Introducing the Cast for Social Computing: Life-Like Characters

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Summary. Life-like characters are one of the most exciting technologies for human–computer interface applications. They convincingly take the roles of virtual presenters, synthetic actors and sales personas, teammates and tutors. A common characteristic underlying their believability or life-likeness as conversational partners is computational models that provide them with affective functions such as synthetic emotions and personalities, and implement human interactive behavior or presentation skills. In *social computing*, a paradigm that aims to support the tendency of humans to interact with computers as social actors, life-like characters are key. They may embody the interface between humans and computers, and thus improve the otherwise poor communicative capabilities of computational devices.

The success of life-like character applications today relies relies on the careful crafting of their designers, mostly programmers. The wide dissemination of life-like character technology in interactive systems, however, will greatly depend on the availability of tools that facilitate scripting of intelligent life-like behavior. The core tasks include the synchronization of synthetic speech and gestures, the expression of emotion and personality by means of body movement and facial display, the coordination of the embodied conversational behavior of multiple characters possibly including the user, and the design of artificial minds for synthetic characters.

In this chapter we will first describe what life-like characters are, and how they differ from related synthetic entities. We will then explain how life-like character technologies may change and improve the interaction between humans and computers. Next, we report on some of the most promising character scripting and representation languages as well as authoring tools currently available. After that, the most successful life-like character systems are briefly introduced, demonstrating the wide range of applications where embodied agents are at work. Some final remarks on this highly active research field conclude this introductory chapter.

1 Introduction

Life-like characters are synthetic agents apparently living on the screens of computers. An early characterization of life-like characters can be found in the work of Joseph Bates who refers to them as *emotional* [5] and *believable* [6] agents. Bates explains the notion of a "believable character" as "[. . .] one that provides the illusion of life, and thus permits the audience's suspension of disbelief" [6, p. 122]. Following the vision of designing creatures that computer users are willing to perceive as believable or life-like, researchers use a variety of different terms: anthropomorphic agents, avatars, creatures, synthetic actors, non-player characters, and embodied conversational agents [59, 22, 28]. While creation of most terms is inspired by specific character applications, such as avatars for distributed virtual environments like chat systems or non-player characters for interactive games, some terms intend to draw attention to a particular aspect of life-like characters. Embodied conversational agents, for instance, are characters that visually incorporate, or embody, knowledge about the conversational process [12].

Fig. 1. Animated agent

To restrict the focus of our discussion, we will draw a line between life-like characters that are graphically represented, or animated (see Fig. 1), and robotic agents that are realized as physical entities to operate in the physical world [9]. The concept of "life-likeness" is certainly not restricted to animated agents. Dautenhahn [17], for instance, extensively discusses life-likeness in the context of robotic agents. A more subtle distinction concerns the restriction to *animated* rather than *animate* characters. According to Hayes-Roth and Doyle [28], animate characters share all the features of life-like characters except for their embodiment; that is, animate characters are not necessarily animated, but can still be perceived as perfectly life-like.

Although life-likeness is often associated with a "life-like" appearance, animate characters highlight the importance of synthetic minds that give characters individual personality and emotions. Bates [6] draws on the experience of professional character animators [58] when he argues that the portrayal of emotions plays a key role in the aim to create believable characters. On a par with emotions, personality is key to achieving life-likeness. Trappl and Petta [59] dedicated an entire volume to illustrate the personality concept in synthetic character research. Emotion and personality are often seen as the affective bases of believability [42], and sometimes the broader term *social* (or "socially intelligent") is used to characterize life-likeness [22]. The presumably most profound account of what it means for a character to be (or rather seem) "life-like" is given by Hayes-Roth [27], who suggests seven qualities of life-likeness. Characters should seem conversational, intelligent, individual, social, emphatic, variable, and coherent, which are distilled from Hayes-Roth's experience with character-based systems in both academia and industry during one decade. Hayes-Roth also suggests a variation of the famous Turing test to evaluate the life-likeness of interactive characters.

Characters can be life-like in a "human-like" or an "animal-like" way. While the design of human-like characters attracted the majority of researchers, there are also investigations on animal-like characters, especially dogs [8]. An ongoing debate concerns the issue whether the "life-likeness" of characters is more effectively achieved by *realistic* or *cartoon-style* agents. Research that aims to create virtual humans typically follows the realistic approach [13, 24], Thalmann et al. [57] even strive for photorealism. On the other hand, most characters developed in the context of entertainment and "infotainment" systems adhere to the approach that uses cartoon-style characters [2, 45, 23, 61]. While the design of realistic characters is a high research aim *per se*, they do not necessarily outperform cartoon-style characters in the perception of the user. As opposed to cartoon-style characters, users have high expectations of the performance of realistic looking characters, which bears the risk that even small behavior deficiencies lead to user irritation and dissatisfaction. The question of realistic vs. cartoon-style agents can eventually only be decided empirically with respect to specific application scenarios. McBreen et al. [39], for instance, investigate the effectiveness and user acceptability of different types of synthetic agents. A related empirical question concerns the benefits of displaying characters as facial agents ("talking heads"), full-body, or "upper-body plus face" agents.

2 Towards Social Computing

Since human–human communication is a highly effective and efficient way of interaction, life-like characters are promising candidates to improve human–computer interaction (HCI). Embodied agents may use multiple modalities such as voice, gestures, and facial expression to convey information and regulate communication. The work of Reeves and Nass [49] shows that humans are (already) strongly biased in interpreting synthetic entities as social actors even if they do not display anthropomorphic features – the Media Equation. The authors carried out a series of classical psychological tests of human–human social interaction, but replaced one interlocutor by a computer with a human-sounding voice and a particular role such as a companion or opponent. The results of those experiments suggest that humans treat computers in an essentially natural way – as social actors – with a tendency, for instance, to be nicer in "face-to-face" interactions than in third-party conversations. More support for this result is provided by Lester et al. [33] who investigated the impact of animated agents in educational software along the dimensions of motivation and helpfulness, and coined 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 students' perception of their learning experience" [33, p. 359].

There are hence strong arguments to make the interface *social* by adding life-like characters that have the means to send social cues to the user and possibly even receive such signals. However, it should not be concluded that *all* interfaces can be improved by making them social. As an approximation, it can be said that character-based interfaces are beneficial whenever the interaction task involves social activity. Training, presentation, and sales certainly fall under this category. By contrast, there are computer-related activities that typically do not require social interaction. Building a spreadsheet, for instance, is a mechanical task and most users would not want to have a colleague watching or interrupting them [21]. The same may hold true for the presence of a synthetic agent. On the other hand, social encounters also include information exchange between people that share similar interests, where life-like characters may act as match-makers at public meeting places. In order to support "community awareness", Sumi and Mase [54] investigated this form of computer-mediated communication.

As an HCI paradigm, the goal of character-based human–computer interfaces seems to be diametrically opposed to that of the "disappearing computer" concept in ubiquitous and invisible computing [60]. Those technologies are intended to "weave themselves into the fabric of everyday life until they are indistinguishable from it" [60, p. 94]. By contrast, the power of character-based HCI derives from the fact that people *know* how to interact with other people by using the modalities of their body (voice, gesture, gaze, etc.) and interpret the bodily signals of their interlocutors. Hence, character-based interfaces aim at realizing embodied interaction and intelligence [12] rather than interaction with "invisible" devices (see also the Gestalt user interface concept of Mariott and Beard [35]).

The vision of *social computing* is to achieve natural and effective interaction between humans and computational devices. As argued above, we believe that by employing life-like characters, social computing can be realized most efficiently. Social computing can be characterized as

- computing that intentionally displays social and affective cues to users and aims to trigger social reactions in users; and
- computing that recognizes affective user states and gives affective feedback to users.

In this paradigm, life-like characters are seen as social actors, and hence as genuine interactive partners for a wide variety of applications, ranging from advisors and sales persona to virtual playfellows. A recent study in the social computing paradigm is the "relational agents" described by Bickmore [7], where characters are in the role of assistants for health behavior change (exercise adoption). He characterizes *relational agents* as computational (typically anthropomorphic) artifacts "[...] intended to produce relational cues or otherwise produce a relational response in their users, such as increased liking for or trust in the agent" [7, p. 27].

Besides displaying social cues, the second key premise for social computing is that life-like characters recognize social cues of their interlocutor, such as the affective state of the user. In this respect, social computing shares the motivation and goal of affective computing [44]. In the context of a tele-home care application, Lisetti et al. [34] take physiological signals of the user so that a life-like character may respond appropriately. Conati [16] suggests an animated agent that adapts its behavior according to assessed user emotions in the setting of an educational game. Prendinger et al. [47] conducted an experiment that utilizes biosignals of users to demonstrate the calming effect of emphatic character behavior.

The related notion of "Social Intelligence Design" [41], on the other hand, emphasizes the role of the web infrastructure as a means of computer-mediated interaction, community building and evolution, and collective intelligence, rather than (social) human–agent interaction. A full-fledged theory of social intelligence (or computing) will have to combine both aspects: (i) macro-level social interactions in a community of human and virtual agents, and (ii) micro-level social interactions between human users and virtual agents as personal representatives of other community members.

3 Authoring Life-Like Characters

One of the most challenging tasks in life-like character research is the design of powerful and flexible authoring tools for content experts. Unlike animators, who are skillful in creating believable synthetic characters, non-professionals will need appropriate scripting tools to build character-based applications [50]. Animating the visual appearance of life-like characters and integrating them into an application environment involves a large number of complex and highly inter-related tasks, such as:

- The synchronization of synthetic speech, gaze, and gestures.
- The expression of personality and affective state by means of body movement, facial display, and speech.
- The coordination of the bodily behavior of multiple characters, including the synchronization of the characters' conversational behavior (for instance, turn-taking).
- The communication between one or more characters and the user.

Observe that the mentioned tasks already assume that characters can be controlled at a rather "high" level, where designers may abstract from low-level concerns such as changing each individual degree of freedom in the character's motion model. The Character Markup Language (CML) contains both low-level and medium-level tags to define the gesture behavior of a character as well as high-level tags that define combinations of other tagging structures

[3]. Furthermore, CML allows one to define high-level attributes to modulate a character's behavior according to its emotional state and personality. The Virtual Human Markup Language (VHML) provides high-level and low-level tagging structures for facial and bodily animation, gesture, speech, emotion, as well as dialogue management [36]. The Scripting Technology for Embodied Persona (STEP) language contains high-level control specifications for scripting communicative gestures of 3D animated agents [29]. Being based on dynamic logic [25], the STEP language includes constructs known from programming languages, such as sequential and non-deterministic execution of behaviors or actions, (non-deterministic) iteration of behaviors, and behaviors that are executed if certain conditions are met.

The human interpretation process 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 [24]. An agent that speaks with a cheerful voice without displaying a happy facial expression will seem awkward or even fake. Another challenge is to keep consistency of agents over time, allowing for changes in their response tendencies as a result of the interaction history with other agents [46, 7].

Allbeck and Badler [1] developed an extensive framework for representing embodied characters and objects in virtual environments, called Parameterized Action Representation (PAR). This representation allows one to specify a large number of action parameters to control character behavior, including applicability conditions, purpose, duration, manner, and many more. Most notably, character actions can by modulated by specifying affect-related parameters, emotion, and personality. In order to achieve a high level of naturalness in expressive behaviors, the authors developed the EMOTE system which is based on movement observation science. With respect to conversational behavior, Cassell et al. [15] propose the BEAT (Behavior Expression Animation Toolkit) system as an elaborate mechanism to support consistency and accurate synchronization between a character's speech and conversational gestures. The BEAT system uses a pipelined approach where the Text-to-Speech (TTS) engine produces a fixed timeline which constrains subsequently added gestures. The meaning of the input text is first analyzed semantically and then appropriate gestures are selected to co-occur with the spoken text.

Most approaches to scripting virtual environments focus on designing the characters themselves and interactions between characters and virtual objects, with rudimentary consideration of the representation of interactions among characters and the user. The motivation for the Affective Presentation Markup Language (APML) developed by De Carolis et al. [18] is communicative functions, which make the language similar to the BEAT system [15]. In addition to turn-taking behavior, APML includes the speaker's belief state (certainty of utterance) and intention (request, inform). The work of Mateas and Stern [38] broadens the spectrum of character scripting to interactive scenario scripting to also include another agent and a human user. The authors propose ABL (A Behavior Language), a language that allows one to author believable characters for interactive drama. Unlike most other scripting approaches, which are XML-based [15, 18], ABL is a reactive planning language with character behaviors written in a Java-style syntax. Most notably, ABL may encode "joint plans" that describe the coordinated behavior of characters as one entity rather than having autonomous characters work out a joint plan (which would require complex reasoning, message passing, and so forth). However, joint plans are still reactive, letting the user interfere with plan execution during interaction.

The next step in providing support for creating life-like character applications for non-specialists is character toolkits that address the needs of content providers. The Multi-modal Presentation Markup Language (MPML), for instance, has been designed so that ordinary people can write multi-modal character contents most easily like they write a variety of web contents using HTML. Moreover, MPML offers a visual editor that allows one to script interactive multi-character presentations in a drag-and-drop fashion using a graphical representation of the presentation flow [48]. MPML also provides an interface to the Scripting Emotion-based Agent Minds (SCREAM) system that enables authors to specify the propositional attitudes and affect-related processes of a character's (synthetic) brain [48]. While MPML typically uses the Microsoft Agent package to control animated characters [40], the Galatea software toolkit allows authors to personalize core features of a facial spoken dialogue agent [31]. Galetea consists of interfaced modules that are all modifiable: speech synthesizer, speech recognizer, facial animation synthesizer, and task dialogue manager. As described above, the BEAT system is a toolkit to synchronize analyzed speech automatically with non-verbal behaviors [15]. The toolkit is extensible, and new rules encoding linguistic and contextual analysis of textual input are easily added.

Another challenge for character-based applications is to adequately account for the user's behavior, in particular the user's affective state [44]. Marking up user input modalities rather than character (output) modalities is a hitherto entirely unexplored application of scripting technology. Mariott and Beard [35] propose a "complete user interaction" paradigm which they call "Gestalt User Interface … an interface that should be reactive to, and proactive of, the perceived desires of the user through emotion and gesture". User interaction modalities such as speech, facial expressions, and body gestures are analyzed and then transformed to an XML structure that can be "played back" by a VHML-based talking head or provide the conditions to decide on the desired character response.

Rist [50] offers interesting reflections on scripting and specification languages for life-like characters. He proposes objectives and desiderata for the design of character languages and discusses the state of current developments in view of the potential (and highly desirable) standardization of scripting languages. Rist also points out limitations of the present focus on XML-based languages and suggests drawing inspirations from the area of network protocols in order to manage more complex and sophisticated character interactions.

4 Life-Like Character Applications and Systems

Recent years have witnessed a considerable and growing interest in employing life-like characters for tasks that are typically performed by humans. In the following, we list some of the more prominent deployed character applications as well as systems in progress. Issues of designing life-like characters and lessons learned can also be found in Hayes-Roth [27].

Life-like characters are used

- as (virtual) *tutors* and *trainers* in interactive learning environments [20, 30, 26, 16, 37, 56],
- as *presenters* and *sales persona* on the web and at information booths [11, 4, 48, 51],
- as *actors* for entertainment [52, 10, 43],
- as *communication partners* in therapy [19, 34, 37],
- as *personal representatives* in online communities and guidance systems [14, 55, 53], and
- as *information experts* enhancing conventional web search engines [32].

One of the most successful application fields of life-like character technology is computer-based *learning environments* where embodied agents can perform in a variety of student-related roles, especially as tutors and trainers [20, 30, 26, 16, 37, 56]. Marsella et al. [37] describe a Mission Rehearsal Exercise (MRE) system for training peacekeeping missions where a realistic virtual human acts as a sergeant in the role of a mentor or as a soldier in the role of a teammate. In order to support highly believable, responsive, and easily interpretable behavior, the authors base their characters on an architecture for task-oriented behavior (STEVE), rich models of (social) plan-based emotion processing (Émile), and emotion appraisal and coping behaviors (Carmen's Bright IDEAS). The MRE system is currently one of the most impressive applications of life-like character technology.

Another application field where life-like characters showed significant progress is character-based *presentation*, especially online sales [11, 4, 48, 51]. Starting with the PPP Persona, Rist et al. [51] developed a series of increasingly powerful character technologies for a wide variety of agent–agent and human–agent interaction scenarios, such as the AiA travel agent, the eShowroom, a RoboCup commentator system (Gerd & Matze), a negotiation dialogue manager (Avatar Arena), the MIAU platform for interactive car sales, and the interactive CrossTalk installation featuring two presentation screens. The work on life-like characters done at DFKI [51] can be seen as the strongest and most covering in the field. While being well motivated and based on psychological and socio-psychological research, it offers powerful technologies for every imaginable interaction mode with and among life-like characters. As previously mentioned, Prendinger et al. [48] developed two scripting tools that focus on creating interactive presentations (MPML) and affect-driven characters (SCREAM). Both technologies are designed for web-based applications that require multiple character interactions including communication with the user. The implementation of an interactive casino scenario demonstrates the power and flexibility of this approach.

One of the most attractive application fields of life-like characters is the *entertainment* sector where characters perform as virtual actors [52, 10, 38, 43]. Paiva et al. [43] provide a useful classification of character control technologies for story and game applications, based on the autonomy dimension. Besides character related autonomy – (partially) scripted, directed, role constrained, and autonomous – the authors also propose a classification of a user's control over characters, that is puppet-like control, guidance, influence, and god-like control. The suggested classification is exemplified by a series of installations: Tristão and Isolda, Papous, Teatrix, FantasyA, and SenToy. Burke [10] describes a powerful architecture that meets the demands of life-like characters for entertainment systems. In particular, he proposes a prediction-based approach that allows for new types of learning and adaptive characters. The previously mentioned work of Mateas and Stern [38] implements an interactive drama – Façade – a real-time 3D interactive drama that demonstrates the capabilities and promise of characters in entertainment systems.

Life-like characters will also play a major role as communication partners in *therapeutic* and *medical* applications [19, 34, 37]. For instance, Marsella et al. [37] propose a system called "Carmen's Bright IDEAS" (CBI) where users are immersed in a story that features an animated clinical counsellor and another agent that receives help and is designed to have problems similar to the user who interacts with the CBI system. The user may influence the development of the councelling session by selecting interface objects ("Thought Balloons") that match his or her current feeling most closely.

The great popularity of Internet-based and computer-mediated communications raises the demand for life-like characters that function as personal representatives of users in *online communities* (for instance, chat systems) and *guidance systems* [14, 55, 53]. Sumi [53] developed the AgentSalon system where a visitor to an exhibition is equipped with a PalmGuide that hosts his or her personal agent which may migrate to a big display – then being visible as an embodied character – and start conversing with personal agents of other visitors. Since the agent stores a user's personal interest profile, the conversation between the personal representatives can reveal shared interests and trigger a conversation between visitors.

A common and one of the most important activities on the web is the *retrieval* of relevant information. Life-like characters have recently also been successfully employed to add value to search engines. Kitamura [32] describes the Multiple Character Interface (MCI) system that aims at assisting users in the information retrieval task. Two MCI-based prototype systems are a co-operative multi-agent system for information retrieval (Venus and Mars) and a competitive multi-agent system for information recommendation (Recommendation Battlers) [32].

The following system can be viewed as a feasibility study on the next generation of natural language understanding systems, including entertainment and helper robots, tutoring, and virtual space navigation systems. Tanaka et al. [56] developed a system called "Kirai" which allows one to direct virtual characters in a 3D environment. Most notably, the system incorporates a natural language recognition and understanding (NLU) component so that characters can be instructed to perform actions in virtual space via speech input. Speech analysis includes syntactic and semantic analysis, anaphora resolution, ellipsis handling, and a simple mechanism to eliminate the vagueness problem of natural language.

5 Concluding Remarks

In this introductory chapter, the state of the art of life-like character scripting languages and applications has been briefly reviewed. While the future of embodied characters remains to be seen, the extensive research on character representation languages and scripting tools certainly indicates a growing demand for embodiments of the human–computer interface. The most convincing evidence for the continued interest is the large number of deployed and upcoming character applications in a wide variety of applications, from learning and entertainment to online sales and medical advice.

Life-like character research lays the foundations of the social computing paradigm, where computers deliberately display social cues and trigger social reactions in users. In order to pass as genuine social actors, life-like characters will eventually also have to be equipped with means to recognize social and affective cues of users, a research topic which we hope to address in a future publication. Although we focused on animated characters here, many of the insights gained can be transferred to the physical siblings of animated characters, namely robotic agents. Animated or robotic, the success of those agents will ultimately depend on whether they are life-like.

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