen emotions (i.e., anger, sadness, and happiness) and gave feedback about the success of postures to convey the emotions. Each video showed the postures of the associated emotion sequentially. These videos are available on our web site [9]. The participants did not know about the related emotion before watching the videos. After seeing a video they were asked to relate it with one of the Ekman's six emotions - anger, disgust, fear, happiness, sadness, and surprise. The first results show that although the associated emotions were mentioned by some participants they were not the most selected ones in the three cases: the postural expressions of anger were associated 32% of the times with sadness, 27% with surprise, 22% with anger, 14% with fear, and 5% with happiness; the postural expressions of happiness were associated 50% of the times with happiness, 30% with surprise, 15% with fear, and 5% with anger; and finally the postural expression of sadness were associated 35% of the times with fear, 20% with disgust, 20% with surprise, 15% with sadness, and 10% with anger. This is an indicator that the postures related to an emotion are not consistently conceived as representing that specific emotion as a whole. It is also an indication that only the best within the groups should be chosen to represent the associated emotion with the Nao robot.

As a second phase of our experimental design, the participants were informed about the emotion associated with each video. They were asked to stop the video when they feel that the postures shown at that time is "strongly conveying" the associated emotion. In this phase, all the participants were convinced that the postures were related to the associated emotion and they could identify a number of postures that strongly represented the correct emotion. Five postures were determined for each of the three emotions. This determination was based on the number of times the postures were chosen and very close postures were eliminated. For example, for the case

of happiness very close postures were consistently chosen by the participants: the arms were raised in a similar way and only the inclination of chest or head was different. In such cases, only one of those similar postures is chosen as the best representative; the other best representatives are determined among other postures chosen by the participants.

For the postures of anger the statistics were as follows. The participants stopped the video for 51 times. These 51 instances correspond to 23 different postures of anger among the 32. The first two of the chosen postures, anger_32 and anger_18 were the ones that were indicated the most, 5 and 4 times respectively (see Figure 2). Seven postures were indicated three times. Among those, three of them were chosen, anger_3, anger_5, and anger_24, with consideration of not being similar to the previous. The indexing of the postures follows the sequence shown on the videos on our website [9].

For the postural expressions of happiness the participants stopped the video for 65 times, corresponding to 24 different postures of happiness. The first two of the chosen postures, happiness_5 and happiness_29 were the ones that were indicated the most, 8 and 7 times respectively (see Figure 3). One posture was indicated for six times, and two postures were indicated for five times; however, these postures were very close to the first two selected by differing only with slight head or chest bending. Therefore, they were not selected. Four postures were indicated three times, among those two, happiness_3 and happiness_4, were chosen with the consideration of not being similar to the previously chosen ones. The last selected posture was indicated only once, happiness_18, but it was quite different from all previously chosen postures.

For the postural expressions of sadness the participants stopped the video for 28 times, corresponding to 13 different postures. Three postures were indicated four times; two of them were chosen, sadness_4 and sadness_16 (see Figure 4). The third one was very similar to the previous ones. One posture was indicated three times; it was chosen as the third appropriate posture, sadness_7. Four postures were indicated two times; two of them were chosen sadness_15 and sadness_31.

In Figure 2, 3, and 4 the five selected postures are given for the emotions of anger, happiness, and sadness, respectively. The most successful posture of anger by Coulson [8] in Figure 1, corresponds to the posture angry_18 in Figure 2. The most successful posture for happiness by Coulson [8] in Figure 1, was indicated by the participants two times, but not chosen as one of the best five in our case. However, it is remarkable that this posture is very close to the mostly indicated posture of happiness_5. The most successful posture for sadness by Coulson in Figure 1, is not indicated by the participants. This is because the backward leaning of this posture is often perceived as conveying the disgust emotion, rather than sadness. However, considering the upper body, the posture sadness_16 is very close to that described by Coulson in [8]. In summary, the best human body postures described by Coulson in [8] and the best ones determined for the Nao robot for the three chosen emotions (i.e., anger, happiness, and sadness) are either the same or very close to each other.

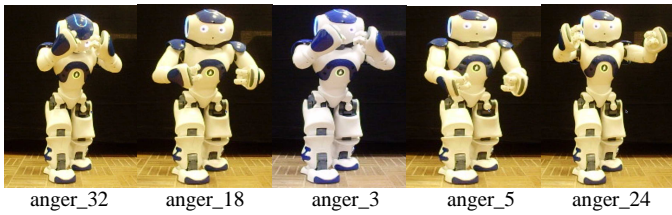


Figure 2. Five selected postures for anger.

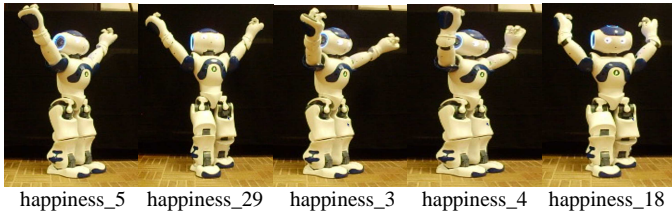


Figure 3. Five selected postures for happiness.

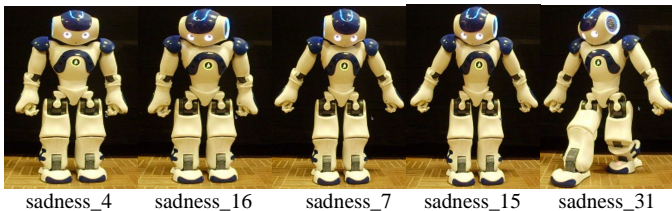


Figure 4. Five selected postures for sadness.

IV. CONCLUSION

The participants could not consistently name the associated emotion for the videos by only watching. However, they were all convinced about the correct emotional content of the postures after they were told - they could confidently identify the ones that best conveyed the emotion afterwards. This observation points out that context is of paramount importance in order to associate a posture with the emotion. In our case, mentioning the emotion related to a video corresponded to generate a context in which the postures should be viewed. When the observers expect an emotional content, they easily identify the postures to be related to that specific emotion.

This study demonstrates that a humanoid-robot can convey appropriate emotions through its posture. Furthermore, it also demonstrates that the postural expressions of emotions of the Nao robot can be generated based on the postural expressions of emotions as we know it from humans. The selected postures in this study should be further tested to convey the associated emotions in a contextual framework, without verbally mentioning the name of the emotion. We aim at performing such a test in an assistive context, with children with autism. The context is constructed in the form of a game. The game motivates the children to pay attention to the robot. They are explicitly and/or implicitly asked for the emotions conveyed by the robot.

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