Chapter 22

The Future of Gaming

Introduction

For our last chapter, we're going to indulge in a little blue-sky speculation about what the future of gaming might hold. It's clear that the commercial game industry has only begun to scratch the surface of what interactive entertainment can do. We are still a long way from exploiting the full potential of this medium.

Gaming Hardware

Many aspects of game design are independent of the hardware running the game: subject matter, theme, and art style, for example. Nevertheless, the future of interactive entertainment is closely tied to the future of computing hardware. At the moment, the principal emphasis in hardware design is on making games look and sound better, and indeed, the amount of audiovisual improvement in the last 20 years has been astonishing. But game hardware does much more than that: It determines how complex and how smart the games can be. That, in turn, affects the kinds of games we can make. We have just started to build games that simulate the behavior of humans, for example, at a level above the trivial. For more powerful simulations, we need more powerful machines.

Specialized game hardware might include dedicated neural network processors and voice-recognition or speech-synthesis chips. We might see special chips dedicated to solving pathfinding problems or to simulating thousands of cellular automations such as ants in an anthill or soldiers on a battlefield. In the more distant future, there could be chips that know the grammatical rules of a language and can generate real dialog on the fly rather than prerecorded responses. Whether such gear will get out of the laboratory and into consumer products is another story; it will depend more on what it costs to build than on how useful it is to games. But hardware R&D for games is already taking place, and it will increase now that game development is starting to be recognized as a legitimate subject of academic study.

In the next few sections, we talk about some of the game hardware commonplace today and where we see it going.

Out-of-Home Entertainment

Out-of-home entertainment refers to video games that you have to leave home to play. Typical kinds of out-of-home entertainment are coin-operated machines (once known as arcade machines but now called video amusement machines within that industry because arcades are no longer common), ride simulator theaters, and immersive networked pod simulators. You may also see the term *location-based entertainment,* but it more often refers specifically to pod simulators. The phrase "Unachievable@Home" is a marketing term increasingly used to describe these types of games because they offer features not available on personal computers or home console gear. For example, a *Dance Dance Revolution* coin-op machine actually provides a superior experience to the same game played at home. If you're interested in providing high-adrenaline entertainment with a lot of powerful hardware, these devices may well be for you.

The Stinger Report (**www.thestingerreport.com**) is a regular newsletter on the subject of out-of-home entertainment that we recommend for additional reading. We're indebted to its editor, Kevin Williams, for his assistance with this section.

Coin-Op Machines The heyday of big video arcades is over, killed for the most part by the high quality of the entertainment that home console games offer. Arcades suffered a revenue crash in 1996, soon after the delivery of the first generation of CD-ROM–based console machines. Console games cost less per hour of play and can be richer and more complex than arcade games because console games don't have to make money every few minutes. Console games also allow the player to save the game and return later, something a coin-op game cannot offer.

Coin-op machines are still around, however, in mixed-entertainment locations such as family restaurants, cinemas, and theme parks and in places where kids are likely to be stuck for a while with nothing to do, such as airports or hotels. Modern amusement machines create their appeal by offering features that you can't get at home, such as expensive hardware—a driving simulator with a force-feedback steering wheel, pedals, and a gearshift, for instance. Such devices will certainly continue to exist, but the high cost of manufacturing them means that they will have to charge a lot to make back their initial price. In addition to these, there is a steady business in bar-top machines—small machines with comparatively simple multiplayer games aimed at adults, placed on the bar in clubs and other drinking establishments. As more and more adults grow up familiar and comfortable with video games, we see this as a growth industry.

Ride Simulator Theaters A *ride simulator theater* is a room designed to give a medium-sized audience—typically from 20 to 100 people—the impression of riding in a vehicle. The floor of the room is actually a large platform mounted on hydraulic actuators and typically fitted with theater seats. The audience faces a large screen on which a story is shown, and the actuators cause the floor to move up and down to increase the feeling of movement. Surround-sound speakers complete the effect.

Ride simulators are extremely expensive, costing several million dollars to build. The early ones were not interactive at all, consisting only of a short movie with an accompanying script that controlled the movement of the floor. The modern ones use computer-generated 3D environments and give the audience something to do—usually shooting at targets—the effects of which are seen on the screen. These actions can also have an effect on the platform. If some of the players handle a large gun, for example, the hydraulics can simulate the gun's recoil. We can certainly expect to see continuing advances in the realism of the experience.

Ride simulators won't ever become a widespread phenomenon as video arcades were; they're just too expensive. Because they have to admit people in groups for short periods, they require a large audience who can afford the time and who are willing to wait in line for a while. This makes them perfect for theme parks and resorts. Ride simulators are also safer than conventional thrill rides and more easily reconfigured with new content, which makes them attractive to theme park operators. The future of such simulators depends upon the economy in the same way that tourism and all forms of expensive leisure entertainment do.

Individual Networked Simulators *Individual networked simulators* are groups of small enclosed cubicles, sometimes called "pods" or "cockpits," each designed for one person or perhaps two. The pods are networked to play a single game so that people can compete against each other alone or in teams. These simulators are not usually owned by individuals. They are installed in theme parks and similar places, and players pay to play for a certain amount of time. They offer high-quality, multiplayer gaming, usually of vehicle-based action games such as flight simulators or mechs. Because the player is usually completely enclosed, these games also offer a highly immersive experience. The Bandai Gundam pods are a good example.

The arrival of the Internet—and especially broadband connections—has reduced some of the demand for these centers. Although the quality of the experience playing on a PC is not as immersive, it's much cheaper, and you don't have leave home to do it. We expect that pod simulators will remain a niche market with demand proportionate to their price. They will, of course, continue to benefit from improvements in computing hardware, but as with ride simulators and the fancier coin-op games, the majority of their production cost is in the mechanical rather than the electronic gear, and that's not going to change as rapidly. Like ride simulators, they will most often be found in dedicated entertainment venues.

Home Video Game Consoles

Game consoles have won the hearts of consumers, and they're here to stay. Designing a game console is tricky business because the manufacturer has to balance the console's cost against its computing power to compete against other consoles on both price and performance. Unlike PCs, consoles can't be customized over a whole range of performance characteristics. Instead, all consoles of a given model are identical (or nearly so) so that any game made for that model is guaranteed to run correctly. This means that the manufacturer gets only one chance to design it properly. We see a number of trends in console machine design that will affect gaming in the future.

Consoles Become More PC-Like There's no doubt that home game consoles will continue to take advantage of the growth in computing power: faster CPUs, more memory, and better audio and video technology. These will have the greatest impact on the look and feel of the games we play. More important, however, home game consoles are starting to take on some of the characteristics of their more powerful cousin, the PC: disk drives and networking capability. The ability to speak to other players using microphones has already substantially changed the feeling of multiplayer networked play. These features will enable console players to have game experiences that, until recently, were available only on PCs: to download and store game upgrades or new scenarios on a disk drive, for example, and to play against other people around the world. As consoles get more PC-like hardware, we can expect to see an ongoing convergence between console and PC games. This convergence will only go so far, however, because the PC's keyboard and mouse continue to offer input options not readily available on console machines and because the distance between the player and the screen will remain smaller for PCs than for consoles.

The Relationship of Consoles to Other Media Players Game consoles are now capable of playing audio CDs and video DVDs, which means there's little need to own a separate media player for each of those devices if you already own a console. We don't expect that game consoles will entirely supplant standalone versions of those devices because some people will want media players without the gaming capability. Nevertheless, we believe that consoles will be an increasingly important part of the family's "entertainment center," the cluster of equipment located underneath the TV. One game console with a built-in DVD drive and hard-disk drive could replace both CD players and DVD player/recorders. Consoles have the potential to become complete computerized "entertainment managers" if their manufacturers want to take them in that direction. All of this adds to their cost, however.

Input Devices Only time can tell whether the motion-sensing features of the Nintendo Wii controller (and others) will prove satisfactory over the long term. Such devices tend to be tiring with prolonged use; nobody likes to wave his arms around for hours at a time. This is exactly why the mouse was invented in the first place: It does not require the user to lift his hand from the desk. However, motion-based interfaces may prove to be so effective that players will be willing to give up longer play sessions in exchange for a more active experience.

We believe that the market for add-on devices such as dance mats and other specialized controllers will continue to grow. As game playing occupies an increasingly larger slice of people's leisure-time entertainment, they will invest in gear accordingly. Although only a minority of gamers will buy them, these devices' profit margins are much higher than those of the base machines, making them a lucrative source of revenue for the hardware manufacturers. And such gadgets do make the experience of playing games designed to take advantage of their particular features much more enjoyable.

HDTV and High-Density Storage The Achilles' heel of all home console machines is their output device, the conventional television. The television's low resolution, 25- to 30-frames-per-second refresh rate, and 4:3 aspect ratio are just adequate for displaying movies and TV shows, but they don't allow either the detail or the speed available on personal computer monitors.

We think that the growing popularity of high-definition television (HDTV) will significantly improve home console gaming. A wide screen offers a more natural viewing experience, allowing events to take place in the player's peripheral vision. The higher resolution will allow for more detailed images and more complex user interfaces. A number of Xbox games already support HDTV resolutions, and as HDTV becomes the standard, all new generations of consoles will certainly do so.

The arrival of Blu-Ray and HD DVD means that console machines can now store a truly staggering amount of information. While this will be valuable for showing HDTV movies at full resolution, a law of diminishing returns has already begun to set in with respect to the amount of content a game offers. It now costs so much to develop a blockbuster video game that fewer and fewer really large games are being developed. The industry is moving more in the direction of shorter but richer games and looking into procedural scene representation (discussed later in this chapter) as a means of reducing the amount of work required to generate video game artwork. The industry will definitely make use of the additional space, but not for every game.

Personal Computers

The personal computer is nearly 30 years old now, and it looks set to be here for the foreseeable future. Although the appearance and capabilities of the PC (by which we mean all personal computers, not just the IBM PC and its clones) might change, even a hundred years from now people will still want a computing device on which they can read and write, do research, and process information. There's no reason that that device shouldn't also provide them with interactive entertainment.

Of course, personal computers will become more powerful. They will get better sound systems and larger, higher-resolution monitors. Development of graphics hardware will continue to drive—and be driven by—computer games, and this will enable richer, more detailed scenes. In addition, new technology now allows programmers to offload nongraphical CPU-intensive tasks onto specialized processors. Hardware designers are creating specialized chips for both physics and artificial intelligence tasks that will probably be added to future graphics cards, making them no longer *graphics* accelerators but *gaming* accelerators. As with home consoles, sheer computing power will make the biggest difference in the way games look and feel on the PC.

Over the last few years, we've seen a variety of specialized hardware for dedicated gamers: force-feedback joysticks and steering wheels, automotive and airplane pedals, and so on. Those will continue to sell—there's no particular reason for them to die out—but they won't ever routinely be bundled with PCs because the demand for them is too small to justify the expense. Virtual reality gear fits into this category as well. It's expensive and unnecessary for most personal computing tasks.

Even with advances in handwriting recognition, the pen will not replace the keyboard as the primary interface for the personal computer. The typewriter superseded the pen as a means of creating text because it was faster and less tiring to use, and that is even more true of modern keyboards. The combination of keyboard and mouse is perfect for most applications except actual drawing. Professional artists use digital pens (graphics tablets) with personal computers, but few other people do, and pens certainly have little use in gaming on PCs. The Nintendo DS has shown that a touch screen is a viable gaming input device on a handheld, but it would be awkward on a PC.

Voice recognition, on the other hand, has tremendous potential for gaming—more even than for business applications. Although dictation is faster than using a keyboard, talking eventually becomes tiring and makes for a noisy, distracting office environment. But games are noisy anyway, and suspension of disbelief will be greatly enhanced by being able to shout, "Group one, charge!" rather than pressing the 1 key and clicking a menu item labeled Charge. And, of course, microphones are already very much in use for communication between players in multiplayer gaming; this will only increase with the growth of broadband Internet connections.

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IN THE TRENCHES: Why Consoles Won't Kill Off the PC

Every time a new generation of consoles comes out, pundits pop up on the Internet and in the gaming magazines to proclaim that the PC is dead as a gaming platform. This assumption is based on the fact that the new generation of game consoles closely approaches, or even surpasses, the computing performance of the PC at a much lower price. And as we said in the previous section on consoles, we can expect to see a growing convergence between console games and PC games as console hardware begins to include such features as disk drives and Internet access.

Nevertheless, the PC is here to stay as a gaming device because its appeal is not based on its performance characteristics alone. The most important difference between the PC and the console is not its hardware but simply where you sit when you use it. The PC is designed to be used at close range by a single person because that's how we need to use it when we're working on documents or surfing the Internet. Certain games—construction and management simulations, for example—are best played that way as well. The game console, on the other hand, is designed to be used by one or more people, sitting farther away so they all can see. This is great for multiplayer experiences such as sports or fighting games, okay for flight simulators and action games, and terrible for any game with a complex, multilevel user interface. That's the area in which PCs excel.

Controversial Subject Matter

Another reason that consoles won't kill off the PC as a game platform is that the PC is the only platform on which you can explore controversial subjects. To publish a console game, you have to obtain the approval of a publicity-conscious hardware manufacturer. The best thing about the PC is that anyone who has one can create a PC game. Neither a profit-gobbling license nor a hugely overpriced development kit is needed, which is why the PC is where the most cutting-edge work is always done.

Continuous Technological Advancement

Finally, the technical quality of PC games will always eventually surpass that of the games on any given console machine. This is because a console machine is an inexpensive device that remains technically static from its launch until it is finally superseded by a new model. The PC, on

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the other hand, is an expensive device that continues to improve year by year. (There have been a few efforts to construct console upgrades, such as the Sega 32X and Sega CD add-ons for the Genesis, but none were really successful—people don't seem to want to upgrade their game consoles.) If you have a game design that demands the very latest technology, the PC is the only place you can put it.

Handheld Game Machines, PDAs, and Telephones

From the simplest toys that play only one game on a black-and-white LCD screen to the PlayStation Portable with its built-in optical drive, handhelds are a hugely popular gaming medium, especially for children. Rugged, portable, and comparatively cheap, they offer increasingly sophisticated games that until recently could be played only on much more expensive machines.

There's a lot of talk about the convergence among handheld devices, and although it's bound to happen to some degree, that doesn't mean that all handheld devices will merge into a single, universal portable computer. There will always be mobile telephones without any real game-playing facilities for people who only want a telephone, and there will always be low-end handhelds with no communications capability. Nobody wants their four-year-old racking up phone charges by accident.

The practical limitations of handheld devices are not in their computing power, which will continue to grow, but simply in their physical dimensions. A handheld can't get bigger than a certain size without becoming a nuisance to carry around. Although you can get a very enjoyable gaming experience from a handheld device, it will never be as immersive as sitting in front of a high-resolution monitor with big speakers and a subwoofer jarring your bones.

We expect to see steady growth in gaming for handheld devices. Telephones and phone-equipped or wireless PDAs offer the most potential because players can compete against each other, and networked multiplayer games for handhelds will grow faster than single-player handheld games. This will be particularly true in the Far East and Europe, where more people use public transportation than in America and so have periods of time during their day with nothing to do. Handhelds offer excellent growth potential for games for the casual gamer—someone who wants to play for 10 or 20 minutes as a break from the daily routine.

Virtual Reality

Virtual reality is a term for a technology that tries to make the player forget where he really is and to feel as if he's in the game instead. In practical terms, this means loading him down with a helmet that includes earphones and a pair of miniature liquid-crystal displays for stereo vision, as well as a position sensor that can determine what direction he's looking. VR was considered something of a holy grail for gaming a few years ago, but now it has almost dropped out of sight. The gear is expensive, and unless it's carefully calibrated to the individual user, it tends to give people motion sickness.

Still, there's a lot of potential for the technology. If you've ever seen a really good 3D movie—one projected with polarized light, not the old red-and-green glasses—then you know how powerful the effect of stereo vision is. On a big screen occupying all your peripheral vision, it really does make you feel as if you're in the scene. To do this on a computer means computing two different images, one for each eye—and, of course, that requires twice as much graphics processing power. To reduce what's called "visual stress"—making the eye work harder than it normally does—VR gear must operate with high resolution at a high frame rate and with sharp focus.

We think there's a future for virtual reality in games, but it's still several years off. The quality of the helmets needs to get much, much better, and the cost needs to get much, much lower. In any case, VR is unlikely to become the standard way of playing. Many people like to play console games in groups, and they enjoy interacting with their friends as they play. Shutting out the rest of the room with a VR helmet will significantly degrade that experience. VR will probably be at its best in single-player or multiplayer networked games.

The Future of Game Programming

The way we program computers, even after 50 years of doing it, is still slow, exacting, and error-prone. Almost all the efforts to devise better kinds of programming languages and better ways of programming have been ignored by the game industry, which usually trades convenience and even reliability in exchange for execution speed. Game programmers are notoriously conservative; it took many years to persuade them to program in high-level languages rather than "down on the bare metal," and it took them many more years to use object-oriented techniques and project-management tools. Even today there's still something of a cult of machismo among the more hard-core programmers, each trying to outdo the others to squeeze a few more instructions per millisecond out of the hardware.

Most game machines contain a single general-purpose central processing unit and one or more dedicated graphics processing units. Their CPUs follow the traditional one-instruction-at-a-time model that goes all the way back to the Jacquard loom. This design was originally intended for computing ballistics tables for artillery guns, not for simulating complex scenes or looking five moves ahead in a chess game. The Cell processor used in the PlayStation 3 encourages the use of parallel processing, but few game programmers are trained to write code for it.

Because computers are designed to perform mathematical calculations, our models are all still mathematical rather than, say, neurological. Mathematics has the advantage that it's highly abstract and can be applied—with varying degrees of accuracy—to nearly anything.

However, despite the fact that the near future doesn't look as if it will offer any major changes to the way computers are built and programmed, we do expect to see a number of advances in computer programming, and these will have a distinct effect on game development as well.

Scene Representation

We've separated scene representation from animation because the two represent different kinds of programming problems. The current state of the art is to present a scene as a set of textured surfaces whose shapes are defined by a database of polygons. 3D graphics-acceleration hardware is essential for doing this quickly. It works very well for the simple problem of displaying static objects in a room, so most of the graphics programming effort now has turned to harder challenges: creating lighting effects, particle effects, fog, and so on.

As for the future, there could come a time when hardware support for drawing polygons seems as antiquated as hardware support for drawing lines does now. There are at least three other ways in which scenes can be displayed, and there might be more that we haven't envisioned.

Mathematical Representations At the moment, scenes are represented as data: thousands or millions of points in 3D space that define the corners of the polygons that make up the surfaces that we see. These data normally are created in a 3D scene editor such as 3D Studio Max, and they take up a lot of memory. They're particularly expensive as a way of representing curved surfaces because they have to break down the curve into a large number of straight lines.

Another way of representing a scene is by describing it as a series of mathematical equations that describe the surfaces, whether curved or flat. Two techniques currently under investigation are nonuniform rational B-splines (NURBS) and Bézier patches. Program code uses the equation to calculate the shapes of the surfaces and project them onto the screen. It takes more computing power than drawing polygons, but it allows the artist to represent more curves in less memory.

Procedural Scene Representation Instead of storing a database of points or mathematical equations, a programmer can "paint" a scene algorithmically by writing program code that generates an image on the fly—a chair subroutine would draw a picture of a chair, for example. This extends traditional object-oriented programming, in which programmers write code that determines how objects behave, to include the concept of code that determines how they look as well. Unlike raw image data, a drawing algorithm can be given new parameters to tell it to draw things in a variety of ways. This technique is used in Maxis's game *Spore,* but so far this is the only major game to try it. It holds great potential for the future, however, because it reduces the amount of effort required by artists to create individual objects. Procedural scene representation is also hardware-independent, another advantage. The code that draws the image need not know anything about the output device; it simply creates pixel data at any desired resolution.

Real-Time Ray Tracing Ray tracing is an extremely slow but powerful technique in which the color of each pixel on the screen is computed, one by one, from a three-dimensional model of a scene, including its light sources. The idea is that each pixel is hypothetically "lit" by a ray of light coming from somewhere within the scene, and the process computes where it originated and what happened to it. Because it computes each ray of light individually, ray tracing can display the effects of mirrors, lenses, translucent surfaces, and anything else that affects light as it travels. The process normally takes many hours to generate a single still frame, depending on how complex the scene is. Ray tracing is often used to create special effects in movies because it has to be done only once for each frame of the movie. In a computer game, in which things are changing on the fly 30 times a second or more, it's much too slow—for now. But there could be a time when real-time ray tracing is made possible by hardware accelerators.

It's impossible to predict which lines of research will prove fruitful. One thing is certain: Whatever is the hottest, most exciting state-of-the-art technique today will be yesterday's news a few years from now. This is one of the reasons a designer should avoid creating designs dependent on a specific piece of hardware—they age too quickly.

Animation

In film and television, animation is prerendered and can be refined in the studio until it looks right in every scene. In computer games, however, animation must be displayed on the fly, often without any way to adjust it to account for differences between one scene and another. This is fairly easy when animating rigid mechanical objects such as machines, and it is very difficult with soft, deformable objects such as people, animals, and fabric. When the action being animated is self-contained and has a natural cycle, such as a person running in a straight line along a flat surface, it looks pretty good. However, there are a number of ways in which computer game animation can be improved in the future.

Facial Animation and Speech Generation The human brain contains special neurological wiring that responds specifically to faces, and the face transmits a huge amount of data about the emotional state of the speaker. Obviously, prescripted facial animation performing in conjunction with fixed audio clips of the character speaking is already commonplace, but the holy grail of facial animation is on-the-fly lip synchronization with artificially generated speech. We've reached the point at which we can do this with rather wooden, robotic-seeming characters, but truly natural-sounding speech will come in time. The other aspect of facial animation, emotional display, also shows great promise. At the moment, a few games are doing this in a fairly clumsy way—a raised eyebrow or a frown—but before long we will be able to do more subtle expressions. The experimental game *Façade* has demonstrated early success at depicting mixed emotions such as a false cheerfulness masking deep-seated anger.

Inverse Kinematics Computer animation involving interactions between two objects often doesn't look right. Consider the simple motion of walking uphill. With each step, the walker's forward foot should stop descending at a point higher than his rear foot because the ground is higher there. The angle of his ankles should also be different from what it is on flat ground because his feet are sloping upward from back to front. If you use the same walk cycle that you would use on flat ground, the walker's forward foot will appear to descend into the earth, and his ankles will be at the wrong angle. To correct these errors, it's possible to use a programming technique called *inverse kinematics* to compute where the heel and toes should stop based on the height of the ground they will contact. The data for the position and orientation of the legs is then modified to account for the different height of the surface. This has to be done at every step to compensate for changes in the angle of the surface. If the terrain flattens or starts to slope downhill, the positions of the legs must change to reflect that.

Inverse kinematics have a great many uses besides depicting walking. In reaching out to pick up an object, for example, the distance the character's arm extends naturally depends on how far away the object is. If the animation for extending the arm is fixed, the model must be the same distance from every object it is going to pick up. If the model is too far away, its arm will stop moving before the hand reaches the object, which will then appear to float up in midair. If the model is too near, its hand will appear to pass through the object. By using inverse kinematics, the model's arm can be made to stop extending at the point where the hand touches the object.

Inverse kinematics are computationally more expensive than using fixed animation, especially when large numbers of animated people are moving around in complex environments such as a cocktail party. But research is underway, and as processors become more powerful, we can expect to see more of this technique.

True Locomotion At the moment, most computer animation moves a 3D model in much the same way a marionette moves. A marionette wiggles its legs back and forth to look as if it's walking, but the puppet isn't really moving by pushing its feet against the ground. The same is true of computer models: The movement of the model through an environment is actually computed by a mathematical formula unrelated to the movement of its legs. Typically, the speed of the model either is fixed or varies according to a straight-line acceleration, as with a rocket. But if the movement of the legs doesn't actually match the speed of the model over the ground, it produces a visual anomaly: The character looks as if she is ice skating. This often appears in sports games in which different athletes run at different speeds depending on their ability ratings, but they all use the same animation cycle for running. In most other games, all characters move at the same speed or at a few fixed speeds, each of which has its own properly tuned animation cycle. For now, only sports games have a wide and continuous range of speeds for all their athletes.

The solution to this problem, even more processor-intensive than inverse kinematics, is *true locomotion*—that is, simulating the movement of a body according to real physics acting on the body, involving its mass, strength, traction on the ground, and many other factors. If done properly, calculations should also take into account such features as the swaying of the person's body as weight shifts and the flexing and deformation of the feet under the changing load conditions of walking. True locomotion is common in prerendered animations such as the dinosaurs in the film *Jurassic Park,* but it has yet to be seen in computer games because we just don't have the processing power to do it in real time, especially for a whole field full of athletes. But it won't be long before we do. It's another thing to look for in the coming years.

Natural Language Processing

Not long after computers were invented, early artificial intelligence researchers confidently predicted that they would have programs speaking and understanding English within ten years. Fifty years later, we're not significantly closer to that goal. Computers do use language to communicate with their users, but it's almost entirely by means of prescripted sentences. Few programs have been devised that can express meaning by generating sentences from individual words, and those few usually do so over a very limited domain.

It turns out that generating and understanding natural language is an exceedingly hard problem. Large areas of the human brain are devoted to it. Language comprehension involves much more than understanding the dictionary definitions of the words and the rules of grammar; it also takes into account the relationships between the speakers, their physical circumstances, the sorts of routine conversational scripts that we follow, and many other variables. To give an extremely simple example, a person who is drowning might shout "Help!" to those on shore, and a person on shore who can't offer help himself for some reason might also shout "Help!" The first person obviously means "help *me*" while the second means "help *him.*" It's up to the listener to observe the situation and draw the correct conclusion about who needs help. Most of us could do this in a fraction of a second, but at the moment, no computer program can do so at all.

A great deal of natural language comprehension is tied into something called "common sense," but common sense is so enormous and illogical that we don't even know how to start to teach it to computers.

Nevertheless, natural language processing will be extremely significant in the games of the future. There are two problems to solve: language recognition and language generation.

Language Recognition Language recognition isn't the same as voice recognition, which we've already dealt with in the section on gaming hardware. *Language recognition* is the process of breaking down sentences to decode their meaning, also called *parsing.* Computers aren't too bad at parsing sentences that refer to a tightly restricted subject. This is what compilers do as the first step in processing program source code. Source code, however, has extremely rigid rules and an unambiguous meaning for everything. English is much more complex, fluid, and illogical. Consider the sentence, "Alice told Betty that she would have to leave." Who would have to leave?

Giving orders in English will be a lot of fun, as long as it doesn't prove to be less efficient than doing it by other means. Most games provide a fairly restricted domain, so orders such as "Attack," "Hold your ground," and even "Start a diversion on the west side of the enemy base" won't be too difficult to interpret. But the real challenge for language recognition will be in games that have simulated characters with whom the player wants to converse. Early text-based adventure games did a certain amount of this, but most of that work was abandoned with the arrival of graphical adventure games and scripted conversations. For the moment, most programs that attempt language recognition fake it, guessing what the player means from keywords in the input and responding more or less appropriately depending on how good the guess was. This is another area in which the game *Façade* broke ground: It tried to make the player's input fit into the context of an ongoing conversation among three people—the player and two NPCs. Most efforts of this sort have only tried to create two-way conversations between the player and one NPC. However, it will probably require several more decades of AI research before we can do language recognition really well.

Language Generation Simple language generation—assembling prerecorded phrases into sentences, called *stitching*—is less difficult than language recognition. Unlike parsing user input, which could be anything, as designers we can limit the scope of what a game character says and guarantee that it's grammatically correct. We're already starting to do this well, and the quality of stitched audio will continue to improve.

In the near future, we won't be able to expect to have wide-ranging conversations with artificial characters, but we ought to be able to simulate reasonable interactions in stereotypical sorts of situations: bartenders, gas-station attendants, invading aliens, and so on. For now, these will probably remain scripted conversations, but we might be able to replace the current mechanism, in which the game just delivers a canned piece of dialog, with a sentence assembled from semantic fragments that vary somewhat depending on the character's state of mind. To give a trivial example, take the sentence, "I don't know," as a response to a question to which the character doesn't have the answer. If the character feels sympathetic to the player, the software could add "I'm sorry, but" before the sentence; if the character feels unsympathetic, it could add, "and I don't care" at the end.

Real language use, in the sense of converting a character's mental desire to make a "speech act," along with the semantic content of that act, into an actual utterance is a far harder problem. Games will undoubtedly be able to do it someday, but as with language recognition, this is primarily a subject for AI research at the moment.

Game Genres

It's nearly impossible to predict what new genres of games might arise in the future. American designers never anticipated the dance simulations that came from Japan. There will undoubtedly be more as the medium expands.

One thing is certain: For interactive entertainment to grow, we have to be open-minded and willing to explore. Why didn't American game designers invent the dance simulation themselves? Probably because the idea of making a game about little girls dancing was just too uncool. The notion that gamers are all adolescent boys is clearly outdated, yet many designers persist in building games as if they were the only market.

To invent a game in a genuinely new genre, you have to throw out all your preconceived notions about computer games and start from scratch with two simple questions: *What activities do people think are fun?* and *Can that activity reasonably be turned into a computer game?*

In the meantime, we'll discuss what we think will happen in some existing genres.

Action Games

The challenges in action games arise mostly from their twitch elements: motor skills, coordination, and timing. To a lesser extent, they also include puzzle solving and exploration—figuring out where to go and what to do to survive and pass through the level. These are well-understood elements of an action game's design. Most of the advances in action gaming in recent years have been in the game's content rather than in the nature of the challenges it offers. *Banjo-Kazooie,* for example, was a very successful game about a bear (Banjo) carrying a bird (Kazooie) around in his backpack. This peculiar bird-bear avatar enabled the designers to create a number of unique moves that would have been incongruous if the avatar were just a bird or just a bear. *Legacy of Kain: Soul*

Reaver was a game about a maimed vampire with only a limited ability to fly. *Toy Story,* of course, was based on the movie and was all about toys in a suburban environment. This kind of imaginative thinking will keep action games moving forward rather than stagnating.

First-person shooters represented a big leap forward when they appeared, but their key innovations were the quality of the display and the richness of the environment rather than the concept itself. Multiplayer first-person gaming goes back at least as far as the early 1980s, when a game called *MazeWars* was programmed for the short-lived Xerox Alto workstation. Since then, most of the advances have been evolutionary rather than revolutionary: nonrectilinear rooms and stairs (the biggest differences between the original *Wolfenstein 3D* and *Doom*), a greater variety of weapons and enemies, and so on. We can expect to see continuing evolutionary advancements in the first-person shooter genre providing better graphics, better sound, and especially, better enemy AI.

Thief: The Dark Project, one of the most innovative action games, turned the shooter on its head by actively discouraging shooting. It was still a first-person game in which the player was armed with a variety of weapons, but the goal was to steal things rather than to kill people, to get through as much of the game as possible without firing a shot. Stealth, not violence, ensured success, but the game still required both hand–eye coordination and puzzle-solving in the best traditions of the action genre. Similarly, *Tom Clancy's Rainbow Six* and other tactical combat shooters replaced frenetic shooting with carefully planned assaults. We hope to see more action games that explore alternative kinds of actions and approaches to victory.

Strategy Games

By far the largest unexplored area of strategy games is the human factor. Armies are led by generals, and generals have human strengths and weaknesses that profoundly influence their performance in the field. Determination, imagination, daring, lateral thinking, personal courage, and sheer analytic intelligence all play important roles in military capability. So does the indefinable quality of leadership, an attribute that determines whether men risking their lives will be confident or fearful, which can sometimes turn the tide of battle all by itself.

There have been efforts to quantify and simulate some of these qualities. As far back as *The Ancient Art of War,* players could choose to fight against simulated versions of Julius Caesar, Genghis Khan, or Napoleon Bonaparte, each of whom was characterized as representing certain military attributes. We've also worked on simulating the psychological condition of soldiers themselves: Microsoft's *Close Combat* gave each soldier a state of mind that varied from courageous and confident to cowering in terror, unable to obey any order.

Nevertheless, there's a great deal more to be done in this area. In most computer strategy games, there's no such thing as psychological operations, nor do they simulate the element of surprise, diversionary tactics, bluffing, feigned retreats to draw out the enemy, or lame-duck tricks to give an impression of weakness. Computer games tend to simulate soldiers as robotic killing machines, obeying whatever order they're given, even if it is suicidal, and unflinchingly standing their ground to the last man. With more processing power and richer, deeper simulations of human reactions, we will start to see war games that depict battles as they are really fought.

Another weakness of real-time strategy games at the moment is an over-emphasis on economic production models. Players concentrate on achieving economic efficiency rather than strategic or tactical superiority. They treat their units as cannon fodder, relying on overwhelming the enemy with sheer numbers rather than with military skill—a tactic uncomfortably reminiscent of Field Marshal Haig at the Somme. Because they're only simulated soldiers, we don't have to care how many of them die except insofar as it gives us fewer units to fight with. This represents an inaccuracy in the simulation. Real soldiers' morale is hurt when their leaders exhibit a flagrant disregard for the value of their lives, and their performance suffers accordingly. In the future, we can expect to see these details simulated properly, and players will have to take care of their soldiers to win.

Role-Playing Games

Computerized role-playing games still bear the marks of their heritage as pencil-and-paper dice-based games. Many players like RPGs this way and enjoy fiddling around with their weapons, armor, and magic items to find the optimal combination of attack and defense potential.

Although there's a definite market for such games, we feel that the emphasis on statistics discourages a larger market, casual players, from playing RPGs. Casual players want to have adventures and collect loot without having to study all the peculiar capabilities of their equipment or to spend a lot of time shopping for it at the local arms merchant. Other genres—action games and action-adventures—offer that kind of gameplay, but for the most part, they have thin plots and little character development. We expect that the traditional numbers-oriented RPG will continue to exist but that a new type of RPG, a sort of hybrid between the action-adventure and the traditional RPG, will emerge over time to satisfy the needs of the casual player. *The Elder Scrolls IV: Oblivion* is a recent example. These hybrid RPG-action-adventure games have the plot and character-interaction elements of the RPG, along with the usual quest structure and character-growth components, but don't require so much fiddling with the characters' inventories or buying and selling.

Sports Games

As we've said elsewhere, sports games don't have a lot of room for creative growth. The game is defined by the nature of the sport. There are new sports from time to time, but they're created by their enthusiasts, not by computer game designers.

Sports games, of course, will continue to benefit from improvements in display technology and other kinds of hardware, and voice recognition could be a lot of fun when you're able to call plays and shout to your "teammates" on the field. But the greatest challenge in creating sports games, and the place where we can expect to see the most improvement in the future, is in artificial intelligence, especially in team games such as soccer. Two areas in sports games need AI: One is strategy, which we might also call play-calling or coaching; the other is tactics, the AI that controls the behavior of individual athletes on the field, especially in response to changing or unexpected play situations. Athlete AI is starting to improve already. We seldom see athletes doing things that seem to be patently stupid anymore—at least, not much more often than real athletes do things that seem to be patently stupid! Coaching is another matter, however. Games don't yet have the smarts to make up the tricks and clever moves that real coaches can devise, but perhaps they will in the future.

Vehicle Simulations Although complacency is risky, if any genre of computer gaming can be said to be stable, it's probably vehicle simulations. Of course, much more can be done, mostly in physics simulations and display technology, but for the most part, vehicle simulations already offer all the gameplay that their fans could want. The aerodynamic models aren't realistic, but they're good enough to provide all but the most demanding players with a feeling of authenticity. We could accurately model *all* the switches and levers in an F-15 fighter jet rather than just some of them, but doing so would make the game harder to play without adding enjoyment to the process.

The quality of the driver AI in racing games is pretty good at the moment. In racing, it's mostly every car for itself, and the cars have to stay in a restricted area, so the AI is chiefly needed for strategic decisions involving refueling, changing tires when rain is threatening, and addressing similar questions. We can probably expect to see this kind of decision-making improve in the future. The casual player isn't likely to notice it, however.

Pilot AI in flight simulators could be improved somewhat, especially in cooperative missions. It's practically a foregone conclusion that if you're given an AI-controlled wingman in a computer game he'll get shot down. It's not clear why wingmen seem to be so vulnerable. It could be that they're mostly designed to assist you rather than to protect themselves, so they take unnecessary risks.

Construction and Management Simulations

Construction and management simulations demand a lot of processing power from the CPU to simulate whatever system they're modeling. As computing power increases, we can expect to see such games modeling larger systems or the same kinds of systems but in more detail. The biggest recent change in CMS games is a switch from isometric perspectives to the free-roaming camera in full 3D.

As the demand for games grows, we might also start to see simulations for niche markets: small groups of people interested in a particular subject that doesn't necessarily have broad appeal. For example, there could be simulations about gardening, automobile traffic, wildlife conservation, or electrical power distribution. What really limits growth in this area is the cost of development.

Adventure Games

Adventure games have stagnated somewhat in recent years. They don't get as much adrenaline flowing as action games or vehicle simulations, and they cost more to develop than other slow-paced games such as war games or city simulations. Nevertheless, we're confident that they won't disappear entirely. A small but distinct market wants games with strong plots and interesting characters, and as gaming matures, this market will grow.

Part of the appeal of adventure games is in the beauty of their locations. Because they move more slowly, players have the time to admire the details of their worlds. As a result, some of them still use painted 2D locations rather than 3D environments. The best 3D engines still can't reproduce the lush detail of an open-air market, for example, in which every pomegranate and bolt of silk is lovingly rendered. However, this will change, and we expect that, in time, more adventure games will be moving to 3D-rendered worlds simply because they offer more freedom to the player and more camera angles to the designer. With a 2D background, every change of perspective requires a new painting; with a 3D engine, the perspective can be adjusted easily to fit the circumstances in the game. For example, *The Longest Journey* used 2D backgrounds, but *Dreamfall,* its sequel, uses 3D environments.

Adventure games will benefit more than any other genre from advances in artificial intelligence. Good stories require believable characters, and to be believable, characters must speak and act normally.

Serious Games

In the last few years, a number of different organizations have started to build and use video games in new ways. Rather than simply providing light entertainment, these games serve additional functions while still being enjoyable to play: as training tools, advertising, political propaganda, military recruiting devices, educational resources, and even delivery systems for healthcare. This search for new uses for games is known as the *serious games movement.*

America's Army is one of the best-known examples of a serious game. While providing high-quality multiplayer play, it also is intended to help recruit young people into the U.S. Army, and the Army distributes it free of charge. On a different subject, a group of graduate students at Carnegie-Mellon University has developed a game about diplomacy named *Peacemaker* that explores the pressures and challenges facing both the president of the Palestinian Authority and the prime minister of Israel. In two examples from healthcare, games have been used quite successfully to distract patients during painful burn treatment (thus reducing the amount of anesthetic they require) and to help people overcome a fear of spiders.

While the use of software for education goes back to the 1960s, it has not found broad acceptance until recently. The new generation of educational games emphasizes understanding ideas rather than the drill and practice of older software. It tries to complement and support, rather than replace, ordinary classroom teaching.

The serious games movement is one of the most important—and swiftest—advances in years. Not only does it provide valuable new uses for the power of the interactive medium, it also helps to create legitimacy and cultural credibility for video games. As games take on increasingly useful roles in society, they can no longer be dismissed as time-wasting entertainment for children. We expect great things from the serious games in both the near and more distant future. For further reading, we recommend the Serious Games Initiative's Web site at **www.seriousgames.org.**

Broadband Networking

The arrival of asymmetric digital subscriber lines (ADSL), cable modems, and above all, fiber-optic links has significantly changed the face of gaming in the last three years, and we can expect more big changes in the future. Broadband will have two significant effects: electronic distribution and higher-speed gaming.

Electronic Distribution

The traditional method for distributing computer and video games is ridiculous. The object is to transfer a string of bits from the publisher's computer to the player's, in exchange for some money going from the player back to the publisher. At the moment, this is done by pressing a plastic compact or DVD disk, putting it in a cardboard box, selling it to a middleman who operates a retail store in a shopping mall, and attracting a player who drives down to the mall and buys the cardboard box with the disk inside from the retailer. The player then puts the CD in her computer, transfers the bits onto her hard drive, and throws away the cardboard. A few weeks or months later, she's done with the game and throws away the CD as well.

Electronic distribution will eliminate most of the waste that this entails. No cardboard boxes; no plastic disks; no heat, light, and security guards for the retail store; and, above all, no cars and trucks driving around the country emitting pollution just to carry the bits (at 60 miles per hour) between point A and point B. Instead, those bits will travel directly from the publisher's computer into the player's computer. In theory, we could eliminate the retailers entirely.

Benefits of Electronic Distribution Apart from eliminating the manufacturing waste, the single greatest benefit to electronic distribution is that it ends the battle for shelf space. At the moment, too many games are being developed for all of them to fit into a reasonably sized retail store. This means that the competition to sell them to retailers is fierce, and the biggest distributors have by far the best chance of getting their products on the shelves. Small-time developers and publishers simply don't have the sales and marketing clout to compete.

Electronic distribution will help level this playing field. You need only one copy of a game on the distribution server, no matter how many people you sell it to, and you don't have to take down one product to make room for another. Shelf space on the Internet is effectively unlimited. Furthermore, small developers can have Web sites that are just as attractive as those of large publishers. Without the need to develop expensive in-store displays or to commit marketing development funds to retailers, developers can run a very efficient sales operation directly to the consumer.

This doesn't mean that small publishers will drive the giants out of business, however. The majority of a computer game's cost is not in the goods or the distribution but in the marketing and development—paying all those creative people to build the game in the first place. Bigger publishers can afford to make bigger games, and bigger games will generally sell better than smaller ones. Big publishers can buy advertising space in magazines and on TV that small publishers couldn't begin to afford, and advertising sells games. They'll always have that advantage. But by taking away the large publishers' control over retail sales, electronic distribution will improve the odds a little for small developers.

Piracy The game industry loses billions of dollars every year to piracy, and many people are concerned that electronic distribution will make piracy even easier. At the moment, sophisticated large-scale piracy requires fairly expensive machinery to counterfeit the specialized compact disks that most game machines require. Publishers will be reluctant to embrace electronic distribution if it makes work easier for the pirates. We believe that this problem is solvable, but the solution requires further work. The game industry will have to find a way to digitally "tag" each unique copy of a game and to make sure that no two identical copies can run at once. Before long, games likely will require an Internet connection and will not run without one—which might not sit well with players.

Speed of Delivery The length of time it takes to drive to a retail store and buy a game is typically 30 to 60 minutes for people living in suburban areas. If you develop a severe hankering for a game, you can usually buy it and be playing it within an hour or so. You can't do that with the Internet as it exists today; the download speeds are too slow. For electronic distribution to offer real competition to retail shopping, it must be able to gratify that desire at least as quickly as shopping does.

Benefits of Retail Shopping There are certain benefits to selling games at retail that electronic distribution won't provide. One is that the perceived value of a retail product is proportionate to the quality of its packaging. A beautifully printed box with a heavy manual inside gives the customer a warm feeling that she is getting her money's worth. (One of the reasons that cassette tapes didn't drive LP records out of the market was that customers liked the album art on LPs—and some mourned its passing with the arrival of the compact disc.) A CD in a jewel case alone feels cheap. A downloaded executable file on a computer doesn't feel like anything at all. Although you can see the game running on your machine, there's no sense of having purchased something that you can hold in your hand.

Although you might think that this shouldn't matter, we feel that it will have a significant psychological impact at the one time of the year more important to the game industry than any other: Christmas. The interactive entertainment business is heavily dependent on Christmas gift giving, and the fact is that people like to see actual boxes under the Christmas tree—the bigger, the better. A slip of paper giving a Web address where software can be downloaded isn't going to feel like much of a gift.

Retailers would also argue that buying in a store gives players the opportunity to look at games side by side and to ask questions of the staff. Although you can get more information by comparing game reviews online than by holding a box in either hand, many casual gamers don't bother to do that much research. Retail shopping offers the chance to browse in a way that online shopping simply doesn't. For all its convenience and efficiency, online shopping doesn't feel the same as running your eye over shelves full of games, nor does it encourage impulse buying.

High-Speed Online Gaming

Online games suffer from bandwidth bottlenecks. They have to be carefully designed to eliminate any advantage that one player might get by having a faster Internet connection than another player. They also have to prioritize their data transmission so that the most important data has the highest chance of being delivered rapidly, while less important data is delivered later and can be dropped altogether if bandwidth conditions deteriorate.

As with everything else they use—memory, processor speed, disk space—computer games expand to consume the bandwidth available, and we will not make this problem go away simply by increasing the available bandwidth a hundredfold or even a thousandfold. But more bandwidth will change the kinds of games that we can play and the ease with which we play them online. Right now, when players start playing large online games, they must either buy a CD full of the graphical data or download it all, a time-consuming process. When the game's provider wants to make a whole new region available to the players, those players are forced to download the new graphics. Either they can do it all in one chunk, which means they have to sit around and twiddle their thumbs until it's done, or they can download it in the background as they play, which hurts gameplay performance. Having more bandwidth will certainly make this a more pleasant process.

Ultimately, speeds will become so high that players never notice any delays. Network connections will be as ubiquitous as electric lights are now. (Microsoft's Xbox Live network is already broadband-only.) When this happens, we can expect to see not just games but entire online environments that people pop into and out of continuously during both their work and leisure time—an idea that Linden Labs's *Second Life* already tries to promote. We have the capacity right now to create part of William Gibson's vision of cyberspace—a "consensual shared hallucination"—but only slowly. Extremely fast communication will enable us to make it a reality, whether for gaming, working, shopping, or doing any other activity. The technology isn't in doubt; the more important question is, who will control it?

The Distant Future

In the TV show *Star Trek: The Next Generation,* Captain Picard relaxes by playing a computerized role-playing game in the "holodeck," a place capable of temporarily creating (somewhat) solid matter, up to and including living things. While it's anyone's guess whether we'll ever develop the holodeck, Picard's "holonovels" have a lot in common with games that already exist: simulated characters, a fantasy setting, and a plot whose progress is influenced by the player. They do contain a few improvements over current games, however. Picard can interact with the people in the story in all the same ways that he could with real people; he isn't perpetually stopping to look at his statistics; and he doesn't have to stuff everything he sees into his pockets in case it might be useful later.

In this section, we'll talk about some of the things that might make Picard's experience come true.

Automated Programming

Most game machines are single-CPU computers with dedicated graphics and sound-processing units. Their CPUs follow the traditional one-instruction-at-a-time model that, as we said earlier, was originally intended for computing ballistics tables for artillery guns. In the more distant future, it is bound to be replaced, although with what isn't at all clear. Neural networks hold a certain amount of promise for pattern recognition; so does massively parallel computing. Molecular transistors are a certainty; optical and quantum computing are a little farther off. We might begin to see programming by evolution, using the principles of natural selection to create programs without human intervention.

This has already been done to create simple electronic circuits with successful but startlingly peculiar results.

It seems certain that computers will eventually learn to program themselves, although by that time they might bear no more resemblance to the machines we know today than the aircraft carrier does to the trireme—and probably less. For that to happen, computers will need a fundamental understanding of the nature of information and the way that it can be stored and manipulated. In particular, they'll have to be able to make the abstractions that human programmers do all the time. Teaching a computer to program itself to calculate mathematical formulas probably won't be that hard because most mathematical formulas are calculated using fairly simple algorithms anyway. The bigger challenge is to teach a computer to model imaginary situations mathematically, to solve the story problems that we remember from algebra class. The hardest part of a story problem was not solving the algebraic equations but determining how the situation described could be modeled mathematically in the first place.

Intelligent Design Tools Automated programming doesn't mean that game designers are doomed to extinction. Captain Picard's Dixon Hill stories are written by real people; they're just executed by a computer. People will always want to design games, and that's not going to change. What will change is the way we do the work. Rather than collaborating with a large team of programmers, artists, writers, and audio engineers, the game designer of the far future could be collaborating with a game-design tool, a program specifically constructed to assist in creating games. We can easily imagine a conversation that goes like this:

> DESIGNER: *We're going to want three kinds of aerial units: fighters, bombers, and transports.*
>
> COMPUTER: *OK. Have you figured out their operational parameters and combat capabilities?*
>
> DESIGNER: *Not yet. But fighters are designed to attack anything in the air; they won't be able to attack ground targets. Bombers can attack both air and ground units. Transports have no weapons.*
>
> COMPUTER: *Why would you ever want fighters if bombers have more functionality?*
>
> DESIGNER: *Because bombers will be slower and less maneuverable than fighters and also more expensive. Compare the performance characteristics of the World War II B-17 with the P-51 Mustang. Also notice the manufacturing time and cost of each.*
>
> COMPUTER [reads history for a nanosecond]: *OK, I understand the principle. Do you want me to use those numbers as a baseline?*
>
> DESIGNER: *Sure, what the heck? It'll do for now.*

Emergent Storytelling One of computerized role-playing games' many weaknesses in comparison with tabletop RPGs is that their plots are fixed, designed in advance by the developer. As a player, you can ignore the plot if you like, but the game won't be very interesting and you won't go far. To see everything that the game has to offer, you have to meet the challenges that it presents. If you don't, nothing happens. Larger games typically offer several subplots to choose from, so you don't have to do everything in a strictly linear order; nevertheless, what you bought is what you get.

On the other hand, live role playing with a human game master frees players to ignore the game master's intended plot, wander around on their own, and explore areas of particular interest to them. Although this might be frustrating for the game master—particularly if he has spent a lot of time devising an adventure for the party, only to have them completely ignore it—a good GM is capable of adjusting the game to suit the circumstances. The players are much more the masters of their own fates in live role playing. The GM also has the ability to adjust the nature of the challenge to suit the nature of the party—if it is badly damaged, he can surreptitiously see to it that they don't meet anything capable of wiping them out in an instant.

This ability to devise new adventures on the fly and to adjust the difficulty of the game to match the abilities of the players is bound to appear in games in the future. At the moment, we have randomly generated adventures in games such as *Diablo,* but this really applies only to the layout of the rooms and the number of creatures in them. It doesn't change the personalities or dialog of the nonplaying characters. The real goal is emergent storytelling, which we discussed briefly in Chapter 7, "Storytelling and Narrative."

Artificial People In 1950, the English mathematician Alan Turing proposed a famous test for determining whether computers are really thinking. Let a computer and a human each chat with another person, the Interrogator, in another room via teletype (today we would use instant messages). The Interrogator must ask them both questions and, on the basis of their responses, try to decide which is the human and which the computer. However, both are trying to persuade the Interrogator that they are human. If in a series of five-minute conversations the Interrogator correctly identifies the real human less than 70 percent of the time, the computer can be said to be thinking. (Turing's definition was slightly more complicated than this, but this is the generally accepted formulation.) Although it was largely abandoned as a serious goal of AI research, the Turing Test remains a popular informal standard for artificial intelligence.

In game development, we have a similar challenge, but the bar is far higher. Turing's test required only that the computer converse in typed text. We hope someday to be able to simulate credible artificial humans, computer-generated characters who look, act, and speak just like real people. Doing this successfully requires vast improvements in many different areas: graphics, animation, physics, simulation, and of course, many kinds of artificial intelligence. A computer-generated person should be able not only to converse in natural language but also to take part in a political debate or to interpret another person's mood just as well as an ordinary human would.

Computer games don't need to have artificial people, of course, any more than the telephone company has to have artificial operators. We can let human players play against one another, just as the phone company can hire real people to answer the phone. But artificial people are a key part of the holodeck fantasy and are probably its biggest challenge—perhaps even bigger than creating the mechanics of the holodeck itself. It's still a worthwhile goal for game development, even if the solution is centuries off.

Interactive Entertainment as an Art Form

In thinking about the future of interactive entertainment, it would be a mistake to consider only the advances that are likely to take place in the world of commercial, mass-market gaming. That would be like assuming that the potential of cinema was limited to what you see in Hollywood blockbusters or that the written word was capable of no more than Danielle Steel novels. Interactive entertainment is an art form, just as filmmaking and writing are. Unlike filmmaking and writing, however, it has not yet been recognized as an art form by the public at large.

Film has the advantage that it is an outgrowth of drama, and of course, drama was recognized as an art form by no less a figure than Aristotle. It took film a little while to achieve this status, but it is now unshakable. Computer games' roots are not in drama, however, but in gameplay. Their nearest noncomputerized parallels are board games and fairground shooting galleries, neither of which is or ever will be recognized as an art form. As a result, we face an uphill battle for recognition.

Part of the reason that board games and shooting galleries aren't art forms is that they contain very little expressive content. Graphically, they're abstract and minimal, requiring a lot of imagination on the part of the players to pretend that the little cardboard counters are really troops and tanks. They also seldom include any narrative or characters. Computer games, on the other hand, have a lot of content, both visible and audible; they have a distinct artistic style; and they often have a great deal of characterization and narrative.

Interactive Artwork

Most works of art require only passive observation, especially in traditional media such as painting, sculpture, and music. The observer brings his own knowledge and personal history to the work, and these color his understanding and interpretation of it, but the influence is entirely inside his own mind. He isn't asked to take an active, participatory role in creating the aesthetic experience.

There's no reason why works of art can't be interactive, however, and some are. In San Francisco, a science museum called the Exploratorium considers its exhibits to be works of art, and it actively seeks artists to design them. Most of the exhibits are interactive, offering a learning experience as well as an aesthetic experience; they illustrate principles of nature but also principles of design.

Not all interactive entertainment is art, but then neither are all movies or all novels. Most movies—and most novels, too, for that matter—are merely light entertainment, popular culture. But just because James Bond novels and James Bond movies aren't generally considered to be art doesn't mean that film or the novel isn't an art form. Interactive entertainment is a collaborative art form in the same way that movies are, and it can be judged according to a variety of aesthetics the way movies are.

Requirements for Recognition

For interactive entertainment to be recognized as an art form, it must do some of the things that other art forms do, the things that people expect of art forms. We believe that game developers and publishers, and people who write about the game industry, can take several concrete steps to help it achieve that status.

We Need Principles of Aesthetics More than 20 years ago, Chris Crawford mentioned in his book *The Art of Computer Game Design* that the interactive entertainment medium needs principles of aesthetics. It remains true today. We're not much farther along than when he wrote those words, though, for two reasons.

First, the serious study of computer games has only just begun. The commercial world is too busy churning out games as fast as it can to think deeply about them, and until recently, the academic world has ignored games as childish toys rather than important elements of popular culture. This is starting to change, and as we begin to see real analysis of computer games, principles of aesthetics will arise.

Second, computer games have been a rapidly moving target. Games have changed, at least in appearance and depth, far more in the last 20 years than movies or television did in any 20-year period of their history, partly because of the rapid development of new hardware. The principles of interactive entertainment aesthetics should perhaps be independent of hardware developments, but this is easier said than done. It took 20 millennia to go from cave paintings to color photography; computer games have made a similar journey in two decades.

However, we're already on the right track. We've all seen games that were clunky and awkward to use and others that were smooth and seamless. We've all noticed games with tacky, slapped-together graphics and others with elegant and atmospheric graphics. These are good first approximations for game aesthetics.

At the moment, they are purely surface impressions, the equivalent of showing basic competence at oil painting or music composition. To be a great painter or a great composer, you must go beyond basic competence; you must reach out and touch your audience's soul. Interactive entertainment is capable of doing this, but it seldom does, and we have yet to devise an aesthetic for it.

We Need Meaningful and Widely Recognized Awards The game industry presents large numbers of awards, mostly given by magazines or Web sites, some by trade associations and parents' pressure groups. Unfortunately, no single set of awards has garnered the level of universal recognition that the Academy Awards have for movies. The Developers' Choice Awards, presented by the International Game Developers' Association, is the closest thing we have, but they still aren't as familiar to the public as they need to be.

Furthermore, we must clearly distinguish between art and craft in our awards. In the film industry, the Academy Awards are actually presented at two different ceremonies. One is the glittering spectacle that everyone knows, broadcast live on TV and attended by movie stars and Hollywood bigwigs. The other is for the technical awards. It's a much smaller affair, usually held in a hotel ballroom and attended only by technical people, the film industry's craftsmen. The "big" Oscars that everyone hears about are all about art: acting, storytelling, art direction, music composition, and so on. The technical Oscars are all about craft: new equipment and techniques that have advanced the craft of moviemaking.

The game industry, on the other hand, has muddled this important distinction. You often see awards for "best graphics," but the criteria don't state whether they're being given for technology or aesthetics. Some people think that best graphics means graphics that are displayed at the highest frame rate or that use the most polygons or that use sophisticated lighting and shading effects. That isn't good graphics, it's good graphic technology—good craft, but not good art. It's the same with sound; one award for best sound is supposed to encompass both music composition (an art) and 3D spatialization of ricocheting gunfire (a craft). As for those elements that Hollywood makes the most of—acting and storytelling—we typically give no awards at all. Small wonder, then, that these remain the weakest and most underappreciated parts of games.

To be recognized as an art form, our awards must emphasize the artistic merit of computer games, not merely their technological prowess or craft.

We Need Critics, Not Just Reviewers Like awards, the game industry is full of game reviews. In fact, that's where most of the awards come from: reviewers. But there's an important difference between reviewing and criticism. A review is a short essay whose purpose is to describe the game, to compare it with other similar games, and to give an idea of whether players might like it and whether it's good value for the money. As they would say in the world of management consulting, it's a decision-support tool—it helps you decide whether to buy the game.

Criticism is not a decision-support tool. Criticism does discuss the basic competence of an art work, but it seldom goes into the question of whether it's good value for the money. The purpose of criticism is to increase understanding, to interpret a work of art in light not only of other, similar works but also of the larger cultural and historical context in which it appears. It's not enough for critics to know all about other games. Critics must bring to their work a wide reading and an understanding of aesthetics, culture, and the human condition.

The movie *2001: A Space Odyssey* is a perfect example of why an art form needs critics as well as reviewers. *2001* left movie reviewers severely confused because it was almost impossible to compare it with other movies. It had very little action: no car chases, no fight scenes, no romance, and almost no discernible plot. In fact, it contained very little *acting* either: The characters in it were intentionally dull and wooden. Movie reviewers simply didn't know what to say about it, and quite a few of them panned it because it didn't contain any of what they thought were "essential" elements of a movie. The film critics, on the other hand, had a field day. *2001* was rich with ideas, crammed with them right to the final frame. It provoked thought about everything from the origin of human intelligence (and perhaps human violence) to our ultimate destiny in the universe. Along the way, it looked at the sterile lives of astronauts and bureaucrats, poked fun at the way we eat, and raised questions about the wisdom of placing human lives under the control of artificially intelligent machines.

2001: A Space Odyssey is a great work of art and one of the most important movies ever made. But by conventional movie reviewers' standards, it was just a curiosity, perhaps even a failure. That is why the interactive medium needs critics as well as reviewers.

Breaking New Ground

Ultimately, the greatest works of art are those that break new ground. They change the rules, challenge the established order, create new principles of aesthetics, and force the viewer to see something in a new way. But how to do it?

Some works of art deserve high praise because they are masterpieces of technique, taking a medium right to its physical limits while still demonstrating superb aesthetic feeling. Michelangelo's colossal statue of David is a good example. But although it's occasionally useful to take a medium to its limits as a technical exercise, it doesn't necessarily produce great art, especially if aesthetics are sacrificed or ignored for the sake of technical achievement. The problem with doing this in computer games is that the limits are always changing. The challenge that Michelangelo faced, working in marble, is still the same for any sculptor working in that medium. But in computer games, the medium changes almost week by week. Today's technical marvel is tomorrow's irrelevancy.

Michelangelo's most important achievement in sculpting David was not technical but artistic. The traditional way of portraying David was as victorious, armed, and holding Goliath's severed head. Michelangelo chose instead to depict David before the battle, vulnerable but filled with a fierce courage. This had never been done before, and it set the work dramatically apart from its predecessors.

The Impressionist movement in painting is another useful example of what breaking new aesthetic ground is about. Impressionism challenged existing notions of what painting was for and what it was supposed to do. It asserted that the eye is not a camera, that painting need not be a photographic reproduction of reality. Yet Impressionism was not a new technology of painting; its tools were still canvas and paint. Rather, Impressionism was a new way of seeing.

Interactive entertainment needs an Impressionism of its own, a daring, risk-taking movement to break through the tired old tropes—not a new way of seeing, but a new way of playing. We hope that you, our reader, might be our new Monet or Cassatt.

Summary

This book doesn't include everything there is to know about game design—that would be a work of many volumes. Instead, we've tried to cover the key tasks in designing computer games and to identify the recurring elements in the most common commercial game genres. We hope that our book has given you the foundations on which to build the design for the great game that you have in your head.

Computer games are the most important new entertainment medium since the invention of motion pictures. Uniquely among all forms of entertainment, they combine the interactivity of traditional gaming with the visual impact and narrative power of the movies. Put simply, computer games enable players to live out fantasies that they could never experience in real life, and this is the source of their enduring appeal. It is your task as a designer to turn those fantasies into immersive and rewarding games. Go to it, and good luck!