# Why Can't a Virtual Character Be More Like a Human: A Mixed-Initiative Approach to Believable Agents

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**Abstract.** Believable agents have applications in a wide range of human computer interaction-related domains, such as education, training, arts and entertainment. Autonomous characters that behave in a believable manner have the potential to maintain human users' suspense of disbelief and fully engage them in the experience. However, how to construct believable agents, especially in a generalizable and cost effective way, is still an open problem. This paper compares the two common approaches for constructing believable agents — human-driven and artificial intelligence-driven interactive characters — and proposes a mixed-initiative approach in the domain of interactive training systems. Our goal is to provide the user with engaging and effective educational experiences through their interaction with our system.

**Keywords:** Mixed-initiative system, character believability, interactive storytelling, artificial intelligence, interactive virtual environment.

## 1 Introduction

Interactive computer characters are becoming widely used in digital systems in a range of domains. Some applications include, for example, virtual patients used in training medical students' communication skills [1], anthropomorphic robotic assistants that can support manual tasks in industrial environments [2], and non-player characters (NPC) in computer games that provide players with dramatic experiences [3]. These virtual or robotic characters are an important part of human centered computing not merely because they provide users with a set of familiar metaphors and conventions to interact with new technology. Like Disney's animated characters [4], they also have the powerful potential to engage users in emotional and personal ways. With a significant improvement of their appearance thanks to recent development of real-time computer graphics technology, there is an increasing demand for these characters to behave in ways that are believable to the users.

However, how to construct believable agents, especially in a generalizable and cost effective way, is still an open problem. This paper compares the two common approaches

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for constructing believable agents — human-driven and artificial intelligence-driven — and proposes a mixed-initiative approach in the domain of interactive training systems. Our goal is to provide the users with engaging and effective educational experiences through their interaction with our system.

This paper is organized as follows. Section 2 provides a background of two primary approaches for creating believable interactive characters – the human-driven and computer-driven characters. Next, Section 3 discusses the need of combining the strength of the previous approaches and proposes a mixed-initiative system in the domain of a specific interactive education system.

## 2 Background

This section describes two major existing approaches for creating believable, human-like virtual characters. We mainly draw from the puppetry tradition in the performing arts and the autonomous agent approach from the artificial intelligence (AI) community.

### 2.1 Human-Driven Puppetry

Performing arts and the entertainment industry have a long-standing tradition of creating believable and engaging characters. In theater, for instance, human actors have developed various strategies to enact characters, either with their own body or through inanimate props (e.g. puppets). Grown out of this tradition are digital puppetry systems, which allow human actors to sit behind the curtain and “Wizard of Oz” virtual characters.

Often used in theme parks and live theatre, Digital puppetry relies mainly on human operators’ skills to control a substantial part of virtual characters’ movement and/or speech in order to create an illusion of life. For instance, Disney's tradition of emotional involvement with the audience using their classic animated characters continues with its modern “Turtle Talk with Crush” show, where performers puppeteer the virtual turtle character in a 15-minute improvisational interaction and conversation with a large audience. More recently, this approached is further developed in the emerging machinima community, where player-controlled game characters enact cinematographic scenes in real-time game engines.

### 2.2 Autonomous Believable Agents

A second broad approach for constructing human-like virtual characters is developed by the Artificial Intelligence (AI) community. AI researchers have spent decades constructing autonomous agents capable of accomplishing a variety of tasks at human-level intelligence. Among them, Joe Bates and his students in the OZ project at CMU [5] coined the term “believable agents” to describe what many consider to be the “holy grail” of computer-driven characters in the context of interactive drama. These computer agents utilize various AI techniques to create the illusion of personality, emotion, and lifelikeness. Since then, the notion of believable agents has been explored in various domains such as interactive narrative, story generation systems, software agents, and robotics. A salient example is the believable agents (i.e. Trip and Grace) in Mateas and Stern's acclaimed interactive drama Façade [6].

In comparison, human-driven (digital) believable agents are flexible and more robust in difficult scenarios such as free conversation in public spaces. However, their level of believability is strongly tied to the expertise of the human operator, and this approach can be very costly. Its AI-driven counterpart, on the other hand, has lower run-time cost and can, in theory, operate continuously. But this second approach requires substantial authorial burden in advance and, more importantly, many of the needed technological components (e.g., perception, common-sense reasoning, and natural language processing) are still far from perfect. As a result, most autonomous believable agents only function properly in very constrained environments.

## 3 Building Believable Agents in Educational Systems

In order to combine to strength of both approaches described above, this section proposes a mixed-initiative framework for creating believable characters. Below, we will briefly describe our application domain, the TeachME™ system, and propose a mixed-initiative system to improve the synergistic collaboration between the human inter-actors and the system.

### 3.1 A Mixed-Initiative Approach

Mixed-initiative systems have received increasing attention in domains such as robotics [7], but are relatively under-explored in virtual characters [8, 9]. Our goal is to provide users with engaging and effective educational experience by creating believable agents that exhibit comparable level of believability as human or human-controlled characters with relatively low requirements/costs. For example, we would like to provide a relatively large number of believable agents per moderately-experienced human operators.

From the human computer interaction (HCI) point of view, mixed-initiative interfaces are situated between the two major interface paradigms — direct manipulation (e.g. a word processor) and intelligent agent (e.g. automated web bots) [10]. Typically applied to systems with a mixture of human agents and computer agents, the term "mixed-initiative" refers to a flexible control strategy where each agent can contribute to the task that it does best by temporarily taking control of the task (i.e. having initiative) [11]. Seen as an "elegant coupling" of automated services with a user's ability to directly manipulate interfaces to access information [12], mixed-initiative systems are gaining popularity in both software and robotic systems. A growing belief is that the collaborative control leads to a more balanced and symbiotic relation between human and computer/robotic agents based on their respective capabilities. By coordinating both parties to request and receive help on actions that they could not have performed alone, mixed-initiative systems can decrease the need for continuous human monitoring and increase overall performance [7, 13].

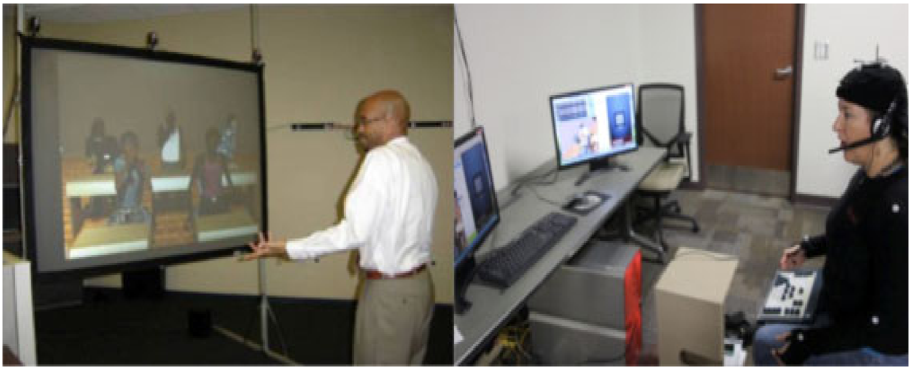

**Fig. 1.** The TeachME™ System (Left: User's View; Right: Inter-actor's View)

### 3.2 The TeachME™ Project

Over the past four years, the lab directed by Hughes has developed several systems in which human inter-actors "puppeteer" virtual characters in interactive systems designed for training and educational purposes. This section gives a brief account of the TeachME™ project, which will be used as the specific domain for us to test our research on mixed-initiative believable characters.

Orlando with its numerous theme parks and entertainment venues is home to a large inter-actor community. In 2007, under the direction of Hughes, a software team led by Dan Mapes of the Institute for Simulation and Training (IST) collaborated with a group of inter-actors led by Jeff Wirth and a team of educators led by Lisa Dieker and Mike Hynes from the College of Education at the University of Central Florida (UCF). They developed a teacher training system called TeachME™ (Teaching in a Mixed Reality Environment). The system provides pre-service and in-service teachers the opportunity to learn teaching skills and to craft their practice without placing "real" students at risk during the learning process. The original application was classroom management [14]. Since then, the system has been used in mathematics instruction, writing classes and counselor training. Starting in summer 2009, Utah State University adopted the system for working with its teachers of children with special needs. Three new partnerships formed in fall 2010 with Old Dominion University, West Virginia University and University Center of Greenville South Carolina; Florida State University, University of Wisconsin Milwaukee and Western Michigan University joined in spring 2011; and there are now emerging partnerships with at least five other teacher preparation programs.

In TeachME™, the user (i.e. teacher trainee) can interact with 3D animated virtual students in a middle-school classroom setting, which is displayed at life size on a rear projection screen (Figure 1, left frame). Through natural language conversation, gesture and body position, the user can interact with the virtual characters. For instance, she can walk toward one of the five virtual students (to a marked spot on the floor) and ask him a question. Using simple two-camera tracking, the system automatically shifts the virtual camera to zoom in on this simulated student.

A group of five virtual students are controlled by an inter-actor behind the scenes (Figure 1, right view). We use infrared-marker motion capture of the inter-actor's head and upper body (the virtual students are seated at desks). We transmit raw position/orientation data over the Internet, along with audio/video data over Skype. Each student's behavior is based on one of the personality types identified by Long [15] and Dreikurs [16]. The team of inter-actors developed detailed back-stories and unique personalities for each student.

Unlike many AI-driven agents that rely on a small pool of pre-recorded voice responses, the characters in TeachME™ behave and converse in a much more believable and human way; after all, a live inter-actor is controlling any virtual student to whom the user directly communicates. Even as the user focuses on one student, the other students carry on their standard pre-programmed behaviors. If the teacher ignores the virtual students as individuals or shows little understanding of their personal motivations, they will get more rowdy or more withdrawn (depending on the character's attributes). Such increases in the level of chaos can be controlled individually or across the entire class by the inter-actor (primarily) or triggered by an on-site trainer through a simple key-based system. This project gives life to the virtual classroom experience, causing many trainees to feel that they spent a half hour in instruction, when the exercises typically last only five minutes.

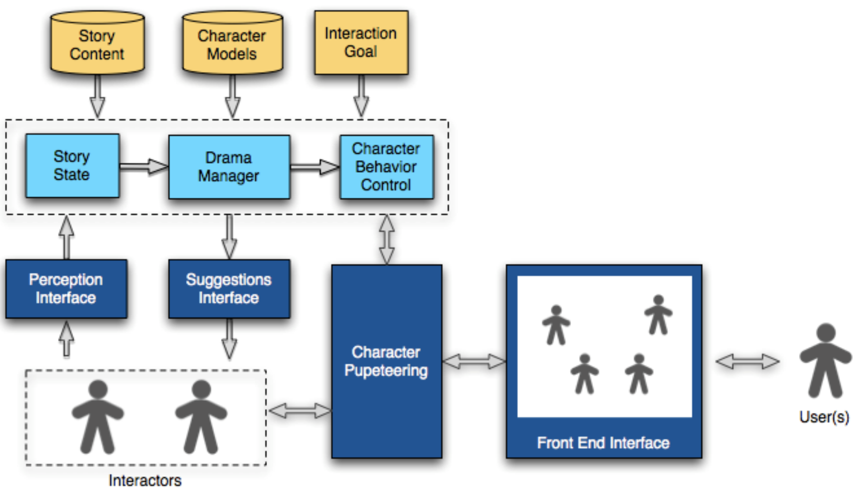


**Fig. 2.** Proposed Mixed-Initiative System Architecture

### 3.3 Proposed System

One key element to achieve our goal of improving the efficiency of creating believable characters is to alleviate the cognitive load of the human operators during the performance and distribute the tasks between the humans and the computer in ways which enhance both parties' strengths. Based on our preliminary study of the human operators in the TeachME™ project, we classified the tasks involved in constructing believable characters into human-friendly and computer-friendly ones. For instance, human are particularly effective in handling freestyle natural language conversations with the user and observing the user's physical and psychological reactions, all of which are widely known as difficult tasks for AI. The computer, on the other hand, is more efficient in routinizable tasks, such as idle animations of the characters. It is also good at overseeing the over-arching experience and adapting the structure of the story based on user interaction.

Different from both of our existing digital puppetry systems and Niehaus and Weyhrauch's proposed mixed-initiative system [17], this proposed system will have an explicit representation of the story. It will allow the overall system (including both the human inter-actors and the AI component) to handle much more complicated narrative structures where the storyline can change algorithmically based on user interaction and allow more user agency in the learning experience.

We loosely divide the system's operation into two main tasks: enacting the believable characters and maintaining the storyline at the plot level. The first task includes 1a) providing characters' direct interactions with the user (e.g. gesture and dialogue), 1b) maintaining the characters' higher-level consistency (e.g. personalities, emotions, patterns of behavior, background story, etc.). The second main task includes 2a) instantiating the pre-defined plot structure based on user interaction, and 2b) restructuring the plot if the initial story fails to work; e.g., if the user continually fails a specific learning task, the story should be reorganized to emphasize similar tasks. Both tasks require 3) the perception of user interaction and 4) the coordination between inter-actor and the AI component to resolve any major potential conflict.

Based on our initial observation described above, a human inter-actor is particularly capable of task 1a), for one character at any point of time, and 3). Both tasks are notoriously difficult for computer systems to accomplish. On-going research in interactive narrative/computer games [6, 18] and story generation [19, 20] has shown that the state of the art artificial intelligence techniques are capable of handling tasks 2a), partially 2b). In this iteration of our system design, the inter-actor and the computer will work together on tasks 1b), 2b) and 4).

Figure 2 above shows our design for the proposed system. The AI-based Experience Management System (EMS) consists of the states of the characters and the story, a drama management module, and a character behavior control module. The drama management module is responsible for executing and reconstructing the events on the fly so that they will best satisfy the overarching goal. Generally speaking, the character behavior control module can control the characters that are not currently controlled by the inter-actor. EMS also contains computational models of pre-authored characters, story content, and the overall goal of the whole interactive experience.

The main human inter-actor provides one character's direct interaction with the user and can partially control the actions of other characters that she is not directly enacting. The character that she enacts can shift in time. A second inter-actor is primarily responsible for handling perception for EMS.

In our system architecture, EMS and the inter-actors communicate mainly in two ways. EMS provides high-level information and suggestions to the main inter-actor. For instance, it will display the emotional state for each character, and provide possible conversation topics and background stories to the main inter-actor. The second inter-actor will observe the actions and reactions of the user and input such information to the computer in real time. As computer vision techniques become more sophisticated, the perception task may be partially handled by the computer in the future.

## 4 Conclusion

This paper proposes a mixed-initiative system to create believable agents in interactive educational systems. The key challenges for our approach are: recognition of different capacities of the human and the computer; design of the mixed-initiative control scheme that is intuitive to human operators; construction of believable characters with relatively low cost; and achievement of the overarching educational goal. Some of these challenges are of particular relevance to HCI because they call for new interaction models which facilitate the shift of shared control between the human and the computer.

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