

ALLEGORIES OF SPACE

The Question of Spatiality in Computer Games

Espen Aarseth

Introduction

In a brilliant and famous passage from his novel *Neuromancer* (1984), the science fiction writer William Gibson analyses the still (e)merging elements of computer culture, ironically describing the digitalization of games, graphics, warfare, work, education, global communication, cityscapes, and the cyborg integration of nerves and electronics, through the voice of a narrator in a children's TV documentary:

'The matrix has its roots in primitive arcade games,' said the voice-over, 'in early graphics programs and military experimentation with cranial jacks.' On the Sony, a two dimensional space war faded behind a forest of mathematically generated ferns, demonstrating the spacial possibilities of logarithmic spirals; cold military footage burned through, lab animals wired into test systems, helmets feeding into fire control circuits of tanks and war planes. 'Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators, in every nation, by children being taught mathematical concepts... A graphic representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding...' (Gibson 1984, 67.)

The keyword here is *space*: "space war", "spacial possibilities", "Cyberspace," "nonspace". In the early eighties, Gibson observed young players

in video game parlors and extrapolated a future of communication and control through game-like globally linked graphical computer systems. His 'space' is "consensually hallucinated", not real (a "nonspace of the mind"), but effective and dominant. Before the digital culture theorists, Gibson has seen the digital future, and places the computer game as one of its main roots. His vision is bleak and ironic (unlike that of the cyberspace theorists and technologists that he unintentionally inspired, and who failed to perceive his irony), but his diagnosis of the importance of the computer game culture is highly perceptive.

The cultural significance of computer games is still being underestimated, by the general public as well as by most cultural theorists and other academics and even by the computer industry itself. Computer games are used by children and adolescents to teach themselves about technology and programming; they are currently the fastest growing cultural industry in the industrialized world, with an annual turnover that has passed the movie industry in the USA; and they represent the cutting edge in user interface design and the development of three-dimensional programming techniques. Games are usually the first type of computer application to take advantage of the newest and fastest computer hardware, and the step up from 32-bit to 64-bit processing was introduced to the masses by way of cheap video game consoles such as the Nintendo64, years before it was available on the standard desktop PCs.¹ It is fair to say that the mass market of computer games is the single most effective cause of the demand for increasingly faster computing from the general public.

Also, a computer game, unlike most other computer applications, lives or dies by the effectiveness of its user interface design. A game that is not intuitive and easy to use will simply not become popular. Therefore, game design should prove the richest area of case material for human-computer interface theorists (for an example, see Andersen 1990). And as Ted Friedman has pointed out, every structurally different computer game is effectively a new medium:

Each new game must rethink how it should engage the player, and the best games succeed by discovering new structures of interaction, inventing new genres. What would be avant-garde in film or literature – breaking with familiar forms of representation, developing new modes of address – is standard operating procedure in the world of computer games. (Friedman, forthcoming.)

This of course makes it hard to theorize about computer games in general; they are undoubtedly the most diverse and fast-changing cultural genre that ever existed.

And perhaps most importantly, computer games represent a new mode of aesthetic as well as social discourse, an alternative to the narrative, which has been the leading paradigm until now: the primary means to convey knowledge and experience. Now, however, the mode of simulation is used as an effective pedagogical tool that privileges – actually, demands – active experimentation, rather than observation, of its subject material. It is also a way to explore the partly unknown, to test models and hypotheses, and thus to construct and acquire new knowledge in a way narrative never could.

But what is a computer game? I will attempt to combine a historical and a structural answer, but first let me outline the main topics of this article. Elsewhere (Aarseth 1997, 101–2), I have claimed that spatiality is a main theme in computer games, and here I will try to verify that claim. But first let me expand it: The defining element in computer games is spatiality. Computer games are essentially concerned with spatial representation and negotiation, and therefore a classification of computer games can be based on how they represent – or, perhaps, *implement* – space.

However, the notion of space as “represented”, or rather, *representable*, is problematic. The question of what *space* is, is of course much too complex to be given a proper treatment here, so a brief working solution will have to do. The literature on *space* is vast and multidisciplinary,² and I will not try to do it justice. Instead, I will discuss two different critical conceptions of “space,” and from these try to negotiate a perspective that serves my approach.

The present effort is part of a larger investigation into the aesthetics and poetics of computer games. Earlier I have addressed the games’ rhetoric and event structure (what I call “ergodic discourse”, see Aarseth 1997, ch. 5), and the temporality of games (Aarseth, forthcoming), and here, spatiality is examined. Inevitably, such an approach, covering the basic categories of *action*, *time* and *space* in a few pages, must seem overambitious, but given the extremely tentative present stage of research on the aesthetics of computer games, where very little has yet been done, the broad general approach is needed before we can start to examine the finer details. The resulting research risks being overgeneralized and short-lived, but in being discarded by better approaches, it will have served its purpose.

A brief outline of computer game evolution

It is hard to be sure what the first computer game was, but it is very likely almost as old as the first computer. As early as 1947, just a few years after the first digital computer, Arthur Samuels made a Checkers game that could "learn" as it was played. (Sinding-Larsen 1993, 260–1) In 1961 a "hacker" at MIT, Steve Russell, created the first *modern* computer game, *Spacewar*, just a few years after computers had evolved from punchcard/teletype systems to the screen/keyboard variety that we are still using. (Levy 1984, 59–69) In *Spacewar*, two players would navigate their spaceships around a planet with gravitational pull, firing torpedoes at each other's ships and trying to avoid getting hit or crashing into the planet. *Spacewar* is a very interesting case, for many reasons: It was the first graphical game, it was the first *two-player* graphical game, and it was (probably) the first game which defined a new, computer-dependent genre, i.e. a game that was not simply based on a pre-digital, traditional game.



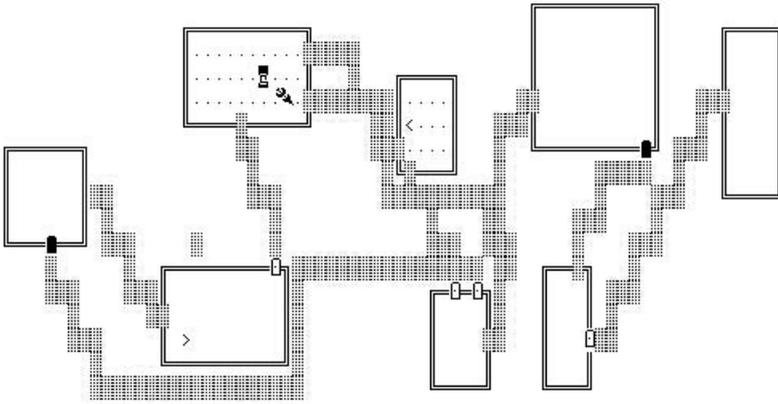
Figure 1. A modern Java implementation of *Spacewar* available on the WWW, for two players (on the same keyboard).

In the early seventies, companies such as Atari began to make coin-operated video games. The first of these was *Pong*, a simple tennis-like game where the user steered a simple paddle vertically and tried to hit the "ball", which would "bounce" semirealistically back and forth off the boundaries of the screen.

William Crowther and Don Woods invented another important genre, the adventure game, in 1976. (See Aarseth 1997, 97–128) Crowther had initially programmed a simulation of a real cave in Kentucky, inspired by the board game *Dungeons & Dragons*, by Gary Gygax (1974). In adventure games, the player explores a text-simulated landscape with simple commands like "GO NORTH", "ENTER HOUSE" etc. In 1979–80, inspired by Crowther and Woods' *Adventure*, Roy Trubshaw and Richard Bartle at the University of Essex constructed an adventure game where several players could play together. They called the game *Multi-User Dungeon* (MUD). The first MUDs were oriented towards game-play, exploration of landscapes and puzzle-solving. Later MUDs, such as James Aspnes' *Tiny-MUD* from 1989, allowed users to create and describe their own textual objects and in this way extend the game (which by then was more of a social meeting place than a game). A more direct derivative of *Dungeons & Dragons* was the fight- and treasure hunt game *Rogue*, created by Michael Toy, Glenn Wichman and Ken Arnold in 1980. (Personal correspondence with Toy) Here the player moves a "@" (the player's character and position) over a two-dimensional area, which is revealed gradually as the "@" passes over.

But as early as in 1979, the first three-dimensional game appeared, a space-strategy/action simulation called *Star Raiders*, made by Doug Neubauer (Atari, 1979).

As you read the scroll, it disappears. On this scroll is a map.



Darmananth the Digger St:14 Dx:7 Co:15 In:16 Wi:16 Ch:9 Lawful
Div:1 G:9 HP:5(13) Pw:1(1) AC:7 Xp:1/6

Figure 2. *NetHack*, a descendant of *Rogue*.

This game has two perspectives on the gameworld, a 3D space action view (see Figure 3), and a two-dimensional grid of planets to visit, representing the strategic aspects of the game. The dual-perspective interface that combines 2D (map) and 3D (world) has later been used in many other games, and illustrates an important point: In most 3D games, even "simple" ones like *DOOM* (Id software 1993), the three-dimensional perspective alone is not enough to represent the complexities of the gameworld, and must be supplemented with a more schematic 2D perspective. This observation stands in striking contrast with the prophecies of certain virtual reality proponents who believe that the 3D interface will render all other perspectives obsolete (cf. Jaron Lanier's notion of "post-symbolic communication," in Barlow 1990). *Star Raiders* was followed by other 3D space games (such as *Elite*, by Ian Bell and David Braben, which used vector graphics) and flight simulator games, the most famous of which is no doubt Microsoft's *Flight Simulator* (1983).

Most of the early games might be described as "man against the environment" approaches, with a personal perspective on the gameworld. The viewpoint may vary, from textual descriptions in the early adventure games, via 2D in the "arcade" action games, and sophisticated 3D in the late nineties, but there seems to be a clear distinction in the games' world models between the player's puppet and other elements, such as the environment itself. One is "in the world, but not of the world", so to speak. However, though this is the leading paradigm, there are exceptions. This distinction (the relationship between user representation and world representation) may also mark the difference between simulations and less "realistic" games.

Lemmings, by Dave Jones, Gary Timmons and Scott Johnston (Psychonosis 1992) is an interesting example of both a game without a central player-character, and an environment that is influenced by the player. The object of the game is to get as many lemmings as possible across the gameworld level, and some of the lemmings can be assigned tasks, such as digging through the ground or building bridges. The others will simply march straight ahead, until they die by accident (usually by falling off a cliff) or are stopped by an obstacle. Although two-dimensional, the variation of possible solutions and the demand for player creativity makes this a brilliant alternative to the more reflex-based action games or one-solution-puzzle adventures.

Another possible distinction can be made between two different spatial representations: the open landscape, found mostly in the "simulation-oriented" games, and the closed labyrinths found in the adventure and action games. We might call this the "indoor" vs. the "outdoors" distinction, or simply distinguish between games that use *doors* to control movement vs. games that do not. This distinction parallels closely the one mentioned earlier between player-character uniqueness (e.g. in *Adventure*) and player-representation integrated in the gameworld (e.g. in *MS Flight Simulator*).

A third distinction could be the player's level of influence on the gameworld, where some simulation games, such as *SimCity* or *Warcraft*, let the player change the world, whereas in other types, such as the adventure games or most 3D action games, the player has no constructive influence and the world is completely static. Recent 3D action games, such as *Duke Nukem* (1995) and *Shadow Warrior* (1997, both by 3D Realms) allow players to smash windows or blow up trees, to make the world illusion seem more real.³ While these touches might help some players feel more at home in the gameworld, they have no real function as game elements.



Figure 6. Typical indoor scene from *DOOM* (Id software, 1993).



Figure 7. A player-distorted view in *DOOM*, where the splintered perspective is caused by turning the "no clipping" cheat code on. The player then sees several rooms overlapping each other, and can move the character through obstacles at will.

DOOM, by John Romero and John Carmack (Id software, 1993), is a typical indoor game, with narrow corridors and locked doors. Here the player-character is pitted against a series of monsters and mazes, with the object of getting through the labyrinth alive. Even in outdoor scenes in *DOOM* the landscape is riddled with obstacles and narrow paths. What may seem like a naturalistic world is in fact a constrictive topology of nodes and connections between them that interferes with unhindered movement. As in *Rogue*, the grandfather of all these games, there is a map that expands as we go, but here as a alternate screen.

There is a broad range of different computer games, and it would be impossible to discuss more than a small cross-section of all relevant variations here. To draw conclusions from this material is therefore to risk overgeneralization. Nevertheless: what distinguishes the cultural genre of computer games from others such as novels or movies, in addition to its rather obvious cybernetic differences, is its preoccupation with space. More than time (which in most games can be stopped), more than actions, events and goals (which are tediously similar from game to game), and unquestionably more than characterization (which is usually nonexistent) the games celebrate and explore spatial representation as their central motif and *raison d'être*.

In terms of playability, themes, tasks, sub-genres, and dramatic structure, nothing much has changed over the last two decades. The successful games from twenty years ago were just as absorbing as the current games today, and the inventory of thematic and structural elements haven't changed much from Crowther and Woods' *Adventure* to the Miller brother's *Myst* (Cyan, 1993) or from *Rogue* to its latest 3D descendant, *Diablo* (Blizzard Entertainment, 1996). What is changing is the scenography, landscape, and (3D) visual effects, which are constantly evolving from bestseller to bestseller. The innovation takes place in spatial representation, and the genre's more slowly evolving complexity in the other areas (such as physical simulation) can be seen as a result of the increasing complexity of the spatial representation.

But what is "spatial representation", and what is its relation to "real space"?

Space and spatial representation

To regard *space* as an object is a common trope in media aesthetics. The use of the concept of "spaces" in the media, instead of "places", "rooms" "regions", "zones" etc. is fashionable, but what does it refer to? What is "a space", and what is its relationship to *space*?

In a recent paper, the philosopher Anita Leirfall takes the cyberspace theorists (especially some of the essayists in Benedikt 1991) to task for confusing the concept of space with *place*. Why say spaces when we really mean places? "Cyberspace", she says, should be seen as a system of signs:

In fact the "sign space" is an example of an operation which reduces or limits the richer and more extensive – or all-embracing – notion of three-dimensional space. A place is always a limitation of, or in, space. Place can never exist independently of its spatial origin. It must stand in a necessary and inevitable relation to space to be considered a space at all. ... every attempt to give a definition of space will face the problem of circularity, while the definition must presuppose space as already given in its definition! (1997: 2).

Leirfall, following Aristotle and Kant, does not accept the notion that Cyberspace, virtual spaces and, implicitly, computer games, constitute an alternative type of space of autonomous qualities. By being *generated*, cyberplaces are "*regions in space*", and cannot exist as parallels of real, three-dimensional space. This is an important point. "Cyberspace" and other such phenomena (e.g. computer games) are constituted of signs and are therefore already dependent on our bodily experience in, and of, real space to be "hallucinated" as space. Moreover, the fact that they are not real space but objects and places is the only reason we can perceive them at all. If they had not been objects, but real space, (somehow) computer mediated, then we would not have been able to tell them apart from real space unmediated.

This conception of "space" is of course a strict one, given the word's several common meanings. Other philosophers, in particular Henri Lefebvre

(1991), distinguishes between natural (physical) space, abstract space, social space etc., and also between *representations of space* and *representational spaces* (33). To Lefebvre, space is produced – socially constructed – by what he calls the “spatial practice” of a society (38). A representation of space is a logical system of relations, while a representational space is symbolic and “lived”, and not consistent or rule-based. These two categories are not dyadic, but stand in a triadic relationship with spatial practice.

While it may be dangerous to “map” Lefebvre’s theory of space onto computer games – they are after all a type of spatial representation he did not anticipate – it might produce a useful perspective for our investigation. As spatial practice, computer games are both representations of space (a formal system of relations) and representational spaces (symbolic imagery with a primarily aesthetic purpose). This result is perhaps too open to be of any real use as it is; a much longer refinement and adaptation of Lefebvre’s theory than can be pursued here seems to be needed. But it indicates that the spatial representation in computer games is ambivalent and double-sided: it is both conceptual and associative.

But can these two different spatial philosophies be reconciled, and united into a perspective of use to us here? Both provide helpful perspectives on what types of phenomena we refer to whenever we use the word “space”, but they are less directly applicable when it comes to the question of computer games. Should we then capitulate and adopt the awfully nondescript term “virtual space” for our phenomena? Even if we disregard all its other problems as an analytical concept, “virtual space” will not help us distinguish between different types of spatial representation in computer games, and merely tells us that space can be simulated. (See Aarseth 1994)

Instead, drawing on both Leirfall and Lefebvre, I will posit spatial representation in computer games as a reductive operation leading to a representation of space that is not in itself spatial, but symbolic and rule-based. The nature of space is not revealed in this operation, and the resulting product, while fabricating a spatial representation, in fact uses the reductions as a means to achieve the object of gameplay, since the difference between the spatial representation and real space is what makes gameplay by automatic rules possible. In real space, there would be no automatic rules, only social rules and physical laws.

A common motive in many, if not most, computer games is the teleporter, a means to move instantly from one point in the gameworld to another. In MUDs, for instance, the administrators often take great care in keeping

links between rooms "topologically correct" so that what is modelled is a consistent terrain, but still the most used way to move between MUD rooms is by teleporting (e.g. in MOOs, the players "@join" other players), instead of moving through intermediate rooms one by one. This figurative element of instant relocation is of course a negation of real space, and as such a striking contrast to the seemingly naturalistic ideal of the games. But the often central function of this device begs the question of whether the fetishism of real space is really hypocritical; when it really matters, the discontinuity of digital communication dominates even these illusions of real space.

From Myst to Myth

Finally, let us briefly examine two different games, both of which seemingly belong to the outdoors category. Both games are about conquering landscapes, but in very different ways. *Myst* presents a graphical "click'n'go" interface over the classical adventure game structure: explore the paths, solve the puzzles, and win the game. The representation seems three-dimensional, but consists of a network of still life pictures, with "hot spots" that the user clicks on to "move". What seems like an outdoors game is very much of the indoor variety: discontinuous, labyrinthine, full of carefully constructed obstacles.

The other game, *Myth* (Bungie, 1997) is a fantasy battle tactics simulator, where (like *Lemmings*) the player directs and deploys the "pieces" (different types of warriors) to destroy the enemy. The visual imagery is superficially quite similar to *Myst*, with lush green parklands, but with little or no wildlife (in both games, one half expects to meet a golf player or two around the next corner). However, here the similarity stops. While *Myst* is about exploring mystical buildings and other openings, *Myth* takes place in an exclusively outdoors setting. Some houses are visible, but they are only window dressing.

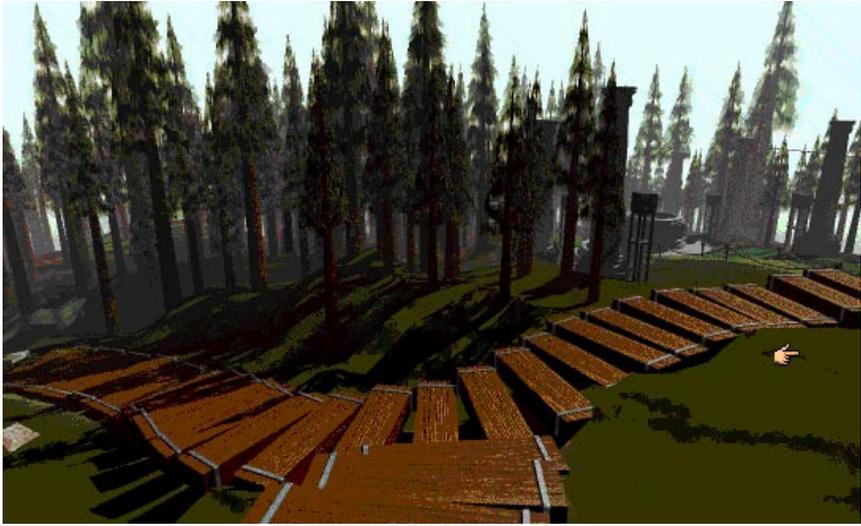


Figure 8. *Myst*. What looks like an open area is really a closed labyrinth with a few possible directions, indicated by the stairpaths.

Where *Myst* is closed, *Myth* gives the impression of being open, and it allows movement in any direction. Most of the terrain can be reached by simple continuous movement of troops. The player, however, has a second perspective. In the upper right corner of the screen, there is a map showing one's own and enemy units as color-coded dots, to be inspected in the main ("camera") window by simply clicking on the map. Such instant discontinuous travel would be invaluable for the field marshals of the real wars of, say, the Middle Ages. However, in the case of *Myth* it does not add to the realism of the gameworld.

Myth can be played in single-player mode, as an episodic quest against the machine-controlled "evil" forces of "the Fallen Lords", or on a network with up to fifteen others, all against all or teams against teams. These two modes represent quite different games, but with the same spatial constraints and possibilities; and in addition, the network version offers several different gameworld arenas (landscapes), and several different types of play ("body count", "capture the flag", "last man on the hill" etc.). So *Myth* (and other games with multi-player options) is not a single game, but a type of discursive field, a machine to play several related games on. The players can even create their own landscapes.



Figure 9. *Myth*: a seemingly open field of endless possibility. Our friend the dwarf has just blown up several bad guys in a single-player game. Notice the Map view (upper right).



Figure 10. *Myth*: The battle against the AI: The AI's melee troops have just engaged the opposing team, which is still marching in from the upper left.

Every game of *Myth* is a fight for position in the landscape. To engage in battle without first securing a strong, ordered position, is in most cases to lose the game. Playing the game corresponds well to the classical theory of tactics in battle: formation, knowledge of the capabilities and weaknesses of types of troops and your opponent's mind are essential to win. The units will go and do as ordered (with a simple click on the unit, and then a click on the position or enemy to be taken) but when the chaos of battle erupts, efficient control is no longer possible, and much therefore depends on how well the player has taken advantage of formation, landscape variation, and knowledge of enemy positions.

Consider the following *Myth* network game, where two teams contest each other's flags on opposite sides of the large arena called "Creep on the Borderlands". The game starts with the units already in ordered formation, with the melee troops in front and the artillery behind. Before the battle begins, the captain of each team must assign troops to each individual player, and discuss their strategies. In this particular game, one of the captains lost his connection to the network, and so no one on his team was assigned any troops. They were reduced to spectators without any influence on the game. The other team discovered this quickly, and thought it would be an easy task to conquer leaderless troops (which in real life it probably would have been).

However, the active team, convinced that this would be an easy victory, simply marched their troops across the arena and into the enemy formations, without a proper plan or formation. But the resistance was quite fierce, and, as it turned out, much more intelligent. The limited Artificial Intelligence (the part of *Myth* that controls the units when no specific orders are given) first used archers against the advancing enemy, then sent in the larger part of its melee units before the enemy team was in formation (Figure 10). This classic tactic crushed the human team in minutes, and the result was a complete victory for the AI, which lost only 43 % of its forces, while the human team was annihilated (Figure 11). This should not be surprising, as it merely shows the importance of spatial formation combined with simple tactics.



Figure 11. *Myth*: The battle against the AI: Only two soldiers from the human team left (right of center); the AI wins.

The landscape in *Myth*, for all its initial beauty,⁴ and as all computer game landscapes, merely *looks* like a landscape, but is really a three-dimensional scheme carefully designed to offer a balanced challenge to the player. Creating a *Myth* landscape, one must have in mind a detailed idea of how one wants the gameplay to commence. Such a landscape is a plan, rather than a map, and this becomes obvious if we look at the difference between single-player landscapes and multi-player landscapes. The single-player landscape is asymmetrical, often linear, with one main path through it, and "evil" troops placed in ambush along the way. Even though it appears to be open to exploration in all directions, obstacles in the landscape, e.g. deep rivers, unclimbable mountainsides or canyons etc., effectively linearizes the options for movement. The promise of continuous space is negated by what turns out to be a strict topology. This is not too different from the landscape architecture in adventure games such as *Myst*. The multi-player landscapes of *Myth* (and other multi-player games), on the other hand, are symmetrical, open and usually arranged around a central point. Since the opponent is human, the challenge is no longer located in the landscape,

which must be "neutral" and equal for all players (otherwise the player with the best starting position will have an unfair advantage). Both types of landscape are "unrealistic" in this respect: In real space, landscapes are usually asymmetrical (with the exception of gardens and planned cities), but they are seldom topologically constricted (at least to the degree found in *Myth*).

In other words, the topology of even the most "open" computer generated landscapes makes them quite different from real space, and controued in ways that are not inherent in the original physical objects they are meant to represent. This makes them allegorical: they are figurative comments on the ultimate impossibility of representing real space.

Conclusion

As I have tried to show, computer games can be classified by their implementation of spatial representation. A thorough classification, however, would need much more detailed analysis than there is room for in this study. Here I hope to have shown the relevance of a spatial perspective analysis to computer games, and how the problem of spatial representation is of key importance to the genre's aesthetics. Computer games, finally, are allegories of space: they pretend to portray space in ever more realistic ways, but rely on their deviation from reality in order to make the illusion playable.

NOTES

1. At the time of writing, it is still unclear when the leading operative system, Windows, will arrive as a 64-bit version.
2. A title word search on "space" in the Melvyl library database (www.melvyl.ucop.edu) returned 17,000 records.
3. There are even small games within the game, such as a functional pool table in Duke Nukem and Pachincko machines in Shadow Warrior.
4. The landscape quickly becomes less beautiful as the battle evolves: the ground is spattered with blood, body parts and broken armour, and blackened by explosions. Perhaps Myth might be read as a visual allegory of civilization's destruction of virgin nature.

REFERENCES

- Aarseth, Espen (1994) "Virtuell virkelighet og retorikk: En kritikk av virtualitetsbegrepet", in Coppock, Patrick J. et al. *Velkommen til den Virtuelle Virkelighet: Nedtegnelser fra et tverrfaglig seminar ved universitetet i Trondheim*. Trondheim: Dept. of Social Anthropology, 225–37.
- Aarseth, Espen (1997) *Cybertext: Perspectives on Ergodic Literature*. Baltimore and London: Johns Hopkins University Press.
- Aarseth, Espen (1999) "Aporia and Epiphany in *Doom* and *The Speaking Clock*: The Temporality of Ergodic Art," in Marie-Laure Ryan (ed.) *Cyberspace Textuality: Computer Technology and Literary Theory*. Bloomington & Indianapolis: Indiana University Press.
- Andersen, Peter Bøgh (1990) *A Theory of Computer Semiotics: Semiotic approaches to construction and assessment of computer systems*. Cambridge: Cambridge University Press.
- Barlow, John Perry (1990) "Life in the DataCloud: Scratching Your Eyes Back In" in *Mondo 2000*, no. 2, 44–51.
- Benedikt, Michael (ed.) (1991) *Cyberspace: First Steps*. Cambridge, MA: Press.
- Friedman, Ted [forthcoming] "Civilization and Its Discontents: Simulation, Subjectivity, and Space" in *Discovering Discs: Transforming Space and Genre on CD-ROM*, edited by Greg Smith (New York University Press, forthcoming) Available on WWW: <http://www.duke.edu/~tlove/writing.htm>
- Gibson, William (1984) *Neuromancer*. London: Grafton.
- Lefebvre, Henri (1991) *The Production of Space*. Oxford: Blackwell.
- Leirfall, Anita (1997) "Space, place and dimensionality," paper presented to the conference *The digital challenge: New information technology, media and communication*, 11–12 des., the University of Trondheim, Dept. of Art and Media.
- Sinding-Larsen Henrik (1993) "Informasjonsteknologi, ansvar og jegets grenser" in Morten Søby and Terje Rasmussen (eds.) *Kulturens digitale felt*. Oslo: Aventura, 259–290.