INTEGRATING FACIAL, GESTURE, AND POSTURE EMOTION EXPRESSION FOR A 3D VIRTUAL AGENT

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ABSTRACT

Facial expressions, gestures, and body postures can portray emotions in a non-verbal way. These methods are frequently employed by actors in theatrical plays or in movies, or even by virtual characters such as those found in computer games, animated storybooks, and website e-assistants. Signals for emotion expressions ("cues"), such as a raised fist and narrowing of the eyes, substantially influence the viewers' assumptions on the emotional state of the person portraying it. To enable humans to recognize emotions of virtual characters, the characters' cues must be portrayed according to the human counterparts.

In this study, we first look at existing systems for synthesizing cues for facial expressions, gestures and body postures. This is followed by examining the emotion recognition problems that arise from utilizing the various systems. Lastly, the systems are integrated together and the implications that arise from the integration are analyzed.

The study showed that hand gestures aided in the emotion recognition rate for postures which others [Coulson 2004] had previously assumed as unimportant. Additionally, it was discovered that the emotion recognition rate using gestures can be greatly improved when emblematic actions are combined with functional actions. This study also confirmed our assumption that an integrated system covering facial expression, gesture and body postures is capable of enhancing the emotion recognition rate beyond the rates of the single systems.

INTRODUCTION

With the increasing prevalence of computers and other related technologies in many facets of today's society, it becomes increasingly important to create systems capable of interacting well with humans. Non-verbal communication may be used to enhance verbal communication or even provide developers with an alternative for communicating information. Previous research has shown that emotions can be effectively portrayed through non-verbal means [Atkinson et al. 2004; Coulson 2004; Ekman 2003]. Facial expressions, posture, and gestures in particular have been recognized as an important modality for non-verbal communication and enable us to determine an individual's mental and emotional state as well as his or her attitude/character traits (not covered in this study as the focus is on emotions).

Unfortunately, the audience's recognition of these patterns is not universal and sometimes dependent on factors such as gender, cultural background, age of the individual, etc. To further complicate matters, humans are also capable of complex emotion displays such as portraying multiple emotions simultaneously through a process known as emotion blending, or to hide the perceived emotions from the observer by masking it with another emotion.

Thus, for the development of a virtual agent to effectively and accurately communicate to the user via non-verbal communications, we first need to study the mechanics behind emotion recognition before looking at methods for improving the emotion display of the virtual agent. The following section starts off with an overview of previous work.

FUNDAMENTALS OF EMOTION EXPRESSION

This section looks at how cues are able to produce emotions. In addition, it provides an overview of how certain factors may affect emotion recognition in a 3D virtual agent.

Introduction to Cues

Cues are non-verbal signals involving either the movement/positioning of individualized parts of the body or the movement/positioning of a group of body parts in concert with each other [Ekman 1978]. Cues such as a raised fist and narrowing of the eyes can indicate that the individual is angry. Movement/positioning classes like facial expressions, body postures, and gestures can involve one or more of these cues, which people (subconsciously) use for interpreting the emotional state.

Facial Expressions

Facial expressions involve facial cues that are displayed using body parts from the head region (e.g., eyebrows, mouth, lips). Common facial expressions such as the raising of the lips (facial cue) as part of a smile (facial expression) is interpreted by others to be a display of emotion of the actor; happiness in this example [Ekman 1978].

Body Posture

Body cues involved in body postures are displayed using body parts such as the torso, arms and legs. They are another component of non-verbal emotion expression. For example, the clenching of a fist and raising it to appear like the actor is trying to attack someone is usually interpreted by others as a display of anger [Ekman 2003].

Gestures and Actions

Gestures are actions/movements of body parts and they are another component of non-verbal communication of emotion. For example, a high frequency gesture such as jumping up and down very quickly can be interpreted by others to be a sign of happiness [Raouzaiou et al. 2004].

Factors Affecting Emotion Recognition

Although the exact factors which can influence the interpretation of emotion have not yet been thoroughly researched upon, four factors have recently surfaced based on current experiments and research. They are gender, job status, culture, and age.

Men and women express emotions differently [Brody and Hall 1992] in terms of the frequencies of occurrence (men often experience anger more often than women). It was also proven that recognition of ambiguous facial expressions is influenced by the gender of the person performing it [Condry 1976; Devine et al. 2000] whereby "masculine" emotions (e.g., anger) are assigned to men while "feminine" emotions (e.g., happiness) are assigned to women. As such, there is a need to be mindful of these gender stereotypes when trying to synthesize emotions.

Stereotypes of job status are known to exist too [Algoe et al. 2000]. For example, managers are often associated with "masculine" emotions and character traits while nurses are associated with "feminine" emotions and character traits. If the virtual agent is assigned human jobs (usually identified by the type of uniform they are wearing), ambiguous emotion expressions may lead others to wrongly assign "masculine" and "feminine" emotions to it.

Culture can also affect the interpretation of emotions [Bianchi-Berthouze el al. 2006]. It was discovered that the Japanese are less animated in their body expressions for emotion than the Sri Lankans leading to the same emotion being read differently.

Lastly, there is neurological evidence to suggest that age can affect the interpretation of emotions. It was shown that people in the 60-80 years old age group tend to suffer from emotion processing impairments and therefore require stronger or more cues to be displayed before being able to associate an emotion.

Emotion Blending and Transition

Human beings are capable of feeling multiple emotions simultaneously [Ekman 2003]. These emotions may transition/morph in time from one state of emotion to another (e.g., a loud noise may suddenly cause a passerby to feel surprise momentarily, which might later transition into a feeling of fear if the passerby feels that his/her life is in eminent danger), or they may also be displayed at the same point in time (e.g., the loss of a loved one in a car accident may cause a person to feel both angry and upset at the same time).

Emotion blending is the mechanism by which multiple emotional expressions are altered or combined simultaneously to convey more subtle information about the performer. Unfortunately, such a process is a complicated one and has not yet been well understood and researched by behavioral psychologists and animators.

CONCEPTS FOR REPRESENTING AND MODELING FACIAL EXPRESSIONS, POSTURES, AND GESTURES

This section looks at the approaches taken by others to represent and model emotion expression. It also describes the approach taken by this study.

Representing and Modeling Facial Expressions

There are several methods for modeling facial expressions such that they can convey emotions in virtual agent. This range from using mathematical models such as muscle vectors, or mesh-spring setups, to using physiological models such as Ekman's facial action coding system (FACS) and the MPEG-II coding for facial action units (FAPS).

The approach taken by this study utilizes FACS [Ekman et al. 1978] as it has been around since 1978 and has undergone several rounds of testing and fine-tuning by the community. In addition, FACS is relatively easy to implement as it only considers the visible facial changes that result from muscle activity rather than simulating the entire muscle itself. This means that superimposing each facial change (known as an AU[1] in FACS) would be possible as each AU is unique and does not interfere with each other.

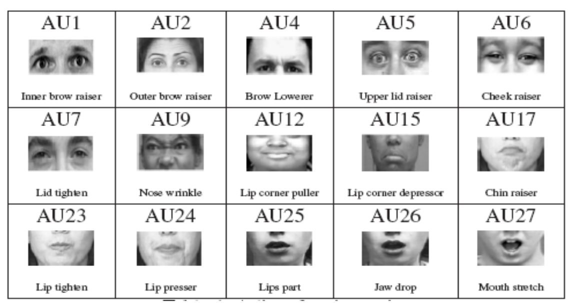


Table 1a: Some AU and their associated facial change obtained from Ekman's study [Ekman 1978].

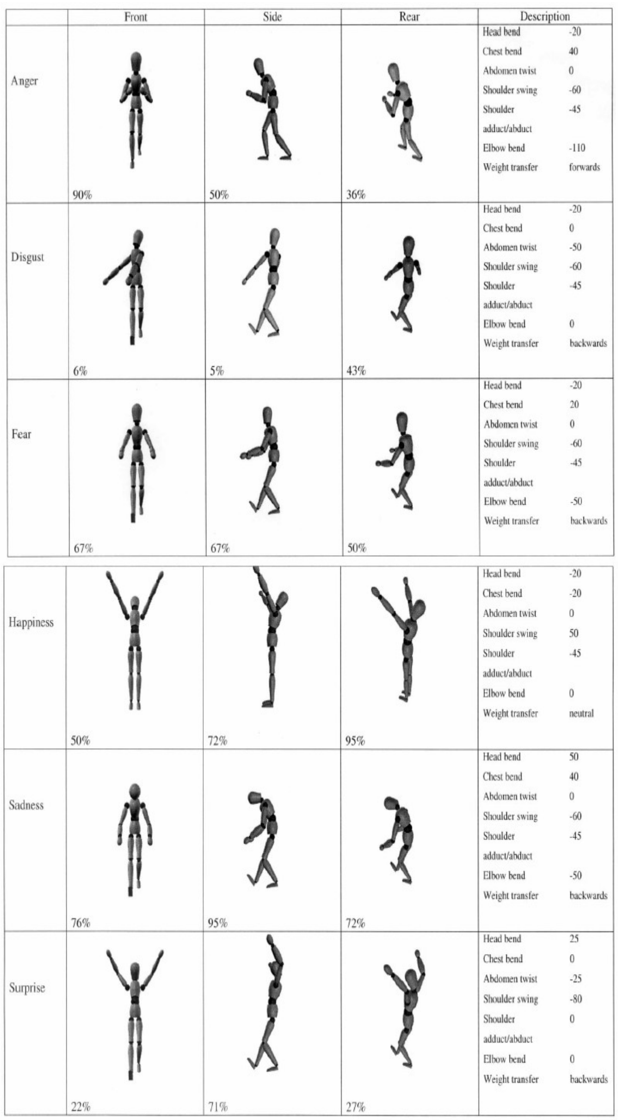
Basic Expressions	Involved Action Units
Surprise	AU1, 2, 5, 15, 16, 20, 26
Fear	AU1, 2, 4, 5, 15, 20, 26
Disgust	AU2, 4, 9, 15, 17
Anger	AU2, 4, 7, 9, 10, 20, 26
Happiness	AU1, 6, 12, 14
Sadness	AU1, 4, 15, 23

Table 1b: Table of the six basic emotions and the AUs involved.

(1) AU denotes an 'Action Unit' and each AU represents a unique facial change arising from a single muscular activity.

Representing and Modeling Postures

There exist a variety of sources which offer more or less detailed descriptions of emotional postures [Birdwhistell 1975; Boone and Cunningham 2001; Darwin 1872].
For instance, in the descriptions put forward by these authors, anger is described as involving a jutting chin, angular body shape, forward weight transfer, chest out and angled forwards, and a bowed head. Unfortunately, prior to Coulson's study [Coulson 2004], no formal research has been done to quantify the anatomical features which produce the emotional posture (i.e., posture was mostly descriptively documented).
Coulson found that the anatomical descriptions obtained from the studies mentioned earlier could be translated into joint rotations, which he then attempted to quantify via testing on human volunteers.
The approach taken by this study to modeling postures relies on Coulson's findings for the angle representation of each emotion as it is the only study which quantifies the respective joint angles.



	Front	Side	Rear	Description
Anger	90%	50%	36%	Head bend -20 Chest bend 40 Abdomen twist 0 Shoulder swing -60 Shoulder adduct/abduct -45 Elbow bend -110 Weight transfer forwards
Disgust	6%	5%	43%	Head bend -20 Chest bend 0 Abdomen twist -50 Shoulder swing -60 Shoulder adduct/abduct -45 Elbow bend 0 Weight transfer backwards
Fear	67%	67%	50%	Head bend -20 Chest bend 20 Abdomen twist 0 Shoulder swing -60 Shoulder adduct/abduct -45 Elbow bend -50 Weight transfer backwards
Happiness	50%	72%	95%	Head bend -20 Chest bend -20 Abdomen twist 0 Shoulder swing 50 Shoulder adduct/abduct -45 Elbow bend 0 Weight transfer neutral
Sadness	76%	95%	72%	Head bend 50 Chest bend 40 Abdomen twist 0 Shoulder swing -60 Shoulder adduct/abduct -45 Elbow bend -50 Weight transfer backwards
Surprise	22%	71%	27%	Head bend 25 Chest bend 0 Abdomen twist -25 Shoulder swing -80 Shoulder adduct/abduct 0 Elbow bend 0 Weight transfer backwards

Table 2: Joint angles for the 6 basic emotions obtained from Coulson's study [Coulson 2004].

Representing and Modeling Gestures

Gestures in this study are modeled by animating the virtual agent since gestures are essentially non-static displays of emotion. As there is a relative paucity of studies on dynamic emotion gestures [Atkinson et al. 2004], the approach taken by this study relies on actors' knowledge of gestures. Raouzaiou et al. (2004) and Atkinson et al. (2004) formulated a short table of emotions that depict general hand and head gestures for each emotion.
This study relies upon those data to provide a basic framework for generating gestures as it is also compatible with the joint-angle system used for modeling of posture.

Emotion	Gesture Class
Joy	*hand clapping-high frequency*
Sadness	*hands over the head-posture*
Anger	*lift of the hand- high speed*
	italianate gestures
Fear	*hands over the head-gesture*
	italianate gestures
Disgust	*lift of the hand- low speed*
	hand clapping-low frequency
Surprise	*hands over the head-gesture*

Table 3: Table of gestures extracted from Raouzaiou's study [Raouzaiou et al. 2004].

SYSTEM INTEGRATION

Previous studies have focused on modeling facial expressions, body postures, or gestures on their own but few studies (if any) have been conducted on an integrated approach whereby all three expressions are modeled at the same time.
To determine the efficacy of an integrated system, three rounds of tests involving human volunteers were carried out. The tests were conducted over the internet in the form of a specially designed internet survey with images and animations embedded into the webpage and a simple short question asking the participants to select the emotion that is best portrayed in the images/animations.
Each round of testing (except for the preliminary round) involved three sections that the volunteers have to complete. In the first section, the volunteers were presented with images of only the virtual agent's face expressing different facial expressions. The virtual agent's full body (including the face) was then made visible in the next section, where the virtual agent was expressing emotion through a combination of body postures and facial expressions. Finally, in the last section, the volunteers were presented with an animated video clip showing the virtual agent performing emotions through a combination of gestures, postures, and facial expressions.

Preliminary Testing

A round of preliminary testing was first conducted among six close acquaintances to stress-test the system for bugs and to optimize the survey pages. Additionally, they were also asked to determine the facial expressions displayed by the virtual agent.

The results obtained for the facial expression recognition are shown in Table 4. It was noted that anger and happy were already capable of obtaining a 100% recognition rate. Sad obtained an 83% recognition rate. On the other hand, surprise, fear and disgust were not capable of achieving any significant recognition rate (below the probability of a random guess).

Emotion	No. of correct recognition	Emotion Recognition Rate
Happy	6	100.00%
Anger	6	100.00%
Sad	5	83.33%
Surprise	3	50.00%
Fear	2	33.33%
Disgust	0	0.00%

Table 4: Facial expression recognition rate from preliminary testing.

First Round of Testing

After the preliminary round, the survey was officially launched and a total of 16 fully completed responses were collected from unique individuals. The results collected for facial expressions are shown in Table 5. The recognition rate for surprise and fear increased to more significant figures possibly due to the larger sample size for this round of testing.

Emotion (Facial Expressions)	No. of correct recognition	Emotion Recognition Rate
Happy	16	100.00%
Anger	16	100.00%
Sad	13	81.25%
Surprise	10	62.50%
Fear	11	68.75%
Disgust	2	12.50%

Table 5: Recognition rate from facial expressions alone.

It was also observed that the facial expression for surprise (10/16) and fear (11/16) was commonly mistaken for one another. This could possibly be due to the fact that both emotions share some similarities such as the opened and laterally stretched mouth and the raised eyebrows (they both have AU1, AU2, AU5, AU15, AU20, and AU26. Surprise only differs from fear by 2 AUs – AU4, AU16). It was postulated that the confusion between the two facial expressions could perhaps be resolved by creating a bigger difference in appearance of the mouth region (making the mouth open wider to show more teeth for fear expression). This modification was applied to the second round of testing.

Figure 1: Facial expression of surprise (left) and fear (right)

When posture was added to the respective facial expression of the emotion, the results obtained are summarized in Table 6.

Emotion (Postures)	No. of correct recognition	Emotion Recognition Rate
Happy	16	100.00%
Anger	16	100.00%
Sad	16	100.00%
Surprise	9	56.25%
Fear	14	87.50%
Disgust	1	6.25%

Table 6: Recognition rate from integrating posture and facial expression.

Fear (14/16) now fared 18.75% better than in the facial expressions test (11/16) while sad was now capable of obtaining a 100% recognition rate.

Surprise (9/16) fared almost similarly as in the facial expressions test while anger (16/16) and happy (16/16) once again achieved 100% recognition rate.

From this test, it appears that integrating posture with facial expression was capable of improving the recognition rate for some emotions (fear and sad) without any adverse effects to the other emotions (surprise, happy, anger, disgust).

In addition, it was once again noted that surprise was sometimes mistaken for fear and this could likely be due to the hands up posture in surprise closely resembling a surrendering position that is commonly associated with fear as well (Figure 2, left).

It was speculated that the occasional confusion between surprise and fear could possibly be resolved by modifying the hands up posture of surprise in a more distinguishing manner whereby the palms are facing outwards and the fingers are slightly curled which reduces the appearance of a surrendering stance that is frequently associated with fear (Figure 2, right). This new posture was subsequently used for the second round of testing.

Figure 2: Surprise posture - old (left) and new (right)

When gesture was integrated with the respective posture and facial expression, the results obtained are shown in Table 7. A website has also been created for viewing[2] the animated gestures as well as for downloading[3] them.

The recognition rate of happy, anger, and sad remained at 100% while fear and disgust obtained approximately similar recognition rates as during the posture test.

(2) http://emotionexpression.yolasite.com

(3) http://www.filefactory.com/file/ag65dgd/n/artwork_pptx

The greatest disparity came from surprise (25%), which had its recognition rate halved as compared to the posture test (56.25%). One possible explanation was that the gesture for surprise was unrealistic as it required the model to lean backwards while lifting its arms. This created an appearance of a falling motion and could have perhaps confused the test participants.

Emotion (Gestures)	No. of correct recognition	Emotion Recognition Rate
Happy	16	100.00%
Anger	16	100.00%
Sad	16	100.00%
Surprise	4	25.00%
Fear	12	75.00%
Disgust	2	12.50%

Table 7: Recognition rate from integrating gesture, posture, and facial expression.

Disgust (Figure 3) was unable to achieve any significant recognition rate in all 3 sections of the test. A possible explanation could be that disgust is rarely associated with many expressions thus leading to it being more difficult to identify.

Figure 3: Disgust facial expression (left) and posture integrated with facial expression (right)

Independent studies by Coulson [Coulson 2004], Hofman and Walk [Hofman and Walk 1984] have similarly concluded that disgust was usually the poorest performing emotion of the six basic emotions. As such, extra attention was set aside to overhaul this emotion by collecting data for the disgust gesture through observing videos of real human emotions. Our initial attempt at analyzing video corpus was not successful as these video sources were often limited in supply and were not easily attainable. An innovative approach was instead carried out by observing hours of unscripted reality TV shows such as “Just for Laugh Gags” and “The Price is Right” as these were frequently broadcasted on public TV network and the emotions portrayed by the subjects tend to be more natural and realistic than those of scripted TV shows. The new posture and gesture that we obtained for disgust no longer followed Coulson’s joint angles data as this new posture now involves covering the mouth/nose with the palms of the hand as though shielding it from something repulsive (Figure 4).

On the whole, integrating more than 1 type of expression appeared to have either a positive or neutral effect on the recognition rate for most emotions except for surprise which resulted in a negative impact. It was also observed that as more and more types of expressions are integrated together, the recognition rate appeared to improve further.

Figure 4: Disgust posture - old (left) and new (right)

Second Round of Testing

The changes proposed earlier were applied to this new round of testing. A total of 25 fully completed responses from unique individuals were collected.

For facial expressions, the results obtained are shown in Table 8.

Emotion (Facial Expressions)	No. of correct recognition	Emotion Recognition Rate
Happy	25	100.00%
Anger	25	100.00%
Sad	24	96.00%
Surprise	17	68.00%
Fear	16	64.00%
Disgust	4	16.00%

Table 8: Recognition rate from facial expressions alone.

A minor tweak was made to the sad facial expression by modifying the mouth to be more upturned/inverted appearance to increase the intensity of the sadness portrayed. That seemed to have increased the recognition rate from 81.25% to 96%. This implies that the intensity of the emotion can adversely affect the emotion recognition rate and if one is not careful about the changes made to certain facial regions, one may unknowingly alter the emotion’s recognition rate.

The attempt at modifying the mouth region to aid in distinguishing the facial expression of fear from surprise appeared to have no effect on the recognition rate of the two emotions. This could possibly imply that the two emotions are not distinguished by the mouth as was earlier postulated during the first round of testing.

For the other emotions, their facial expression recognition rate remained approximately similar which was expected since no modifications was made to them.

Figure 5 summarizes the results obtained from the three rounds of facial expressions testing.

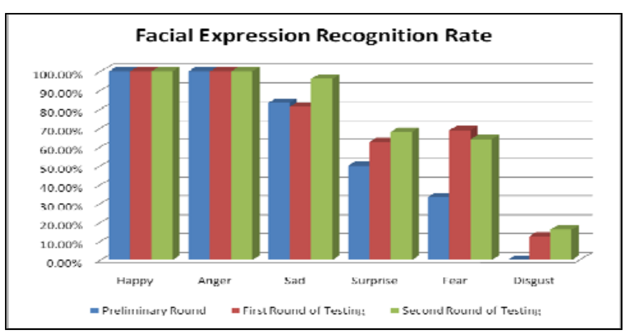


Figure 5: Facial expression recognition rate for the 3 rounds of testing

When posture was added to the respective facial expression, the results obtained are summarized in Table 9.

Emotion (Postures)	No. of correct recognition	Emotion Recognition Rate
Happy	25	100.00%
Anger	25	100.00%
Sad	25	100.00%
Surprise	17	68.00%
Fear	25	100.00%
Disgust	7	28.00%

Table 9: Recognition rate from integrating posture and facial expression.

Happy, anger, and sad maintained a 100% recognition rate which was similar to the results for the earlier round of testing.

The confusion between surprise and fear appeared to have been resolved as evidence by the recognition rate for surprise increasing by almost 12% after making the earlier mentioned changes to the hand posture. This implied that hands do appear to play a part in emotion expression too. Coulson had ignored the posture of the hands in his study as he felt that they were not capable of conveying any cues but the test conducted in this study showed that the positioning of the hands could be used as markers for distinguishing between fear and surprise.

Disgust showed the biggest improvement in this round of testing (from an initial recognition rate of 6.25% to 28%) after it was completely reworked upon. A likely explanation for this improvement is that Coulson's approach to posture expression relied solely on functional actions whereas the recent changes made in this study added in an additional emblematic action component. Functional actions refer to the behavioral significance of an emotion. They are generally determined by the tenseness of the muscle due to an emotion, which subsequently results in a particular posture being presented. Coulson's study focused on documenting that tenseness in the form of joint angles. Emblematic actions on the other hand refer to the gestures that are commonly associated with the emotion.

The functional action for disgust is to turn away from the source of repulsiveness whereas the emblematic action is to raise the hands to cover the nose/mouth as though trying to shield off those crevices from something toxic. By employing this additional emblematic approach, new cues can be added to the posture expression of an emotion. The tests conducted in this study showed that it is helpful in overcoming the recognition problems of weak emotions such as disgust as these emotions usually have very few distinct cues that people recognize.

Figure 6 summarizes the results obtained from the two rounds which involved integrating facial expressions with body posture.

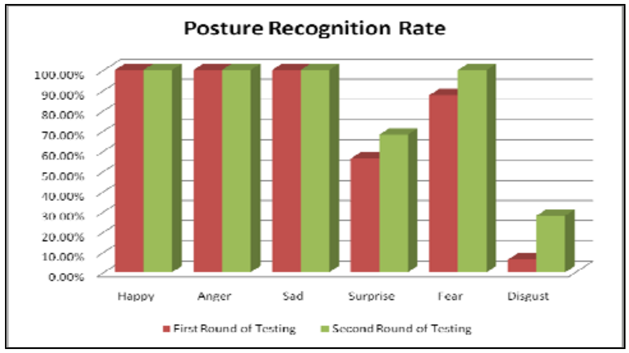


Figure 6: Recognition rate when posture is integrated with facial expression.

When gesture was integrated with the respective posture and facial expression, the results obtained are shown in Table 10.

Emotion (Gestures)	No. of correct recognition	Emotion Recognition Rate
Happy	25	100.00%
Anger	25	100.00%
Sad	25	100.00%
Surprise	20	80.00%
Fear	23	92.00%
Disgust	17	68.00%

Table 10: Recognition rate from integrating gesture, posture, and facial expression.

Happy, anger, and sad once again obtained a 100% recognition rate which was similar to the previous round of testing.

Surprise, fear and disgust on the other hand had their recognition rates significantly improved.

Surprise's recognition rate increased from 25% in the previous round of testing to 80% after modifying the unrealistic bending animation. The new positioning of the palm and the curling of the fingers that was adopted for the posture expression might have also contributed to this improvement.

Fear's recognition rate increased from 75% to 92%, which was likely due to the minor tweak that was done by having the virtual agent turn its head away from the source of fear. Once again, this proves that altering the intensity of an emotion can affect its recognition rate.

Disgust also exhibited a huge improvement in its recognition rate (from 12.5% to 68%) after its gesture was overhauled to include emblematic actions. This proves the importance of having emblematic actions to aid weak emotions.

Figure 7 summarizes the results obtained from integrating gesture with body posture and facial expression.

By comparing Figures 5-7, it was observed that integrating gestures with body postures and facial expressions produced more superior results than relying only on a combination of body posture and facial expressions, and this is in turn more superior than solely relying on facial expressions alone.

In addition, the increment in recognition rate from the integration of the various types of expressions was non-linear and was capable of increasing exponentially for emotions such as disgust.

The caveat emptor for implementing integrated systems is that extra care must be taken to ensure that the system is optimally tweaked or it might result in a lower emotion recognition rate; such as in the case of surprise during the first round of testing whereby an unrealistic surprise gesture lowered the recognition rate instead of improving it.

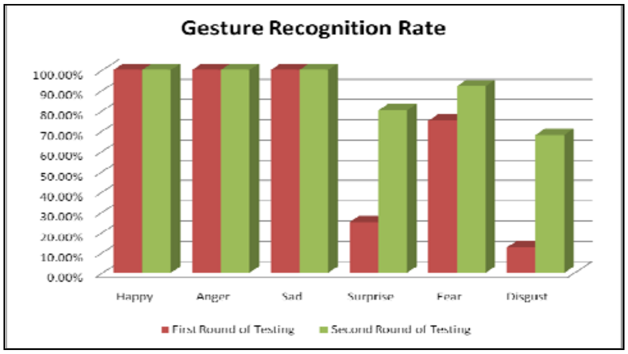


Figure 7: Recognition rate when gesture is integrated with posture and facial expression.

CONCLUSION

This study looked at the individual systems for synthesizing facial expressions, body postures, and gestures and the issues associated with these systems when they are implemented in a virtual agent. It then investigated the effects of integrating the various systems together before making improvements to the individual systems to enable them to work in synergy with one another.

The tests that were carried out revealed that an integrated system of gestures, body postures, and facial expressions that is properly tweaked was capable of producing better emotion recognition rates than a system which only relied on body postures and/or facial expressions.

This study is also an extension of Coulson's research as it shows how the posture and gesture of weak emotions such as disgust can be improved upon by relying on additional emblematic actions on top of functional ones used by Coulson in his study.

Lastly, this study showed that Coulson was wrong in his assumption that hand gestures were not important for emotion recognition. The tests conducted in this study revealed that hand gestures may serve as markers for differentiating between certain emotions such as fear and surprise. Based on facial expressions and body posture, fear and surprise appear to be quite similar, often confusing the test volunteers.

Future Directions

Future directions for improving this study are to look at methods for implementing advanced emotion display in virtual agents to enable them to be capable of emotion masking, emotion blending, and emotion transition.

Emotion masking allows the virtual agent to display a different emotion from what it currently perceives or experiences [Buisine et al. 2006]. People usually perform this due to factors such as cultural backgrounds, gender, etc. (apart from conscious manipulation). For example, public figures often have to hide their emotions – especially those of sadness – as showing sadness is often regarded as a sign of weakness in many cultures.

The same can be applied to virtual agents in computer games. For example, the heroic character in a computer game often has to appear brave and courageous at all times. This can be achieved by masking negative emotions such as sadness and fear even when the character is outnumbered by enemies and is facing impossible odds of winning. In doing so, the character appears more human-like to the user since the user is able to sense that the character is merely putting up a front to keep up with its appearance while deep down, it is still experiencing human emotions (i.e., fear). If emotion masking was not applied here, the character would appear to be unfazed by the precarious situation that it is in and this can lead to a reduction in the human-like realism and emotional depth of the character.

Another potential area of research is emotion blending. Emotion blending allows multiple emotions to be combined and displayed simultaneously. Current studies [Cowie et al. 2002; Noot et al. 2003; Albrecht et al. 2005; Niewiadomski et al. 2005; Buisine et al. 2006] are limited to the blending of only two facial expressions simultaneously as they rely on the concept of allocating a positive emotion (e.g., happy) to the lower half of the face while reserving the upper half for negative emotions (e.g., anger). This concept was based on Gouta's [Gouta and Miyamoto 2000] and Bassili's [Bassili 1979] research. However, there have been no formal studies done to date on performing emotion blending with body postures and gestures.

If the face and body could be further subdivided into more than two regions, it might be possible to blend multiple emotions simultaneously. An allocation system could perhaps be worked out to determine which region a particular emotion is most commonly recognized from. That emotion would then have priority over that region of the face or body. This may enable the blending of multiple emotions while at the same time ensuring minimal impact to the recognition rates of the various emotions being combined since the more important cues of each emotion are preserved. This method may also make it possible to blend body postures and gestures.

Emotion blending is important for creating realistic virtual characters because humans are capable of feeling and expressing multiple emotions at the same time. For example, when a character in a computer game witnesses a close friend being slain by an evil villain, the character might be programmed to feel sadness (from losing a friend) and anger (towards the villain), perhaps even vowing revenge, which closely mimics the emotions felt by real people in similar situations. An accurate blending of these two emotions would thus be essential to allow the player to associate more closely with the character since the player is able to comprehend what the character is going through.

Another area of research to look at is emotion transitioning. It describes how the various face and body parts change in time when an emotion changes to another emotion. This intermediate process usually occurs for a fraction of a second and is often used for detecting if someone is lying [Ekman 2003]. This could perhaps be employed by characters in computer games for scenarios where the character needs to tell a lie. If done improperly, the change in emotion could appear awkward and unrealistic and the user may not be able to pick out the subtle cues to indicate that the character is not truthful.

Lastly, it would be beneficial to look into the creation of a database for universally accepted gestures of each emotion.

Currently, there is scarce literature on the specific gestures that are commonly associated with each emotion. A database of gestures could possibly be constructed by observing large quantities of video corpus (often limited in supply and not readily available) or by observing unscripted TV reality shows, which was the approach taken in this study. Alternatively, the gesture database could also be formulated based on actor's impression since they are more adept at portraying emotions intentionally for their audience.

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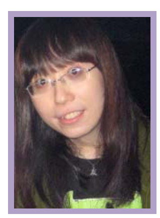
BIOGRAPHY



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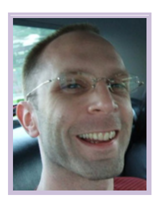

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