

Modeling the Dynamics of Non-Player Characters' Social Relations in Video Games

Magalie Ochs, Nicolas Sabouret and Vincent Corruble

LIP6 - Université Pierre & Marie Curie, France

Abstract

Building credible Non-Playing Characters (NPCs) in games requires not only to enhance the graphic animation but also the behavioral model. This paper tackles the problem of the dynamics of NPCs social relations depending on their emotional interactions. First, we discuss the need for a dynamic model of social relations. Then, we present our model of social relations for NPCs and we give a qualitative model of the influence of emotions on social relations. We describe the implementation of this model and we briefly illustrate its features on a simple scene.

Introduction

One of the main drives for the Game AI community has been to develop synthetic characters, including Non-Player Characters (NPCs), that are more credible and engaging. Beyond the physical dimension (graphics, animation, etc.), the emotional dimension of NPCs is usually seen as key to preserve the immersive quality of a virtual world. Though many aspects of the game can be scripted, the player's actions cannot and therefore they (or rather the Player Character's actions) need to have visible and believable impacts on the other NPC's actions, through the emotions they generate. Modeling emotions credibly leads to NPCs who appear more responsive, reactive to the player's playstyle. However, NPC's emotional reactions should follow their own logic, which is in part character dependent. For instance, a character's emotional reaction should vary depending on the character's personality. This line of research has been explored in previous work, including in (Sehaba et al., 2007). Another important issue is the impact of social relations on the NPCs emotional reactions. This also is key since in many games, especially role-playing games and adventure games, the player has to impersonate a specific role in a complex story. Social relations are therefore somewhat pre-defined by the scenario, but the evolution of the story and of social relations needs to take into account the choices of the player. In many games, this is done to some extent through some relatively simple means. For example, an alignment (good vs. evil, loyal vs. chaotic) can constrain available actions and induce

specific types of reactions from NPCs (for example in *Baldur's Gate*). In other games, the Player Character's actions change its "reputation" in the virtual world, affecting indirectly the attitude of NPCs such as guards or merchants, up to a point where, respectively, after enough misdeeds, he/she could be attacked at first sight, or be offered less favorable deals. Though interesting, these means remains relatively crude from the cognitive science standpoint. Various results from psychology can be used to elaborate a finer representation of social relations. However, most of the models available in the literature are static in nature. In this paper we propose a model of social relations between synthetic characters that is dynamic — social relations will evolve over time — and connected to an emotional model. The methodology is to infer as much as possible from the psychology literature so that the implementation of the model requires only a small number of parameters to be set. The approach can be used to compute the evolution of social relations over an entire scenario, or also within a single scene such as a dialog.

This paper is organized as follows. First, we discuss related work. Secondly, we introduce a computational representation of Non-Player Characters' social relations. Thirdly, we describe an emotion-based model of the dynamics of NPC's social relations. To conclude, we present the implementation of the proposed model and test it with a single dialog.

Related work

Several researchers have proposed to model the social context of virtual characters to increase their believability. For instance, (Rousseau and Hayes-Roth, 1998) suggest a social-psychological model including personality, emotions, and attitudes. The character's behavior is computed based on its personality and attitudes. In (Walker et al., 1997) and (André et al., 2004), the linguistic style of dialog between virtual character is determined according to social variables (social distance and power) (Walker et al., 1997) and user's emotions (André et al., 2004). (Gratch, 2000) proposes a social layer that manages communication and biases plan generation and execution in accordance with a social context. In (Prendinger and Ishizuka, 2001), social filter programs are proposed to constrain a character's expression of emotion depending on the social context (represented through social power and social distance), the virtual character's personal-

ity, and its emotions. (Bickmore and Cassell, 2001) propose to use the character's social relations with the user to identify the appropriate subject to discuss with the user.

As it turns out, the models of social context in existing work are generally *static*. Researchers have mainly focused on the impact of social context on virtual character's behavior. Few researchers propose a model of the dynamics of social context. (Prendinger et al., 2002) propose functions to model the dynamics of a character's attitude and familiarity toward another character according to the valence of emotions triggered during the interaction, *i.e.* their positive (*e.g.* joy) or negative (*e.g.* fear) aspect. However, this model does not take into account the distinct impacts of different types of emotions. Research shows that emotions of same valence but different types (like shame and distress) may have different impacts on social relations (Shiota et al., 2004; de Rivera and Grinkis, 1986). In this paper, we go further by proposing a model of the dynamics of character's social relations based on emotions, in checking those of the character and those expressed by its interlocutor.

Non-Player Characters' Social Relations

Background

In computational models of social characters, social relations are generally represented by a finite set of variables. Each of them characterizes a specific dimension of a social relation between two agents (virtual or human). No consensus exists on the type and number of variables required to model social relations. However, the literature seems to outline four main social variables: the *degree of liking* (Isbister, 2006; Rousseau and Hayes-Roth, 1998; Prendinger and Ishizuka, 2001) one has for another¹; the *dominance* (Isbister, 2006; Rousseau and Hayes-Roth, 1998; Prendinger and Ishizuka, 2001), *i.e.* the power that an agent can exert on another agent; the *solidarity* (Bickmore and Cassell, 2001), *a.k.a.* social distance (Brown and Levinson, 1987), is sometimes used (Walker et al., 1997; André et al., 2004), which can be defined as the degree of "like-mindedness" or having similar behavior dispositions (*e.g.* similar political membership, family, religions, profession, gender, etc.) (Bickmore and Cassell, 2001); the *familiarity* may be used to characterize the type (private or public) and number of information exchanged between two agents (Bickmore and Cassell, 2001). Based on this literature, in our model, we consider these four social variables to represent a social relation.

Note that social relations are directed and not necessarily symmetric. For instance, the fact that a character *i* likes another character *j* does not necessarily mean that *j* likes *i*. In our model, like in (Prendinger and Ishizuka, 2001; Bickmore and Cassell, 2001), the social relations are defined from the point of view of a given virtual character.

Representation of NPC's social relation

In our dynamic model of social relations, the relation of a NPC *i* with a character *j*, from the point of view of *i*, at time *t* is formally represented as follows:

¹The term *attitude* is sometimes used to refer to the degree of liking.

$$\text{social_relation}_{i,j}(t) = \begin{pmatrix} \text{liking}_{i,j}(t) \\ \text{dominance}_{i,j}(t) \\ \text{familiarity}_{i,j}(t) \\ \text{solidarity}_{i,j}(t) \end{pmatrix}$$

with:

- $\text{liking}_{i,j}(t) \in [-1, 1]$ represents the degree of liking *i* has for *j* at time *t*. The closer the value is to -1 (*resp.* 1), the more *i* dislikes (*resp.* likes) *j*;
- $\text{dominance}_{i,j}(t) \in [-1, 1]$ corresponds to the power that *i* thinks it can exert on *j* at time *t*. The closer this value is to -1 (*resp.* 1), the more *i* feels submissive to (*resp.* dominant on) *j*;
- $\text{familiarity}_{i,j}(t) \in [0, 1]$ represents the average degree of confidentiality for *i* of the information that *i* has transmitted to *j*. A value close to 1 means that *i* feels familiar with *j* (in terms of confidentiality of the information transmitted). If *i* feels unfamiliar with *j*, the value is equal to 0;
- $\text{solidarity}_{i,j}(t) \in [0, 1]$ represents the degree of "like-mindedness" or having similar behavioral dispositions that *i* thinks to have with *j*. The closer the value is to 1, the more *i* thinks to share equivalent goals, beliefs, and values. The value 0 represents a situation in which *i* does not think to share same goals, beliefs or values with *j*.

As stated above, social relations are not necessarily symmetric, *i.e.* :

$$\exists i, j \text{ social_relation}_{i,j}(t) \neq \text{social_relation}_{j,i}(t)$$

The next section presents our emotion-based model of the dynamics of social relation.

The Emotion-based Dynamics of Social Relations

Research shows that, during an interaction, one's emotions and those of his interlocutor may lead to a change in their social relations (Ortony, 1991; de Rivera and Grinkis, 1986; Shiota et al., 2004). In this paper, we do not focus on the emotion model, which has been widely studied in the literature, but rather on the dynamics of the social relations. Thus, we use the well-known OCC model (Ortony, 2002) to represent the NPC's emotional state, which considers the following pairs of emotions: *joy/distress*, *hope/fear*, *admiration/reproach*, *pride/shame*. Each pair can be represented by a variable whose value is in $[-1, 1]$. Thus, an emotion is represented by a vector $V \in ([-1, 1])^4$.

Following (DuyBui, 2004; Sehaba et al., 2007), three different emotional vectors are defined in our model:

- the emotions triggered by an event (whose values depend on both the triggering event and the NPC's personality);
- the emotional state of the NPC (which depends on the entire affective experience of the character);
- the emotions expressed by the NPC². They can differ from the emotional state since a character may decide to display

²A character may express several emotions at the same time.

an emotion different from its felt emotions (Prendinger and Ishizuka, 2001).

Impacts of emotions on social relations

In the following, we analyze separately the dynamics of each variables of a social relation of a NPC i during an interaction with a character j according to their emotions. If no event occurred, we suppose that the social relation does not evolve. In the contrary case, the intensities of the emotions triggered by the event are used to update the social variables.

Liking. (Ortony, 1991) shows that the degree of liking one has for another depends on the emotions induced by the latter. Therefore, one's positive emotions triggered during an interaction with someone else may induce an increase in the degree of liking the former has for the latter. Conversely, negative emotions caused by another one may generate a decrease in the degree of liking (Ortony, 1991). However, an emotion triggered during an interaction with another person but not caused by the latter is supposed to have no impact on the degree of liking. For instance, let's imagine a situation in which Jack informs John about a very sad event, John will not necessarily like John less than before. Thus, we model that a *positive emotion* of i caused by j induces an increase in the degree of liking i has for j . Conversely, *negative emotion* of i caused by j generates a decrease in the degree of liking i has for j (Figure 1).

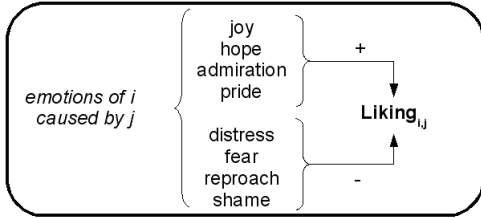


Figure 1: Impacts of emotions on liking

Dominance. According to (Shiota et al., 2004; Keltner and Haidt, 2001), pride emotion reflects dominance whereas shame corresponds to an inferior status. Given the definition of the combined emotion of anger in the OCC model (Ortony et al., 1988), reproach appears to reflect dominance. In the PAD model (Mehrabian, 1996), anger is associated with a high degree of dominance, and distress and fear to a low degree. Consequently, we can model that emotion of *pride* or *reproach* of i caused by j induces an increase in the dominance value that i thought to have on j . Conversely, an emotion of *fear*, *distress*, *admiration*, or *shame* of i caused by j infers a decrease in the dominance i thought to have on j .

In (Knutson, 1996), expression of sadness or fear reflects a low value of dominance and the expression of anger a high value. Finally, some types of emotions expressed by someone affect the dominance value of the person who perceives it. We can model that the expression by j of an emotion of

fear or *distress* induces an increase in the dominance of i . Consequently, if the event triggers fear or distress for i and j with the same intensity the dominance of i on j will not change (Figure 2).

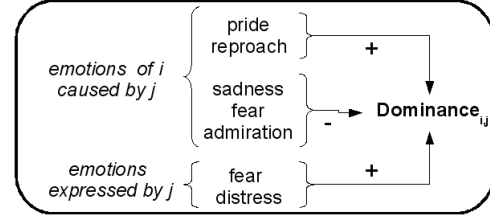


Figure 2: Impacts of emotions on dominance

Solidarity. According to (de Rivera and Grinkis, 1986), negative emotions caused by another person leads to a desire to reject him. In other words, one's negative emotion caused by someone else induces a decrease in the solidarity value that the former had with the latter. However, the triggering of positive emotions does not modify the solidarity value. Indeed, the attraction resulting from a positive emotion corresponds to a desire to give to the other (such as tenderness) or to have something the other has (such envy) (de Rivera and Grinkis, 1986). We model that a *negative emotion* of i caused by j induces a decrease in the value of solidarity that i thought to have with j (Figure 3).

As highlighted in (Keltner and Haidt, 2001), during interpersonal relations, expressed emotions reflect an individual's mental state (goals, beliefs, expectations, plan, etc). Consequently, after the occurrence of an event, a person perceiving another one's expression of emotion similar to her own triggered emotion, may imagine that they share similar goals or values. Conversely, opposite types of emotion may reflect conflicting goals or values. For instance, if an event triggers joy for a person because he had the goal that this event occurred and if, following this event, his interlocutor expresses distress, he may think that the latter had the opposite goal. Finally, we model that the congruence between one's triggered emotion and the emotion expressed by his interlocutor will influence the solidarity variable. An incongruence (*resp.* congruence) may lead to a decrease (*resp.* increase) in solidarity. If the triggered emotion of i is *joy* or *hope* (and is not caused by j) and j expressed emotion of the same type, the solidarity increases. On the contrary, if j expresses an opposite type of emotion, the solidarity decreases (Figure 3).

Moreover, research shows that solidarity influences liking. Indeed, it appears that one likes more similar persons (Smith and Mackie, 2007). Then, we can suppose the an increase in solidarity of i with j induces an increase in the degree of liking i has for j .

Familiarity. In the literature, emotions seem to not have a direct impact on the familiarity (*i.e.* on the degree of confidentiality of the information transmitted by a

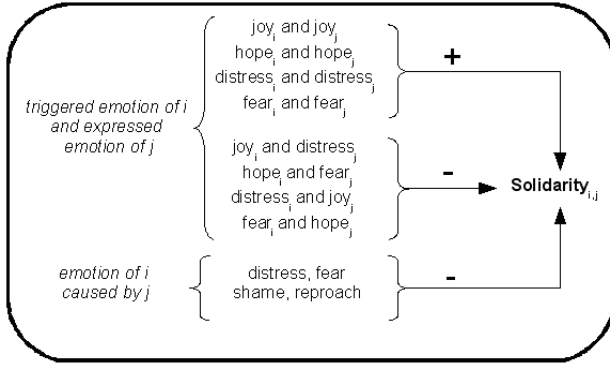


Figure 3: Impacts of emotions on solidarity

person). However, research shows that one confides more in another when the former likes the latter (Collins and Miller, 1994). Therefore, we model that the more the character likes another one the more it will transfer a confidential information to it. In other words, the familiarity is indirectly connected to the liking variable. Indeed, an increase in the confidentiality of the information transferred leads to an increase in the familiarity value.

In the next section, we present an implementation of the model introduced above and illustrates it through an example of interaction between two characters.

Implementation

The model of social relations presented above is semi-quantitative. In order to make it operational, we have defined the update function φ described below.

Let $Et_i(evt)$ be the vector representing the intensities of the emotions of the character i triggered by an event evt occurred at time t , and $Ex_j(t)$ the vector of the intensities of the emotions expressed by the character j at time t .

- We first define the function f :

$$f : (Et_i(evt), Ex_j(t)) \rightarrow \Delta SocialRelation_{i,j}(t)$$

This function takes as input the NPC's triggered emotions and those expressed by its interlocutor, and returns a vector representing the variation of the social relation given these emotions ($\Delta SocialRelation_{i,j}(t)$). f is increasing for each dimension of $\Delta SocialRelation_{i,j}(t)$ with respect to each dimension of the emotional vectors $Et_i(evt)$ and $Ex_j(t)$ (except for the solidarity which increases when the emotion values are close). This function returns the null-vector when the emotion vectors are null.

- We then define the function g :

$$g : (social_relation_{i,j}(t), \Delta SocialRelation_{i,j}(t)) \rightarrow social_relation_{i,j}(t+1)$$

This function takes as input the current social relation $social_relation_{i,j}(t)$ of the NPC with its interlocutor and the vector of the social relation's variation returned by the

previous function $f(\Delta SocialRelation_{i,j}(t))$. g returns the updated social relation. g is increasing and has a low slope on 1 and -1 to represent the fact that the social relation is hard to alter when on the extremes. For instance, a sinus-based function can be used.

- Finally, the function φ is defined as follows:

$$\begin{aligned} \varphi : (social_relation_{i,j}(t), Et_i(evt), Ex_j(t)) \\ \rightarrow social_relation_{i,j}(t+1) \end{aligned}$$

This function takes as input three vectors representing respectively the current social relation of the NPC with its interlocutor, its triggered emotions, and those expressed by its interlocutor. It returns the updated social relation.

$$\begin{aligned} \varphi(social_relation_{i,j}(t), Et_i(evt), Ex_j(t)) \\ = g(social_relation_{i,j}(t), f(Et_i(evt), Ex_j(t))) \end{aligned}$$

Note that in our model, the triggered and expressed emotions have to be provided. Methods to compute triggered emotions and to update a virtual character's emotional state consistently with its personality have been proposed in previous work (Prendinger et al., 2002; Sehaba et al., 2007). Different existing tools could be used to identify the emotions expressed by the character's interlocutor (both human and virtual) (Picard, 1997).

Illustrative example. To illustrate the dynamics of a NPC's social relation, we have implemented the model and tested it with the scene described in Table 1. The context of the scene is a police interrogation (a burglar facing a policeman) at the police station. After a break-in in a jewelry, the police arrested the burglar but the loot is missing. The policeman wants the burglar to confess where the money and the jewels are hidden.

The left column in Table 1 show the dialogue between the policeman and the burglar. For each action or utterance of the policeman, the right column gives the triggered emotion of the burglar and its intensity, whose computation is based on the OCC model (Ortony et al., 1988). For instance, let us consider the third sentence when the policeman reassures the burglar and prepares some coffee. According to OCC, the prospect of an event that would increase the NPC's satisfaction triggers hope (here, the burglar would appreciate both to face a comprehensive policeman and to drink a coffee). The intensity of the emotion depends on both the probability of the event and its desirability. For instance, in the fourth sentence, receiving a cup of coffee only triggers joy with a low intensity (0.2) whereas the 8th sentence triggers both joy and hope with higher intensities. On the contrary, the recall of an undesirable past event triggers distress (e.g. in the 7th sentence, the policeman speaks about the kidnapping of the burglar's child).

At the beginning of the interaction, we suppose that the burglar is submissive related to the policeman (*dominance* = -0.3) and dislikes him (*liking* = -0.5). Figure 4 illustrates the dynamics of the burglar's social relation with the policeman.

<i>Dialog between the policeman and the Burglar</i>	<i>Burglar's triggered emotions</i>
1. <i>Policeman</i> : The facts are not in your favor, you know. Ten people saw you threaten the manager with a weapon	Fear=0.9
2. <i>Burglar</i> : So, what do you want?	
3. <i>Policeman</i> : You know, I'm not a bad guy...(the policeman is preparing a cup of coffee)	Hope=0.2
4. <i>Policeman</i> : Do you want some coffee? (the policeman offers a cup of coffee to the Burglar)	Joy=0.2
5. <i>Policeman</i> : ...I know that your child has been kidnapped. Same thing happened to me last year, I had to negotiate with those b*** I know what it is (<i>expression of distress</i>)	Distress=0.7
6. <i>Policeman</i> : I want to help you. Just tell me where you hid the money	Hope=0.6
7. <i>Burglar</i> : I need this money to save my child!	
8. <i>Policeman</i> : We have received new information about the kidnappers. We know where your kid is being kept	Joy=0.6, Hope=0.8
9. <i>Policeman</i> : Tell me everything and I'm sure I can find a solution to avoid you going to jail	Hope=0.8
10. <i>Burglar</i> : Ok, I'm going to tell you what really happened...	

Table 1: Scene between a burglar and a policeman

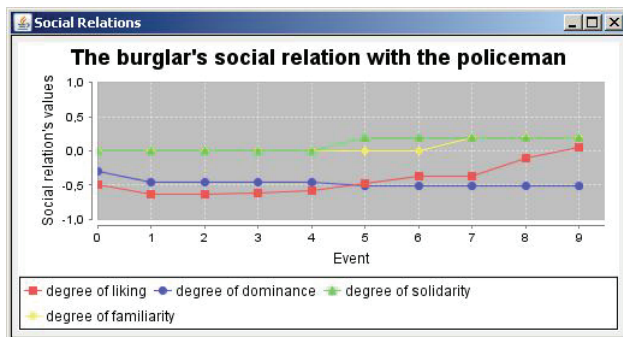


Figure 4: Dynamics of the burglar's social relation with the policeman

Let us consider for instance the third utterance (hope with intensity 0.2). As presented in the previous section (see Figure 1), the emotion of hope triggered by the policeman increases the degree of liking the burglar has for the policeman. Since the intensity of the emotion is rather low and since it is the only positive emotion in this event, the impact will however stay low and no significative change will happen. On the contrary, on the 5th interaction (distress with high intensity), since the policeman is not responsible for the negative emotion (he is not the kidnapper), the event has no impact on the degree of liking. Moreover, we have a congruence of the triggered emotion and the emotion expressed by the policeman. As shown on Figure 3, this increases the solidarity and, by side effect, the degree of liking.

In this example, the values of social relation will be used to determine which information the character transfers to its interlocutor. Since the degree of liking, dominance and familiarity reach given thresholds, the burglar will finally confess where the money and the jewel are.

Conclusion

In this paper, we have presented a model of the dynamics of NPC's social relations taking as inputs the emotions triggered by the scenario and other characters' actions. Our approach takes into account various results from cognitive science and psychology, and is then implemented in a social engine that computes and updates automatically the numeric variables describing the status of social relations. One motivation behind our design choices has been to limit the complexity (number of parameters, etc.) of our engine so that, though richer than most tools currently used by the game industry, it remains usable by game designers who are not trained in psychology and work on tight development schedules.

Though we have only illustrated our work on a small, short dialog corresponding to a single scene in a game, we believe that this model and the corresponding social engine as a wide applicability for video games where the social credibility of NPCs actions is key (this includes notably role-playing games and adventure games). In the short term, we plan to incorporate this model in game AI engine, currently being developed in collaboration with industry partners, so as to enhance the quality of dialogs with NPCs in adventure games. In the long term, our model can serve as a support for interactive storytelling. Although the example presented here is very simple, it contains a number of dramatic elements that are explicitly described by the game programmer as emotional events in our model.

In previous work (Sehaba et al., 2007), we presented an emotional model and engine that computes and updates a character's emotional state taking into account the character's personality and scenario events. We believe that the combination of all these elements will provide game developers with a tool that will greatly help the design of credible NPC's in immersive environments.

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