

Social Computing

Life-like Characters as Social Actors

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ABSTRACT

Social Computing aims to support the tendency of humans to interact with computers as if they were veritable social actors. Technology that reinforces the bias toward social interaction by producing appropriate responses may improve the communication between humans and computational devices. We believe that the most natural way to realize social computing is by using life-like synthetic characters with context aware affective behavior.

We will describe an architecture for emotion-based agents (SCREAM) that allows to automatically generate emotionally and socially appropriate responses of synthetic characters. The proposed system is intended as a scripting tool where content authors state the mental make-up of an agent by declaring a variety of parameters and behaviors relevant to affective communication and obtain quantified emotional reactions which are then input to an animation engine visualizing the agent as 2D animation sequences.

Three web-based interaction scenarios featuring life-like animated characters will highlight individual aspects of (simplified versions of) our system.

Moreover, we will discuss narrative intelligence as a promising technology to complement characters' socially intelligent behavior. Since people make sense of the behavior of others by structuring their behavior into narrative, this field might contribute to objective of social computing.

1. INTRODUCTION

Recent years have witnessed a growing interest in employing animated agents for tasks that are typically performed by humans. To mention some of the more prominent applications, embodied characters are now used as virtual tutors in interactive learning environments [13, 23, 19], as virtual sales agents and presenters [1, 11, 22], and as virtual actors for entertainment [47, 37].

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It might be too premature to tell success stories in terms of significantly improved learning curves or revenues from on-line sales due to the deployment of animated agents. However, there is strong evidence from psychological investigations saying that humans treat computers as social actors (Reeves and Nass [45]) and hence the use of embodied characters as interlocutors (rather than a pure text-based interaction mode) might intensify the tendency of humans to treat media in an essentially natural way. More support in favor of the positive impact of animated agents can be found in Lester *et al.* [25, 26] on the 'persona effect'

"[...] which is that the presence of a lifelike character in an interactive learning environment—even one that is not expressive—can have a strong positive effect on student's perception of their learning experience." [25, p. 359]

In order to be effective, embodied characters have to be *believable* in their respective roles as tutors, presenters, or actors, i.e., they should allow the viewers to suspend their disbelief (Bates [3]).¹ There exists general agreement that emotion and personality are central requirements for an animated agent's believability. More specifically, agents have to be able to express emotions reflecting their mental state and exhibit a consistent personality. Another key factor for believable agents is sensitivity to the peculiarities of the social context in which they are situated, resulting in (socially) appropriate behavior. In this paper, we suggest the term *social intelligence* to characterize agent behavior that fulfills those requirements.

Besides 'mind'-related concepts for believability, there is vast evidence that an agent's embodiment may significantly contribute its believability (and likeability) for users (see, e.g., the studies performed by McBreen *et al.* [29]). Currently, we use 2D cartoon-style animations to embody agents. Although the visual appearance of those characters is quite simplistic (in the sense of 'not naturalistic'), believability does not seem to be affected. A well-known example are the Disney characters that provide the illusion of life by their behavior rather than their appearance.

The rest of the paper is organized as follows. In Section 2, the main components of the SCREAM emotion-based agent

¹Sometimes 'life-likeness' is used instead of 'believability'. We will use both terms interchangeably.

architecture are described: emotion generation, emotion regulation, emotion expression, and the agent model. Also, the topic of emotion recognition is briefly sketched. In Section 3, the system is explained by means of three interaction scenarios that employ characters based on the SCREAM architecture. Section 4 discusses some issues of narrative intelligence. Section 5 concludes the paper.

A few words regarding our contribution to the topic of the particular event this paper is submitted to², are in order here. Our paper describes a certain aspect of cognition, namely the cognitive elicitation and processing of emotion, as a key feature for the believability or life-likeness of synthetic characters. Although competing paradigms for emotion processing exist, e.g., neuroscience and ethology inspired (non-cognitive) approaches to emotion (e.g., Velásquez [53]), no comparison of those two paradigms has been undertaken. Currently, those two paradigms are applied to different subjects. While cognitive approaches aim to model life-like behavior of human-like characters, non-cognitive approaches are used to simulate life-like behavior (mostly basic drives) of animats (synthetic animals). As to the specific subject of the event, “Non-Monotonic and Uncertain Reasoning in the Focus of Competing Paradigms of Cognition”, the present paper does not explicitly investigate those relations. However, the application domain considered in the paper is inherently uncertain and hence might suggest some relevant issues and problems.

2. SOCIAL INTELLIGENCE

In this section, we will give a detailed description of an agent architecture that is designed to allow for socially intelligent behavior. Also, the issue of (physiological) emotion recognition is briefly discussed.

2.1 An Architecture for Emotion-based Agents

We have developed a system called SCREAM (**SCR**ipting **E**motion-based **A**gents **M**inds) that allows to script a character’s affect-related processing capabilities.³ It is intended as a plug-in to content and task specific agent systems such as interactive tutoring or entertainment systems that provide possible verbal utterances for a character. Our system may then decide on the kind of emotion expression and its intensity, based on a multitude of parameters that are relevant to the current interaction situation. Parameters are derived from the character’s mental state as well as the peculiarities of the social setting in which the interaction takes place, and features of the character’s interlocutor(s), e.g., the user. While the nature of an (appropriate) affective reaction is obvious in many cases, more complex interaction scenarios will likely face the problem of ‘conflicting emotions’. Consider a situation where an animated teammate that is very angry and extrovert interacts with a new team member in the course of an important mission. The ‘conflict’ here consists in the fact that the character’s display of its anger might increase the insecurity of the new member and thereby endanger the success of the mission. Our system provides various controls to ensure situationally adequate behavior consistent with a character’s mental makeup.

²First Salzburg Workshop on Paradigms of Cognition (SWPC 1/2002), “Non-Monotonic and Uncertain Reasoning in the Focus of Competing Paradigms of Cognition”.

³The contents of this section significantly draws on the work described in Prendinger *et al.* [40, 43, 44].

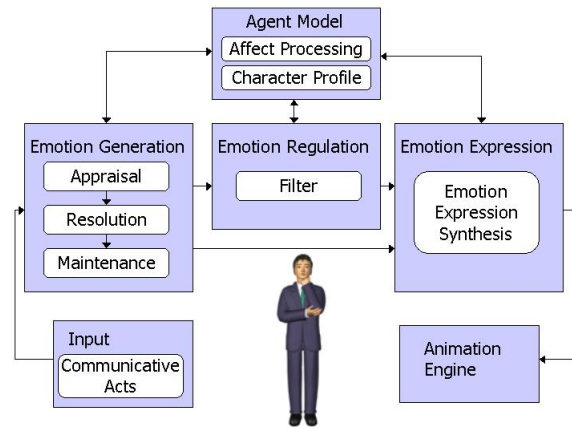


Figure 1: SCREAM System Architecture.

Characters are adaptive in the sense that affective features of the interaction history result in updated values for certain mental states, such as attitudes and social relations.

Fig. 1 gives an overview of the system architecture of SCREAM. Each of its components will be discussed in detail in the following sections.

2.1.1 Emotion Generation

A core activity of an emotion-based agent mind is the generation and management of emotions, which is dealt with by three modules, the *appraisal* module, the *emotion resolution* module, and the *emotion maintenance* module. They will be described in the following. We start with a brief description of the input to the emotion generation component.

Input to an Agent’s Mind. The input consists of communicative acts of the form

$$\text{com_act}(S, H, \text{Concept}, \text{Modalities}, \text{Sit})$$

where S is the speaker, H the addressee, Concept is (an abstraction of) the information conveyed by S to H in situation Sit , and Modalities is the set of communicative channels used by S , such as specific facial displays, acoustical correlates of (expressed) emotions, linguistic style, gestures, and posture. Communicative acts have preconditions, that must be explicitly modelled by the author. The sentence “Are you doing tricks?”, uttered by an animated dealer in a casino with an angry voice and fierce facial display might have the following (self-explanatory) preconditions:

$$\begin{aligned} &\text{wants}(\text{dealer}, \text{player}, \text{fair_play}, 3, \text{s15}) \\ &\text{blameworthy}(\text{dealer}, \text{player}, \text{not_fair_play}, 5, \text{s15}) \end{aligned}$$

The numbers “3” and “5” refer to intensities and will be explained below.

Appraisal Module. Reasoning about emotion models an agent’s *appraisal process*, where events are evaluated as to their emotional significance for the agent (Ortony *et al.* [36]). The significance is determined by so-called ‘emotion-eliciting conditions’, which comprise an agent’s relation to four types of abstract mental concepts:

- *beliefs*, i.e., state of affairs that the agent has evidence to hold in the (virtual) world;

- *goals*, i.e., states of affairs that are (un)desirable for the agent, what the agent wants (does not want) to obtain;
- *standards*, i.e., the agent’s beliefs about what ought (not) to be the case, events the agent considers as praiseworthy or blameworthy; and
- *attitudes*, i.e., the agent’s dispositions to like or dislike other agents or objects, what the agent considers (not) appealing.

Following the emotion model of Ortony, Clore, and Collins [36] (the OCC model), we conceive emotion types as classes of eliciting conditions, each of which is labelled with an emotion word or phrase. In total, twenty-two classes of eliciting conditions are identified: *joy*, *distress*, *happy for*, *sorry for*, *resent*, *angry at*, and so on. Consider the emotion specification for fortunes-of-others emotion *resent* (being distressed about another agent’s joy). The following rule is written in Prolog-style form close to the actual code:

```
resent(L1,L2,F, $\delta$ ,Sit) if
    directed_to(L1,L2,Sit) and
    dislikes(L1,L2, $\delta_{NApp(F)}$ ,Sit) and
    joy(L2,L1,F, $\delta_{Des(F)}$ ,Sit)
```

This specification reads as follows. The (locutor-)agent $L1$ resents agent $L2$ about state of affairs F in situation Sit with intensity degree δ if $L2$ is the addressee in Sit , $L1$ dislikes $L2$ with ‘non-appealingness’ degree δ_{NApp} , and believes that $L2$ is joyful about F with ‘desirability’ degree δ_{Des} . Whether this belief is true or not is entirely in the content author’s control, and typically specified in the communicative act description. We assume intensities $\delta_i \in \{0, \dots, 5\}$ such that zero is the lower threshold, i.e., the corresponding mental state is not active, and five is the maximum value. By default, intensities δ_i are combined to an overall intensity δ by logarithmic combination $\delta = \log_2(\sum_i 2^{\delta_i})$.

Since a reasonably interesting agent will have a multitude of mental states (beliefs, goals, attitudes, and so on), more than one emotion is typically triggered when the agent interacts with another agent. However, since an agent should clearly express a specific emotion at any given time, we need some way to resolve the agent’s emotions. This problem will be discussed in the next paragraph.

Emotion Resolution Module. The emotions generated in an agent at a given time are called *active* emotions (in Sit) and are collected together with their intensities in a set $\{\langle E_1, \delta_1, Sit \rangle, \dots, \langle E_n, \delta_n, Sit \rangle\}$. The presence of multiple emotions is resolved by computing and comparing two states. The *dominant emotion* is simply the emotion with the highest intensity value (the case where no unique dominant emotion exists will be decided by the agent’s personality, see below). On the other hand, the *dominant mood* is calculated by considering all active emotions. Similar to Ortony [35], we distinguish between ‘positive’ and ‘negative’ emotions. Examples of positive emotions are ‘joy’, ‘happy for’, and ‘sorry for’, whereas ‘resent’ and ‘angry at’ are negative emotions. Then the dominant mood results by comparing the overall intensity value associated with the positive and negative emotion sets, which is obtained by logarithmic combination. The *winning emotional state* is decided by comparing the intensities for dominant emotion and dominant mood. Thereby, we can account for situations where

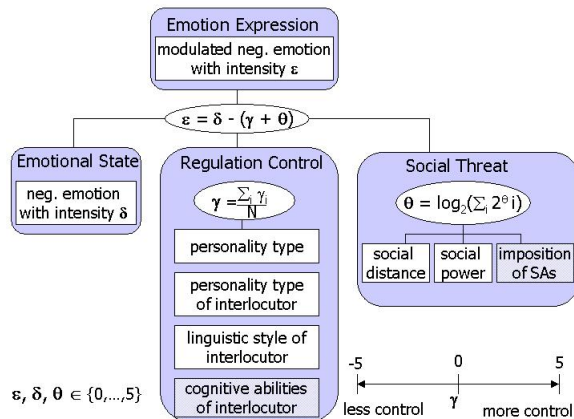


Figure 2: Emotion regulation parameters.

an agent has a joyful experience, but is still more influenced by its overall negative emotions (mood) for another agent. In situations where equal intensities (of active emotions, moods, etc.) result, we consider the agreeableness dimension of an agent’s personality. The agreeableness dimension is numerically quantified, with a value $\gamma_A \in \{-5, \dots, 5\}$. Consequently, an agent with disagreeable personality (e.g., $\gamma_A = -3$) would favor a winning negative emotional state to a (winning) positive emotion if both have the same intensity level.

Emotion Maintenance Module. This module handles the decay process of emotions. Depending on their type and intensity, emotions may remain active in the agent’s memory for a certain time during the interaction (Reilly [46]). A decay function decreases the intensity levels of the active emotions each ‘beat’ by n levels until the intensity is equal or smaller than zero. A beat is defined as a single action-reaction pair between two agents. The actual decay rate is determined by the emotion type and the agent’s personality such that with agreeable agents, negative emotions decay faster than positive ones.

2.1.2 Emotion Regulation

In their seminal work on non-verbal behavior, Ekman and Friesen [16] argue that the expression of emotional states (e.g., as facial expression) is governed by social and cultural norms, so-called *display rules*, that have a significant impact on the intensity of emotion expression. We will treat emotion regulation as a process that decides whether an emotion is expressed or suppressed. Moreover, a value is calculated that indicates to what extent an emotion is suppressed. An agent’s emotion regulation is depending on a multitude of parameters [42, 12]. As shown in Fig. 2, we broadly categorize them into parameters that constitute a social threat for the agent, and parameters that refer to the agent’s capability of (self-)control.⁴ Although this distinction is somewhat arbitrary, we found that it allows authors to state regulation parameters in a simple and intuitive way.

Communication is always embedded into a social context where participants take social roles with associated commu-

⁴The parameters shown in the semitransparent boxes, ‘cognitive abilities of interlocutor’ and ‘imposition of speech acts’, are not implemented.

nificative conventions. Following Brown and Levinson [7], we take *social power* and *social distance* as the most important social variables. We assume that roles are ordered according to a power scale, where $social_power(L2, L1, \theta_P, Sit)$ means that agent $L2$ is θ_P ranks higher than agent $L1$ ($\theta_P \in \{0, \dots, 5\}$). On the other hand, social distance refers to the familiarity or ‘closeness’ between agents, and can be stated as $social_distance(L1, L2, \theta_D, Sit)$ such that $\theta_D \in \{0, \dots, 5\}$. Based on θ_P and θ_D , the *social threat* θ for $L1$ from $L2$ is computed as $\theta = \log_2(2^{\theta_P} + 2^{\theta_D})$. If θ_P and θ_D are both zero, θ is set to zero. Note that the social variables are not meant to reflect ‘objective’ ratings of power or distance, but the modelled agent’s assumed assessment of the ratings.

The following set of parameters describe the agent’s *self-control* each of which takes a value $\gamma_i \in \{-5, \dots, 5\}$. Greater positive values indicate that the agent is capable and willing to suppress negative emotions whereas greater negative values indicate that the agent tends to also express negative emotions. Besides the agent’s agreeableness, we also consider the *extroversion dimension of personality*. Extrovert agents typically express their emotions independent of their impact on another agent whereas introvert agents tend to refrain from doing so. For artistic reasons, we discourage authors from using the zero value, since agents with ‘neutral’ personality might fail to express their emotions succinctly. Moreover, if the agent assumes that the *interlocutor’s personality* is unfriendly (disagreeable), it will rather not express a negative emotion. An interesting phenomenon in interactions among humans are *reciprocal feedback loops* where one agent’s linguistic friendliness results in the interlocutor agent’s adaption of its otherwise unfriendly behavior.

The overall control value γ is computed as $\gamma = \frac{\sum_i \gamma_i}{N}$ where the denominator N scales the result according to the number of considered control parameters. Basically, the equation captures the intuition that different control parameters may defeat each other. Thus, the control of an agent that is very extrovert but deals with a very unfriendly interlocutor might be neutralized to some degree.

The **(Social) Filter Module** operates on the winning emotional state, the social threat, and the overall control value. It outputs an *external emotion* with a certain intensity $\epsilon \in \{0, \dots, 5\}$, i.e., the *type* of emotion that will be displayed by the agent. The Filter module consists of only two rules, one for positive emotions and another one for negative emotions. The general form of a social filter rule is as follows.

external_emotion(L1, L2, E, ϵ , Sit) **if**
 social_threat(L1, L2, θ , Sit) **and**
 control(L1, L2, γ , Sit) **and**
 winning_emotional_state(L1, L2, E, δ , Sit)

The most difficult problem here is to adequately combine the intensity values associated with the social threat experienced by the agent, the agent’s control capability, and the emotional state. The default combination function for negative emotions is $\epsilon = \delta - (\theta + \gamma)$. Intuitively, the function balances the social threat against the agent’s control, whereby high values for threat may neutralize the lacking self-control of the agent to a certain extent. The filter rule for positive emotions is syntactically identical but uses a different combination function: $\epsilon = \delta - (\theta - \gamma)$. Here, it is the agent’s low control that dominates the expression of emotions. Alternatively, we provide a decision network to determine whether

and to what extent an agent expresses its emotional state, based on its check for negative consequences of emotion expression (Prendinger and Ishizuka [40]).

2.1.3 Emotion Expression

External emotions must eventually be described in terms of the agent’s reactions and behaviors. We use a simplified version of Ortony’s categorization of emotion response tendencies [35], and distinguish between expressive and information-processing responses.

- *Expressive responses* include somatic responses (flushing), behavioral responses (fist-clenching, throwing objects), and two types of communicative responses, verbal and non-verbal (e.g., frowning).
- *Information-processing responses* concern the agent’s diversion of attention and evaluations (which we partly handle in the Affect Processing module).

The Animation Engine currently used only allows for rather crude forms of combining verbal and non-verbal behavior [30]. Body movements (including gestures) may precede, overlap, or occur subsequently to verbal utterances.

2.1.4 Affect Processing

The Agent Model describes an agent’s mental state. We distinguish *static* and *dynamic* features of an agent’s mind state, such that the agent’s personality and standards are considered as static whereas goals, beliefs, attitudes and social variables are considered as dynamic. Here, we are mainly concerned with change of attitude as a result of social interaction.

Ortony [34] suggests the notion of (*signed*) *summary record* to capture our attitude toward or dispositional (dis)liking of another person. This record stores the sign of emotions (i.e., positive or negative) that were induced in the agent L by an interlocutor I together with emotions’ associated intensities. In order to compute the current intensity of an agent’s (dis)liking, we simply compare the (scaled) sum of intensities of elicited positive and negative emotions (δ^σ , $\sigma \in \{+, -\}$), starting in situation $Sit_0^{L,I}$, the situation when the interaction starts. We will only consider the intensity of the winning emotional state δ_w . If no emotion of one sign is elicited in a situation, it is set to zero.

$$\delta^\sigma(Sit_n^{L,I}) = \frac{\sum_{i=0}^n \delta_w^\sigma(Sit_i^{L,I})}{n+1}$$

Positive values for the difference $\delta^+ - \delta^-$ indicate an agent’s liking of an interlocutor and negative ones indicate disliking. The more interesting case where an interlocutor the agent likes as a consequence of consistent reinforcement (suddenly) induces a high-intensity emotion of the opposite sign, e.g., by making the agent very angry, is captured by the following update rule.

$$\delta(Sit_n^{L,I}) = \delta^\sigma(Sit_{n-1}^{L,I}) \times \omega_h \mp \delta_w^\sigma(Sit_n^{L,I}) \times \omega_r$$

The weights ω_h and ω_r denote the weights we apply to historical and recent information, respectively. ω_h and ω_r take values from the interval $[0, 1]$ and $\omega_h + \omega_r = 1$. A greater weight of recent information is reflected by using a greater value for ω_r . As to the question how the obtained (dis)liking value affects future interactions with the interlocutor, two interpretations are considered. While *momentary (dis)liking*

means that the new value is active for the current situation and then enters the summary record, *essential (dis)liking* results in the new value replacing the summary record.

2.2 Emotion Recognition

The ability to show believable affective reactions is an important feature of animated characters, if we want them to be perceived as socially intelligent. Equally important for a character’s social intelligence is its ability to *recognize* other agents—especially, the user’s—emotional state and react accordingly. Emotion ‘recognition’ in our Casino scenario (see below) is based on stereotypes, e.g., a user who loses a game is assumed to be distressed. However, stereotypes will not work in many situations, as in the following example (see Picard [39, p. 706]):

“Suppose that a computer starts to give you help at a bad time. You try ignoring it, then frowning at, and then maybe glaring at it. The savvy computer infers you do not like what just happened, ceases the interruption, notes the context, and learns from the feedback.”

Recognizing a user’s emotional state attracted considerable interest recently. In her influential book on *Affective Computing*, Picard [38] characterizes this research field as computing that relates to, arises from, and deliberately influences emotion. Affective computing for human-computer interaction typically tries to reduce frustration of users (Schreier *et al.* [50]).

We are currently starting to experiment with an *Affective Storyteller* character that adjusts the speed of its synthetic speech according to physiological data from the user. Specifically, bio-sensors attached to the ProComp+ device (Thought Technology) are used to detect the user’s emotional state.

3. ILLUSTRATIVE EXAMPLES

In this section, we will explain the behavior of characters that based on the SCREAM architecture in the context of three illustrative examples. Each example focuses on a particular aspect of the agent architecture.

- *Coffee Shop Scenario*. This demonstration is dedicated to showing the impact of social role awareness to agent behavior.
- *Casino Scenario*. The main issue of this demonstration is attitude change depending on user input.
- *Japanese Comics Scenario*. This simple demonstration takes into account familiarity change in addition to attitude change.

A common feature of the examples is that all of them are web-based interaction scenarios where a user may communicate with animated characters.

3.1 Coffee Shop Scenario

In our first interaction scenario, we implemented a virtual coffee shop where the user may take the role of a customer and communicate with an animated waiter.⁵ We will

⁵This scenario was originally described in Prendergast and Ishizuka [41].

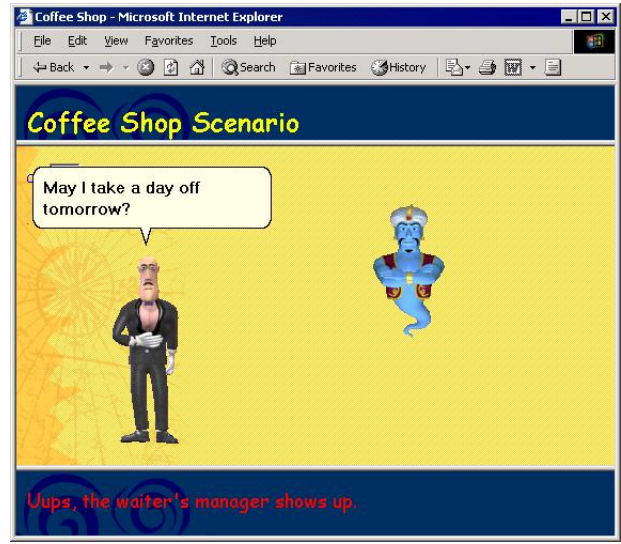


Figure 3: Coffee Shop Scenario.

demonstrate our system by two example runs. In the first example run, the user takes the role of a (friendly) customer who interacts with an unfriendly, introvert waiter agent (James) that interacts with a friendly manager agent as an employee (see Fig. 3). Table 1 shows the annotated trace from the interaction. Fig. 4 displays some of James’ beliefs that have actually been used in the first example run. Note that only social threat related parameters are implemented, whereas parameters for regulation control are left out for simplicity.

The second example run is a variation of the previous example where we assume a friendly, extrovert waiter agent that is aware of conventional practices towards customers but not towards his friendly manager (see Table 2).

We conducted a small experiment on the impact of animated agents featuring social role awareness. As in the example runs above, participants would play the role of a customer in a virtual coffee shop and interact with an animated agent portraying a waiter. The waiter agent interacts with a manager agent and another customer agent that turns out to be an old acquaintance of the waiter. In the experiment, participants promoted the conversation by simply clicking a radio button next to the conversational contribution (that appeared in a separated window) instead of using the speech recognizer, so that they would not be distracted from the agents’ reactions.

Sixteen participants, all students from the University of Tokyo, were randomly assigned to interact with one of two different versions of the system (8 subjects each). The two versions were identical except for the following features.

- In the **Unfriendly Waiter** version (C1) the waiter agent (James) responded to the user in a rude way, but changed to friendly behavior when interacting with his manager and the other customer (an old friend).
- In the **Friendly Waiter** version (C2), James displayed polite behavior to the user but disobeyed the manager’s order and turned down his old friend.

Table 1: Conversation involving friendly customer, unfriendly, introvert waiter, and his friendly manager.

Sit.	Speaker	Utterance	Annotation
s0	Customer	I would like a glass of beer.	User may select the linguistic style (polite, neutral, rude).
s1	Waiter	No way, this is a coffee shop.	The waiter agent considers it as blameworthy to be asked for alcohol and shows that he is <i>angry</i> . The agent ignores conventional practices, as the social distance between waiter and customer is high.
s2	Manager	Hello James!	The manager of the coffee shop appears.
s3	Waiter	Good afternoon. May I take a day off tomorrow?	Performs welcome gesture. Being aware of the social threat from his manager, the waiter uses polite linguistic style.
s4	Manager	It will be a busy day.	Manager implies that the waiter should not take a day off.
s5	Waiter	Ok, I will be here.	Considers it as blameworthy to be denied a vacation and is <i>angry</i> . However, the waiter is aware of the threat from his boss (agent) and thus suppresses his <i>angry</i> emotion.

Table 2: Conversation involving unfriendly customer, friendly, extrovert waiter, and his friendly manager.

Sit.	Speaker	Utterance	Annotation
s0	Waiter	Welcome to our Coffee Shop!	Starts the conversation because of his extrovert personality.
s1	Customer	Bring me a beer, right away.	User chooses rude linguistic style.
s2	Waiter	I am sorry but it seems you are in the wrong place. We are not allowed to serve alcohol here.	Concludes that the customer is <i>distressed</i> and feels <i>sorry</i> for the customer. The intensity of the waiter’s emotion expression is diminished by the fact that the customer’s linguistic style is rude.
s3	Manager	Hello James!	The manager of the coffee shop appears.
s4	Waiter	Good to see you. Tomorrow I will take a day off.	Waves at manager in casual way.
s5	Manager	It will be a busy day.	
s6	Waiter	Too bad for you. I will not be here.	Waiter is angry as the manager refuses to allow a vacation. Since the waiter does not respect conventional practices towards the manager, the waiter expresses his <i>angry</i> emotion and refuses to obey the manager’s order.

```

% emotion type ‘angry at’ in situation s1
holds(did(order_beer,customer),s1).
causes(order_beer,regulation_violated),s0).
blameworthy(james,order_beer,4).
wants(james,regulation_respected,3,s1).
% emotion expression ‘anger’ in situation s1
personality_type(james,extrovert,-2,agreeable,-3).
social_power(customer,james,0).
social_distance(james,customer,0).
% emotion type ‘angry at’ in situation s5
holds(did(refuse_vacation,manager),s5).
causes(refuse_vacation,no_vacation,s4).
blameworthy(james,refuse_vacation,3).
wants(james,get_vacation,5,s5).
% emotion expression ‘neutral’ in situation s5
social_power(manager,james,3).
social_distance(james,manager,2).

```

Figure 4: Some Prolog facts in the mental model of the waiter agent James which are used in the first example run.

After a 3-minute interaction session, subjects were asked to fill out a questionnaire evaluating the naturalness (appropriateness) of James’ behavior. We hypothesized the following outcome of the experiment:

- In the **Unfriendly Waiter** version (*C1*), subjects would rate James’ behavior as unnatural towards themselves (as customers) but natural towards the other agents (manager, friend). Moreover, they would think that in general, James has an unfriendly (disagreeable) personality.
- In the **Friendly Waiter** version (*C2*), on the other hand, subjects would consider James’ behavior natural towards themselves but inappropriate towards the other agents, and would find James’ personality friendly.

T-tests (assuming unequal variances) on the data in Table 3 showed that subjects considered James’ behavior significantly more natural (appropriate) in the *C2* version than in the *C1* version ($t=-4.4$; $p=.0011$). Concerning James’ behavior towards the other agents, however, the experiment revealed the opposite of what we expected. Subjects considered James’ behavior less natural in the *C1* version (mean = 4.88) than in the *C2* version (mean=5.5). A possible reason is that although James ignored conventional practices

Table 3: Mean scores for questions about interaction experience. Ratings range from 1 (disagreement) to 7 (agreement).

Question	Unfriendly Waiter (C1)	Friendly Waiter (C2)
James natural to user	3.00	6.00
James natural to others	4.88	5.50
James in real life, movie	5.00	4.63
James has good mood	2.25	2.25
James is agreeable	2.38	4.75
James likes his job	1.63	2.63

towards the manager and the old friend in the C2 version, its behavior could still be considered as kidding. Another reason might be that due to the short interaction time, subjects could not figure out the personality of, e.g., James’ manager. Consequently, if they assumed that James’ manager is a very relaxed person, James’ behavior could still be seen as appropriate.

We also asked subjects whether they could imagine to meet a waiter like James in a real coffee shop or as an actor in a movie. For both versions, subjects tended to agree, although less strongly than we expected (C1: mean=5; variance=2.57, C2: mean=4.63; variance=3.41). However, since James reacted consistently friendly/unfriendly towards each other agent, his behavior was still considered as believable.

Regarding James’ personality, subjects found him significantly more agreeable in the C2 version than in the C1 version ($t=-3.5$; $p=.0019$). This result is interesting since in both versions, James shows (un)friendly behavior about half of the total interaction time. It supports our claim that behavior motivated by a social role, such as James’ friendly behavior towards the manager in the C1 version, is conceived as part of the agent’s social role and not his personality. Moreover, subjects considered the waiter’s appreciation for his job significantly higher when James was friendly to the user than when he was friendly to his manager or friend ($t=-2.18$; $p=.0269$).

As to James’ mood, we did not find any difference between the two versions (C1: mean=2.25; variance=0.78, C2: mean=2.25; variance=0.22). For the C2 version, this result shows that subjects clearly differentiate between personality and mood. On the other hand, Moffat’s [31] work seems to imply that for sufficiently short time periods, it is hard to distinguish whether an agent’s behavior is motivated by its mood or its personality.

3.2 Casino Scenario

As our second interaction setting, we choose a casino scenario where a user and other characters can play the “Black Jack” game. Fig. 5 shows the situation where the character “Genie” practices Black Jack with the user by commenting the game of character “Al” (Genie is the character at the bottom-left of the Internet Explorer window, and Al is the male character to the right of the dealer).

We will now watch the user playing five games of Black

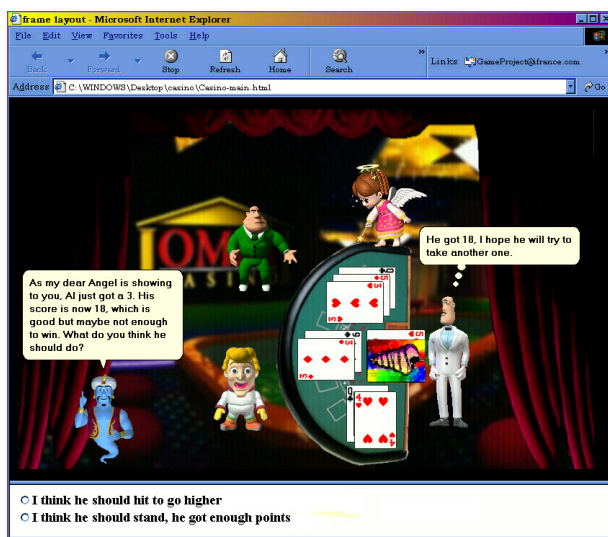


Figure 5: Casino Scenario.

Jack and thereby demonstrate how Genie’s mental make-up as well as the (affective) interaction history determine his behavior. For expository reasons, we let the user *never* follow Genie’s advice, and we use a very sparse Agent Model. Among others, Genie is assumed as rather agreeable and extrovert, he is socially close to the user and also (initially) slightly likes the user. His goals are that the user wins (with low intensity), and that the user follows his advice (with high intensity). Note that the outcome of the game, i.e., whether the user wins or loses, is independent of her or him following Genie’s advice.

- In the **first game** (user loses) Genie’s winning emotional state is *distress* with intensity 4, because the user did not follow his advice. However, he displays *distress* with low intensity as his agreeable personality effects a decrease in the intensity of negative emotion expression.
- In the **second game** (user loses) Genie is sorry for the user with intensity 4, since positive (‘sorry for’ the user’s lost game) emotions decay slowly and sum up, which leads to an increase in Genie’s liking of the user. His personality traits let him express the emotion with even higher intensity.
- In the **third game** (user loses) Genie gloats over the user’s lost game, because at that point, the negative emotions dominate the positive ones as a consequence of the user’s repeated refusal to follow Genie’s advice. Hence Genie’s attitude changes to slightly disliking the user which lets him experience *joy* over the user’s *distress* (*gloat* with intensity 5). Again, Genie’s friendly personality decreases the intensity of the external emotion.
- In the **fourth game** (user wins) Genie’s emotional state is *bad mood* with intensity 5, slightly more than his *happy for* emotion (as the user wins the game this time). Here an overall, unspecific affective state (mood) is expressed with low intensity, rather than a specific emotion.

- In the **fifth game** (user wins) Genie’s dominant emotional state is *resent* with intensity 4, because he slightly dislikes the user and consequently is distressed that the user won although she or he ignored his advice. Genie expresses his emotion with reduced intensity.

An exhaustive exploration of all possible interaction patterns in the described game scenario reveals that Genie’s reactions are conform at the beginning games and show more variety in the subsequent games. This can be explained by the evolution of Genie’s attitude toward the user, depending on whether the user follows or refuses to follow Genie’s advice. In effect, Genie’s attitude decides, e.g., whether he is *sorry for* or *resents* the user’s lost game. However, in accordance with Genie’s agreeableness, his emotional reactions are mostly positive.

3.3 Japanese Comics Scenario

Borrowing the idea from Fujio Akatsuka’s manga series (Japanese comics) “Akko-chan’s Got a Secret!”, a character called ‘Little Akko’ (Akko-chan) plays the heroine of stories for kids. Little Akko has the power to be transformed into any person upon telling her wish to a magic mirror. By this magic, she has the power to solve many problems and even make other people happy. Fig. 6 shows her transformed into Little Chika, a girl whom her brother Kankichi likes. Social relationships in this comics book typically evolve in a quick and direct way and hence the stories lend themselves to easy demonstration of our model.

We started to experiment with attitude and familiarity change based on a small set of emotion types: *joy*, *distress*, *attraction*, and *aversion*. Observe that according to the emotion specification given in the OCC model [36], *attraction* and *aversion* crucially dependent on the agent’s attitude and familiarity relations toward its interlocutor.⁶

attracted_to(L1,L2, δ ,Sit) if
likes(L1,L2, δ_{App} ,Sit) and
familiarity(L1,L2, δ_F ,Sit)

aversion_against(L1,L2, δ ,Sit) if
dislikes(L1,L2, δ_{NApp} ,Sit) and
familiarity(L1,L2, δ_F ,Sit)

Familiarity change is simply modeled by incrementing the familiarity value by a small (intensity) amount when a positive emotion is elicited. Unlike a character’s (dis)liking, familiarity increases monotonically, i.e., once characters are socially close, they cannot subsequently get unfamiliar. Currently, our notion of familiarity is based on the (severe) simplifying assumption that emotions are taken as the only familiarity changing factor. Cassell and Bickmore ([10]), on the other hand, consider the variety and depth of topics covered by conversing agents.

Currently, the interaction setting is fairly simple. The user can communicate with the “Angel” character (Little Akko transformed to Little Chika) by controlling an avatar, the “Space-boy” character in the role of Kankichi. By offering Little Chika items she likes, the user may increase her positive attitude and familiarity, otherwise her liking level for Kankichi goes down. Consider the conversation following Little Akko’s statement that she likes sweet things.

⁶By default, intensity values are computed by logarithmic combination as before.

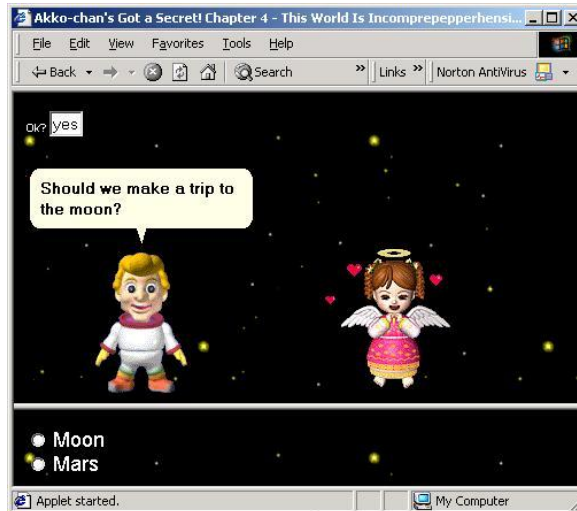


Figure 6: Japanese Comics Scenario.

- User may select “Strawberry milk” or “Lemon tea”
Space-boy: Would you like to drink strawberry milk?
Angel: Great! I like this drink. Now I want to eat a dessert.
- User may select “Chocolate cake” or “Grapefruit”
Space-boy: Would you like to eat a grapefruit?
Angel: No! I do not like that. Anyway, let us now play an interesting game.
- User may select “Calculate” or “Hide and Seek”
Space-boy: Do you want to play the Calculate Game?
Angel: I really like that game! Now I got hungry. I like rice better than bread.
- User may select “Sushi” or “Sandwiches”
Space-boy: Would you like to eat some Sushi?
Angel: Yes! That is what I like! What about making a trip to a beautiful place?
- User may select “Moon” or “Mars”
Space-boy: Should we make a trip to the moon?
Angel: I enjoy being with you!

When Angel gets strawberry milk, she expresses *joy* as one of her goals is satisfied. After being offered a grapefruit, she shows her *distress* since she does not want this kind of dessert. However, in the conversation above, the user happens to repeatedly select items the Angel likes, which has two kinds of effects. Both the Angel’s liking value toward the Space-boy and the familiarity level increase, and hence add to the intensity of the Angel’s *attraction* toward the Space-boy (familiarity was incremented by 0.2 per elicited positive emotion). After the Space-boy offers the Angel a trip to the moon, her emotional state comprises two active emotions, *joy* (intensity 2) and *attraction* (intensity 3), and she expresses the emotion with the higher intensity (see Fig. 6). As we set the decay rate to a high level, all previously elicited emotions (including *distress* and *aversion*) are not part of the Angel’s emotional state.

Although we believe that positive attitude and close social distance should have on the agent’s emotion expression, it is not clear to us, how emotions such as *affection* or *aversion* should be instantiated by actual behavior. Currently, we use a direct way by simply letting the agent declare those emotions, e.g., *affection* as “I enjoy being with you”. However, in some cases, attitude/familiarity based emotions might be used as biasing mechanisms for calculating the intensity of emotion expression, rather than emotions that are externalized by behavior.

4. NARRATIVE INTELLIGENCE

Epigraph

“Knowledge is Stories.” —Roger Schank [49]

In this section, we will discuss *narrative intelligence* (NI) as a promising technology to achieve natural interactions between humans and computers, which was set out as the goal of social computing. Rather than describing an implemented system and demonstrations, we will give some preliminary remarks on the potential and technology of narrative intelligence in the context of human-agent interaction.

4.1 Motivation

Narrative can be said to experience a revival in the life-like characters community, having been more or less neglected by the AI community after the extensive research on story understanding and generation performed by Roger Schank’s group at Yale in the late 1970’s [48]. The OZ Project led by Joe Bates at CMU brought narrative back into focus in the early 90’s. The project’s research goal was to build virtual worlds with characters and story [2, 27]. A similar effort has been undertaken by the group of Barbara Hayes-Roth at Stanford in the Virtual Theater Project [20, 21].

While the systems from the OZ Project and the Virtual Theater Project have been mainly developed for the purpose of entertainment, the field of narrative intelligence supports a much broader variety of applications, including story-centered learning and knowledge management (see the overview paper of Mateas and Sengers [28]). The literature on narrative intelligence supports two interpretations.

The *first* interpretation is given by Sengers [52] who characterizes narrative intelligence as follows:

“[...] that artificial agents can be designed to produce narratively comprehensible behavior by structuring their visible activity in ways that make it easy for humans to create narrative explanations of them.”

Sengers’ characterization is derived from narrative psychology that claims that people make sense of the behavior of other humans by structuring their visible activity into narrative (Bruner [8]). More specifically, people frame the activity of other agents into story in that they try to interpret other agents’ actions as intentional behavior, e.g., by attributing desires and attitudes to them. The conclusion drawn by Sengers is that animated character designers should provide characters with visible cues to support people in their attempt to generate a narrative explanation of the character’s actions, and hence improve their understanding of the character’s intentions.

The *second* interpretation of narrative intelligence is that it constitutes a property of the interaction system itself rather than being a property of the characters. Don [14], e.g., proposes the use of techniques from oral story-telling in order to organize information in a knowledge base. A narrative structure suggests to view multi-modal contents as ‘events’ that can be experienced in temporal sequence (as a ‘story’) rather than as objects in virtual space, and hence supports users in organizing the information in memory. This idea is also realized in the online car presentation scenario developed at DFKI (André *et al.* [1]), where a central planner controls a team of characters and thereby allows to represent different points of view, specifically the pros and cons of a certain car.

4.2 Applications of Narrative Intelligence

Narrative intelligence is already being employed in various applications that will be briefly sketched in the following paragraphs.

Learning Environments. Mott *et al.* [32] motivate NI in the context of learning environments where students are to be actively involved in ‘story-centric’ problem-solving activities. Their fundamental hypothesis is that

“[...] by enabling learners to be co-constructors of narratives, narrative-centered learning environments can promote the deep, connection-building meaning-making activities that define constructivist learning”. [32, p. 80]

The authors argue that narrative lends itself to active exploration of a domain through challenging and enjoyable problem-solving activities, which is essential for constructivist learning.

Trust and credibility of a virtual sales agent. In their work on an embodied real estate agent, Bickmore and Cassell [4] employ conversational story-telling and small talk to convey information in an engaging way that serves interpersonal goals such as rapport building and credibility. Conversational stories have to be locally occasioned (relevant to their listeners) and recipient designed (tailored to the specific audience they are delivered to).

Organizational Memory. Corporate knowledge can be beneficial for effective and efficient decision-making within organizations. The saving, representing, and sharing of corporate knowledge is referred to by the generic concept *organizational memory* [6]. Lawrence and Thomas [24] motivate story-telling to enhance knowledge exchange in organizations. Stories about mistakes and difficult situations are typically the most interesting experiences to exchange.

4.3 Narrative Intelligence Technology

We argued that narrative intelligence can be seen as a property of characters as well as a property of systems that involve characters. In this section, we report on some technologies that have been proposed to implement narrative intelligence as a character or a system property, respectively.

We start out with three properties of narrative that are discussed in Bruner’s theory of narrative [9] (as reported in Sengers [52]).

- *Narrative Diachronicity.* A basic property of narrative is diachronicity which means that events are understood the way they relate over time rather than on their moment-by-moment significance.

- *Intentional Stance Entailment*. This property says that what happens in a narrative is less important than what the involved characters feel about it. It is suggested that characters explicitly express the reasons for their actions and the emotions that trigger their actions.
- *Canonicity and Breach*. A narrative is pointless when everything happens as expected. There must be some problem to be resolved, some unusual situation, some difficulty, someone behaving unexpectedly. However, norm deviations can themselves be highly scripted.

4.3.1 Characters with Narrative Intelligence

Sengers [51] proposes design requirements for *comprehensible agents* that are based on narrative psychology. Her characterization of agent comprehensibility reads as follows:

“Behaviors should be *as simple as possible*. The agent’s comprehensibility comes from thinking out the *connections* between behaviors and *displaying* them to the user.” [51, p. 1228]

The most salient properties of comprehensible agents is that they clearly express *what* they are doing, *why* they are doing what they do, and also the *relationships* between the agent’s activities must be made clear. Most importantly, she introduces a theory of transitions between an agent’s actions, that makes conflicts and influences of two behaviors explicit to the viewer, and rules out the frequent impression that agents jump around between independent actions.

4.3.2 Environments with Narrative Intelligence

We are not aware of any approach that implements narrative intelligence on the system level. We briefly sketch two approaches that might serve as a starting point.

Story Morphing. Elliott *et al.* [18] propose the technique of *story-morphing* that relies on a given fixed base plot structure (script) that allows to generate numerous distinct stories (*story-morphs*) by varying the affective models of the involved characters. The internal lives of the characters are driven by Elliott’s Affective Reasoner [17]. Story-morph ‘tags’ refer to emotionally meaningful units in a narrative, e.g., that a character likes or dislikes a certain activity.

Recall that in our implementation of two simple interactive games, we followed a method similar to story-morphing. While the ‘story’ is given by the rules of the game, the affective response of interactive characters is decided by their mental state. In the Casino scenario the user is guided by an animated advisor to play the Black Jack game whereby the advisor’s reactions vary according to its goals and personality profile as well as the user’s decisions (“hit”, “stay”) and the outcome of the game. In the second scenario, an animated version of a Japanese comics, the user may control an avatar to interact with a female character, and try to guess her wishes correctly. The character’s affective reactions depend on the user’s choices and her personality.

Autonomy and Directability. In their work on interactive entertainment, Blumberg and Galyean [5] promote the view that characters in virtual environments should be both autonomous and ‘directible’ by an external entity, the computational ‘director’. They propose an architecture where characters are autonomous but can also be controlled at various levels of behavior (motivational level, task level, direct

motor level). As a motivating example the authors describe the case of a virtual dog that is convincing as an autonomous pet but ignores the user it is supposed to play with. Here, the director might increase the value of the dog’s internal variable “motivation to play with user”. On the other hand, if the interaction requires the user to focus on a different aspect of the story, the dog might be instructed to lie down and sleep.

In the terminology of Blumberg and Galyean, narrative intelligence could be encoded by means of the ‘director’ of the environment that is responsible for the ‘story-ness’ (e.g., canonicity and breach) of the event sequence. For the case of improvisational theater, Hayes-Roth and co-workers suggested the *directed improvisation* technology [20, 21], which allows for entertaining improvisations without a particular control on the development of events.

5. DISCUSSION AND CONCLUSION

In this paper, we discuss social computing, a research field which aims to support the tendency of people to engage in natural interactions with computational devices. In order to boost the bias of humans to treat computers as social actors, we suggest to employ life-like animated characters.

We propose the following two features for a character’s life-likeness (or believability):

- *Embodiment* requires that the characters is given a synthetic ‘body’ for emotional display and synthetic (affective) speech.
- *Social intelligence* refers to an agent’s ‘mind’ that generates affective and socially appropriate behavior.

We focus on socially intelligent character reactions and illustrate certain aspects of a such behavior by demonstrations. In this research, problems related to natural language understanding and generation are not addressed. All verbal utterances of users and characters are pre-defined by the content author. The system’s responsibility is to select the most appropriate utterance for any given social interaction situation.

Although the visual appearance of a life-like character is highly important for the experience of the user, this paper does not discuss issues related to a character’s embodiment. The merit of embodiment is that it allows to exploit the ability of humans to synchronize speech with facial expressions, gestures, and posture, which supports the smoothness of conversation. By the use of gestures, e.g., embodied characters are given means to simulate turn-taking behavior and feedback (Cassell *et al.* [11, p. 36]).

- *Give turn*. Character looks at interlocutor, raises eyebrows, followed by silence.
- *Want turn*. Character raises hands into gesture space.
- *Take turn*. Character glances away, and starts talking.
- *Give feedback*. Character looks at interlocutor, nods with head.

Besides facial displays corresponding to Ekman’s [15] so-called ‘basic emotions’ (fear, anger, sadness, happiness, disgust, and surprise), we also use acoustic correlates of basic emotions, as defined by Murray and Arnott [33]. For instance, if a speaker expresses *happiness*, her or his speech is

typically faster, higher-pitched, and slightly louder, whereas the speech of a speaker expressing *sadness* is slightly slower and low-pitched.

Another avenue in social computing research is to implement systems with narrative intelligence, which meets the tendency of humans to frame other agents' behavior into narrative. Currently, however, we are lacking a clear idea how this might be realized, let alone in which type of applications narrative intelligence would be most useful.

In summary, this paper describes some issues in the field of human-computer interaction, with an emphasis on communication between humans and synthetic characters. An emotion-based agent architecture is proposed that aims to achieve believable interactions with human users. The main goal of this research is termed social computing, which refers to technology that facilitates natural interactions between people and computational devices.

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