Towards a Socially and Emotionally Attuned Humanoid Agent

Christopher PETERS[1] Catherine PELACHAUD[1] Elisabetta BEVACQUA[1]
Magalie OCHS[1,2] Nicolas Ech CHAFAI[1,2] Maurizio MANCINI[1]
[1]*LINC University of Paris 8*
[2]*France Telecom R&D*

Abstract. The ability for AI controlled humanoid agents to interact and resonate with the user and with each other in a social and emotional manner is of the utmost importance for creating a sense of plausibility, immersion and ultimately enhancing user experience. In order to express themselves effectively, agents will need to be adept in a broad range of communicative verbal and nonverbal behaviors based on internal models that are not incoherent with their human counterparts. In this work, we present a number of avenues of research that we feel help enhance agents abilities to communicate socially and emotionally. The core of this work consists of models of attention and emotion which are augmented with communication management and behavior expressivity control. The work presented here has particular potential as a basis for supporting, at a low-level, individual agent behavior driven by high-level specifications from dialog systems in the next generation of human-user interfaces.

Introduction

Human-user Interaction have become an increasingly useful, if not challenging domain, for the testing and application of human-level artificial intelligence techniques. Virtual agents populate web applications, interactive systems, video games, etc. A common difficulty in each of these spheres is the control of the animation of the agents: Pre-scripted animation is simply not adequate for truly interactive systems. Autonomy in terms of deciding which action to take and which behavior to show is a must for plausibly animated agents. In interactive systems that contain a social aspect an essential role of virtual agents is to communicate with other agents, both user and computer controlled.

It is our view that humanoid virtual agents should be endowed with capabilities to allow them to perceive their physical and social context, to feel and express emotions, to dialog and communicate with other agents. In current technology, agents often behave as if being in an empty world: they are not aware of their surrounding, they do not pay attention to whom they are talking to, they do not try to grasp the attention of other agents, etc. In our view, what really matters in interaction is not that agents look like a human, but rather that they are able to resonate with the users through naturalistic communicative and emotional capabilities.

Communication involves complex processes. It is fundamentally multi-modal. Nonverbal behaviors do have a major role in the interaction between people. They have several functions such as: they may be used to process the environment and others; they may indicate our mental and emotional state; they may be used as signals to be read by others. For a virtual character to be encompassed with these functions requires that it can: (1) generate multi-modal communicative behavior; (2) have emotions and display expressive behaviors; (3) perceive the environment and the other's gaze and behaviors; (4) manage the conversation by showing feedback.

In this paper we describe how we model these various capabilities. After describing our model of perceptual attention, we present our emotional model. In the following section we explain how we model communicative behaviors. We then turn our attention to our model of communication management that encompass two types of interactants, namely speaker and listener. We end our paper going through a scenario where we detailed our emotion computational model.

Perceptual Attention

The ability to sense information from the environment in a manner congruent with real humans is an important prerequisite for plausible agent behavior. We provide agents with real-time synthetic vision, attention and memory capabilities (see [23]). All three capabilities interact with each other in order to collect information and orient the agents senses with respect to the environment. The visual sensing module is monocular with multiple resolutions; it operates in a snapshot manner by taking frequent updates of the visible region of the scene from the point of view of the agent and passing them to the visual attention module. The purpose of the visual attention module is to choose a set of visible objects or locations in the scene for enhanced processing by the agent and is based on a popular real-time model from cognitive engineering [14]. We use it with virtual scenes by passing full scene renderings from the synthetic vision module in order to compute the saliency map: a 2D gray-scale spatial ranking of the scene in terms of areas that `pop-out' and are thought to attract visual attention. A memory system [25] stores uncertainty levels for each object to ensure the focus of attention moves throughout the scene; values are combined into an uncertainty map, with which the saliency map is modulated in order to provide the final attention map. Artificial regions of interest are enumerated from the attention map and are used to create artificial scan-paths for the agent.

In a gaming environment, these capabilities provide autonomous and human-like looking behaviors and help drive more subtle movements, such as eye saccades and blinking. Such systems serve as a basis for implementing higher-level cognitive and behavioral mechanisms: for example, we have used these capabilities, along with theory of mind, to control autonomous interaction initiation between agents (see the Communication Management Section).

Emotion

Emotion is a crucial element in any gaming experience: virtual characters who are able to display emotions are more likely to be able to invoke an emotional reaction in the user and thus add to the users' experience. An affective virtual agent should be able to adopt an emotional behavior to convey its emotions and be able to represent its environment in terms of its own emotions and those of other characters [5]. Three emotional processes have to be simulated [27]: the elicitation of emotion, expression of emotion and experience of emotion. These allow an agent to identify the circumstances

in which an emotion is triggered, display emotions and manifest emotional influence on their reasoning and actions, respectively. Appraisal theory [34] is one way in which we may give an agent the ability to identify the emotional meaning of a situation. According to this theory, emotions are elicited by a subjective interpretation of an event, which depends both on situational and cultural factors and on a particular individual's features. Major determinants in emotion elicitation include the person's beliefs and goals. The interpretation of an event corresponds to the appraisal of a set of variables called appraisal variables. Particular combinations of these variables lead to emotion elicitation (using, in many cases, the OCC model of emotion [20]). Appraisal variables are often hard-coded [8, 32] or based on the agent's plan [11]. In contrast, we aim to create a domain-independent model of emotion elicitation that enables the virtual agent to assess its own emotions and those of other characters or users without having prior access to their plans. We propose to represent emotion elicited-events based on a BDI approach [31]. The mental state of a BDI agent is composed of mental attitudes such as beliefs and intentions. It corresponds to its cognitive representation of the world at a given instant. It includes a representation of the events perceived in the environment. Accordingly, an occurred emotion elicited-event is also represented through mental attitudes. Emotion elicited-events can then be represented by a particular mental state. Based on the OCC model, we have described values of appraisal variables through beliefs and intentions. For instance, a desirable event corresponds to the belief that an occurred event enables an agent to achieve one of its goals. According to appraisal theory, we have represented emotion elicited-events by combinations of values of appraisal variables; that is, by a combination of mental attitudes. From this formalization of emotion elicited-events, a
virtual agent can identify in real-time its own emotions triggered by a situation. By knowing other characters intentions, their emotions can also be identified. More details on this computational model of emotion elicitation and associated model of facial expressions of emotions can be found in [19].

Communicative behaviors

In social settings, the study of proper communicative behaviors are of importance for believable and interactive characters. Humans communicate in a rich variety of ways through multiple channels [16, 32, 7, 17]: through our choice of words, facial expressions, body postures, gaze, gestures... Nonverbal behaviors accompany the flow of speech and are synchronized at the verbal level, punctuating accented phonemic segments and pauses. They may have several communicative functions [28, 4], such as managing the dialog flow, emphasizing a word, or even providing information on our mental and emotional state.
In our model, we follow the taxonomy of communicative functions proposed in [28] where four main categories are defined. Behaviors are gathered depending if they provide information about the speaker's beliefs, intentions and affective state. The fourth category corresponds to behaviors that provide meta-cognitive information about speaker's mental state (the speaker may try to remember or recall an information). Each communicative function is defined as a (meaning, signal) pair. Each function may be associated with different signals; that is for a given meaning, there may be several ways to communicate it. Vice versa, a same signal may be used to convey different meanings.

To control the agent's behavior we are using a representation language, called `Affective Presentation Markup Language' (APML) where the tags of this language are these communicative functions [7]. In APML, text to be spoken by the agent is annotated with tags denoting emotion and interaction information (see Section entitles Scenario).

Distinctive behavior through expressivity and multi-modal behavior modeling

We aim at defining conversational agents that exhibit qualitatively *distinctive* behaviors. It means that even if the communicative intentions and/or emotional states of two agents are exactly the same they will behave in a different way according to their general and current behavior tendencies.
To this aim we provide a set of parameters to allow one to define behavior profiles and then leave to the system the task of animating the agent. Our approach is to manipulate the behavior tendency of the agent depending on its communicative intention and emotional state. Differences will be noticeable both in the signals chosen by the agents to communicate and in the quality of behavior.
A social agent needs to decide which of its available modalities of expression to use: speech, gestures, gaze, facial expressions, body movements and body posture [20, 35]. We have implemented a mechanism to choose between these different available modalities during conversation based on a hierarchy of preferences for modalities.

In terms of expressivity modeling, many researchers (see, for example, Wallbott and Scherer [36], Pollick [30]) have investigated human motion characteristics and encoded them into categories, for example, slow / fast and weak / energetic. We define the *expressivity* of behavior as the "quality" of the communicated information through the execution of some physical behavior. We have defined and implemented expressivity [12] as a set of parameters that affect the quality of execution of behaviors, as performed by arms or head movements. These parameters are: speed of arms / head, spatial volume taken by the arms / head, energy and fluidity of arms / head movement, and the number of gesture stroke repetitions.

Moreover in our model we distinguish between *global* versus *local* behavior tendencies. For example let us consider a person that gestures a lot while speaking, performing large and fast movements. Then we can expect that in general circumstances she prefers to convey non-verbal signals more on the gesture modality than another modalities. This general tendency is what we call *global* indicator of the agent's behavior. On the other hand there can be some events or situations in which one's basic tendencies change, and one gesture in a greatly different way. For example a person that never does hand/body gestures while she talks may change her behavior if she is very angry at someone. This specific tendency is what we call *local* indicator of the agent's behavior. In our model the local indicator is derived from the global indicator (that conversely is a static parameter) at runtime depending the actual agent's communicative intention and emotional state.

Communicative Management

Communication management deals with the agents ability to autonomously start, maintain and end interactions. Furthermore, communication should not stop when the agent is listening, but the agent should provide feedback to the speaker.

Start of interaction and Perceptual Theory of Mind

Interaction initiation behaviors such as gaze orienting, waving and name utterances are of great significance for adding realism to interactive agent systems and virtual communities where visual social interaction behaviors are desired between agents and avatars [15]. In real environments, people must routinely deploy their senses in order to scan for possible contacts, must gain the attention of one they wish to interact with, must signal interest in communicating both verbally and non-verbally and must seek the cooperation, as well as gauge the willingness, of the other to reciprocate in conversation. For a human viewer, in behavioral plausibility terms, sometimes it is not the destination that counts (i.e. conversation), so much as getting there (i.e. the acts involved in initiating the conversation). We implement an automatic non-verbal interaction initiation system based primarily on direction of attention and perceptual theory of mind.

This allows for special social perception by [24] incorporating a perceptual theory of mind model based on evolutionary psychology and supported by neurophysiological evidence [22]. In our model, an intentionality detection (ID) mechanism filters perceived agents into this special pathway and segments them into eye, head and body subparts. A direction of attention detector (DAD) computes the direction of the eyes, head and body of the other agent with respect to the self. Orientations are merged into an *attention level* metric through a subpart weighting process, which is boosted if mutual attention exists between the agents, as signaled by a mutual attention mechanism (MAM). Results are stored in short-term memory. An agent may integrate these metrics over a time interval on demand in order to formulate theories of whether the other has seen it, whether the other has seen this agent see it and the interest that the other agent appears to have in this agent.

These theories drive a hierarchical finite state machine between various interactional states, such as monitoring the environment, grabbing the attention of the other and gauging the reaction of the other. Thus, unlike other systems, agent behavior is based not only on the goals of the agent, but also on its theory of the intentions of the other in order to avoid the social embarrassment of engaging in conversation with an unwilling participant [10]. Our evaluation of conversation initiation behaviors seems to suggest that users may be as sensitive to subtle non-verbal social cues in the virtual environment as in the real situation [26].

Feedback

During a conversation, two flows of information are established between speaker and listener, one concerning the effective content of the speaker's speech and the other regarding the listener's reaction. Conversation does not happen as a unique flow of information (the speaker providing information to the listener) but it is a continuous exchange of information between interacts. The listener informs at all time whether she is engaged and interested in the conversation, whether she understands and agrees, and furthermore which emotional and attitudinal reactions are elicited in her by the speaker's speech [1, 29]. These signals are called *feedback*; without them a communication becomes difficult and frustrating.

We distinguished two main clusters of feedback signals: cognitive feedbacks and reactive feedbacks. The *cognitive feedbacks* embed signals emitted after a cognitive evaluation of the speaker's actions and says: the listener may show her agreement/disagreement, belief/disbelief, that she understands or she does not, or even that she accepts or not what is being said. The other cluster, the *reactive feedback*, gathers the signals the listener emits unconsciously [1].

A complete feedback model requires to develop a computational model of both feedback types. Implementing the cognitive feedback requires to have a semantic representation of the discourse as well as a representation of the mental state of the listener (her knowledge, her choices, her beliefs,...). We have left aside this difficult task for the moment and have started implemented the reactive model. The listener's behaviors is defined as a set of rules based on corpus analysis [17, 9, 3]. Feedback signals (like head nods, verbal responses) often appear at a pitch variation in the speaker's voice; frowns, body movements and gaze shifts are produced when the speaker shows uncertainty; facial expressions, postural and gaze shifts are provided to reflect those made by the speaker (mimicry).

Interaction Maintenance

In applications featuring conversational interaction with a user, the use of gestures may enhance the communication and help to maintain the interaction. Gestures help the speaker formulate his thoughts and create a link with the speaker's thoughts and have a pragmatic value in the sense that they illustrate his communicative efforts. To maintain a listener in a conversational interaction, we need to study this pragmatic dimension of gestures. The aim of our study is to point out the importance of the pragmatic value of gestures and their rhetorical relations when trying to create applications in which agents are able to maintain the user's interest during conversation interaction.

While previous works [12, 2] have focused on gestures that elicit focal attention through the collection of objective data from an eye tracker, we have been collecting subjective data from a corpus of conversational interactions in 2D traditional animations. From this data, we have been considering the pragmatic intention of the speaker from the expressive parameters of gestures (see previous Section on Communicative Behaviors) in order to establish rhetorical relationship (relations of similarity or contrast) between the elements of the verbal or non-verbal utterance.

More particularly, we have gathered a corpus of 2D animations depicting conversation scene. We have defined a schema for the annotation of gesture expressivity at a low-level of segmentation that we used to annotate the cartoons. Annotations took place at the gesture phase level. Interested in the communicative value of gestures, we looked at the modulations of gesture expressivity over time rather than their values. This led us to introduce two notions of expressivity breaks: irregularities, and discontinuities. In irregularities, within a sequence of gestures with a constant expressivity, only one gesture phase has a different value. On the other hand, discontinuities refer to sudden variation in the expressivity values; that is two successive sequences of gestures are performed with different expressivity. These types of gesture expressivity breaks suggest that they act as a relation of similarity with a function of segmentation, for the

irregularities, and as a relation of contrast that derives from the speaker's effort to communicate her intention, for the discontinuities.
We have started to investigate how these breaks may be used to trigger an increase in user's attention, for example, by creating a contrasting gesture in an otherwise similar sequence by modulating the gesture expressivity parameters.

Scenario

We have constructed a scenario featuring two agents in dialog in order to demonstrate our research ideas, particularly in terms of feedback and emotion models.
The scenario has been constructed using the Torque game engine [36] and a real-time version of the Greta agent. In APML, text to be spoken by the agent is annotated with tags denoting emotion and communication function [6].
In the scenario, two agents, Lucy and Greta, meet. The following dialog takes place:

Greta : Hi Lucy
Lucy : Hi Greta ; How are you ?
G : I am fine and you ?
L : Oh I had a terrible day :(
G : (surprise - a little concern) oh really ?
L : Yes. I had to do a demo for a conference. But it is over now (relief, positive emotion)
G : (shows relief) 'phew'

Each sentence in the dialog is represented by a single APML file and is annotated accordingly. For example, the APML file for Greta's reply to Lucy with "Oh really" is as follows:

```
<?xml version="1.0"?>
<!DOCTYPE apml SYSTEM "apml.dtd" []>
<apml>
<performative type="inform">
<theme affect="concern">
Oh really
<boundary type="LH"/>
</theme>
</performative>
<pause sec="2.0"/>
</apml>
```

We explain now the different steps our computational model undertake when computing which emotions arise within this dialog for a particular conversational situation. We describe how the mental states of the agents trigger different emotions.

The emotion elicitation of Lucy

During the demo of the conference, Lucy's mental state is:

- She has the goal that her demo operates well:
  Goal(operationalDemo)

- She has the belief that it is possible that her demo fails :
  Belief(∃event(Feasible(event, ¬operationalDemo)))

So, Lucy has an emotion of **fear** because she has the following mental state:

Goal(p) ∧ Belief(∃event(Feasible(event, ¬p))) where p = operationalDemo

Where Feasible(event, p) means that event can take place and if it does p will be true after event

After the demo of the conference, Lucy's mental state is:

- She has the goal that her demo operates well :
  Goal(operationalDemo)
- She believed before the end of the conference (noted Event2) that it is possible that her demo fails :
  Belief(Done(Event2,Belief(∃event(Feasible(¬operationalDemo)))))
- She believes now that her demo cannot fail anymore :
  Belief(¬(∃event(Feasible(¬operationalDemo))))

So, Lucy has an emotion of **relief** because she has the following mental state :

Goal(p) ∧ Belief(Done(Event2,Belief(∃event(Feasible(¬p)))))
∧ Belief(¬(∃event(Feasible(¬p))))

where p = operationalDemo and Done(event, p) means that event has just taken place and p was true before event.

Moreover, Lucy changes her mental state after the demo of the conference because :

- She has the goal during the conference that her demo operates well :
  Goal(operationalDemo)
- She has achieved her goal at the end of the conference:
  Belief(operationalDemo)

So, Lucy has an emotion of **joy** because she has the following mental state:

Belief(Done(Event2,Goal(p)) ∧ p) where p = operationalDemo

Let us turn now our attention to the second agent, Greta.

During the conversation, Greta feels empathic emotions of **relief** and **joy** because:

- She knows the emotion elicitation mental state. In this case, she knows the mental states that trigger the emotion of joy and relief as described above.
- Lucy told Greta her goal ("I had to do a demo for a conference"), and Greta can suppose Lucy's beliefs. So, she knows the mental state (goals and beliefs) of Lucy.
- From this knowledge, she can infer Lucy's emotions.

Such an elicitation is an important way to tie mental states, defined by agent's beliefs and goals, to emotion modulation, and hence drive the emotional expression of the agent. Figures 1 and 2 illustrates the facial expressions Greta displayed depending on her emotional states and communicative intent.

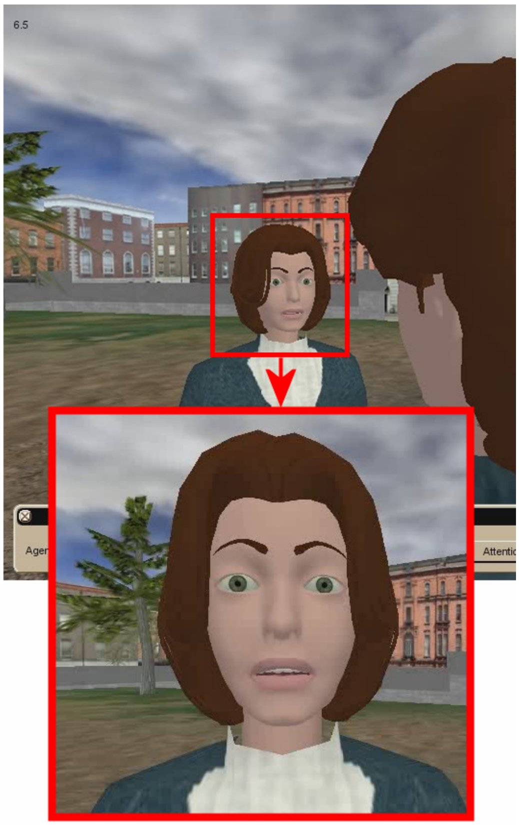

Fig.1. Feedback of surprise from the Greta agent on the left (close-up shown on inset) based on the dialog of the speaking agent of the right. In the scenario shown here, the agent also provides feedback by nodding at the speaker.

Fig.2. A number of different facial expressions generated by the agent as feedback in her role of listener. Controlled by APML, these are just a few examples of the wide range of facial expressions the Greta agent is capable of.

Although work is still in progress in enumerating new annotation tags relevant for feedback, this scenario is a proof-of-concept of what we are trying to achieve in terms of feedback during conversation between two agents. We are also using the scenario as an example case for emotion elicitation based on mental state, as outlined above.

Conclusion

This paper has presented some avenues of research that we have been following with a view to contribute to the social and emotional interaction skills of the next generation of real-time interactive agents. Our work focuses on low-level high-detail interaction scenarios between a small number of agents and is particularly suited to applications that require a social aspect. Among many challenges is the effort to extend our models beyond scenarios involving only two interactants, to handle more agents. This is especially challenging due to the predominance of existing theory for low number of interactants, making formulation of appropriate models difficult.

Acknowledgement

This work has been funded by the Network of Excellence Humaine, IST-2002-2.3.1.6 Contract no. 507422 http://emotion-research.net/

Reference

[1] J. Allwood, J. Nivre, and E. Ahlsn. On the semantics and pragmatics of linguistic feedback. Semantics, 9(1), 1993.
[2] G. Barrier, J. Caelen, and B. Meillon. La visibilité des gestes: Paramètres directionnels, intentionnalité du signe et attribution de pertinence. In Workshop Français sur les Agents Conversationnels Animés, pages 113-123, Grenoble, France, 2005.
[3] J. Cassell, C. Pelachaud, N. Badler, M. Steedman, B. Achorn, T. Becket, B. Douville, S. Prevost, M. Stone, Animated Conversation: Rule-Based Generation of Facial Expression, Gesture and Spoken Intonation for Multiple Conversational Agents. Proceedings of SIGGRAPH'94, pp. 413-420, ACM Special Interest Group on Graphics, 1994.
[4] N. Chovil. Social determinants of facial displays. Journal of Nonverbal Behavior, 15(3):141-154, Fall 1991.
[5] C. Crawford. On Game Design. New Riders Games, 2003.
[6] B. DeCarolis, C. Pelachaud, I. Poggi, and M. Steedman. APML, a markup language for believable behavior generation. In Helmut Prendinger and Mitsuru Ishizuka, editors, Life- Like Characters, Cognitive Technologies. Springer, 2004.
[7] P. Ekman. About brows: Emotional and conversational signals. In M. von Cranach, K. Foppa, W. Lepenies, and D. Ploog, editors, Human ethology: Claims and limits of a new discipline: contributions to the Colloquium, pages 169-248. Cambridge University Press, Cambridge, England; New-York, 1979.
[8] C. Elliot. The Affective Reasoner: A process model of emotions in a multi-agent system. Computer science, Northwestern University, 1992.
[9] D. Friedman and M. Gillies. Teaching virtual characters to use body language. In Intelligent Virtual Agents, Lecture Notes in Artificial Intelligence. Springer-Verlag, 2005.
[10] E. Goffman. Behaviour in public places: notes on the social order of gatherings. The Free Press, New York, 1963.
[11] J. Gratch. Emile: Marshalling passions in training and education. In The Fourth International Conference on Autonomous Agents, pages 325-332, Barcelona, Catalonia, Spain, 2000.
[12] M. Gullberg and K. Holmqvist. Keeping an eye on gestures: Visual perception of gestures in face-to-face communication. Pragmatics and Cognition, 7:35-63, 1999.
[13] B. Hartmann, M. Mancini, and C. Pelachaud. Towards affective agent action: Modelling expressive ECA gestures. In Proceedings of the IUI Workshop on Affective Interaction, San Diego, CA, January 2005.

[14] L. Itti. Models of Bottom-Up and Top-Down Visual Attention. PhD thesis, California Institute of Technology, Jan 2000.
[15] K. Isbister. Better Game Characters by Design: A Psychological Approach. Elsevier Science and Technology Books, 2006.
[16] A. Kendon. Movement coordination in social interaction: Some examples described. In S. Weitz, editor, Nonverbal Communication. Oxford University Press, 1974.
[17] R. M. Maatman, J. Gratch, and S. Marsella. Natural behavior of a listening agent. In 5th International Conference on Interactive Virtual Agents. Kos, Greece, 2005.
[18] D. McNeill. Hand and Mind: What Gestures Reveal about Thought. University of Chicago, 1992.
[19] M. Ochs, R. Niewiadomski, C. Pelachaud, and D. Sadek. Intelligent expressions of emotions. In Jianhua Tao, Tieniu Tan, and Rosalind W. Picard, editors, The 1st International Conference on Affective Computing and Intelligent Interaction (ACII05), pages p. 707-714, Beijing, China, 2005. Springer.
[20] A. Ortony, G.L. Clore, and A. Collins. The cognitive structure of emotions. Cambridge University Press, 1988.
[21] C. Pelachaud, V. Carofiglio, B. De Carolis, and F. de Rosis. Embodied contextual agent in information delivering application. In First International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS), Bologna, Italy, July 2002.
[22] D.I. Perrett and N.J. Emery. Understanding the intentions of others from visual signals: Neurophysiological evidence. Current Psychology of Cognition, 13:683-694, 1994.
[23] C. Peters. Bottom-Up Visual Attention for Autonomous Virtual Human Animation. PhD thesis, Department of Computer Science, Trinity College Dublin, 2004.
[24] C. Peters. Direction of attention perception for conversation initiation in virtual environments. In International Working Conference on Intelligent Virtual Agents, pages 215-228, Kos, Greece, September 2005.
[25] C. Peters. Designing Synthetic Memory Systems for Supporting Autonomous Embodied Agent Behaviour, Proceedings of the 15th International Symposium on Robot and Human Interactive Communication RO-MAN), pp. 14–19, September 2006.
[26] C. Peters. Evaluating perception of interaction initiation in virtual environments using humanoid agents. In Proceedings of the 17^{th} European Conference on Artificial Intelligence, pages 46-50, Riva Del Garda, Italy, August 2006.
[27] R. Picard. Affective Computing. MIT Press, 1997.
[28] I. Poggi. Mind markers. In N. Trigo M. Rector, I. Poggi, editor, Gestures. Meaning and use. University Fernando Pessoa Press, Oporto, Portugal, 2003.
[29] I. Poggi. Backchannel: from humans to embodied agents. In Conversational Informatics for Supporting Social Intelligence and Interaction - Situational and Environmental Information Enforcing Involvement in Conversation workshop in AISB05. University of Hertfordshire, Hatfield, England, 2005.
[30] F. E. Pollick. The features people use to recognize human movement style. In A. Camurri and G. Volpe, editors, Gesture-Based Communication in Human-Computer Interaction - GW 2003, number 2915 in LNAI, pages 10-19. Springer, 2004.
[31] A. S. Rao and M.P. Georgeff. Modeling rational agents within a BDI architecture. In Proceedings of International Conference on Principles of Knowledge Representation and Reasoning (KR), pages 473-484, San Mateo, CA, USA, 1991.
[32] S. Reilly. Believable Social and Emotional Agents. Computer science, University of Carnegie Mellon, 1996.
[33] A.E. Scheflen. The significance of posture in communication systems. Psychiatry, 27, 1964.
[34] K. Scherer. Introduction to Social Psychology: A European perspective, chapter Emotion. Oxford, 2000.
[35] Z. Ruttkay and C. Pelachaud. Exercises of style for virtual humans. In Symposium of the AISB02 Convention, Volume Animating Expressive Characters for Social Interactions, London, 2002.
[36] The Torque Game Engine (TGE), GarageGames, http://www.garagegames.com.
[37] H. G. Wallbott and K. R. Scherer. Cues and channels in emotion recognition. Journal of Personality and Social Psychology, 51(4):690-699, 1986.