DOCUMENT RESUME

ED 380 066 IR 016 987

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TITLE Magical Stories: Blending Virtual Reality and Artificial Intelligence.
PUB DATE [95]
NOTE 6p.; In: Imagery and Visual Literacy: Selected Readings from the Annual Conference of the International Visual Literacy Association (26th, Tempe, Arizona, October 12-16, 1994); see IR 016 977.
PUB TYPE Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Artificial Intelligence; Computer Games; Computer Graphics; *Computer Simulation; Fine Arts; *Simulated Environment; *Visual Arts
IDENTIFIERS *Interactive Fiction; *Virtual Reality

ABSTRACT

Artificial intelligence (AI) techniques and virtual reality (VR) make possible powerful interactive stories, and this paper focuses on examples of virtual characters in three dimensional (3-D) worlds. Waldern, a virtual reality game designer, has theorized about and implemented software design of virtual teammates and opponents that incorporate AI techniques including fuzzy logic, neutral nets, and genetic algorithms. He asserts that one of the primary goals of VR is to generate virtual actors with whom the participant can interact in a contextually meaningful fashion, and proposes a classification scheme for such characters, as determined by intelligence level and centrality to the game. Virtual characters that can reason about their environment in original ways are being developed. PLACEHOLDER, a VR art project inspired by Native American myths and stories, features virtual characters where VR explorers can play the role of a bird, snake, person, or other creature. Participants, embodied in "smart costumes," take on the animal's pattern of movement, character, physical abilities, and may explore different sites or mark home territory. Other examples of virtual characters are: Dolby's "Virtual String Quartet," which synchronizes animated figures with 3-D sound; and an "avatar," a virtual character that reflects a person's look, mood and personality, and who represents him or her in a virtual world. (Contains 8 references.) (MAS)

Magical Stories: Blending Virtual Reality and Artificial Intelligence

Hilary McLellan

We've always had virtual worlds: virtual worlds for the imagination to enter. Stories, myths, movies. From the campfire to the silver screen, and now the computer screen. Stories are one of the most fundamental and powerful synthetic experiences available to us. Interactive stories are changing our relationship to information. And most recently, the addition of artificial intelligence techniques to virtual reality extends our ability to create interactive, enacted stories with characters that perform in powerful new ways.

Artificial intelligence researchers such as Roger Schank and John Seely Brown have increasingly focused on stories. For example, Roger Shank has extended his study of scripts for everyday events, such as placing an order in a restaurant, to cover full-blown stories. Scank has concluded that people have expectations concerning story structure, what he calls 'archetypes.'

Can you do the walk? Can you do the talk? Can you improvise? Virtual characters are increasingly able to do this with the addition of artificial intelligence techniques and powerful modeling of human (and animal) behavior. With artificial intelligence features, it's not just the content, but interaction with other characters, both real and computer-generated, that are adding to engagement and immersion.

We can think of virtual characters as a form of puppet. Puppetry is the theater of manipulated objects. Virtual characters are calling their own shots, based on the programming that's embedded in them. There are wonderful 2-D virtual puppets, including a Virtual Mark Twain and a Virtual Mario, that are controlled directly by human puppeteers --- sort of like stand up comics --- but this paper will focus on the characters in 3-D worlds.

One designer has developed a Virtual Globe Theater where virtual actors act out a scene from Romeo and Juliet. You can have any seat in the theater, even a bird's eye view. The setting is highly interactive (and historically accurate). However, the virtual actors are just going through a programmed routine; there's no interactivity or improvisation. This is a wonderful application, but there are even more 'intelligent' virtual characters.

Virtual Characters in Games

Virtual reality game designer Jonathan Waldern (1994) has theorized about --- and implemented --- software design of virtual teammates and virtual opponents that incorporate AI techniques, including fuzzy logic, neural nets, and genetic algorithms. According to Waldern, one of the primary goals of VR is to generate software constructs or 'entities' (virtual actors) with whom the participant can interact in a contextually meaningful fashion. Waldern reports that the essential characteristics of a virtual actor are: (1) They

have goals and motivations, not all of which are necessarily apparent to the participant; (2) They may be observed to receive sensory input both from the virtual world and from the participant; and (3) They have the capability to learn and hence adapt to any aspect of their environment.

Waldern proposes a classification scheme for different types of virtual actors, based on what AI characteristics are emphasized: (1) V-Extras; (2) V-Agents; (3) V-Actors; (4) V-Androids; and (5) V-Experts. Each category is progressively more "intelligent" and more central to the action in the game. For example, a V-Expert is an entity that may evolve it responses to events based on observation and experience within a virtual environment.

The software implementation of Waldern's virtual actors features several AI techniques: fuzzy logic, neural nets, and genetic algorithms (Waldern, 1994). In ordinary logic, a proposition is either true or false, but with fuzzy logic, a proposition is given a probability value between zero and one. A neural net consists of a two-dimensional array of neuron elements, each of which receives an input from its neighbors when they are activated, creating a network for sending signals. This is similar to the characteristics of living organisms in terms of ability to correlate ambiguous data and ability to learn by comparing outputs to a set of known results. Genetic algorithms are a powerful evolutionary technique whereby the population of problem-solving algorithms (strings of code) are permitted to breed and mutate so that when a problem is encountered, the population is evaluated to assess the quality of the solution each algorithm offers. By employing AI techniques, Waldern (1994) explains that it should be possible to create entities that are entertaining and instructive to communicate with.

Virtual Characters in Research and Development

A group of researchers led by Norman Badler, at the Center for Human Modelling and Simulation at the University of Pennsylvania, are creating simulated characters that can reason about their environment in original ways. Taubes (1994) reports that the center's main project is a computer model designed to mimic human movement. This model is used by engineers to test computer-designed products including bulldozers, buildings, and helicopter cockpits. Scientists in the center's "synthetic-conversation group" teach the computer-simulated humans the rules of speech, facial expression, and gesture. Virtual characters like Gilbert and George can then interact with minimal human oversight, improvising based on information they have been supplied with. In one exchange between a bank teller and a customer who wants to withdraw fifty dollars when there is only three dollars in his account, the banker is able to determine that there's not enough money to make the withdrawal. Badler suggests that these characters will come to look more and more like us, behave like us, and respond to language and stimuli as we do within the confines of a 3-D virtual world (Taubes, 1994).

Virtual Characters in Art

The example of Gilbert and George models logic and human movement. what about mood and personality? Bates (1992) argues that it is not sufficient to solve for the physical dynamics and movements; one must also solve for the culture. Different cultures have very different ways of telegraphing intention and mood through body language, so ideally these will be captured.

According to Bates (1992), "Most existing research on virtual reality concerns issues close to the interface, primarily how to present an underlying simulated world in a convincing fashion. However, for virtual reality to achieve its promise as a rich and popular artisitc form, as have the novel, cinema, and television, we believe it will be necessary to explore well beyond the interface, to those issues of content and style that have made traditional media so powerful. (p. 133)"

Bates reports that almost always, television, movies, and novels include at least three other key elements besides the physical space: "First, there are living creatures, usually human, and usually embodying some intelligence and emotion. These let the viewer see the world as a place of life, purpose, and feeling. Second, there is long-term structure to the events portrayed, which is to say that some kind of story is told. The story gives intensity and meaning to the world. Finally, the world is presented in an effective, emotionally powerful style. Cinematic and narrative technique are highly developed examples of the art of presenting worlds. (p. 134)"

As Bates points out, traditionally, very little research and development in virtual reality focused upon computational models of cognitive-emotional agents, long-term dramatic structure, and presentation style --- essential features for a successful artistic medium. But this is changing.

For example, in a VR art project that research artist Brenda Laurel helped to design, inspired by Native American myths and ceremonies, VR explorers can play the role of a bird or a snake or another creature, taking on the pattern of movement and the vantage point of that animal (Frankel, 1994; Laurel, 1994). This is the PLACEHOLDER project that she developed with Rachel Strickland. PLACEHOLDER was funded by Interval Research and the Banff Center for the Arts.

According to Laurel (1994), science is a dialogue with nature. She comments, "Some patterns and rhythms can only be appreciated through analysis. Both science and art are about the natural world and the unseeable. Art deals with human nature. Making art with computers is so very hard to do because it is so cut off from nature. Virtual reality is the antithesis of this."

PLACEHOLDER is an artistic research project inspired by topography as well as Native American myths and stories. PLACEHOLDER features a virtual world that is inspired by the landscape of several locations in the vicinity of Banff National Park in Alberta, Canada. These sites include a sulphur hot spring in a natural cave, a waterfall in a canyon, and a formation of hoodoos (tall, narrow rock formations or pillars) overlooking a river. Laurel comments, "The cave was the place we began for obvious Jungian reasons." In addition to the virtual world, there is a map of the PLACEHOLDER site that looks like a Native American graphic or rock painting.

This application can accomodate two people wearing head-mounted displays (who may be physically remote). It is designed to support exploration and play. People can walk around, speak, and touch and move virtual objects within the PLACEHOLDER world.

According to Laurel, people (as well as animals) mark the spaces that constitute their home turf. The following questions were asked in conceptualizing this project: How do people mark places? How can people mark places for imaginative play? People sometimes leave marks in natural places --- pictograms, petroglyphs, grafitti, or trail signs for example. One group, the Anastazi people of the southwest marked places with rock carvings. The PLACEHOLDER project features markers --- Placeholders. These Placeholders are in the form of voices. In PLACEHOLDER, people can leave Voicemarks - bits of spoken narrative - that can be created, listened to, and rearranged by anyone who passes through. These messages and comments within the that virtual world then serve as story starters. The virtual landscape accumulates definition through messages and storylines that participants leave along the way. The people who visit PLACEHOLDER will change it. Laurel reports that one goal of the PLACEHOLDER project is to foster new forms of narrative play.

Laurel (1994) reports that in the PLACEHOLDER project, the designers tried out different camera positions in an attempt to provide a dialogue that featured Cubist qualities and Constructivism. These were not a good match for the subject.

Realism and impressionism proved to be better matches so these artistic traditions informed and inspired the PLACEHOLDER project.

According to Laurel, immersive virtual reality systems often suffer from a design strategy featuring a "severed hand" and "severed head" syndrome --- partial avatars or representations of the user's body within the virtual world. This kind of feature affects perception; it's not really natural. So the PLACEHOLDER project attempted to address this issue. Related to this, iconic gestures of the glove --- such as pointing --- are not that good at indicating the direction of intended movement; movement of the pelvis is much better for this. Also, an interface that only includes one hand is unnatural. So any kind of VR input device should include both hands, not just one, to optimize the feeling of natural interaction. For the PLACEHOLDER project, inexpensive "grippies" were used as interface devices. These are held in both hands and users grip them to signal interactions.

The issue of embodiment --- seeing a representation of oneself or the character one is "playing" --- was a central design issue in the PLACEHOLDER project (Laurel, 1994). There is a set of animal characters --- crow, snake, spider, and fish. As Laurel explained, "Four animated spirit critters." These animals talk to you as you get closer, each with a distinctive voice. A person visiting the world may approach and assume the "character" of one of the spirit animals and thereby experience aspects of its unique visual perception, its way of moving about, and its voice. Laurel refers to this kind of character within the virtual world as "smart costumes." When you take on the smart costumes, this changes what your body can do. Your voice changes. Perception may change. For example, snakes can see infrared and PLACEHOLDER tries to model this --- the space becomes brighter. Thus the critters function as "smart costumes" that change more than the appearance of the person within. You become embodied in "smart costumes." In PLACEHOLDER, the smart costumes are mostly about audio --- since the spaces in PLACEHOLDER are dark. Explaining this darkness, Laurel (1994) emphasizes that the resolution of the head-mounted displays in VR are currently at the level of what is legally blind so that other factors like audio are very important.

To make up for limitations of visual resolution, designers must be concerned with stylistic issues. In PLACEHOLDER, the images of the animals are flat, iconic --- like the simplified, symbolic image of an animal on a rock painting or some ceremonial image. The representations of the animals are like flexible sandwich boards --- you can show gait, but not limbs. Limbs were not well defined in PLACEHOLDER (Laurel, 1994).

Related to this, the designers of the PLACEHOLDER project studied carefully how to design the movements of the "smart costumes" in response to the gestures of the person embodying the various characters. For example, how should the movement of a crow be represented? What's a flap? The designers found that when users embodying the crow flapped their arms to emulate (and initiate) the crow's movement, one flap moved the participant very far --- too far --- that is, disproportionately far compared to what we expect from the actual flap of a bird's wings (Laurel, 1994).

Researchers at the MIT Media Lab are studying ethology, the science of animal behavior, as a basis for designing animal characters in virtual worlds (Sheridan & Zeltner, 1993). Thus, "smart costumes" may have potential in both the science and humanities curricula. Actually, the MIT researchers have produced an animated short film, Grinning Evil Death, to demonstrate their design of virtual characters based on ethology.

The 1993 Guggenheim Soho Museum exhibit, "Virtual Reality: An Emerging Medium" featured artwork by several artists, including Thomas Dolby (Teixiera, 1994). Dolby prepared a VR artwork that featured a powerful interactive audio component as well as a visual

component. Dolby's "Virtual String Quartet" featured the first artwork to synchronize animated figures with three-dimensional sound so that various sounds appeared to originate from different points in space. In the "Virtual String Quartet," viewers (participants) found themselves in a rehearsal space where a string quartet played Mozart's Quartet No. 21. Moving to a different location within the rehearsal space shifted the sound so that the sounds from each instrument always appeared to eminate from that instrument. There was a further element of interactivity: You found out by tickling the violin player, he really wanted to be a bluegrass player and his playing would shift in this direction when he was "touched." Similarly, the bass player wanted to be Charles Mingus --- playing a jazz bass line. The music underlying this VR artwork was performed by The Turtle Island String Quartet (Teixiera, 1994).

Avatar Representatives

Another type of virtual character is an avatar who represents you in a virtual world. This extends the notion of virtual agents online that perform tasks such as sorting through databases to find information on specified topics. Perlin (1994) envisions this scenario: "You're at a simulated conference. You and everyone else at the conference are represented by human-like "avatars" within an immersive virtual environment. Later that day, your own personal avatar roams through a virtual shopping mall and goes into the virtual stores where you like to shop in cyberspace. The avatar reflects your look, mood, and personality (or perhaps what you would prefer people to think are your look, mood and personality) (p. 46-47)." VPL Research pioneered this kind of system with its RB2 (Reality Built for Two) where participants in a virtual meeting could playfully take on the avatar of a lobster or some other creature.

Perlin (1994) recommends that we should design these avatars so that "they have personality and a certain joie de vivre." This is a very appealing idea, although it doesn't convey the full potential of virtual characters.

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