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Designing Animated Agents as Social Actors and Dramatis Personae for Web-based Interaction

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SUMMARY Recent years have witnessed a growing interest in employing animated agents for tasks that are typically performed by humans. They serve as communicative partners in a variety of applications, such as tutoring systems, sales, or entertainment. This paper discusses design principles for animated agents to enhance their effectiveness as tutors, sales persons, or actors, among other roles. It is argued that agents should support their perception as *social actors* by displaying human-like social cues and as *dramatis personae* by facilitating a narrative interpretation of events. We will describe an architecture for emotion-based agents and requirements for narrative intelligence in agents and environments. A simplified version of our model will be illustrated by two interaction scenarios that feature cartoon-style characters and can be run in a web browser.

key words: *Conversational agents, human-like and believable qualities of agents, narrative intelligence, emotion and personality, agent modeling, web-based environments.*

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 in progress, embodied characters are used

- as virtual *tutors* in interactive learning environments [17], [18], [23], [26],
- as virtual *sales persons* on the web and at information booths [1], [4], [6], [13], [27],
- as virtual *presenters* [3], [25] of non-interactive content,
- as virtual *communication partners* in therapy [30],
- as virtual *actors* for entertainment [36], [37], [40],
- as virtual *personal representatives* in online communities [14], [47], and
- as virtual *information experts* enhancing conventional web search engines [28].

The main effort in designing animated agents is to make them *life-like* or *believable* [5]. Life-likeness is intended to provide the viewer with the illusion of life, and similarly, believability should allow viewers to suspend their disbelief. Life-like characters are intended to communicate like real people and be able to engage naturally in conversation and other tasks with humans.

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In this paper, we will discuss the premises under which synthetic characters can be pedagogically effective as tutors, convincing as presenters, and dramatically interesting as actors, among other roles. Rather than describing application-specific requirements for characters, we will focus on features that are common for different kinds of animated interface agents. We believe that the premises of successful agent applications fall under two main categories. First, animated agents should be designed as *social actors* that display (and possibly recognize) social cues such as a certain (social) role, affective and socially appropriate verbal response, and non-verbal behavior including the 'embodied' expression of emotions and turn taking. Second, animated agents should be designed as *dramatis personae* and hence as actors that act in way that supports a narrative interpretation of events. Furthermore, the interaction environments themselves should be narrative-centered.

The rest of the paper is organized as follows. In Section 2, we will motivate the design requirements of agents as social actors and dramatis personae. Section 3 describes the main components of the SCREAM system, an architecture for emotion-based agents. In Section 4, agents' embodiment is motivated by describing its communicative functions. Section 5 is devoted to explaining two interpretations of narrative intelligence. Section 6 illustrates our model by means of two web-based interaction scenarios that implement the technique of story-morphing. In Section 7, we summarize and conclude the paper.

2. Background

A rather surprising finding about the interaction between humans and computers is that humans are already strongly biased to interpret the behavior of synthetic entities that display some human-like features as life-like and believable. This was shown by Reeves and Nass [39] who carried out a series of classical tests of human-human social interaction, but replaced one interlocutor by a computer with human-sounding voice and a particular role such as companion or opponent. The results of those experiments suggest that humans treat computers in an essentially natural way—as social actors—with a tendency, e.g., to be nicer in 'face-to-face' interactions than in third party conversations.

More support for this result is provided by Lester *et al.* [29] who investigate the impact of animated agents along the dimensions of motivation and helpfulness, and coin the term '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." [29, p. 359].

The human interpretation process, however, is very sensitive to and easily disturbed by a character's 'inconsistent' or 'unnatural' behavior, whatever type of 'nature' (realistic or not) is applicable. The challenge here is to maintain consistency between an agent's internal emotional state and various forms of associated outward behavior such as speech and body movements (Gratch *et al.* [22]). An agent that speaks with a cheerful voice without co-occurring happy facial expression will seem awkward or even fake. Another challenge is to keep consistency of agents over time, allowing for changes in the their response tendencies as a result of the interaction history with other agents (Prendinger and Ishizuka [38]).

Besides the human tendency to conceive animated agents (and even computers with basic human-like features) as social actors, narrative psychology suggests that people make sense of other humans and possibly animated agents by structuring their visible behavior into narrative (Bruner [8]). More specifically, intentional (desire and attitude driven) behavior is made comprehensible to humans by framing it into narrative or 'story'. Consequently, Sengers [43] proposes that animated character designers should provide visible cues to support people in their attempt to generate a narrative explanation of the character's action, and thereby improve their understanding of the character's intention. If characters are conceived as taking a role in a story—as dramatis personae—they will more likely appear life-like or believable to humans. In addition, the interaction scenario has to provide the basis for narratively meaningful (interesting) events.

3. Emotion, Personality, Social Role

We have developed a system called SCREAM (SCRipting Emotion-based Agent Minds) that facilitates scripting a character's affect-related processing capabilities. The system allows to specify a character's mental makeup and endow it with emotion and personality which are considered as key features for the life-likeness of characters. A character's mental state can be scripted at many levels of detail, from driven purely by (personality) traits to having full awareness of the social interaction situation, including character-specific beliefs and beliefs attributed to interacting characters or even the user. For portability and extensibility, the SCREAM system is written in Java and Jinni 2000, a Java based Prolog system [7].

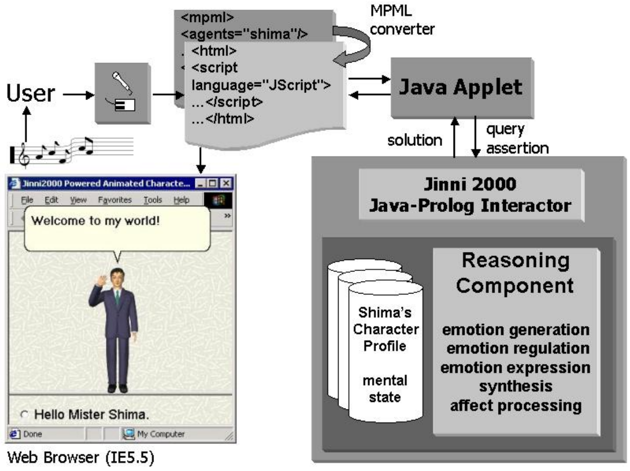

Fig. 1 Implemented System Overview.

The Microsoft Agent package [33] is used to embed animated characters into a web page based JavaScript interface. The package comes ready with controls for animating 2D cartoon-style characters, speech recognition and a Text-to-Speech (TTS) engine. In order to facilitate the process of scripting more complex scenarios, including, e.g., sequential and parallel embodied behavior of multiple characters, we have developed an XML-style markup language called MPML (Ishizuka *et al.* [25]). The MPML (Multimodal Presentation Markup Language) system converts the XML specification to code that can be interpreted in a web browser (JavaScript in Internet Explorer 5.5 or higher). MPML provides an interface to SCREAM and thus supports both behavior autonomously generated (by SCREAM) and pre-scripted agent behavior (defined in MPML). Fig. 1 gives an overview of the implemented system.

The following paragraphs offer a walk through the main components of the SCREAM system (a detailed description can be found in Prendinger *et al.* [37]): Emotion Generation, Emotion Regulation, Emotion Expression, and the Agent Model that is also responsible for updating a character's mental state.

A core activity of an emotion-based agent mind is Emotion Generation and the management of emotions, which is dealt with by three modules, the *appraisal* module, the *emotion resolution* module, and the *emotion maintenance* 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.* [35]). The significance is determined by so-called 'emotion-eliciting conditions', the agent's beliefs, goals, standards, and attitudes. Following the emotion model in [35] (the OCC model), we conceive emotion types as classes of eliciting conditions, each of which is labelled with an emotion word of phrase. In total, twenty-two classes of eliciting conditions are identified: joy, distress, happy for, sorry for, resent, angry at, and so on. All emotions have associated intensities $\delta \in \{0, \ldots, 5\}$ depending on the intensities of its conditions, e.g., the intensity of an agent's attitude toward its interlocutor. 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. The emotion resolution and maintenance modules determine the most dominant (winning) emotion and handle the decay process of emotions, respectively.

The expression of emotions is governed by social and cultural norms that have a significant impact of the intensity of emotion expression. We will treat Emotion Regulation as a process that decides whether an emotion is expressed or suppressed. We categorize regulatory parameters into ones that constitute a social threat for the agent (social role, distance, power), and parameters that refer to the agent's capability of (self-)control (personality, interlocutor personality, linguistic style). Our personality model considers just two dimensions, which seem crucial for social interaction. Extroversion refers to an agent's tendency to take action: sociable, active, talkative, optimistic. Agreeableness refers to an agent's disposition to be sympathetic: friendly, good-natured, forgiving. An overall control value is computed based on the given (possibly mutually defeating) control values. E.g., the control of an agent that is very extrovert but deals with a very unfriendly interlocutor might be neutralized to some degree.

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 that were induced in the agent L by an interlocutor I together with emotions' associated intensities. The sign is either positive (e.g., for the emotions 'joy', 'happy for') or negative (for emotions 'distress', 'angry at', and so on). 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 a special update rule that weights historical (affective) and recent (affective) information to obtain the current attitude.

An agent's emotions are expressed by its bodily behaviors. Embodiment has also important functions to guide communication, which will be described in the following section.

4. Embodiment

When humans communicate, they employ a variety of signals in combination with verbal utterances, such as body posture, gestures, facial expressions, and gaze. In a similar way, animated agents may use their bodies to convey meaning and regulate communication. The most extensive study of non-verbal behaviors for synthetic characters, especially gestures, can be found in Cassell's work on embodied conversational agents [12].

Emblematic gestures are culturally specified gestures, e.g., signalling "okay" by a "thumb-and-index-finger" ring gesture. An example of a *propositional* gesture is the use of both hands to measure the size of an object in symbolic space while saying "there is a big difference" (see Fig. 2). There are four types of gestures that support the conveyance of communicative intent (so-called 'co-verbal' gestures [12]).

- *Iconic* gestures illustrate some feature of an object or action, e.g., mimicking to hold a phone while saying that someone has been called.
- *Metaphoric* gestures represent a concept without physical form, e.g., a rolling hand gesture while saying "let's go on now".
- *Deictic* gestures locate physical space relative to the speaker, e.g., by pointing to an object.
- *Beat* gestures are small baton-like movements to emphasize speech. A special form of a beat gesture is the *contrastive* gesture [15] that depicts a 'on the one hand ... on the other hand' relationship if two items are being contrasted (see Fig. 3).

An important class of gestures (including facial gestures) serves the expression of an agent's *emotional state* such as 'hanging shoulders' to signal sadness (see Fig. 4). Although face may express emotions most succinctly (Ekman and Friesen [20]), we rather rely on signals involving the whole body as the size of the characters used is relatively small.

Gestures also realize *communicative functions* including conversation initiation, turn taking, back channelling ("nodding"), and breaking away from conversation [11]. The communicative behavior corresponding to the (communicative) function of "giving turn" is typically realized by looking at the interlocutor with

Fig. 2 "Big difference".

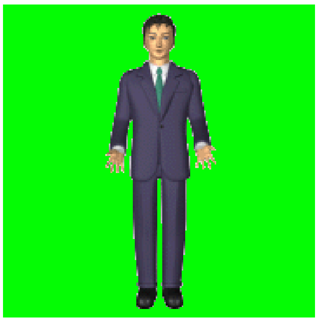

Fig. 3 "Contrast".

Fig. 4 "Sadness".

Fig. 5 "Take turn".

raised eyebrows, followed by silence, whereas "taking turn" is signalled by glancing away and starting to talk (see Fig. 5).

Agent behaviors in our system are 2D animations controlled by MPML and have to be specified at the signal level for each given communicative situation. APML (Affective Presentation Markup Language), on the other hand, allows to specify the meaning associated with a communicative act that may be instantiated by different signals depending on the agent's personality, gesture style, or culture (de Carolis *et al.* [10]). However, since the signals (here, animation sequences) provided for our characters are fixed, a direct scripting approach seems appropriate.

5. Narrative Intelligence

In this section, we will discuss *narrative intelligence* as a promising technology to achieve dramatically interesting interactions between humans and animated agents, turning them into dramatis personae. We will start with some remarks on the background and potential of narrative intelligence in the context of human-agent interaction.

Narrative can be said to experience a revival in the life-like characters community, having been more or less neglected by the Artificial Intelligence community after the extensive research on story understanding and generation performed by Roger Schank's group at Yale in the late 1970's [41]. 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 [31]. A similar effort has been undertaken by the group of Barbara Hayes-Roth at Stanford in the Virtual Theater Project [24]. 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 (for an overview see [32]).

The literature on narrative intelligence supports two interpretations. The *first* interpretation is given by Sengers [43, p. 3]: "[...] 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 [42] consequently proposes design requirements for so-called 'comprehensible agents' that are derived from narrative psychology [8]. 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. In order to achieve comprehensibility, 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.

The *second* interpretation of narrative intelligence is that it constitutes a property of the interaction environment itself rather than being a property of the characters. Don [19], 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.

Following Bruner's theory of narrative [9], Sengers [43] discusses the following properties of narrative (among others).

- *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.

In the next section, we will describe two scenarios that instantiate those three properties of narrative to some extent. Narrative diachronicity is achievd by having agents maintain an 'affective interaction history' (i.e., an agent keeps track of previously elicited emotions resulting from communicating with the user), and adapt their behavior according to the interaction history. Intentional stance entailment is satisfied by letting characters express their emotions and indicate the reasons for having them. In a simplified way, canonicity and breach is obtained by the user complying with or ignoring the agent's desire.

Fig. 6 Playing Black Jack.

6. Story-Morphing

In this paper, we use a technique called *story-morphing* to achieve a simple form of narrative. Story-morphing 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 (Elliott *et al.* [21]). In addition, the user may change the evolution of events by interacting with the characters. Story-morph 'tags' [21] refer to emotionally meaningful units in a narrative, e.g., that a character likes or dislikes a certain activity which is defined in the character profile. We will describe two web-based scenarios that allow to generate story-morphs by manipulating the character profiles of the agents involved in the interaction, a casino scenario and a Japanese comics scenario.

6.1 Playing Black Jack

In the casino scenario the user and other characters can play the "Black Jack" game. Fig. 6 shows the situation where the character "Genie" in the role of an advisor 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). In an interaction session, the user is guided by the advisor Genie to play the Black Jack game whereby Genie's reactions vary according to his goals and personality profile as well as the user's decisions ("hit", "stand") and the outcome of the game.

Story-morphs are produced by Genie's mental make-up as well as the (affective) interaction history with the user. For expository reasons, we let the user never follow Genie's advice, and we use the following character profile. 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 the game, i.e., whether the user wins or looses, is independent of her or him following Genie's advice. Let us watch the user playing the beginning three rounds of Black Jack.

- *First round* (user ignores advise and looses). Genie's winning emotional state is 'distress' with high intensity, because the user did not follow his advice. He displays his distress with low intensity as his agreeable personality effects a decrease in the intensity of negative emotion expression.
- *Second round* (user ignores advice and looses). Genie is sorry for the user with high intensity, since positive ('sorry for' the user's lost game) emotions decay slowly and sum up. However, his personality traits let him express the emotion with even higher intensity.
- *Third round* (user ignores advice and looses). Genie gloats over the user's lost game with high intensity, 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. Again, Genie's friendly personality decreases the intensity of the external emotion.

By way of example, in the third round Genie opens his arms widely while saying "Ha! Want to decide by yourself? Never listen to my advice. You got the result." He thereby expresses his joy over the user's (assumed) distress ('gloating') and explains the reason for his emotional state.

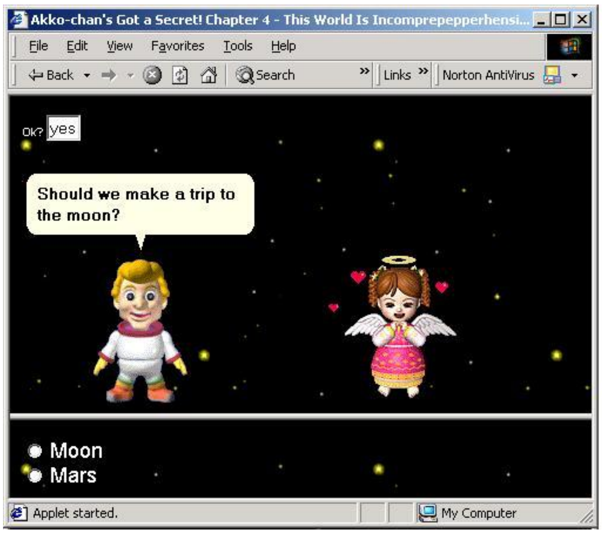

Fig. 7 Interactive Japanese Comics.

Different story-morphs are obtained by different interaction patterns, i.e., decisions of the user. They result from 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. Given that the user may either "hit" or "stand" in each round, there exist 2^n story-morphs (n the number of rounds) for each setting of Genie's character profile.

6.2 Interactive Japanese Comics

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 may solve many problems and even make other people happy. Fig. 7 shows her transformed into Little Chika, a girl whom her brother Kankichi likes.

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. Attitude and familiarity may change based on a small set of emotion types: joy, distress, attraction, aversion. Note that attraction and aversion are dependent on the agent's attitude and familiarity relations toward its interlocutor. Familiarity change is simply modeled by incrementing the familiarity value by a small (intensity) amount when a positive emotion (joy) is elicited.

Consider the conversation following Little Akko's statement that she likes sweet things.

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

When Little Akko 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 like this kind of dessert. However, in the conversation above, the user happens to repeatedly select items Little Akko likes, which has two kinds of effects. Both Little Akko's liking value toward the Kankichi and the familiarity level increase, and hence add to the intensity of the Little Akko's 'attraction' toward Kankichi. After Kankichi offers the Little Akko a trip to the moon, her emotional state comprises two active emotions, 'joy' and 'attraction' (both with medium intensity), and she expresses the combined emotion with higher intensity (see Fig. 7). As we set the decay rate to a high level, all previously elicited emotions (including distress and aversion) are not part of Little Akko's emotional state.

Arguably, our implementation of an episode of this comics book is simple, where the social relationship evolves in a quick and direct way. Story-morphs here are generated by the user's direction of Kankichi (with the expectation that the user is eager to win and maintain Little Akko's sympathy by following the hints indicating her wishes) and the nature and intensity level of Little Akko's wishes.

Do the Black Jack game or the Comics scenario lend themselves to compelling narratives? Although interesting story-morphs are derived by users' decisions and varying character profiles, the narrative structures underlying both scenarios are rigid and entirely determined by the rules of the game. In the following, more flexible technologies for interactive stories will be briefly described.

6.3 Technologies for Interactive Story

Interactive story systems can be categorized according to whether narrative events are driven by a plot manager or autonomous characters. In plot-based systems, a distinguished module, the plot manager, controls the development of the story and specifies the possible actions of the human protagonist (Sgouros *et al.* [44], [45]). The story plot is dynamically updated to reflect the interference of the user with synthetic actors. This framework allows to balance interactivity of the user and plot control.

Other authors, however, argue for less strict interactions, e.g., Aylett's 'emergent narratives' [2]. In character-based systems, narrative knowledge is not explicitly represented, and the development of the story line is within the responsibility of autonomous agents. In order to insure narrative control, (autonomous) characters' behavior is described in terms of roles (Cavazza *et al.* [16]). For an extensive discussion of competing approaches to interactive narrative, the reader is kindly referred to the paper of Spierling *et al.* [46].

7. Conclusion

Recent years have witnessed a growing interest in life-like, believable characters as a crucial component of enhanced learning, presentation, and entertainment systems. This paper describes two design requirements for animated agents that will significantly contribute to the success of those applications. Animated agents have to be designed as social actors and dramatis personae. Both requirements are motivated from findings in psychology suggesting that humans are biased to perceive synthetic agents as veritable communicative partners that are embedded in a meaningful narrative context, as they would perceive a human conversant.

As an avenue for future research, we hope to generate more compelling stories that allow for flexible and interesting interactions with animated agents.

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