# Model of Facial Expressions Management for an Embodied Conversational Agent

Radosław Niewiadomski and Catherine Pelachaud

IUT de Monreuil, Université Paris 8, France,
{niewiadomski,pelachaud}@iut.univ-paris8.fr

**Abstract.** In this paper we present a model of facial behaviour encompassing interpersonal relations for an Embodied Conversational Agent (ECA). Although previous solutions of this problem exist in ECA's domain, in our approach a variety of facial expressions (i.e. expressed, masked, inhibited, and fake expressions) is used for the first time. Moreover, our rules of facial behaviour management are consistent with the predictions of politeness theory as well as the experimental data (i.e. annotation of the video-corpus). Knowing the affective state of the agent and the type of relations between interlocutors the system automatically adapts the facial behaviour of an agent to the social context. We present also the evaluation study we have conducted of our model. In this experiment we analysed the perception of interpersonal relations from the facial behaviour of our agent.

**Keywords:** embodied conversational agents, social context, facial expressions

## 1 Introduction

Human facial behaviour is influenced by many social and cultural aspects. In a series of experiments it was proved that people modify spontaneous facial expressions in interpersonal relations [6, 9, 13, 14, 19, 20]. For this purpose they often use different types of display strategies like showing fake, inhibited, or masked expressions etc. The ability to control emotional expressions (i.e. suppress, substitute, or simulate expressions of emotions) is part of emotional skills and competences often called *emotional intelligence* [10] . By analogy to human beings, we expect that embodied conversational agents (ECA)[1] can also benefit from these emotional skills. Emotionally effective and socially competent agents are more likely to build a successful relationship with a human user. According to Reeves and Nass [17] people have some implicit expectations about the social and emotional behaviour of the electronic media. Because of that, computers have to respect social rules and, in particular, rules of interpersonal relations. The violation of social norms (such as being impolite) by the computer is viewed as a social incompetence and is offensive [17]. In this paper we aim at improving

[1] An ECA is a virtual humanoid able to communicate verbally and not verbally.

the facial communication of embodied agents. We introduce an architecture that uses a variety of facial expressions (like fake or masked expressions) to manifest relations between the embodied agent and the user. We expect that by improving the expressive skills of an ECA we can contribute to successful communication between humans and computers. In order to build the architecture we need an agent that is able to:

- express different types of facial expressions,
- know which factors influence facial behaviour,
- know how they influence facial behaviour.

In a previous paper[4] we proposed a model for generation of different types of facial expressions. Psychologists (e.g. [9]) classified facial expressions according to meaning, role, and appearance. Facial expressions do not always correspond to felt emotions: they can be fake (showing an expression of an unfelt emotion), masked (masking a felt emotion by an unfelt emotion), superposed (showing a mixed of felt emotions), inhibited (masking the expression of emotion with the neutral expression), suppressed (de-intensifying the expression of an emotion), or exaggerated (intensifying the expression of an emotion) (see [15] for detailed discussion). We call *complex facial expressions* the expressions that are different from the spontaneous facial displays of simple emotional states (e.g. display of anger or sadness). They can be displays of some combinations of emotions as well as expressions of emotions, which are modified according to some social rules. We model complex facial expressions using a face partitioning approach. It means that different emotions are expressed on different areas of the face. More precisely, each facial expression is defined by a set of eight facial areas (brows, upper eyelids,...). Then the complex facial expressions are composed of the facial areas of input expressions using a set of rules [4].

In this paper we focus on facial expression management. We aim at determining factors that influence the facial behaviour in interpersonal relations and at building the model of the facial behaviour management for an ECA. Depending on some parameters that define interpersonal relations and the emotional state of the agent our algorithm modifies agent's default (i.e. "spontaneous") facial behaviour. It means that in certain social contexts our agent will use some *complex facial expressions* instead of *simple* ones. Thus we need to find rules between factors that influence the facial behaviour in interpersonal relations and the occurrence of particular type of complex facial expressions. Our rules of facial behaviour management are mostly based on the results of the annotation of a video-corpus we have made for this purpose.

The remaining part of this paper is structured as follows. In next section we present an overview of existing architectures that model certain aspects of social interaction, while section 3 presents the theory of politeness, which is used in our model. Section 4 is entirely dedicated to the study of the video corpus we made in order to gather information about facial behaviour in interpersonal relations. Then, in section 5, the details of our model are presented while, in section 6, we

present the evaluation study we conducted. Finally we discuss future works in section 7.

## 2 State of Art

The social context was often implemented in the agent's domain. First of all, different architectures modify with success the verbal content of a communicative act. Usually they adapt the style of linguistic act to the requirements of the situation by implementing some forms of polite behaviour [2, 12, 21]. There exists also a system that models the closeness in relations by the use of adequate messages [7]. Also other forms of communication like posture and gaze are used by some agents in interpersonal relations [3]. Surprisingly, the facial behaviour was rarely considered in this context. Among others Prendinger et al. modelled "social role awareness" in animated agents [16]. They introduced a set of procedures called "social filter programs". These procedures are a kind of rules for facial expression management. Defining social filter programs Prendinger et al. considered both social conventions (politeness) and personalities of interlocutors. The social filter program defines the intensity of an expression as the function of a social threat (power and distance), user personality (agreeableness, extroversion), and the intensity of emotion. As a result, it can either increase, decrease the intensity of facial expression, or even totally inhibit it.
The agent called Reflexive Agent [8] is also able to adapt its expressions of emotions according to the situational context. This agent analyses various factors in order to decide about either displaying or not its emotional state: emotional nature factors (i.e. valence, social acceptance, emotion of the addressee) and scenario factors (i.e. personality, goals, type of relationship, type of interaction). In particular the Reflexive Agent uses *regulation rules* that define for which values of these factors the concrete emotion can (or cannot) be displayed [8]. Although many factors that are related to the management of facial displays are considered in this model, it allows to apply only one type of complex facial expressions i.e. inhibition.

The solutions presented above do not allow human users to perceive the difference between different facial expressions; e.g. they do not allow distinguishing between spontaneous and fake smiles. As a consequence these applications deprive facial expressions of their communicative role. Instead we aim at building an agent that will modify the facial expressions depending on the relation it has with the interlocutors. These changes need to be perceivable and interpretable by human interlocutors.

## 3 Politeness Strategies

Brown and Levinson proposed a computational model of politeness in language [5]. According to this theory, any linguistic act like request or promise can threaten the "face" of the speaker and/or hearer. Politeness consists in taking remedial actions to counterbalance the negative consequences of these face

threatening acts.
Brown and Levinson proposed the classification of all actions that prevent face threatening. They defined five different strategies of politeness: bald, positive and negative politeness, off-record, and "don't do the action". These strategies are ordered according to the impact they have on avoiding threatening situations. The fist one - bald strategy - does nothing to minimize threats to the face, while the fifth one - "don't do the action" - allows the speaker to surely avoid threatening the face but, at the same time, it precludes the communication of his intentions.
The decision about strategy to be used depends on the level of threat of an action (FTA). Brown and Levinson proposed to estimate FTA of an action by using three variables: the social distance, the power relation, and the absolute ranking of imposition of an action. Social distance refers to the degree of intimacy and the strength of the relation, while social power expresses the difference in status and the ability to influence others. The last parameter depends on the objective importance of an action in a specific culture or situation. It can be the cost in terms of services, time or goods. FTA value is calculated as the sum of these three values. Finally, the more antagonistic a given act is (higher FTA value), the more likely a high ordered strategy is to be chosen [5].

## 4 Video-corpus

Our model of facial expressions is mostly based on the results of annotation of a video-corpus. For this purpose we decided to re-use the approach proposed by Rehm and André [18]. They analysed the relationship between different types of gestures and politeness strategies in verbal acts. They built a video-corpus called SEMMEL that contains various examples of verbal and nonverbal behaviour during face threatening interactions. They found that nonverbal behaviour is indeed related to politeness strategies. However, the facial expressions had not been considered. Inspired by the encouraging results of Rehm and André's experiment, we decided to analyse the SEMMEL video-corpus in order to find relations between politeness strategies and facial behaviour.

### 4.1 Annotation Scheme and Results

We used 21 videos with eight different protagonists. The overall duration of the analysed clips is 6 minutes and 28 seconds. In this study we used the original annotation of politeness strategies proposed by Rehm and André (strategy.basic track). They considered four politeness strategies: bald, positive politeness, negative politeness, and off-record strategy [18]. In our study the facial expressions (and corresponding emotional states) were annotated by a native speaker annotator. In our annotation scheme we considered four types of facial expressions: expression of the true emotional state, inhibited, masked, and fake expression. Because of a relatively small number of examples analysed so far we decided to consider only one feature of an emotional state: i.e. valence. Thus

| Pattern | Strategy | | | | All |
|---|---|---|---|---|---|
| | bald | positive | negative | off-record | |
| negative masked | 0 | 0 | 1 | 4 | 5 |
| negative inhibited | 0 | 0 | 1 | 2 | 3 |
| negative expressed | 0 | 2 | 0 | 2 | 4 |
| fake negative | 0 | 0 | 0 | 0 | 0 |
| neutral expression | 4 | 8 | 34 | 7 | 53 |
| fake positive | 0 | 5 | 16 | 6 | 27 |
| positive masked | 0 | 0 | 0 | 0 | 0 |
| positive inhibited | 0 | 0 | 2 | 0 | 2 |
| positive expressed | 2 | 3 | 1 | 2 | 8 |
| All | 6 | 18 | 55 | 23 | 102 |

**Table 1.** The occurrence of different patterns of facial expressions

we distinguished between positive, negative emotions, and a neutral state. As a consequence, we did not consider separate emotional states and expressions corresponding to them, but some *patterns* of facial behaviour. For example, a pattern called "positive masked" describes any facial expression that occurs in a situation in which any positive emotion is masked by another one. The following patterns of facial expressions were considered in the annotation process: negative masked, negative inhibited, negative expressed, fake negative, neutral expression, fake positive, positive masked, positive inhibited, positive expressed. We analysed the frequency of the occurrence of each of them. The detailed results of our annotation are presented in Table 1. We can see that different types of facial expressions are not evenly distributed along different strategies of politeness. Some expressions are more often used with one type of politeness behaviour and other with another one. The "neutral expression" pattern was the most often observed (52% of all cases) and "fake positive" pattern was observed in 26.5%. Some patterns were not observed at all. None of "positive masked" expressions or "fake negative" expressions was annotated. We use this information to build our model of facial behaviour in interpersonal relations.

## 5 Facial Expression Management Model

In this section we explain how our embodied agent adapts its expressive behaviour to the situation. In more detail, basing on the results of annotation study presented in the previous section we establish a set of rules that models relations between different types facial expressions and the social context. In particular for each strategy of politeness we established the most characteristic pattern of facial expression according to the annotation results. The pairs (politeness strategy, pattern of facial expressions) were used to define the rules that our agent will apply in order to modify its facial behaviour.

### 5.1 Variables

Different sources show that two variables, social distance (SD), social power (SP), are important factors that describe interpersonal relations. According to [22] all personality traits relevant to social interaction can be located in two dimensional space defined by the orthogonal axes of dominance and affiliation. So two variables: dominance (corresponding to SP) and affiliation (corresponding to SD) are sufficient to describe interpersonal relations. Moreover Brown and Levinson include SP and SD in their theory of politeness (see section 3). Power (SP) and social distance (SD) are two factors that influence human expressions according to various studies about facial behaviour [6, 13, 20].
Facial behaviour management is also conditioned by emotional factors. In particular, facial behaviour depends on the valence (Val) of emotion [6, 14]. Negative emotions are more often masked or inhibited, while positive emotions are often pretended.

Thus, in our model, we consider three variables to encompass the characteristics of interaction and features of emotional state of the displayer, namely: social distance (SD), social power (SP), and valence of emotion (Val).

### 5.2 Rules

We consider three different emotional states: negative, positive, and neutral emotional state. For each of them we looked for the pattern of facial behaviour that corresponds the best to each politeness strategy. The choice is based on the frequency of the co-occurrence of strategy $j$ and pattern $i$ in the annotated video clips (see Table 1). In more details, for each strategy of politeness $j$ (j=1..4) and the emotional state $k$ (k=1..3) we choose the pattern $i$ (i=1..10) such that the value a(i,j,k):

$$a(i,j,k) = \frac{x_{ijk}}{\sum_{z=1}^{4} x_{izk}}$$

is maximal (the value $x_{ijk}$ expresses the co-occurrence of $i$-th pattern of a facial behaviour and the strategy $j$ in the emotional situation $k$). In the situations in which the data gathered in the annotation study was insufficient to make a choice, we used also the conclusions from other experiments [6, 13, 14]. In Table 2 we can see which pattern of facial expression $i$ will be used for each type of emotion (positive, neutral, negative) and strategy of politeness.

### 5.3 Processing

The values of social power (SP) and distance (SD) and the label of an emotional state $E_i$ are the inputs of our model. *SP* and *SD* take values from the interval [0,1]. The emotional state is described by an emotional label from a finite set of labels. This set contains emotions whose expressions can be displayed by the agent. The label that identifies the neutral state is also considered as a valid

| face threat | bald | positive | negative | off-record |
|---|---|---|---|---|
| positive emotion | positive expressed | positive expressed | positive inhibited | positive expressed |
| neutral state | neutral expressed | fake positive | neutral expressed | fake positive |
| negative emotion | negative expressed | negative expressed | negative inhibited | negative masked |

**Table 2.** Facial behaviour and strategies of politeness.

input. The valence Val($E_i$) of an emotion $E_i$ can be found using any dimensional model of emotions. We use the data proposed in [1]. In our model any emotional state can be either positive or negative (the neutral category concerns only the neutral state).
Brown and Levinson introduced the concept of the level of threat of a linguistic act (FTA). This value is used to choose between different politeness strategies (see section 3). Let $w$ be a variable that is a counterpart of the FTA in our model. We establish this value as the difference: $w = SD - SP$ which takes values in the interval [-1,1]. We use $w$ to choose the pattern of facial behaviour. Following the approach proposed by Walker et al. [21] we define for each strategy an interval of acceptable values. For this purpose we split the interval of all possible values of $w$ into four equal parts: $w \in$ [-1, -0.5] (very low) is associated with the bald strategy, $w \in$ (-0.5,0] with positive politeness, $w \in$ (0,0.5] with negative politeness, while $w \in$ (0.5,1] (very high) with the off-record strategy. Finally our facial management rules are of the type: *if Val($E_i$) is* {*positive* | *negative* | *zero*} *and w is* {*very low* | *low* | *high* | *very high*} *then the expression of* $E_i$ *is* {*expressed* | *fake* | *inhibited* | *masked*}.

Using Table 2 we decide on the facial expression pattern of an emotion $E_i$. In the case of negative masked or fake positive pattern we use the expression of fake joy or masked joy. Finally, for any emotional state $E_i$, values of social distance *SD* and of social power *SP*, by using our rules, we can generate an adequate facial expression using an approach presented in [4].

## 6 Evaluation

Our experiment consists in checking whether subjects are able to guess the social context of the situation from the facial expressions displayed by the agent. We aim at verifying if the agent that follows our rules of facial behaviour management behaves in accordance with human expectations. As a result we expect that our subjects are aware of certain rules of facial behaviour in interpersonal relations and that these rules are concordant with the rules of our model.

### 6.1 Scenario Set-up

Our evaluation study consists in showing subjects a set of animations that we generated using the Greta agent [4] and a model of complex facial expressions [15]. Each of them presents the same sequence of events. The verbal content is identical and animations can be distinguished only by the facial behaviour of the agent. Our intention is to demonstrate that facial behaviour is different in different social contexts. The subjects were also told a short story with different versions whose variations correspond to situations of different interpersonal relations. Subjects' task was to match each animation to one story variation.

**Scenario** For the purpose of the experiment we prepared a short scenario that was presented to the participants at the beginning of the experiment. Our scenario describes a sequence of events that happens at an airport departure lounge. Two persons are playing cards. During the game different events take place. One person, we called her the protagonist, wins the first turn, but then she discovers that her opponent is cheating, finally she looses another turn. The sequence of events is favourable for diversification of emotional reactions. The protagonist of the events is played by the Greta agent. Her opponent is not visible to the subject. Three different types of relations are considered in three variations of the story presented to the subjects: interaction with a friend (A), interaction with a stranger (B), and interaction with a superior (C). These cases were chosen in order to emphasise the differences between different types of interpersonal relations. The first situation illustrates relations between two persons that are close to each other. The second situation is a typical example of a relation in which the social distance is high (Greta interacts with a stranger). Finally, in the last case our intention was to model a situation of submission. The distance is high and the opponent has a power over the displayer. We assume that these relations are constant during the interaction i.e. the values of power and distance do not change.

**Animations** For the purpose of the experiment we generated five different animations. Three of them correspond to different politeness strategies (positive politeness, negative politeness, and off-record in turn, see Table 2). The animations used in the experiment were constructed as follow:

- Animation A1 - corresponds to low social distance and low or neutral power (negative and positive expressions are expressed freely, the fake joy is used instead of the neutral expression);
- Animation A2 - corresponds to high social distance and neutral power (positive expressions are inhibited, while negative ones are masked);
- Animation A3 - corresponds to high social distance and high dominance of the observer over the displayer (negative expressions are masked, positive expressions are displayed, fake joy is used instead of the neutral expression);
- Animation A4 - negative expressions are masked by happiness, fake expression of sadness is used;

– Animation A5 - negative expressions are expressed freely, fake expression of anger is used, happiness is masked by anger.

Animations A1-A5 differ only in facial behaviour. The agent's utterances do not change between animations, even if in the real-life verbal communication is usually modified according to the values of power and distance (see section 3). In this experiment we aimed at measuring the effect of facial expressions only, thus we had to avoid the influence that different verbal messages might have on the subjects' evaluation. For this purpose we decided to use "neutral-style" utterances, which are identical for all animations. The subjects were informed about this fact before the experiment. In Figure 1 some examples that illustrate the variety of facial reactions displayed by the agent at the same instant in different animations are presented. In particular, the first row includes the reactions of the agent when she discovers the dishonesty of her opponent, while in the second row we can see the agent's reactions when loosing a turn.

**Fig. 1.** Examples of different facial expressions displayed by the agent at the same instant in different animations

### 6.2 Procedure

20 persons (8 men and 12 women) participated in the experiment. The animations were presented in a random order. Firstly, the participants watched all the animations. They could also re-view them if they found it necessary. After seeing all animations they matched each video with one of the situations A), B), or C). The same animation could not be attributed to more than one situation. It means that two animations had to be rejected. After the session participants were also asked to justify their choices.

### 6.3 Results

In order to evaluate our algorithm we established the frequency of occurrence of the expected answers among the subjects' answers. Let us enumerate the expected matchings in our test:

- ANS1 - The animation A1 is attributed to the situation A,
- ANS2 - The animation A2 is attributed to the situation B,
- ANS3 - The animation A3 is attributed to the situation C.

First, we have counted the number of completely right answers. Six out of twenty participants (30%) identified all three animations correctly (i.e. ANS1–ANS3 were satisfied). The number of persons whose answers were all incorrect was, however, similar (25%). Then we measured the number of persons who gave the majority of responses correctly. Thus, in this condition it was sufficient that at least two answers from three satisfy ANS1 – ANS3. As a result the majority of participants (55%) answered the majority of responses correctly. Finally, we also measured the number of good responses in general. ANS3 was recognized the most while ANS2 was the less one. Table 3 presents the number of good responses and the confusion matrix for each answer.

| | A1 | A2 | A3 | Other | Accuracy |
|---|---|---|---|---|---|
| A1 | 11 | 4 | 0 | 5 | 55% |
| A2 | 1 | 9 | 2 | 8 | 45% |
| A3 | 5 | 0 | 12 | 3 | 60% |
| Other | 4 | 7 | 6 | 23 | 58% |

**Table 3.** Matrix of confusions of subjects' answers (subjects' answers are in columns).

### 6.4 Discussion

The aim of this experiment was to verify the rules of facial behaviour management model. The overall tendency observed was concordant with our expectations as there were more correct answers than incorrect ones. The accuracy of answers exceeded significantly the chance level in all cases. The majority of subjects answered in most cases in accordance with our rules. At the same time, the probability of accidental good matchings was small. Moreover, in all cases the predicted answers occurred more often than any other answer. It means that matchings ANS1 – ANS3 were in general confirmed by our subjects. On the other hand, many persons provided answers different from our expectations. In particular, the percentage of the participants that answered all questions differently to our expectations is relatively high.

## 7 Conclusion

In this paper we described an architecture that uses facial expressions in order to express interpersonal relations of an ECA. The agent is able to mask, hide or even simulate the expression of its emotions taking into account the social context. Its facial expressions reflect the management of the display of its emotions. We presented also the evaluation study of our model of facial behaviour in interpersonal relations. We studied if subjects were able to guess the social context from the facial expressions generated by our model. The results indicate that our rules are plausible for subjects, at least from the European culture.

In future we plan to consider the inter-cultural differences, other types of facial expressions (like suppression or exaggeration), as well as other factors which influence the facial behaviour in interpersonal relations. So far, for sake of simplicity, we have considered neither the personality of displayer, the circumstances of interaction (see [19, 11]) nor the features of the emotional state of a displayer other than valence (e.g., the intensity and the dominance value). For instance, in our model, as sadness and anger have the same valence, the expression of sadness is processed in the same way as the expression of anger. We believe that all these elements need to be integrated in order to create a more reliable and socially competent embodied agent.

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