The Intensity of Perceived Emotions in 3D Virtual Humans (Short Paper)

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ABSTRACT
Synthetically generated 3D humans often fail to express a full range of emotions or present different levels of the same type of emotion. Transcending the facial expression, what should a happy synthetically generated human look like? What about a slightly happy or ecstatically happy? This paper reports a study aimed at identifying the appropriate bodily expressions for various emotions in 3D human-like figures at varying emotional strength. Thirty-six volunteers were asked to discriminate and categorize thirty cards with static poses of 3D human-like characters into the Ekman's six basic categories of emotions. This is to judge the compatibility of each posture in relation to each category and to rate their level of emotion within the group.

Categories and Subject Descriptors
H.5.1 [**Information System**]: Information Interfaces and Presentation – *Multimedia Information System – evaluation/methodology*;
I.4.7 [**Computing Methodologies**]: Image Processing and Computer Vision – *Feature Measurement – Feature Representation*;
J.4. [**Computer Applications**]: Social and Behavioural Science – *Psychology*.

General Terms
Experimentation, Human Factors, Theory

Keywords
Basic emotions, 3D human character, non-verbal communication

1. INTRODUCTION
To be believable and human-like 3D virtual characters need to have goals, emotions and interact naturally and reasonably with their environment [1]. They also need to be capable of expressing their behaviour in a manner appropriate to the level of emotion they are expressing, like humans do. If a synthetically generated character fails to express the required suitable emotional expression, it will most likely break users' suspension of belief.

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Ekman's six primary emotions [2]: sadness, happiness, fear, anger, disgust and surprise are clear and recognised amongst different cultures, but his work is mainly concerned with faces. Coulson [3] has studied the attribution of emotion to the postural expression of mannequins from three viewing angles. However, he did not consider the strength of emotion expressed, and used a mannequin with little detail in bodily features such as hand gestures. This paper presents a study on the postural expression of emotion of 3D human-like characters. An experiment was conducted to measure the perceived emotion expression of static postural images of 3D characters as well as the strength of the emotion. This research provides taxonomy of emotion expressions for the construction of believable 3D virtual humans.

2. BACKGROUND
Various researchers have argued that incorporating emotions in characters is essential to create intelligence and reasoning [4], [5] and [6]. For example, Minsky [4] indicates that it is impossible to implement intelligence without emotions. In addition, Picard [5] has argued that the inclusion of emotions and affective behaviours in interfaces may contribute to a richer interaction and impact on the participants' ability to interact. The perception of innate emotions and behaviour in a character is important to impart a sense of possessing unique characteristic [7]. This phenomenon can create genuine responsiveness to the users' experiences.

In our daily life, interactions with socially unskilled individuals are often incongruent and difficult. An uncomfortable communication can often lead to anxious appraisals by those involved [8]. A similar phenomenon occurs when dealing with virtual characters. An individual's perceived behaviour realism of synthetic characters is positively associated with their experience with the characters [9]. Consequently we believe that the lack of emotional expression in synthetic characters can limit and/or have a negative impact on the communication with humans.

The emotional state of synthetic character, as for humans, should be demonstrated through all available channels such as speech, facial and bodily expressions. A smiling face with an unhappy body posture may change the meaning of the signal. However, the systematic manipulation of gesture and body expression of 3D characters remains a challenge.

A systematic study was carried out by Coulson [3] to group common attributes shared by the postures of the six affective states. He used attributes of six joint rotations to describe the postures, which included: head bend, chest bend, abdomen twist,

shoulder forward/backward, shoulder swing, and elbow bend. The attributes considered could clearly discriminate emotional states especially for anger, sadness and happiness. He suggested that the low recognition of some emotions such as fear showed the need for features to describe motion; for example direction, velocity, and amplitude [3]. His findings indicate that it is possible to recognize emotion from body posture. Thus, the dynamic of body gestures is a further factor to distinguish the emotions others want to convey.

This paper reports a study of the emotional expression in body postures. While Coulson [3] used a wooden stick figure, lacking in many details (e.g. hand gesture, foot position, gender clues), in the study reported here, the images used are of static 3D male characters where the detail of the body parts such as fingers and foot position are also included in the pose. Furthermore this study enquires about the strength of the emotion expressed by 3D virtual human postures, that was not done by Coulson [3] and the postures chosen here are different and in a greater number than those used by Coulson.

A 3D virtual model was considered rather than using photographs of a real person because the study was driven by the need to create virtual expressive believable characters rather than conduct a study on human emotional expression.

3. EMOTIONAL STRENGTH OF BODY POSTURE

Still images of static postures can be used as an effective and expressive medium of communication [10] and [11]. The postures and gestures used for this experiment have been modelled as possible bodily expressions of the six Ekman's basic facial emotions. Thirty images of 3D human figures have been created that express these six primary emotions through different poses, and placed on cards.

Since the intention of this study was to evaluate the perception of emotion from just the human body, all the faces in the 3D characters were removed by covering them with a filled oval to ensure that the judgement of emotion was not influenced by the face. The images of human figures were developed using the Curious Lab Poser 5 animation packages. For each of Ekman's six basic emotions: happiness, sadness, anger, fear, surprise and disgust [2] five poses were created based on two main sources: (i) literature (mostly in the psychology studies that offer more or less descriptions of emotional postures [3], [11], [12], [13], [14],[15]) and (ii) the collection of images that can be found with a Google[1] search on that category name.

In this study, the expressions, as well as the groupings, were experimented earlier and agreed by the authors and two other participants who did not take part in the main study. This posture grouping will later be labelled as the "predefined" postures emotion group.

A total of thirty-six volunteers (18 men and 18 women) took part in the experiment; the average age was 29 years old. The participants were volunteers from the general population, of mixed ethnic background, education and occupation. No distinction was considered in their background information as the Eckman's basic emotions are universally recognized. The participants were given a general information sheet about the study and asked to sign a consent form. The participants were then administered a questionnaire asking them to provide information about their background for demographic purposes. Subsequently they were asked to complete two main tasks. In the first task, they had to group all 30 cards into the six categories of Ekman's emotions by placing them under one of the emotion categories provided. A category was indicated by the human face expressing the six emotions, taken from Faigin [16], together with a label naming the emotion displayed on a board. Both approaches, the visual and the text, were used since the facial expressions of basic emotion are immediately recognized, while the label reinforced such first sight recognition.

Based on the groups of images they had created in the first task, the participants were then asked to rearrange all the cards placed in the same category from the lowest to the highest perceived level of emotion. The aim was to find out the intensity rating for all the postures in each category. The users rated the perceived emotion conveyed by each of the picture using a five-point Likert-type scale, where "1" represented the lowest level of emotion and "5" represented the highest level of emotion. The participants were allowed to choose more than one posture under the same level if they felt that those images represent the same level of emotions, and leave some levels blank if there were less than five cards that had been grouped for that emotion. In general, each participant spent approximately 30 minutes judging the images to complete both tasks.

4. RESULTS

The results of the experiment were analysed and it was found that the postures of happiness and anger had the highest accurate identification (more easily recognizable from body poses in a given context) by the participants with 77.2% and 69.4% respectively. Sadness and fear were less identified and disgust represents the lowest acceptable identification with only 43.3%. The details of the percentage identified for all six emotions are shown in Figure 1.

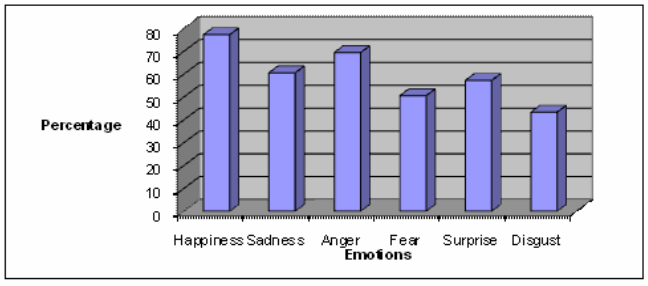

Figure 1. Percentage of posture identification

The expression of happiness H2 (posture of body held erect with straight arms held above the head and clenched fist) got the highest score with 92% recognition, this is followed by happiness H3 with 86% and happiness H4 (clapping hands up high) 72%. For the expression of sadness, S3 and S1 get the highest score with 97% and 86% respectively. The third highest score is S5 (bent arms pressed closely against the chest) with only 50%. For the expression of anger, all three postures performances were significantly high. Image A5 that displays wagging finger and clenched fist on the other hand received 92% while image A1

[1] www.google.com

(portrayed as if to strike violent with elbow squared) received 89%. Image A2 that portrayed arms rigidly suspended by the side of the body received 83%.

For the fear expression, only posture F2 received high percentage of 83%. This image represents a posture of crouching down with both arms closed to the chest, both hands clench and pressed closely to the mouth. Another two postures, F1 and F3 only gained 58% and 53% respectively. The first two postures that express surprise, which are S3 and S4, received the same rating of 75% from the subjects. In both expressions, the body were reclining and chest well expended but in S3, both arms were widely open to the side of the body whereas for the S4, both arms were at the upper side, central to the body with open palm as to protect.

As stated earlier, out of the six basic emotions that were used in this experiment, disgust retained the lowest rating from the subjects. For this type of emotion, D5, which shows the turning away of the whole body with one shoulder raised as if want to stop something retained 67% from the participants. This is follow by D2 (posture like denying or pushing something with both hands in front of the body) received 61% and posture D3 which shows both elbow raised to the side and open palms gained only 36% from the subjects. In this experiment, the 'not sure' option was used as control mechanism, but this option does not contribute to any identification of scores. Out of 36 participants, this option was selected by 18 participants.

Coulson's study [3] suggested that anger, happiness and sadness were attributed to large number of postures with some identified by 90% or more of the sample. In this study, only happiness and anger gained the high accurate identification but sadness and surprise gained slightly lower identification. Both of the studies agreed that disgust is the lowest acceptable or the most difficult posture to recognize with less than 50% of identification.

4.1 Validity of the Sample Created

In this experiment, the non-parametric Friedman test [17] was used to measure if significantly different levels of empathy for each emotion were identified. To test whether the created sample of emotional postures had an equal distribution of poses, which was no one emotion had more poses in the collection than another, the following null hypothesis was measured:

> H_0: The sample with 6 conditions (the emotions) has the same distribution

Result from the analysis showed that the value for the 30 postures is 1.487, which was bigger than p value (chi-square approximation, corrected for ties), 0.914. This indicates that H_0 was accepted. The mean rank for each emotion is show in the Table 1 below.

Table 1. Rank sum and mean rank using Friedman analysis

Emotions	Rank sum	Mean rank
Sadness	97.5	3.25
Happiness	101.1	3.37
Fear	104.5	3.48
Anger	105.5	3.52
Surprise	109.0	3.63
Disgust	112.5	3.75

In the second task, the experimenters predicted that there would be a different level of empathy for different posture in all six basic emotions. H_0 for each category of emotion is elaborate below. All the six emotions have the same H_0 hypothesis. An example of one H_0 hypothesis is as follow:

> H_0: Sample for all 5 postures of happiness has the same distribution (there is no difference in the level of emotion).

Since different participants produced different rating scores for all conditions, first of all, rating 0 was given to the blank field.

Rating 0 represents the lowest ranking in this analysis. Then the score for each posture was ranked horizontally across the rows for the five conditions. After that, the critical value of F was computed. Lastly, the value of F and critical chi-square values (df = 4) was compared to determined whether to retain or reject the null hypothesis. The result of calculation for all six emotions is shown in Table 2.

Table 2. Friedman's F values

Emotions	F values
Sadness	87.461
Anger	49.722
Happiness	31.294
Fear	28.944
Surprise	28.828
Disgust	20.294

As the result, the null hypothesis for all six emotions is rejected because the obtain values of F are greater than critical chi-square value (9.49). There are actually distinctively different levels of emotion for each posture in every category of emotion as shown in the F value in table 2.

5. DISCUSSION AND CONCLUSION

The main result of this experiment showed that subjects could distinguish between different postures of expressive emotions. In general, happiness gains the highest percentage of recognition. This is followed closely by anger. The most difficult emotion to recognise by the subjects was disgust. There were also appears to be different levels of emotion for each posture in the same group. By using the Friedman analysis, the level of acceptance was measured and given an order of sequence for each posture. For example the mean rank and order of sequence for happiness is illustrate in the Figure 2.

Label	H2	H1	H5	H3	H4
Happiness Emotions					
Mean rank	4.00	3.26	3.19	2.31	2.24

Figure 2. Order of sequence for happiness emotions

Beside the analysis above, there are several postures that were identified in more than one group of emotions. These postures

were defined in two conditions; (i) any particular posture that was chosen by the participants was equal or had a higher percentage compared to the percentage of those postures retain in predefined group or (ii) the percentage in predefined group was still higher but at the same time the percentage of associating that particular posture with another emotion was also quite high. Out of thirty images of static emotional expression, there were eight postures that fall into this category. From these eight images, five postures fell into the first condition and the other three were in the second condition. Figure 3 and Figure 4 show all the postures that were put under these two conditions.

Posture					
Predefined Group	Anger 36%	Fear 17%	Surprise 31%	Disgust 22%	Disgust 31%
Other Chosen Emotion	Happi-ness 58%	Sadness 42% Anger 31%	Fear 31%	Anger 39%	Sadness 42%

Figure 3. Condition one (same or higher percentage than predefined group)

Even though, S5 and F3 represent the third highest accurate identified posture by the subjects, these two postures still can be grouped into more than one type of emotions since 33% of the subject categorised S5 as fear and 39% categorised F3 as sadness emotion.

Posture	 S5	 A2	 F3
Predefined Group	Sadness 50%	Anger 47%	Fear 53%
Other Chosen Emotion	Fear 33%	Disgust 33%	Sadness 39%

Figure 4. Condition two (more than one group of emotions)

The results presented here indicate that subjects can differentiate the basic emotion of human figures by just observing the posture of static body expression.

6. REFERENCES

[1] O'Reilly, W. S. N. 1996. Believable Social and Emotional Agents. PhD Thesis, Carnegie Mellon University. Pittsburgh, PA .

[2] Ekman, P. 1992. An Argument for Basic Emotions. Vol. 6 (3-4). Cognition and Emotion 169-200.

[3] Coulson, M. 2004. Attributing Emotion to Static Body Postures: Recognition, Accuracy, Confusions and Viewpoint Dependence. Vol. 28(2). Journal of Nonverbal Behavior, 117-139.

[4] Minsky, M. 1986. The Society of Mind. Simon and Schuster. New York, USA .

[5] Picard, R. W. 2003. Affective Computing: Challenges. International Journal of Human Computer Studies, Vol. 59(1-2), 55-64.

[6] Biocca, F., Harms, C. and Burgoon, J. K. 2003. Toward a More Robust Theory and Measure of Social Presence: Review and Suggested Criteria, Vol. 12(5). Presence: Teleoperators and Virtual Environments, MIT Press, 456-480.

[7] Vinayagamoorthy, V., Steed, A. and Slater, M. 2005. Building Characters: Lessons Drawn from Virtual Environments. In: Towards Social Mechanisms of Android Science: A CogSci 2005 - XXVII Annual Conference of the Cognitive Science Society Workshop (2005) 119-126.

[8] D. T. Mullins, D. T. and Duke, M. P. 2004. Effects of Social Anxiety on Nonverbal Accuracy and Response Time in Facial Expressions. Vol. 28(1). Journal of Nonverbal Behaviour, 3-33.

[9] Vinayagamoorthy, V., Brogni, A., Gillies, M., Slater, M., and Steed, A. 2004. An Investigation of Presence Response across Variations in Visual Realism. In: The 7th Annual International Presence Workshop, 148-155.

[10] Sondhi, G., and Sloane, A. 2006. Emotions And Digital Photo Sharing. In: A Smart Home. In: Proceedings of the 1st workshop on Emotion and Computing-Current Research and Future Impact, 11-14.

[11] Kleinsmith, A. and Bianchi-Berthouze, N. 2007. Recognizing Affective Dimensions from Body Posture. In: Affective Computing and Intelligent Interaction, 48-58.

[12] Montepare, J., Koff, E., Zaitchik, D. and Albert, M. 1999. The Use of Body Movements and Gestures As Cues to Emotions in Younger and Older Adults. Vol. 23(2). Journal of Nonverbal Behaviour, 133-152.

[13] Wallbott, H. G. 1998. Bodily Expression of Emotion. Vol. 28. European Journal of Social Psychology, 879-896.

[14] Boone, R.T. and Cunningham, J. G. 1998. Children's Decoding of Emotion in Expressive Body Movement: The Development of Cue Attunement. Vol. 34. Development Psychology, 1007–1016.

[15] de Meijer, M. 1989. The Contribution of General Features of Body Movement to The Attribution of Emotions. Vol. 13(4). Journal of Nonverbal Behaviour, 247-268.

[16] Faigin, G. 1992. The Artist's Complete Guide to Facial Expression. Watson-Guptill Publications. New York, USA.

[17] Greene, J. 2001. and D'Oliveira, M.: Learning to Use Statistical Tests in Psychology, Second Edition. St Edmundsbury Press Ltd. Suffolk, UK.