TOWARDS EXPRESSIVE ANIMATION FOR INTERACTIVE CHARACTERS

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ABSTRACT

This paper describes issues important for the creation of interactive computer animated characters. Qualities required to make a character appear animate are derived from writings in perceptual psychology and the arts. These qualities are dependency, randomness, temporal phrasing, intentionality, and exaggeration. They are then applied to the design of a motion representation for an interactive animation system. Necessary features of a motion representation are found to be: parameterization, hierarchy, description of object-object relationships and separation of objects and motions.

KEYWORDS: computer animation, interactive systems, motion representation, motion perception.

Imagine a simple scene, a fish in a fish tank. It is swimming around, minding its own business, when it notices your approach (through some sensor). Its eyes flick over to follow you. If you are still, the fish approaches you slowly, appearing friendly, but cautious. Suddenly you say "boo" -- the fish freezes, jumps with surprise, and dashes away. If you make no further alarming actions, it may approach you again. Perhaps it will even tease you by playing cat and mouse.

How can such an interactive animated character be created? Most computer animation systems to date have been used for the definition of non-interactive (or scripted) animation. Badler and Smoliar include a survey of movement representations used in these systems. While any of these representations can be used to produce expressive characters, the expressiveness is the burden of the animator who is defining a particular sequence (as is the case in traditional animation.) In an interactive scenario, much of the burden falls on the animation system itself.

Our approach is to study human perception of animacy to find out what factors are important in perceiving expressiveness. We will discuss how to incorporate these factors into the motion representation of the interactive animation system.

HUMAN PERCEPTION OF ANIMACY

The movement of animate objects has special qualities from which a viewer readily determines animacy. We are interested in codifying these qualities in order to create interactive animated characters. We have been able to draw on a large body of empirical wisdom from the theatre and the arts, in addition to insights from perceptual psychology.

The following are desirable qualities which are important in human perception of animacy.

1. Dependent and Independent Movement.

The movement of two objects can be described in terms of the influence of one over the other. This perception carries important and relevant information, helping to establish the relationship between the two objects.

The degree to which each is offset from its previous course, and the extent to which a new course corresponds to the course of a partner, establishes the degree to which each is leader and follower. Michotte investigated, and defined, in considerable detail, motion patterns which cause the impression of causality.

Within a single figure, parts of the body which lead the motion are perceived as more independent than those which follow. This is well understood in dance, and used to create clearly readable lines of motion (Waleszek). Disney animation uses this principle extensively to contribute more lifelike compliance to figures. For instance, a figure wielding a baseball bat first draws the bat, which resists the pull. As the bat gains momentum, it takes over, pulling the figure along with it, sometimes to hilarious extremes (Thomas 1983).

2. Random, Animate, and Mechanical Motion

Exact repetition of a movement is perceived as mechanical, inanimate motion (Stewart 1984). Random motion cannot easily be perceived as animate, either. As more randomness is added to a motion when it is repeated, the perception of animacy is increased.

3. Temporal Phrasing of Movements

Parsing a motion (breaking it down into meaningful phrases or events) is something people do readily and naturally (Newtson). What constitutes an event is not well explained by experimental psychology, though the power of the phenomenon has been demonstrated by Newtson. Further, he found that when subjects were asked to identify events at different resolutions, their responses demonstrated a hierarchical structure of events.

Many parts of language are used to describe these kinds of temporal units: "a day," "dinnertime," "the man sets the table," "he sets down a glass." These phrases all have different durations, and have a clear relation to each other in a meaningful hierarchy (Scheflen). Music and dance use formal approaches to structuring hierarchical time events (Humphrey).

Disney used dramatic conventions in defining animation as a series of events each having a beginning, middle and end. Every action, in order to be clearly understood, ought to be framed by a special anticipation action, and a reaction or follow-through action. These guidelines are powerful enough to imbue one motion sequence with many different meanings by manipulating the pacing of the action. For instance, consider the following event: the head turns to look at some object (anticipation), the whole body turns to follow the head (main motion), the figure walks towards the object (conclusion/follow through). Executed quickly and smoothly, this motion can be significantly different than the same motion executed slowly, with long pauses in between each phase. The first case might convey an impression of an enthusiastic greeting, while the second might express a more cautious attitude. (Thomas 1981).

4. Intentionality

This is a quality which is readily recognizable in a system, yet whose formal definition is difficult. Dennett describes intentionality as an assumption on the part of the observer that the system (generally a complex and not fully understood one), will adhere to rules of logic; that it will display common-sense (for instance, it will not seek its own destruction without a reason) (Dennett).

Heider and Simmel have demonstrated that observers give consistent high-level interpretations (e.g. chase, flight, protection) to an animation using simple objects. However, no complete satisfactory explanation has yet been made as to precisely what factors elicit these impressions. Stewart has been able to show that violation of some of Newton's laws of physics also provide strikingly animate interpretation. A dot which begins to move without any apparent outside force appears animate, as do dots which diverge from a path in order to avoid a barrier. Curved paths appear more animate than straight paths (Stewart 1984).

As a practical matter, a computer model of an animated character should convince the viewer that its behavior is intentional. Such a behavior model might be expected to be a set of rules directing a character's reactions to various conditions. It might include some modelling of goals.

However, simpler models of interesting dynamic behavior may also achieve the impression of intentionality. Of interest is the possibility, suggested by Dennett, that the best impression of intentionality would be manifested by a system which seems too complex to fully understand. Furthermore, Dennett observes that the impression of intentionality has a certain amount of tolerance. This suggests that a model which is basically consistent and regular in its movements, could introduce a certain degree of irregularity, and would exhibit the quality of intentionality.

5. Exaggeration

This is a quality which pertains to all forms of communication. Interesting or unusual features of an object or a movement are often exaggerated to emphasize those features (Brennan). Exaggeration is achieved by increasing the contrast between two objects. A fast object becomes faster, a slow object slower. Where one object is influencing another, exaggeration would make the contrast between one's independence and the other's dependence more extreme.

Disney animators developed a sophisticated understanding of the use of exaggeration to intensify the personality and expressiveness of their characters (Thomas 1981).

Exaggeration can be a variable quality which is dependent on a given situation. A greeting can be more or less enthusiastic depending on which two characters are meeting.

COMPUTER REPRESENTATION OF ANIMACY

The following set of features are proposed as necessary for an interactive computer animation system to support the characteristics of animacy described in the previous section.

1. Parameterization

The most important feature of an interactive animation system is that its movement representations must be parameterized. That is, there must be a series of parameters in each movement sequence which can be used to vary the animation at run-time (Parke). For example, a definition of a walk sequence could have parameters with which to vary the step size, step frequency, knee lift, hip rotation, etc. A single parameter change (such as step size) can control the motion of many different parts of the body.

Parameterization supports animacy in two ways. First, the system is able to generate a rich set of motions which help prevent the perception that the motion is mechanical rather than animate. By manipulation of the parameters, a motion can be used many times without ever being exactly the same. Second, the parameters provide a way of controlling exaggeration. The amount that the jaws of a fish open while eating could be exaggerated by increasing the appropriate parameter to draw attention to this action.

2. Motion Hierarchy

An interactive system should also support a hierarchy of motion descriptions (Zeltzer). Each high-level motion (e.g. "go to the store") is made up of a series of simpler motions (e.g. "leave the house", "walk up the street") which are in turn made up of even simpler motions (e.g. "walk a step".) The bottom nodes of this hierarchy are made up of primitive motions (e.g. a single step.)

A hierarchy provides a natural way of breaking animation down into the recognizable chunks which people perceive as temporal phrasing. Since this phrasing is explicit in the motion description, the animation system can emphasize this phrasing through techniques such as anticipation and follow-through (Thomas 1981). For instance, if the next high-level motion was for a character to run twenty paces, the animation system could bring attention to this by showing an anticipatory winding up just prior to the run.

Furthermore, the higher level motions can be thought of as goals for the character. As such, the perception of the phrasing not only provides a way of understanding the action but also provides a way of sensing the intentionality of the character.

3. Logical Relationships between Objects

The system should provide a method for describing logical relationships which must remain true during the animation. These relationships include collision avoidance, maintenance of balance and connectivity of animated objects. Since the motion descriptions are variable at run time, the animation system must provide these checks itself.

In addition to maintaining a logical consistency in the animation, these relationships also support the perception of animacy by differentiating the dependent and independent parts of the animation. For example, a range of proximity could be specified between various fish in a school to provide each with some local variance and yet maintain the group through larger motions.

4. Separation of Motion and Object Representation

Finally, it is important to separate the description of the motion from the considerations of object representation. First, it allows the motion descriptions to be used in a library such that a single motion can be applied to several different objects. Second, this allows different renderings (e.g. vector, raster) to be generated from a single motion description.

CONCLUSION

Having examined the requirements for creating interactive animated characters, and proposed some design considerations, we are now building systems to verify them. We currently have several independent projects investigating the ideas described above. Some simple models of animate characters have been implemented. Further research will extend these models to encompass all of the qualities discussed above. Also, the design and first level implementation of a flexible parameterized motion representation has been completed.

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