A FRAMEWORK FOR INTERPERSONAL ATTITUDE AND NON-VERBAL COMMUNICATION IN IMPROVISATIONAL VISUAL MEDIA PRODUCTION

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ABSTRACT

Computer generated characters are now commonplace in television and film. In some media productions like the Matrix™ they feature as frequently as the real cast. A visual media that is being explored by the research community is that of real-time improvisational theatre using virtual characters. This is a non-trivial problem with many research challenges; this paper starts to address one, which is the automatic generation of appropriate non-verbal communication between characters based on their personality and relationship to one another. We focus on our of model interpersonal attitude used for generating expressive postures and eye gaze in computer animated characters. Our model consists of two principle dimensions, affiliation and status. It takes into account the relationships between the attitudes of two characters and allows for a large degree of variation between characters, both in how they react to other characters' behaviour and in the ways in which they express attitude.

INTRODUCTION

There is a growing trend towards visual media making its way from the television and movie screens to the Personal Computer. It is now increasingly common to use the Internet as a distribution route for visual media. For example Disney made their back catalogue available through the online film service Movielink™ and the feature film *This is Not a Love Song* was launched via a streamable service on the web to save on distribution costs.

One particularly interesting innovation that has been enabled by computer technology is interactive drama, in which users take an active part in the medium, influencing the course of the narrative whether by playing the part of characters or in some other capacity. This has the potential for greatly enhancing users' engagement with the medium and for creating a whole new form of drama. This has already been tried on BBCs Radio 4 with *The Dark House*, where users voted by phone on how the plot should unfold. As more people have access to broadband Internet connections and computers with powerful graphics capabilities, as well as interactive television, there will be great potential for developing interactive narratives.

There have been many approaches to make on-line drama interactive. One approach is to create a narrative situation with computer controlled characters that the user can interact with. Some researchers have created autonomous characters that are capable of improvisational drama, for example Perlin and Goldberg (29) and Hayes-Roth and van Gent (5). Others have attempted to create systems that deal with the narrative as a whole for example Mateas (30) and Szilas (30). Though this is a fascinating research area the limitations of current artificial intelligence means that the narrative creation capabilities of computers are still very much inferior to those of real people. Therefore we are interested in interactive dramas that consist of a group of real people meeting on-line to create a narrative. In this arrangement, a group of people would share an on-line world where each user has a graphical avatar that plays out their actions. Narratives created can be solely for the enjoyment of the participants or can be open to spectators. For example Craven, Benford, Greenhalgh, Wyver, Brazier, Oldroyd and Regan (31) investigate how on-line worlds can be used as an interactive medium for television production, described as Inhabited TV. In this approach, inhabitants of themed virtual worlds take part in activities and events, which are then broadcast on television to a much wider audience.

In their work with real actors rehearsing in virtual environments Slater, Howell, Steed, Pertaub, Garau, and Springel (13) note the lack of expressive non-verbal communicative behaviour (commonly know as body language) is a hindrance to creating dramas on-line. It is therefore very important that our avatars are able to display such behaviour. Cassell and Thórisson (20), however, note that having the user control the expressive behaviour of a character can be distracting from more important tasks and generally produce an inferior experience. They therefore recommend that expressive behaviour should be largely autonomous with limited input from the user. We are currently working on developing avatars and virtual worlds that are photorealistic using our 3D and virtual character software development kit TARA. However as Ballin and Aylett (37) and Ballin et al (32) say that a plausible virtual character needs not only to look visually right but behaviourally needs to be believable. Hence why current research is now equally focusing on making the expressive features of the characters more faithful.

The rest of this paper will describe our system for autonomously generating expressive behaviour in virtual actors, giving two examples of animated behaviour we are working on: posture and eye gaze.

DEMEANOUR

We are developing a general framework for animating the non-verbal behaviour of virtual characters called Demeanour. For drama and rehearsal, relationships between characters are vital and therefore it is very important that character's react to each other's non-verbal behaviour. It is also very important that characters display a clear personality. Demeanour allows a number of different factors to influence the behaviour of characters, including user input, a model of the character's personality, the current social context and the behaviour of other characters. It is easily extensible to include new factors. An XML based language is provided to define how these various factors influence the characters' behaviour.

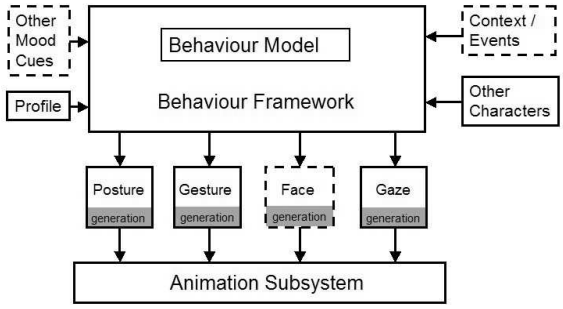

Figure 1 A high-level overview of the Demeanour architecture

Real actors tend to use non-verbal behaviour to express the personality of their character, it is thus important to be able to customise non-verbal behaviour between characters. In Demeanour each character has its own personality defined in a profile. Different parameters are held in the profile such that the framework alters the character's behaviour. In the case of virtual theatre we can design profiles that exaggerate certain behaviours, this is obviously powerful for certain types of dramatic behaviour. For example a hunched over posture might express tiredness or sadness, and exaggerating this posture, by increasing the degree to which the character's head and body are bent over, would increase the degree of emotion expressed by the character.

The demeanour framework is independent of any particular modality of non-verbal behaviour and a plug-in system makes it simple to add new types of behaviour. The following sections describe a model of interpersonal attitude we have developed using Demeanour and two behaviour modalities we are using, posture and eye gaze.

INTERPERSONAL ATTITUDE

One of the main focuses of our work is the simulation of behaviour that expresses the relationships between people and how they feel towards each other. We simulate what is normally called attitude in the non-verbal expression literature. This is essentially an individual's conscious or subconscious evaluation of how they feel and relate to about another person. Attitude is expressed by body language in a number of ways, in our work we focus on how it is expressed by people in conversational groups.

Cassell and Thórisson (20) divide expressive behaviour into two types that account for most existing research: emotional expression (22, 23) and envelope behaviour, i.e. the type of behaviour that manages the process of conversation and interaction such as turn taking or leaving a conversation (21, 19). Attitude is less studied. The popular OCC model of emotion (24) takes into account relationships to others, but in order to evaluate the emotional impact of events occurring to other people rather than to express the relationships themselves. Prendiger and Ishizuka (7) and Rist and Schmitt (8) have studied the evolution of relationships between characters but, again, have not studied the non-verbal expression aspects. Pertaub and Slater (17) were able to elicit a powerful response in people giving a talk to an audience of virtual characters who either gave positive or negative feedback, which is closely related to attitude. However, they did not have a computational model for generating positive or negative behaviour.

Various researchers have worked on relationships between animated characters. Prendiger and Ishizuka (7) and Rist and Schmitt (8) have studied the evolution of relationships between characters but have not studied the non-verbal expression aspects. Cassell and Bickmore (4) have investigated relationship models between characters and users. Closer to our work, Hayes-Roth and van Gent (5) have used status, one of our dimensions of attitude, to guide improvisational scenes between characters.

We have based our model of interpersonal attitude on the work of Argyle (1) and Mehrabian (6). Though there is an enormous variety in the way that people can relate to each other Argyle identifies two fundamental dimensions that can account for a majority of non-verbal behaviour, affiliation and status. Affiliation can be broadly characterised as liking or wanting a close relationship. It is associated

with close postures; either physically near such as leaning forward or other close interaction such as a direct orientation. It is also associated with a tendency to make more frequent eye contact. Low affiliation or dislike is shown by less eye gaze and by more distant postures, including postures that present some sort of barrier to interaction, such as crossed arms. Status is the social superiority (dominance) or inferiority (submission) of one person relative to another. It also covers aggressive postures and postures designed to appease an aggressive individual. Status is expressed in two main ways, space and relaxation. A high status can be expressed by making the body larger (rising to full height, wide stance of the legs) while low status is expressed with postures that occupy less space (lowering head, being hunched over). People of a high status are also often more relaxed, being in control of the situation, (leaning, sitting and asymmetric postures) while lower status people can be more nervous or alert (e.g. fidgeting or head scratching). High status is generally associated with lower levels of gaze, though much higher levels of gaze than normal, and particularly a fixed stare sometimes express very aggressive dominance. The meaning of the two types of expression are not fully understood but Argyle (1) suggests that space filling is more associated with establishing status or aggressive situations while relaxation is more associated with an established hierarchy.

Attitude and its expression can depend both on the general disposition of the person and their relationship to the other person, for example status depends on whether they are generally confident of their status and whether they feel superior to the person they are with. The expression of attitude can also vary between people both in style and degree

The relationship between the attitude behaviour of two people can take two forms, compensation and reciprocation. Argyle presents a model in which a person has a comfortable level of affiliation with another person and will attempt to maintain it by compensating for the behaviour of the other. For example, if the other person adopts a closer posture they will react by with less affiliative behaviour such as reducing levels of gaze. Similar behaviour can be observed with status, i.e. people reacting to dominant postures with submission. Conversely there are times where more affiliation generates liking and is therefore reciprocated, or where dominance is viewed as a challenge and so met with another dominant posture. Argyle suggests that reciprocation of affiliation occurs in early stages of a relationship. Status compensation tends to occur in an established hierarchy, and challenges occur outside of a hierarchy.

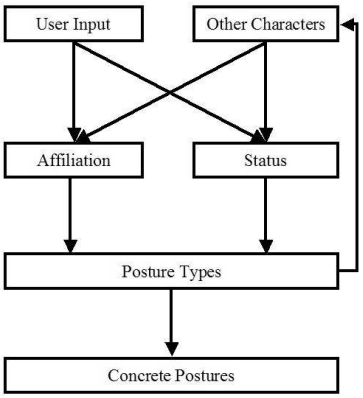

Figure 2 The posture generation process for attitude behaviour in Demeanour

Our model of interpersonal attitude generates values taken from both of the characters' attitudes and is based on a number of factors: their mood as set by the user; the behaviour of other characters and their personality as defined in the characters' profile. These attitude values are used to generate the character's behaviour.

The first stage in the process is to generate a value for each of the dimensions of attitude. As described above these depend both on the character itself and the behaviour of the other character. The characters own reactions can be controlled directly by the user. A number of sliders are presented to the user with parameters that map onto the two dimensions. They take two forms, parameters representing the personality of the character, for example 'friendliness' maps on to affiliation, and parameters representing the character's evaluation of the other character, for example 'liking of other'. These parameters are combined with variables corresponding to the behaviour types of the other character (see equation 1) to produce a final value for the attitude. For example, affiliation depends on how close or distant the other person is being, and possibly other factors such as how relaxed the other character is. Thus the equation for affiliation is:

$$affilation = \sum_i w_i^{self} sliderValue_i + \sum_i w_i^{other} behaviourType_i$$

Equation 1: Affiliation is summation of a characters' internal behaviour and other characters behaviour type

Where w_i^{self} is a weighting over the parameters representing the characters own reactions and w_i^{other} is a weighting over the other characters behaviour types. These weightings not only control the relative importance of the various behaviour types but their sign controls whether the character displays

reciprocation or compensation. There is an equivalent equation for status.

(A) Internal attitude and personality/mood parameters		
internal attitude	positive contribution	negative contribution
affiliation	friendly, *otherLiking*	Misanthropic, shyness
status	Confidence, machismo, *OtherInferiority*	Shyness
flirtation	flirtatiousness, *otherAttractiveness*	
(B) Effect of posture of other character		
attitude	other's posture	
affiliation	close, distant, relaxed, spaceFilling	
status	spaceFilling, relaxed, nervous, shrinking	
flirtation	close, distant, flirty, spaceFilling, touching	

Table 1 The factors affecting the various interpersonal attitude parameters

In order to generate behaviour, attitude values are mapped onto a behaviour type, which represents a description of behaviour in terms of its expressive meaning, as discussed above. The behaviour types are: close (high affiliation), distant (low affiliation), space filling (high status), shrinking (low status), relaxation (high status) and nervousness (low status). As attitudes can be expressed in different ways, or to a greater and lesser degree the mapping from attitude to behaviour type is controlled for a weighting for each behaviour type that is part of a characters profile. As well as being used to generate concrete behaviour, the behaviour type values are also passed to the other character to use as described above. The posture values are clamped to be between 0 and 1 to prevent extreme postures.

POSTURE

Human bodies are highly expressive; a casual observation of a group of people will reveal a large variety of postures. Some people stand straight, while others are slumped or hunched over; some people have very asymmetric postures; heads can be held at many different angles, and arms can adopt a huge variety of postures each with a different meaning: hands on hips or in pockets; arms crossed; scratching the head or neck, or fiddling with clothing. Computer animated characters often lack this variety of expression and can seem stiff and robotic; however, posture has been relatively little studied in the field of expressive virtual characters. It is a useful cue as it is very clearly visible and can be displayed well on even fairly graphically simple characters.

Research on posture generation has been limited relative to other modalities. Cassell et al (3) have investigated shifts of postures and their relationship to speech, but not the meaning of the postures themselves. As such their work is complimentary to ours. Coulson (23) uses an OCC model of emotion to generate postures. Bécheiraz and Thalmann (2) use a one-dimensional model of attitude, analogous to our affiliation, to animate the postures of characters. Their model differs from ours in that it involves choosing one of a set of discrete postures rather than continuously blending postures. This means that it is less able to display varying degrees of attitude or combinations of different attitudes.

(A) Effect of attitude on posture		
attitude	positive posture type	negative posture type
affiliation	close, touching	distant
status	relaxed, space filling	nervous
flirtation	close, flirty, spaceFilling, touching	
(B) Typical postures of each type		
Posture type	Posture	
close	leaning forward, direct orientation	
distant	arms crossed, turning away, hands on hips	
spaceFilling	standing straight, legs wide	
shrinking	hunched over, head low	
relaxed	leaning, legs crossed	
nervous	head scratch, hand hiding mouth	
flirty	self-touching, 'head cock'	
touching	Touching other characters arm / shoulder	

Table 2 How interpersonal attitude affects posture

As described in the previous section the attitude model generates a high level description of the behaviour of the character in terms of a value of each of a number of behaviour types. The behaviour modules themselves must translate this description into concrete behaviour. Each behaviour type can be expressed as a posture in a number of different ways, for example space filling can involve raising to full height or putting hands on hips while closeness can be expressed as leaning forward or making a more direct orientation (or some combination). Actual postures are calculated as weighted sums over a set of basic postures each of which depends on a behaviour type.

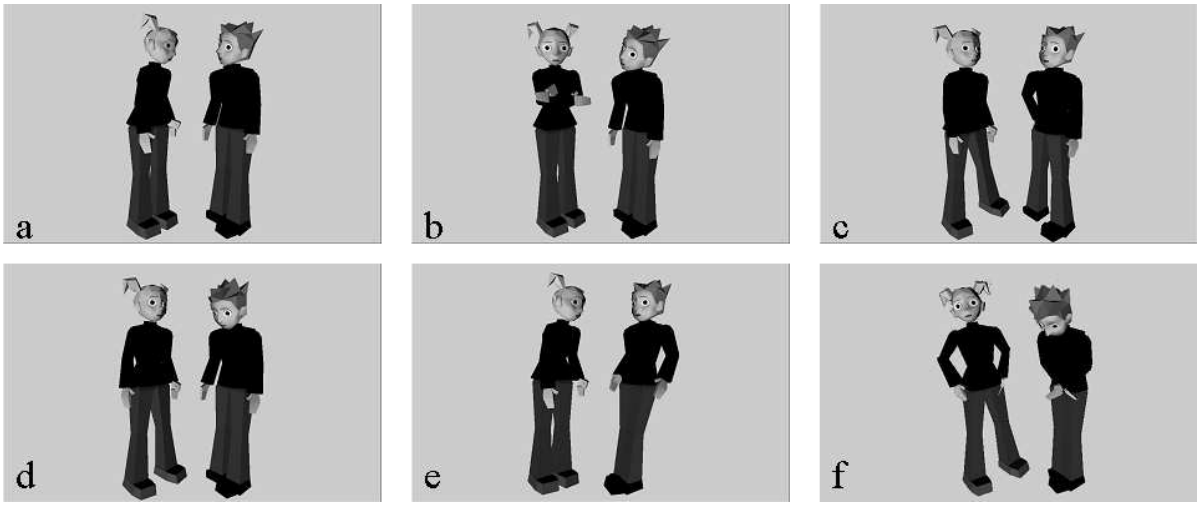

Figure 3 Examples of postures generated displaying various attitudes. (a) Affiliation reciprocated by both parties, displaying close posture with a direct orientation and a forward lean. (b) The male character has high affiliation and the female low affiliation turning away with a distant crossed arm posture. (c) Both characters are dominant; the female has a space filling, straight posture with raise head, while the male also has a space filling posture with a hand on his hips. (d) The male character responds submissively to the dominant female character, his head is lowered and his body is hunched over. (e) The female character responds with positive affiliation to the male character's confident, relaxed, leaning posture. (f) A combined posture: the female character shows both low affiliation and high status and the male character low affiliation and low status.

The basic postures were designed based on the description in Argyle (1) and Mehrabian (6) combined with informal observations of people in social situations. The weights of each basic posture are the product of the value of its behaviour type and its own weight relative to the behaviour type. The weights of the basic postures are varied every so often so that the character changes its posture without changing its meaning, thus producing a realistic variation of posture over time. Each basic posture is represented as an orientation for each joint of the character and final posture is calculated as a weighted sum of these orientations. Figure 3 shows example output postures.

EYE GAZE

Natural eye gaze is critical to the realism and believability of an animated character. This is because eye gaze is fundamental in showing interest levels between characters and as means of anticipating events. Typically a person will look to another before exhibiting any behaviour, such as moving towards them or speaking to them. In conversation, a listener will typically spend a large proportion of their time looking at the speaker. A complete lack of gaze towards the speaker is a clear message of the lack of interest of the audience towards the speaker and will be picked up very quickly.

From an early age children learn to first look at the eyes of a person to determine the intention of that person towards them. Are they looking at them? Are they looking at some other person? Are they looking at something that might be a threat? By first looking at the eyes of another the intention, and therefore an appropriate response, can immediately be judged, see Baron-Cohen (16).

Mutual gaze, in which two people are looking into each other's eyes is a powerful mechanism that induces arousal in the individuals, so typically mutual gaze is short (of the order of a second). Patterns of mutual gaze much longer than that either induces negative arousal, for example when someone stares aggressively, or positive arousal in an intimate setting. It is clear then that if a character does not look at an individual at all, it is seen as strange because it is an inbuilt primitive defence mechanism to look at other people (and their eyes) to determine the intent of that person (interest, disinterest, threat etc.). It is also strange if there is eye contact for too long due to the increased arousal this produces.

Argyle and Cook (15) have done extensive studies with pairs of individuals to understand levels of eye gaze, and mutual gaze, and has detailed results covering (among other things) conversations and the level to which individuals will look at the other while speaking (35%)[1] and listening (75%) etc. We have used these results to influence our model of gaze and mutual gaze in-group settings.

[1] This figure is just one very specific case from a range of different cases covered in (15)

Existing simulations of eye gaze fall into two broad categories. Gillies and Dodgson (19) and Chopra-Khullar and Badler (25) simulate the eye gaze of characters navigating and performing actions in an environment but do not handle social factors of gaze between people. Our work is closer to the other type of simulation that deals primarily with social gaze. Garau, Slater, Bee and Sasse (12) and Colburn, Cohen and Drucker (27) simulate the patterns of eye gaze between pairs of characters based on frequencies of mutual gaze. Vilhjálmsson and Cassell (18) use eye gaze to help regulate the flow of conversation by indicating when a speaker is about finish talking, when someone wants to start or end a conversation and other similar information. Rickel and Johnson (26), in their character based virtual reality tutoring system, use gaze primarily as a method of indicating to the user an area of interest in the environment. Thórisson (28) simulates eye gaze in the context of more general work on multi-modal communicative behaviour during conversation.

Our eye gaze model, as part of the Demeanour framework separates out the interests of the individuals – that is the people or objects that currently demand that persons attention, from the low level details which trigger particular behaviour of the individual such as eye or head movement to look between individuals and at other objects. Each character has a set of 'things' that are currently of interest to some level, where we define 'interest' to be a need to look at that thing. The level of interest is specified as the proportion of time spent looking at that object. So for example if the character is in conversation with another character, while talking the level of gaze will be set to (say) 35%, and whilst listening to about 75% to approximate the natural gaze levels in conversation between two people.

The natural animation of characters comes from the conflicting constraints of needing to look at things of interest for a certain period of time, tempered by the (social) need to not stare!

Figure 4 An example of Demeanours eye gaze regulating a conversation

We have said that a character has a set of 'things' of interest at any one time, together with the proportion of time to look at that thing. There is also a maximum 'stare' time for each object, and, if that thing is a person, there will be a target for maximum mutual gaze. The animation framework for eye gaze continually monitors the gaze of each character and tracks how long has been spent gazing at a particular object, and the overall time gazing at that object. When these values reach the thresholds for an individual, it triggers the gaze control framework to take action to change the gaze of a character.

In conversation between people a person will look at another then look away, usually by averting their gaze rather than moving their head, but they are not looking specifically at any other object, just averting their gaze. In our model we achieve this by having a number of 'halo' points around the head of a character that can be selected to look at if we need to look away, and have no other object that demands our attention.

FUTURE WORK

At the time of writing this paper, BT has joined the collaborative project edrama (38), sponsored by the UK's PACCIT programme (40). The project aims to enhance the existing edrama platform developed by Hi8us (39). The current system enables young people to engage in live drama improvisation online, remotely. Compromising a 2 dimensional graphical world in which each user is represented by a graphical avatar, the field-tested cross-curricular tool exploits ICT, drama and literacy to deliver a range of subject areas. The enhancements will include AI components for automated bit part characters, and advanced rendering and animation techniques for avatars and virtual environments. Results from the Demeanour project will be trialled within the enhanced eDrama software, in order to test the effectiveness of the Demeanour avatar framework in supporting interactive online drama.

In a separate study, we would also like to investigate the degree to which characters displaying attitude produce similar emotional reactions in subjects to those produced by real people (17). We would particularly like to use this method for investigating social situations in virtual reality that it is undesirable to produce in real life, such as extreme aggression and violence.

A technological extension to our work currently underway includes supporting gestures. Future work includes modelling interactions between more than two characters and investigating better user interfaces for entering mood data, as well as supporting affective face animation. We are also want to implement the software to support multiple characters.

CONCLUSION

This paper has presented a high-level overview of Demeanour our working framework for expressive social virtual characters. We have explored the use of interpersonal attitude for the generation of non-verbal communication specifically posture and eye-gaze. Our initial results are encouraging and in particular attitude seems to account for a wide range of behaviour.

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