A Model for Interactive Art

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Abstract. The new technologies of computer systems and artificial intelligence enable new directions in art. One new direction is the creation of highly interactive works based on computation. We describe several interactive artworks and show that there are strong similarities that transcend categories such as drama, music, and dance. Examining interactive art as a general approach, we identify one important dimension of variability having to do with the degree to which the art is focused on the process of interaction as opposed to generating a final product. The model that results from our analysis suggests future directions and forms of interactive art. We speculate what some of these new forms might be like.

1. Introduction

Technology finds many applications in the arts. Computer systems and computer technology are no exception. One particular application of computers to the arts is the enablement of a new class of interactive art. One could argue that art has always involved interaction among artists, performers, and audiences, but the computer has enabled a qualitatively different form of interaction where computation plays a key role. Our goal is to identify the key features of this new interactive art, to give examples, and to extrapolate these ideas to suggest new directions for artists.

We will begin by describing two of our own works, with an emphasis on what roles are played by the artist, machine, performer, and audience. We will find striking similarities between the works, even though one could be described as interactive drama, and the other as interactive music. We will also discover some important differences having to do with whether the emphasis is on the art process or art product. Armed with a unifying model for interactive art, we will look at some other examples and suggest some new approaches to interactive visual arts and interactive dance.

2. Interactive Drama: The Woggles in *Edge of Intention*

Our first example is *Edge of Intention*, a preliminary step toward interactive drama (Bates *et al.* 1992). *Edge of Intention* is a virtual world that contains three autonomous animated creatures, called *Woggles* (see Figure 1). Each Woggle has goals, emotions, and personality, and expresses these through movement and facial expression. A person we will call the *player* can interact with the Woggles (by playing the role of a fourth Woggle), while observing them on a computer graphics display. Woggles engage in simple social games, exhibit aggression, fear, sadness and joy, play and sleep, and perform several other behaviors.
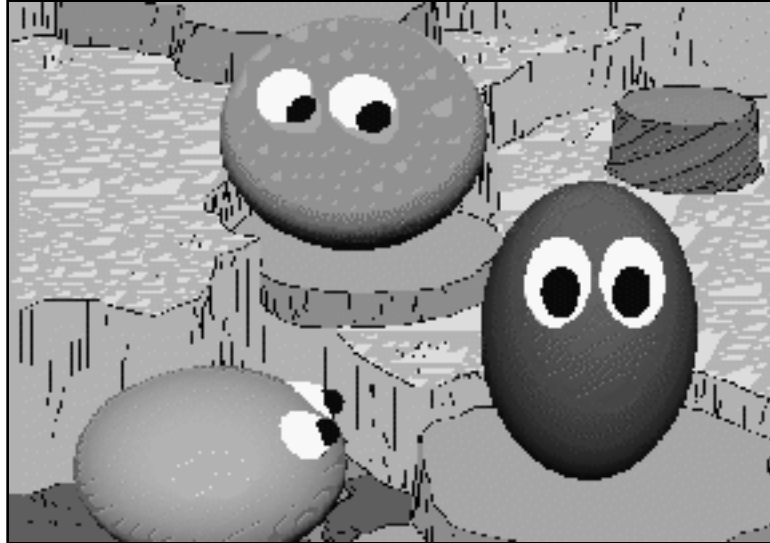
Figure 1. Image of the Woggles from *The Edge of Intention.*

In this work, the player can interact with the system, becoming one of the actors. The artistic purpose of the piece is to raise the question of whether the automated creatures should be treated with moral concern. This will happen only if the player sufficiently believes in the life and emotions of the Woggles. The difficult problem is for Woggles to exhibit sufficiently rich, varied, and meaningful behavior, especially in response to player actions, to give this illusion of life.

To achieve this goal and raise the moral question, it is not sufficient to rely on "canned" sequences that are scripted in advance, because it is impossible to plan for every possible interaction. The solution in *Edge of Intention* is to use a computer system to carry out the goals of the author. (Loyall and Bates 1993) Rather than authoring a specific dramatic interaction, the author creates an interactive system capable of generating any number of dramatic interactions in response to input from the player. The author then delegates control and all artistic decisions to the system.

Figure 2 illustrates a conventional authoring task, for example writing a book. Here, the author generates a static work of art, and the reader reads the book. For art to become interactive, there must be input from the reader (who, in our terminology, becomes the *player*), and there must be some artistic intelligence that responds to the player.
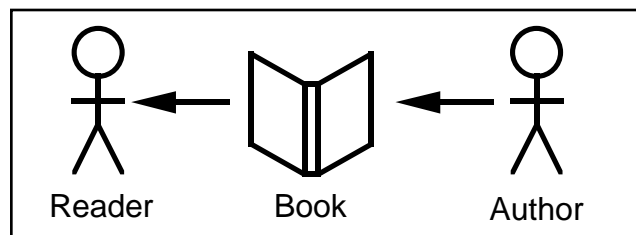

Figure 2. Conventional authoring.

Figure 3 illustrates the new configuration. The role of the author is now to create a system to interact on his or her behalf. The box with a small person inside represents an artistic system or agent, created by the author, that generates dramatic interactions with the player. It is

particularly important that the interactive system itself exhibits competence as an artist. We would not consider an interactive story with simple branching to be an example of this form.

Many would call this machine-based representative of the author an "intelligent system." We will avoid this term because in the field of Artificial Intelligence, "intelligence" has fairly restrictive connotations dealing with cognitive skills, logical reasoning, and knowledge representation. We want to stress that the mind has esthetic, emotional, and artistic aspects that are only beginning to be addressed in the Artificial Intelligence community. Until the term "intelligence" is commonly understood to include this broader conception of the mind, we will choose other terms to avoid confusion.
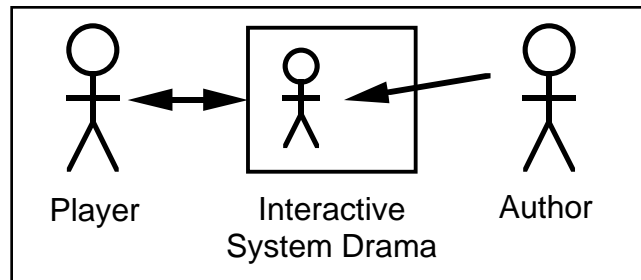

Figure 3. Interactive drama.

The art that arises from this configuration is a combination of the intentions of the author, realization of these intentions by the interactive system, and the participation of the player. In traditional art, the author produces a relatively static artifact such as a book, a musical score, or a dramatic script, and we identify this artifact as the work of art. In Figure 3, it can be seen that the static artifact is replaced by an interactive system, and it is less clear where the artwork lies. For the author, the interactive system itself is clearly a work, but art only "happens" when someone interacts with the system. In some cases, the *process* of interaction is the art. In others, there is a clear *product* of interaction such as a music performance or an image. The ambiguity of "where is the art" is, for us, one of the attractions of this approach.

In practice, an audience often observes the interactions of the player with the system, leading to the configuration shown in Figure 4. This arrangement seems to be common in interactive art, because interaction usually takes place between the system and one individual. (It is hard to interact with multiple players.) In contrast, the traditional non-performing arts usually have a unified audience and there is no player. Players *are* found in the traditional *performing* arts. Here their role is expert interpretation of the author's (or composer's, choreographer's, or playwright's) work.
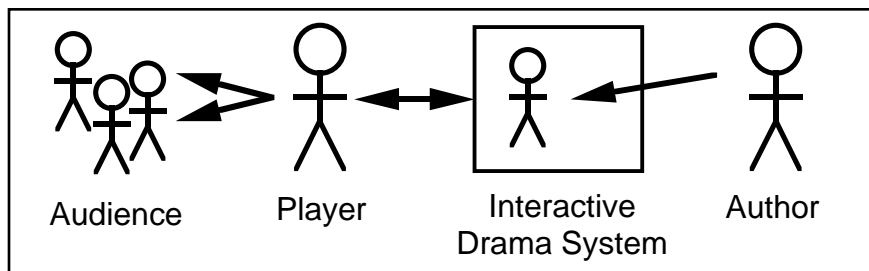

Figure 4. Interactive drama with an audience of observers.

3. Interactive Music: *Nitely News*

Nitely News (Dannenberg 1994) is a work for a live performer interacting with a computer music and animation system. (See Figure 5.) The object of the interactivity is to combine elements of improvisation and formal composition in live performance. Composers often find it difficult to include improvisational elements in a composition because improvisation usually implies giving up compositional control to the performer. If the composer holds the reigns too tightly, the performer has no freedom to improvise, but if the composer lets go of all control, the work ceases to be a composition.

Figure 5. An image from Nitely News. The live trumpeter (left) improvises while watching a computer-generated image of a dancer (right) and listening to computer-generated music.

In *Nitely News*, the composer controls the work not by writing specific notes, but by planning specific interactions and by responding to the improviser in certain ways. The interactive context established by the composer guides the improviser toward a certain style and form. In addition, much of the music is generated by the computer, and all of that music is under the control of the composer, subject to the requirement that it must blend with and react to the improvisation in a coherent fashion.

We can illustrate traditional music performance using a variation of Figure 2, as shown in Figure 6. We describe this as conventional "non-interactive" music making. Few musicians would describe their craft as "non-interactive," and we readily admit that this description is extreme. However, we believe the interactivity enabled by computer systems is of a qualitatively different nature.

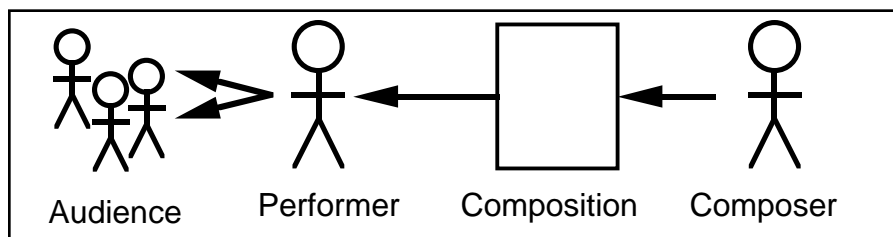Audience   Performer   Composition   Composer

Figure 6. Conventional music making.

Figure 7 is the corresponding diagram for interactive music such as *Nitely News*. Note the similarities to Figure 4. Again, we see that the creator, a composer in this case, has delegated decision-making to an agent of his or her design. The interaction is between a live performer and the computer system, and an audience attends the performance. As with interactive drama, the question of "Where is the art?" is ambiguous. The composer thinks of *Nitely News* as a composition, but it is also true that composition takes place at each performance.
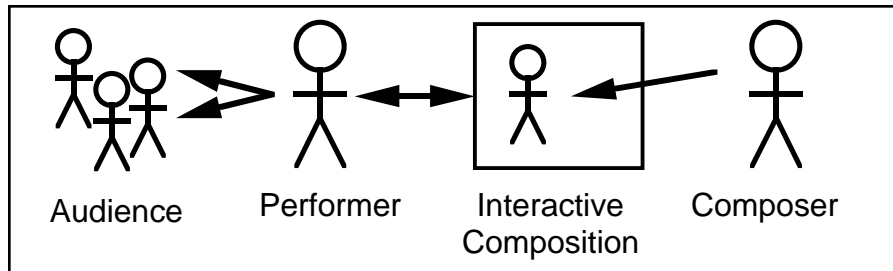

Figure 7. Interactive music.

4. Two Models for Interactive Art

Edge of Intention and *Nitely News* provide two models for interactive art. Both involve an artist (author or composer) who creates an interactive computer system that acts as an agent for the artist. In both models, a system carries out the goals of the artist at a speed that makes interaction possible. By design, the system is affected by input from a player or performer. In addition, the system must perform a substantial amount of decision-making and generation of artistic content. Our models rule out simple systems with no artistic competence that are nonetheless interactive, such as electronic keyboards, hypertext, or paint programs.

We feel that the behavior of interactive art is more appropriately associated with cognition, the mind, and creativity than with physics, matter, and tools. We would not consider a traditional musical instrument to be a work of interactive art. Rather, we look for computer systems where large amounts of internal state (memory) give rise to complex behavior. Such systems can perform rudimentary perception, create internal models of their users, plan future activities, and call upon stored concepts. Of course, systems have varying degrees of sophistication, so there is no sharp boundary between interactive and non-interactive art.

The models also rule out artistic but non-interactive systems. For example, the Aaron program of Harold Cohen is a famous image-making system based on artificial intelligence techniques (Roads 1979, McCorduck 1991). This system is outside the scope of our models because there is no significant interaction component. The system *does* act as an agent of the artist, but the purpose is not to allow real-time interaction with a player. In the case of Aaron, there is no interaction because the system is not influenced by any actions of its viewers.

There are some interesting differences between *Edge of Intention* and *Nitely News*. In the *Edge of Intention* model, the primary objective is the *process* of interaction experienced by the player. The player is not expected to be an artist or skilled performer. There is no need for an audience, although one is often present. When present, the audience enjoys the *process* of interaction vicariously, but the art is intended for the enjoyment of the player, not the audience. Another example of this phenomenon is observers in a video arcade. Also, in virtual reality systems,

images sent to head-mounted displays are often displayed on video monitors for the enjoyment of an audience.

In the *Nitely News* model, the primary objective is the *product* of a musical performance as opposed to the process. Because the product is especially important, the performer is an expert musician and the product is intended for the enjoyment of the audience, not the performer. It even makes sense to produce a recording of a performance for the enjoyment of an audience that is not present at the live performance.

5. One Model or Two?

It seems to us that the two models described above are in fact points along a continuum. At one extreme:
   • the focus is on *process*,
   • the player is likely to be amateur or unskilled,
   • the audience is unnecessary, and
   • if present, the audience experiences the interactive process vicariously.
At the other extreme:
   • the focus is on *product*,
   • the player is likely to be highly skilled,
   • the audience is a critical part of the enterprise, and
   • the audience can appreciate the results of the performance without any deep understanding of or interest in the process of interaction or art generation.

There are intermediate points as well. Consider the interactive art installation of Karl Sims (Sims 1993) at the Pompidou Center. A computer generates a set of images, each of which is displayed on a video monitor. Each monitor is on a pedestal and there is a pressure sensitive pad on the floor in front of each monitor. A "player" can approach a monitor and step on the pad to tell the system that the image there is good. This is the selection step in a genetic algorithm that produces a new set of images. (Sims 1991) By repeatedly selecting "good" images, the audience helps the computer evolve its image generation algorithms to produce still more interesting images.

In this system, the players are not intended to be skilled artists, so we would expect to see an emphasis on *process*. In the installation, some of the viewers are a rather passive audience observing the process of others interacting with the system. On the other hand, interesting images are generated and appreciated, so the *product* aspect is also important. This work seems to fall somewhere between the more extreme positions of *Edge of Intention* and *Nitely News*.

We conclude that our models are similar enough that they can be considered as different examples of one model. The one model gives rise to a variety of systems that vary along at least one important dimension having to do with the skill of the player and the focus on process or product.

6. Other Art Forms

Having examined and analyzed some examples of interactive art and placing them in a general framework, it is interesting to speculate about other art forms. Is there really a general model for a

broad range of interactive artwork, or are the parallels between *Edge of Intention* and *Nitely News* a coincidence?

6.1 Visual Arts

We have already discussed the work of Karl Sims in the domain of interactive visual art. Our model suggests that there may be yet other approaches. In one, the focus could be more on the artistic product (image). This might involve skilled artists as "players" who interact with an intelligent system. In the same way that *Nitely News* fosters cooperation between a composer and improviser, an interactive art system might enable new artworks that combine the sensibilities of two artists: one develops the interactive system, and the other works with it to generate images.

Moving in the other direction, one can also imagine there might be a kind of "process art" for use by non-artists. By "process art," we mean interactive image-making where the process of making or evolving images takes precedence over the images themselves. Video games approach this idea, but current games do not involve players in image making so much as exploring dramatic worlds or exercising quick reflexes in simulated combat. Perhaps some artistic intelligence to guide the image-making efforts of amateurs could result in an interesting new art form.

6.2 Dance

Our models for interactive art can be applied to dance. Previous efforts to use technology in the service of dance include design and notation systems for choreography such as LifeForms (Schiphorst 1993) or Motigraphicon (Ungvary, Waters, and Rajka 1992). Others have investigated the use of computers to create dance or to suggest movements (Brightman 1989). Notation systems are certainly interactive, but the interaction is between the choreographer and the design system. Furthermore, there is no ability to generate choreography from within the system. In the case of computers used to generate choreography, there are few systems that actually interact with dancers, responding in sophisticated ways to the dance as it progresses.

Examples of systems moving in this direction are interactive works by Myron Krueger (1991) and David Rokeby. Krueger's VideoPlace uses a video camera to capture a high-contrast image of the player. A mirrored silhouette of the player is projected onto a screen in front of the player, creating the illusion that the player is in some virtual world. The computer system manipulates the image to create various virtual activities such as painting or playing with virtual creatures. The system is very effective in evoking dance-like whole-body movements. Mandala (Warme 1994) is a low-cost commercial system apparently based on this work. Rokeby's "Very Nervous System" and "The Desert Dreams a Mirage – Silicon Meets Carbon, 1992" (Rokeby 1993) use cameras as motion sensors. Movement affects music or sounds and images which are generated in real time. The "Very Nervous System" is especially effective with dance movements.

Could our model be applied to dance? We can imagine a dance system along the lines of *Nitely News* in which choreographic expertise is embedded in an interactive system. The system must communicate with dancers. This could take place via video projections of artificial dancers, through wireless communication to hearing-aid-sized ear pieces, or through musical cues. The system must also perceive the dancer(s), for example through video cameras, joint angle sensors, or other means. The dancers would be skilled in choreography as well as dance and would

contribute improvisationally to the choreography. The dance would be performed for an audience.

In another scenario, an interactive dance system might be intended for amateur dancers. In this case, the process of interaction would be the primary goal and an audience need not be present. The audience might be a group of dancers. One could imagine that music and video images might interact with dancers in a sort of virtual reality game where communication is by body movement (i.e. dance).

7. Summary
We have presented a model for interactive art with 4 main components:
- a human artist,
- an artistically competent agent that realizes the artist's intentions,
- interaction, including input from human "players" and output from the computer system, and
- an optional audience.

This model can vary along at least one important dimension that relates to the artistic goals of the work. Is the primary objective to provide an interesting interactive experience, or is the objective to create interesting artifacts or performances? Most interactive artworks will have both objectives to some degree.

Our model also admits a range of sophistication, autonomy, and competence in the interacting agent. The point at which a system should be labeled interactive art as opposed to a tool, instrument, or stage prop is not well-defined, but we stress the point that computers allow very sophisticated systems that are qualitatively different from previous art.

8. Conclusions
Interactive art and its supporting technologies are the subject of several conferences. The United States and international artificial intelligence communities have recently shown significant interest in AI-based art, especially including interactive art. There were AI-based arts exhibitions at the AAAI-92 and AAAI-94 conferences (American Association for Artificial Intelligence), and one is expected at AAAI-96. Research papers on AI and the arts were presented at AAAI-94 and will be at the IJCAI-95 (International Joint Conference on Artificial Intelligence) and AAAI-96 conferences. In addition, AAAI has sponsored a series of workshops and symposia over the last five years on interactive characters, interactive stories, and interactive art and entertainment in general. The ICMC (International Computer Music Conference) features concerts involving interactive systems and technical sessions that address music perception, real-time control, music representation, and other related issues. In recent years, ACM SIGGRAPH (Association for Computing Machinery Special Interest Group on Graphics and Interactive Techniques) has paid increasing attention to interactive systems including interactive art. The Machine Culture exhibit at the 1993 SIGGRAPH conference (Penny 1993) is an excellent example.

Interactive art is an important development that is enabled by computer technology. By analyzing examples of interactive art, we can achieve a better understanding of existing and future works. Interactive art forces us to broaden our notions of what art is, how it is made, and how to

approach it. We think that interactive art offers great opportunities and great challenges as information, computing, and communication technologies permeate our daily lives.

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