Pervasive Game-Play: Theoretical Reflections And Classifications

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Abstract. This article explores the theoretical nature of pervasive games (PG). After an epigrammatic introduction to the novel paradigm of pervasive computing and its influence on the making and understanding of games followed by a classification of what I call the four "axes" of pervasive gaming, I discuss in more detail the modifications of (mainly) game rules, game entities, and game mechanics that are mandatory to seize the extended realm of pervasive gaming in comparison with traditional screen-based computer games. Subsequently, I reflect on the intercorrelation of gaming and playing as they are implied in pervasive game-play with special stress on the conception of spaces consisting of tangibility, information, and accessibility.

Keywords: Pervasive computing, pervasive games, computer game theory (ludology), rules, mechanics, theory of space.

1 Introduction

As this article intends to demonstrate by discussing an array of 'classic' as well as 'altered' elements of computer games, it is of vital importance to realize the delicate nonequilibrium of, on the one hand, the randomness of the social and physical contexts in which pervasive gaming thrive, and, on the other hand, the more ordered, rule-based, and discretely arranged game mechanics so essential when we want to create appealing and sustainable games that merge the real and the virtual space. It is therefore important to investigate both the technical and the phenomenological implications of pervasive games. Pervasive games should be fabricated, analyzed – but also "felt". Furthermore, we must think about the nature of space. And finally, we must consider if the current "ludology" of computer games ontology still holds when it comes to pervasive games.

The term 'pervasive computing' is IBM's re-phrasing of Xerox's expression 'ubiquitous computing'. Literally, 'pervasive' means 'totally penetrating'. The word is derived from the Latin *pervasus*, the past participle of *pervadere* ('to go through, pass through, or pervade'). If something is 'pervasive' it means that it is spread throughout our physical environment. In the age of information technology, not only are computers (and the like) everywhere, all the time; we also have access to digital information and networks from almost any location we choose. Wireless technology and the Internet are steps towards increased, seamless communication and the convergence of advanced electronic media. However, this kind of ubiquitous access is largely confined to urban areas. Pervasive computing devices can be embedded in almost any type of object imaginable, including cars, refrigerators, heating systems, clothing, and appliances, not to mention various consumer goods. Pervasive computing technologies connect to worldwide networks without boundaries and provide quick and secure access to a wealth of information and services (Hansmann et al., 2001). In a few years from now, computational devices will have become so naturalised within the environment that it is likely that people will not even realise that they are using computers. Examples of pervasive computing hardware include mobile phones and smart phones, personal digital assistants (PDAs), digital cameras, web cams, interactive whiteboards, interactive TV, laptops, and tablet PCs. On the software side, one could mention groupware systems (a subset of 'social software'), simulation software, business intelligence systems, SRS (Social Recommender Systems), Instant Messaging, peer-to-peer file-sharing systems, level editors, and much more. When it comes to traditional computer games (*Half-Life*, *Quake*, *Doom*, etc.) it should be noted, however, that while there are a few third-party level editors that are open source, the bulk of software is protected by a proprietary licence.

Two essential characteristics of the pervasive computing evolution that relate strongly to pervasive games stand out:

(1) The explicitness of *computational tasks*.
(2) The overall importance of *physical space*.

The former implies that actions are carried out in ways that transcend the traditional Graphical User Interface (GUI). Mobile devices and many forms of wearable or embedded computing shift our attention from metaphorical data manipulation to simulated, hands-on, and direct interactions with physical objects. This aspect interweaves with the second aspect of pervasive computing, namely, that objects obeying the laws of physics are responsive to digital manipulation, and thus take on a double meaning: they are objects in the outside (nongame) world, yet they can also simultaneously be objects within a simulated world. A growing number of games already run on mobile devices such as cellular phones or PDAs, but only a few of these devices can sense their physical environment. Further development in this direction involves sensor technology, calibration techniques, and positioning equipment. Massively Multi-Player Online Role-Playing Games (MMORPGs) such as *Everquest* and *The Matrix Online*, clearly aim at being pervasive in the sense of incorporating a wide spectrum of information and communication technologies. However, they do not fully exploit the potential of combining physical and virtual space.

In addition, we witness a growth in the design of game systems that use ubiquitous computing techniques to propel forward player experiences that connect objects within the real world with objects of the virtual world. *SuperFly*, by the Swedish game company It's Alive Mobile is a good example. The player's aim is to become a virtual celebrity. The projects *Can You See Me Now?* and *Uncle Roy All Around You*, both created by the UK performance group Blast Theory, use hand-held, digital devices, GPS location tracking, and online agent technology in an attempt to use location and mobility as game features from within the real world. While one player stays at home and moves a virtual character around a representation of a real city, other players speed around the real streets, trying to hunt down the virtual quarry. These systems do not, however, integrate the production and technological amalgamation of robotics and cybernetics (also called adaptronics), artificial life, and complex adaptive systems in the game design as well as in the game design process.

Similarly, the preponderance of hardware and software currently made for the game market is restricted to the field of graphics, game and AI engines, 3D rendering techniques, and real-time motion control, all of which relate more or less to either output interfaces (visual presentation of game worlds) or game mechanics, i.e., any part of the game's rule system that covers possible modes of interaction during gameplay. In order to increase attention paid to game machinery, beyond the static mode of immobile users and/or stagnant, screen-based interfaces, it is vital to observe the interactions between humans and computers and the mediation of human communication by computers through naturally established interfaces which are, in turn, supported by technology built into our surroundings, or aimed at the mobile user.

2 Pervasive Gaming Formats

I define pervasive games as an over-arching concept or activity subsuming the following game formats and technologies (Lindley, 2004):

- A *mobile game* is a game using portable technology that takes changes in relative or absolute position/location of the player into account in the game rules. Although this general definition also applies to, say, chess, it still excludes games for which mobile devices simply offer a delivery channel where key features of mobility are not relevant to the game mechanics. Hence, one could distinguish between *mobile interfaced games* and *mobile embedded games*.

- A *location-based game* is a game that includes relative or absolute but static position/location in the game rules.

- A *ubiquitous game* uses the computational and communications infrastructure embedded within our everyday lives.

- *Virtual reality games* are games generated by computer systems with the goal of constructing wholly autonomous and completely immersive game worlds.

- *Augmented reality games* and *mixed reality games* seek to integrate virtual and physical elements within a perceptual game world.

- *Adaptronic games* are games consisting of applications and information systems that simulate life processes observed in nature. These games are embedded, flexible, and usually made up of 'tangible bits' that oscillate between virtual and real space.

Following this I will propose a general definition of pervasive gaming:

Pervasive gaming implies the construction and enacting of augmented and/or embedded game worlds that reside on the threshold between tangible and immaterial space, which may further include adaptronics, wearable, mobile, or embedded software/hardware in order to facilitate a 'natural' environment for gameplay that ensures the explicitness of computational procedures in a post-screen setting.

However, pervasive gaming tends to be used as buzzwords. Some may typify massively multiplayer online games as authentically pervasive games, while others argue that only games that are (at least partly) played out in the real physical and tangible world, i.e., games which use both virtual and augmented reality computing techniques, count as truly pervasive games. How, then, is a pervasive game not a mixed reality or augmented reality game?

One answer to this is conceptual, the other technical. It is, indeed, difficult to distinguish precisely between various open-ended or augmented games and truly pervasive games since a main feature of all types (or genres) is systems that holds a constant invitation to transgress boundaries between fiction/reality, physical/virtual, quantifiable/fuzzy, etc. (Brynskov and Ludvigsen, 2006). If we use a more technical approach to differentiate between pervasive games and augmented/mixed reality games, we could suggest that while the latter games are often facilitated by technologies *not necessarily embedded in the physical world*, pervasive games most often include calibration or other forms of locality based measurements (GPS, signal triangulation, etc.). This means, essentially, that the role of physicality as well as the role of physical bodily movement is predominant in pervasive games, not only in the actual play, which involves the mobile user, but also in the design of pervasive game worlds and the technology that supports such worlds.

Further, we need to separate *time*, *space*, and *presence* (or immersion). This separation will also be important in our attempt to explain the pervasive game-play:

Time. Computer games can be pervasive in the sense that they belong to a set of persistent games. The game is always on. However, the user may log in and out of the game (and the game world). *EverQuest*, *Guild*, *Ultima Online* or other Persistent World-Games are good examples.

Space. The pervasiveness factor also implies that the physical and/or virtual play space has been expanded. We must distinguish between Alternative Reality Games that use a wealth of media artefacts and singular technologies (computer, fax machine, snail-mail, PDA, etc.) and games that merge physical and virtual space through other means, e.g., augmented and mixed reality technology. Examples of the latter include games designed in the Mixed Reality Lab in Singapore. Also, a research and design group from University of Glasgow has developed *Seamful Game: Equator* in which the search for wifi areas in the city – usually considered to be an activity outside of the boundaries of the game – is part of the gameplay itself. The lack of informational infrastructure, which is normally concealed and unexplained, is thus entirely present as an in-game feature allowing users to explore and understand it. In any case, pervasive gaming relies on more than just the standard input-output devices (screen, mouse, controller, keyboard, etc.) by incorporating wireless technology, head mounted displays, tracking and positioning systems, etc. into the gameplay.

Presence. Finally, 'pervasive' might refer to the (psychological) fact that many games have an immersive quality, sometimes referred to as 'flow'. Thus, the line separating playing in a real world and participating as a character in a fictional and virtual game world is, in some instances, blurred.

3 Inside The Pervasive Gaming Toolbox

3.1 The Four PG Axes

In order to refine the broad spectrum of the general definition above, we will zero in on four axes – or, rather, zones in a coordinate environment – that together mark what I call the possibility space of pervasive gaming. The four axes can be described thus:

- **Distribution**. Pervasive computing is situated at the junction of information technologies and a networked digital environment that is always on, always available, and unobtrusive. Pervasive computing devices are frequently mobile or embedded in the environment and linked to an increasingly ubiquitous network infrastructure composed of a wired core and wireless edges. This combination of embedded computing, dynamic networking, and discrete information sharing clearly affects and strengthens the distribution paradigm of IT.

- **Mobility**. New challenges for pervasive computing also include mobility, i.e., computing mobility, network mobility, user mobility, and context-aware (smart) and cross-platform services. Of particular interest to PG is the growth of mobile 3G technologies, and technology that allows bridging between two or more Local Area Networks.

- **Persistence**. The persistence factor touches upon the notion of temporality. Persistence means total availability all the time.

- **Transmediality.** In pervasive games we (often) see a challenge of the traditional model of the relations between sender, message, and receiver, as it emphasises the active role of the user. Patterns of media consumption have been profoundly altered by a succession of new media technologies which enable anybody with internet access to participate in the archiving, annotation, appropriation, transformation, and recirculation of media content (Jenkins, 2003). Transmediality works as unacknowledged support for bits and pieces of media material to create an aura of user-oriented amusement. It further indicates that, currently, no medium can be defined as a self-sufficient application that is based on partial groupings (Walther, 2005c). On the contrary, the dispersal of multiple media spread out over large-scale networks and accessible through a range of devices is a good illustration of how media commune in circular, not linear, forms. This means both the repurposing of content in an intertextual web and the actual structure of media and their interrelations. These media carry information, entertainment, games, role-play, and characters in a non-stop circuit of jointly coupled citations and codes of utilization that can be promptly attuned and functionally altered.

3.2 The PG Possibility Space

Combining distribution, mobility, persistence, and transmediality we enter what could be called the PG possibility space. This space has the potential as a locale for developing, consuming, and thinking about gaming in the years to come. It is a space that deals in *networking,* given its focus on nonlocality, nonmetric systems, and constant accessibility. It is a space that celebrates the *freedom of device* – games can be played on anything, and game devices may trigger anything, anywhere, anytime. It might be worth pointing out that what currently stands in the way of such convergence are rigid intellectual property regimes, and that these are rather more likely to become more pervasive in years to come. Further, it is a space that favours *nonclosure*; although pervasive games still cling to the law of goal-orientation (closure) to a certain extent, they nevertheless open up new ways of collaborative world building, as well as invite continuous structural expansion. Finally, the PG possibility space embraces transmediality and *circular storytelling* as the norm of mediated entertainment. Stories produced and consumed in bits or fragments may very well be the future standard of multi-mediated narration.

3.3 Rules

In traditional computer games the player has a double role as both observer of and an actor in the observed representation. Pervasive gaming goes even further; in complicating the coupling of identity and structure, as these games are projected directly into the player's reality and constitutes a second world within the world. An important corollary of this structural coupling is that real objects become pervasive. They are real due to their tangible and physical qualities, and real in the sense of information-embedded devices open for manipulation, cybernetic control, and input and output feedback – i.e., they can be played with.

How are rules tested by the *pervasiveness* of pervasive games? And how can they be used to describe pervasive games? What about game entities and game mechanics? In the subsequent sections I describe the basic characteristics of these three elements followed by some reflections on the PG ontology and epistemology.

The definition of rules. In line with economic game theory we can define games as complex, rule based interaction systems consisting of these three key mechanisms: absolute rules, contingent strategies, and possible interaction patterns. Game rules are absolute in the sense that while the players may question the rationality of the rules at hand, they are nevertheless obliged to obey, to 'play by the rules'. Rules are therefore absolute commands (Neumann & Morgenstern, 1953) and unquestionable imperatives. They transcend semantic issues, cultural signification, moral agendas, etc. This does not, incidentally, preclude the fact that game rules are discussed in a cultural or ethical milieu.

In contrast to rules, strategies are contingent, nonabsolute entities since they count as the more or less detailed plans for the execution of turns, choices, and actions in the game. Other strategies than the ones actually carried out could have been outlined and performed. Both in the shape of short-term tactics and as long-term schemes, strategies are contingent. In economic game theory, a strategy is an overall plan for how to act in the assembly of different states that the game may be in (Juul 2004: 56). Game theory studies the affiliations of the rules and the strategic behavior in competitive situations (Smith, in print). Finally, interaction patterns are the moves and choices, which become part of the game being played thus interfering with the restrictions and options of the game. As the implementation of game strategies tend to cluster in selected regions of the possibility space of the game (in approximation of what is known as the 'dominant strategy' in game theory) forming a path through the game space, we may even insinuate that the interaction patterns, taken as a whole, are the game itself – especially if we view it from the perspective of the player (Holland 1998). Interaction patterns are the possible as opposed to necessary combinations or the emergent outcome of rules and strategies. This differentiation can be listed even more briefly:

- Rules are commands.
- Strategies are plans for game executions.
- Interactions patterns define the actual path through the game and specify the topography of human-computer (or player vs. rule) dynamics.

Clearly, the interaction patterns work as 'middle ground' as they occupy a domain located between the machine that upholds the rules (the computer) and the human player who has to find and optimize the best way to accomplish the goal of the strategy.

The notion of game play, which we shall pursue in depth in the subsequent section, involves all three levels of a game, which also explains the difficulty in defining the concept properly. Game play is the actualization of a specific stratification of rules, strategies, and interactions as well as the realization of a certain amalgamation of commands, plans, and paths. For a player, a successful game play means a delicate balance between knowing the rules and mapping one's strategy in accordance with both rules and the possible actions of opponents. Games should be equally challenging and rewarding, hovering between boredom and anxiety hereby assuring a space of flow through the network of choices. For a computerized game system, a successful game play implies a balance between fixed rules and the control of player input in variable settings.

What defines a rule? A rule, being algorithmic in its core design, consists of a simple, unequivocal sentence, e.g., “you are not allowed to use hands while the ball is on the pitch”. Hereby, a rule constitutes the possibility space of a game by clearly stating limitations (not use hands) as well as opportunities (the ball is on the pitch). It is always possible to define a game both in negative and positive terms: rules limit actions; they determine the range of choices in the possibility space; they encircle the arenas to be played in; yet they also frame what can be done.

At this point, I am speaking of all games, i.e., both traditional games, including sports, and computer games. *Heroes of Might and Magic* rests on rules stored in and processed by a computer. Chess or *Monopoly*, by contrast, relies on rules not accumulated in the database and algorithms of a computer but written down on paper and stored in the players’ mind during the play. In a game of soccer, for example, a referee administers such rules. Implicit rules that are normally considered exterior to the ‘real’ rules (e.g., clock in chess matches) must be engaged explicitly in digital games. These rules have to be programmed as well. Weather conditions or the general physics of a soccer game are usually taken as ‘out-of-game’ features in the real world. When we simulate a soccer game in a computer, however, the rules of soccer and the general physics (including random variables such as surface granularity, crowds, time of day, etc.) must be built into the rule algorithms and the input-output control of the computer.

Rules specify the constitution of the playing ‘deck’ or, more broadly, the playing ‘field’. In games, behavioral patterns inside this field are limited, constrained, and highly codified (Huizinga 1994; Caillois 2001; Walther 2003a). Rules are guidelines that direct, restrict, and channel behavior in a formalized, closed environment so that artificial and clear conditions inside the ‘magic circle’ of play are created (Salen & Zimmermann 2004). The outside of this circle, reality or nonplay, is essentially irrelevant to game play. Confronted with unambiguous rules, strategies (or tactics) might entail best practice solutions variable to the given rule constraints. Hereafter, interaction patterns map the various player interventions and can hence be viewed as a texture of moves and choices overlain on top of the possibility space of the game. Furthermore, interaction patterns can refer to the social and competitive intermingling of players during the fulfillment of the game. In that respect, the patterns correspond to the outcome of absolute rules and social dynamics.

The formal organization of games can be regarded as a *parameter space*. In this space, the current state of the game counts as a point and ultimately a dimension in the parameter space. A played game has therefore n possible state dimensions. In Tic-Tac-Toe, for instance, the nine squares constitute the parameter space of the game and thus the possibility domain for the arrangement of the board pieces. The rules of the game define the possible edges in the space connecting states. Rules define the possible game, whereas a particular game is a path through the state space. The crucial factor is that there can be no variability or multiple paths through the possibility space of a game without the compulsory parameters of the game. Hence, the parameter space constitutes the transcendental level of the game, whereas the particular game path expresses the contingent realization of the space.

This dialectic between parameter space and actual game path also sheds some light on why games are complex; basically it is because there is an uneven relation between the unchanging set of rules and the actual and changing realization of a particular game. This asymmetrical tie between rules and realization (or rules and strategies) can be termed game emergence. Most often it is impossible to predetermine the actual moves and outcome of a game only by knowing the set of rules. Also, most games are games of imperfect information (Nash, 1997). At the outset, the rules of chess are simple, and yet the wealth of distinct chess playing tactics is quite enormous. A child can memorize chess rules, but to master all grand openings in the actual game is probably a lifetime achievement.

The alteration of rules. In Jesper Juul's highly influental 'classic' computer game model, there are six invariant parameters of game rules:

> (1) *Rules*:games are rule-based. (2) *Variable, quantifiable outcomes*: games have variable, quantifiable outcomes. (3) *Values assigned to possible outcomes*: the different potential outcomes of the game are assigned different values, some positive, some negative. (4) *Player effort*: players must invest effort in order to influence the outcome (i.e., games are challenging). (5) *Players attached to outcome*: players are attached to the outcomes of the game, in the sense that players will be winners and happy if there is a positive outcome, and losers and unhappy if there is a negative outcome. (6) *Negotiable consequences*: The same game (set of rules) can be played with or without real-life consequences (Juul, 2003).

It is evident that, with respect to pervasive gaming, some of these rule parameters were altered. Let me narrow the changes down to two issues:

Variable, quantifiable outcome. To Juul, this means, among other things, that the outcome of a game is designed to be beyond discussion, and that this is an intrinsic token of game rules. This fits perfectly with practically all computer games excluding 'sandbox games' like The Sims, MMOG's, etc.. However, when moving the logic structure of the digital computer into the tangible world, the quantifiability of a rule system seems to shift into a more fuzzy type of interaction between constitutive and regulative rules. In his book, *The Construction of Social Reality,* Searle explains that social rules may be regulative or constitutive (Searle, 1995). *Regulative* rules legalise an activity, whereas *constitutive* rules may create the possibility of an activity. Constitutive rules provide a structure for institutional facts. In the context of explaining the (extended) PG rule system, computation can be regarded as a conceptual framework or underlying system of norms that, in turn, may constitute a possible space for regulative behaviour. In pervasive gaming, constitutive rules are hosted by the virtual domain while the regulative rules spring from the social and physical domain. While the rules of a game may explicitly forbid an acitivity that is perecly legal in the real world, and vice versa, this further means that constitutive rules belong to the set of quantifiable norms, while regulative rules govern *ad hoc* player interaction with the game world. Another way of distinguishing the computational rule logic from the real-time interaction patterns of game-play is to differentiate between *global regulations* (provided by the computer's state machine) and *local operatives* (controlled by the player's behaviour with the physical as well as information-embedded game world).

Negotiable consequences. In pervasive gaming, *real-life consequences* are exactly what drive the play experience forward. The entire teleology of game-play, in fact, rests on the outcomes that transpire and are enacted on the physical arena. A game of chess might have severe consequences if played out in real life, but since the movement of pieces across a board merely *represents* physical structures, it follows that the rules of chess apply to the discrete topology of pieces and plane of play, and not the phenomenological experiences that this topology may cause. In the domain of pervasive gaming, it is precisely negotiability that signifies the toggling back and forth between real-life consequences and discrete representations that pushes gameplay forward. Thus, the PG tangibility consequence brings out a level of uncertainty to the gaming phenomenology; this uncertainty becomes part of the rule structure, i.e., it must be inscribed in the computational representation.

We now move to game entities and game mechanics in our discussion of how pervasive gaming might modify the traditional computer game paradigm.

3.4 Game Entities

In line with the object-oriented programming paradigm, I define a game entity as an *abstract class of an object that can be moved and drawn over a game map*. There can be an enormous number of entities in a game: inventory objects in an adventure game; non-playing characters (NPCs) in a FPS (first-person shooter) game; or a text message in a strategy game. Since a game has many entities, the ways that they can interact increase geometrically.

Pervasive gaming further adds to the complexity of game entities. A PG entity can take three forms: (a) a *game object*, i.e., any object that can be encountered, seen, or interacted with during game-play; (b) the entity can be a *human agent*, since an essential part of a pervasive game is to collaborate and engage in conflict with flesh polygons; and finally (c) the entity may simply be a *physical object*.

Again, it is the negotiability or uncertainty principle that does the trick. Pervasive game-play implies *contingency handling,* e.g., addressing questions such as, are the passing people on the street NPC's; is the elevator a token of the game's passage from one level to the next, connected to a network of sensors, or is it simply an element of the building's non-pervasive construction?

3.5 Game Mechanics

Lundgren and Björk define game mechanics as simply *any part of the rule system of a game that covers one, and only one, possible kind of interaction that takes place during the game, be it general or specific*. A game may consist of several mechanics and a mechanic may be a part of many games (Lundgren et al., 2004).

Thus, we can generally define game mechanics as an *input-output engine*. The task of this engine is to ensure a dynamic relation between game state and player interference. Furthermore, the engine is responsible for simulating a direct connection between the I/O system of computational, discrete logic and the continuous flow from initial to final state in a physical setting. In a certain sense, then, game mechanics postulates a deep transport from the laws of computation to the natural laws of physics. Note, however, that the latter laws must be implemented in the algorithmic system of the computer. In pervasive games, the process of simulation (which always includes selection of the aspects of a real-world situation to be simulated) takes place in real time.

In relation to pervasive games, the following issues of game mechanics are specifically noteworthy:

- *Physically embedded game mechanics*. This element is perhaps best shown by an example. The frontrunner in pervasive gaming, the Fraunhofer Institut für Angewandte Informationstechnik (FIT), has designed *NetAttack*. The game is presented as a new type of indoor/outdoor augmented reality game that makes the actual physical environment an inherent part of the game itself. The mechanics apply to the outdoor environment where players equipped with backpacks full of technology move around a predefined game field trying to collect items, as well as applying to the indoor setting in which a player sits in front of a desktop computer and supports the outdoor player with valuable information. In order to control the information flow that links physical and virtual space, the various components communicate via events and a TCP/IP-based high-level protocol. A central component guarantees consistency and allows the configuration of the game. Before starting to play the game, the outdoor game area must be modelled and the game levels configured. In other words, modelling the game means embedding the necessary mechanics into physical space.

- *Input-output engine with a dual purpose*. Interaction with tangible objects in PG implies, as noted above, a certain level of fuzziness. Therefore, the input-output engine must be constructed to provide a probability algorithm for the actual interaction as part of the rules; however, the engine must also dictate a global, discrete, and binary rule (state) to the interaction. It is in this respect that PG mechanics could serve a dual purpose: on the one hand maintaining and stimulating the contingency of interactions with real-life objects; on the other hand, structuring the controlled set of actions embedded in the state rules. Hence, the input-output engine becomes a machine that frames both contingency and necessity.

In the design of computer games, a *finite state machine* (FSM) is frequently used to manage the execution threads and if-then-else statements in the course of game-play, i.e., as the tree of moves unfolds. One example of how an FSM functions is the operation of the *damage trigger* (particularly relevant to FPSs). When a damage trigger is transmitted to another entity, the pain function pointer is called, thus triggering a state transition of the affected entity into possibly a death or attack state. The damage inflicted in the game is an input to the FSM, which may act as a trigger for a state transition. In pervasive game universes, possible states and state functions are exponentially multiplied. Each FSM can be considered an autonomous agent in a multiagent system involving trigger mechanisms from both the real and the modelled worlds.

4 Space In Pervasive Gaming

This section deals with the matter of spatiality in pervasive games from two angles. The first – technical – paragraph tackles the intricate mixture of the real and the virtual by distinguishing between tangibility space, distributed information space, and accessibility space. The second paragraph explores the relation between what I call "play-space" and "game-space" adopting a more phenomenological (or psychological) terminology.

However, in light of both technical formalities and phenomenological lexis it is characteristic for pervasive games that they expand the gaming space, often by reconfiguring the social landscape of cities into a dense grid of game objects, game goals, and game worlds, thus obscuring the demarcations between the real and the virtual. Pervasive games play with these demarcations.

Truly pervasive games – excluding, for instance, traditional computer games intended for mobile phones – evolve around specific sites or locations. The public sphere of e.g. a downtown area of a major metropole becomes a social framework in which interactions with the game *and* its surroundings are crucial. What, then, is most important? Is it the game itself, or is it rather the social and geographical infrastructure that supports it?

4.1 Tangibility, Information, And Accessibility

The formal architecture of pervasive gaming relies on the interconnection of social domain, virtual domain, and physical domain. Real world properties as well as public, shared or private properties of the social domain must be represented and, to a certain extent, controlled in the virtual domain, i.e., via computers. This domain is, in turn, accessible through a graphical user interface that further represents the game states (Magerkurth et al., 2004).

Players may share the same virtual domain while being physically distant from each other. In fact, one can benefit from this by envisioning and constructing new modes of gameplay. The Australian Sports Over A Distance augmented game *Table Tennis For Three* (which I have been involved in) supports social interaction familiar from traditional sports between physically remote participants through an interaction setup that is only possible because of the distance: a table-tennis game playable by three players who are in three different locations (Mueller, Walther et al., in press).

But what are the implications of this multiple space setup in relation to pervasive gaming? And how can we formalise the complexity that arises from the merging of different kinds of spatiality in PG?

First of all, the perception of space differs according to our perspective, whether from a human level or from a strictly mathematical angle (Walther, 2003b, 2006a).

The mundane space that a human subject inhabits is not by nature geometrical; rather, it is structured in accordance with matter-of-fact actions. In such a spatial environment, the various orientations are related to directions (practical vectors), places, ranges of space, and things, in contrast to dimensions, points, lines, and absolute objects. The space for action is a praxis-architecture – a phenomenological space, we might call it – that is not defined by length, height, and width, but rather by territory, proximity, and distance (Nielsen, 1996). A personal space zeroes in on the required equipment and relations to institute meaning, whereas a geometrical space is continuous and unbounded.

Second, the space of every day life is *heterotrophic* in its design of multiple layers with which it constantly confronts us with a surplus of potential strategies for spatial couplings. The space of mathematics is *isotropic,* where all coordinates are evenly spread in all directions. Thus, when a human subject navigates through space it is *contingent* – where to go next? – and *intentional* in the use of space through motives and affects.

The point here is that pervasive gaming space mixes isotropic and heterotrophic spaces. The teleological goal structure of a game necessitates a certain amount of *accessibility* by which the user can obtain information about space and proceed from, for example, one level to the next (Walther, 2003a). A PG space must amalgamate physical *metric* space and informational and networked *nonmetric* space and, finally, merge them into accessibility space (Bøgh Andersen, 2002). A metric space consists of a nonempty universe of points together with a family of distance relations that satisfy the axioms of distance (Bricker, 1993). A nonmetric space may be defined as a topological or nodal connected space. Real life as such would not by itself be interesting in a gaming sense. We need to organise and structure the nonteleological and open meanings of mundane space in order to make it playable (or actually game-able). Hence, accessibility is the portal to the information- embedded spatial game world.

Tangibility Space. An important aspect of PG, the whole idea of playability, is the player's interaction with physical reality. Tangibility space, however, is not just the sum total of the available, real-time world and its vast amount of objects. Rather, it must be understood as the *heterotrophic organization of potential spatial patterns of behaviour*. This organization of space facilitates a playground, and is often aided by multiple information units located in material objects. These objects can be treated as 'tangible bits' (Ishii and Brygg, 1997), elements of reality that can be touched, altered, and manipulated – as in the real, non-game world – but nevertheless still belonging to the virtual realm as they are controlled by digital technology.

Distributed Information Space. To a large extent, the epistemology of PG involves blending physical and virtual space. In spatial terms, this means that the information-embedded space is facilitated by and projected onto the tangibility space. This kind of space is the digital representation of tangibility space. Yet, besides serving as a map of the game-world, it may also function as a phenomenological space in its own right, i.e., it is experience embedded due to real-time changes, tracking of player motion, etc.

Accessibility Space. Finally, we have accessibility space, which, as noted earlier, is the key to the oscillation between embedded information and tangibility in the pervasive game universe. One way of explaining the delicate relation between the triadic space structures is to say that accessibility space *maps* the information-embedded space system that is in turn *mapped* onto tangible reality.

4.2 Play-Space And Game-Space

There is a fine line between being there, somewhere, and being there with a purpose. To explore a territory, whether in the real, physical world or in the flowing realm of one's fantasy, involves the incessant modification of intentions. It is an advanced procedure of trial-and-error set in a socio-semantic circumstance. You go right. Not interesting. You move to the left. Wait, here's something. You rush straight forward. Now, *that's* where the action is. However, the elusive co-existence of presence – being there – and intentionality – moving around for a reason – is also known as *rules*. Mapping a place through adventurous discovery in order to figure out the story underneath the space, and possibly inventing new ones in the same process, is all about *playing*. Learning to move and advance in a space filled with discrete norms of orientation, meaning that you can do this but not that, is the art of *gaming*.

Thus, there are two firmly interwoven modes of game space: there is *play-space* and there is *game-space*. Together they form the much hyped and commonly misunderstood term "game-play". We call those games that mix up the tangibility of every day spaces with the closed information spaces found in digital computers *pervasive games*. Such games may be the next generation in computer games. Make people move around. Don't tie them in front of the screen. Moreover, these games are particular captivating because they deliberately place the relation between rules and world voyaging, gaming and playing, at the nucleus of the very rule system itself. In other words: you learn how to master the rules of the game by playing them out in the real world. Pervasive gaming is game-play out in the open.

In the play mode, one does not want to fall back into reality (although there is always the risk of doing so). In the game mode, it is usually a matter of climbing upwards to the next level and not losing sight of structure. Play is about presence, while game is about progression (Walther, 2003a). Play-space could be a city, and game-space could be the rules and informational network dictating what can and cannot be done during game-play.

Falling Out Of Play. Look at people playing. One notices that there is always the inherent but beguiling hazard of being "caught" in reality. Nothing is more distressing for play than the aggressive intermission of reality which at all times jeopardizes play *as* play or simply threatens to terminate the privileges of play. Then it's back to normal life. This is, of course, a structural feature of all play and, hence, of all game-play. This is true of chess and soccer. It is also apparent in *Doom* and *Myst*. Interruption and termination must be avoided at all costs – in the continuous pursuit of having fun – but, since they are inescapable, they must be build in to the very "being" or ontology of playing games.

Now, consider pervasive gaming, game-play out in the open. As a player I rush down a street in order to amass my next item to be uploaded via my PDA so that my game-buddy at home can keep track of my doings and goal-seeking so far. It's 4 pm, there is heavy traffic, and I am momentarily barred from reaching the corner with the alacrity I wished for.

In chess, there are no strident interrruptions between two or more discrete fields. I move my queen independently of physics, be it weather, traffic jams, or the occasonally bad habits of my fellow citicens. In a game of soccer, you block your opponent, and he tries to tackle you. However, a nice set of training principles that look for ways to avoid the physicality of blocking is always an option. That is what the refinements of dribble are all about. In pervasive game-play, mixing play-space and game-space, "real" problems, as the ones described above, remain, well, real problems. If not, the aesthetics of producing eloquent game mechanics turns into a matter of ethic. I do not, in the quest of fullfilling the game's teleology, knock down the old – real – lady on the sidewalk only because she is refraining me from targeting the "pac man" further down the road a little bit faster.

Therefore, we must be careful in judging the fun factor of game-play. It is not only the city, the social context, in itself, that is the locus of enjoyment in the pervasive game-play. Yes, I can go explore, and yes, I meet people, and yes, the site of navigation has become much wider than a trivial board. Nevertheless, the promise of space might indeed become the constraints of the game. Serious gamers do not want to waste their time looking for "interesting" places to explore. They much rather want to understand the structure so as to move forward revealing new game areas or climb upwards in the hierarchy of levels.

Why? Because play is centred in a discovery of open spaces that invite observation through the duration of temporality. Gradually, one learns how to pilot inside play, and since the completion of more and more successful tasks takes time, it corresponds to the distinctive forms that keep differentiating the play system into finer grades of subsystems. One inhabits spaces like these via certain as-if-structures; one assumes a role and lives out characters whether in the form of other players or agents that one can adapt as a player. The gamut of play equalises a measurement of its geometry – how big is the playing field, and where are its borders? – and these lengths and widths become in turn the source of gaming's internalisation of both geometrical space and discrete progression.

In contrast, play seems to focus on investigations of semantics, since the task is, not only to measure its space, but furthermore to elaborate upon its modes of interpretation and means for re-interpretation. Not only do we explore a world while playing. Its potential meaning and the stories we can invent in that respect also drive us. Play spaces tend to expand, either in structural complexity or in physical extent. This expansion is further reflected in the praxis of play, for instance when players argue over the exact thresholds of a play domain. Another feature that distinguishes playing from gaming is the notion of presence, as I pointed out earlier. Obviously, the sensation of presence is tightly interwoven with phenomenological concepts like "immersion" and "flow". Play commands presence. We have to be there – not only *be* there, but also be *there*. We go with the flow; or, rather, while swallowed by the presence of playing we are *in* the flow. A game's success is intimately tied to the organisation of space and time. Gamers need to trust this organisation. Since a game hinges on a certain finite structure in order to promote infinite realisations of it – the correlation of rules and tactics – the very articulating of presence so important for play must already be presupposed in a game. One already knows in a game that the mission is to *keep on gaming*, which really means, in my vocabulary, to *keep on playing*, that is, to prolong the sensation of presence. The energy can then instead be directed towards elucidation of the game's structure. "How do I get to the next level?" and not "Why do I play?"

Although one should indisputably respect the ethical boundaries of pervasive games that transport game-play out in the open, one does not want to hang on too long for the old lady to cross the street. While waiting, the question above might turn up thus threatening to disintegrate the exquisitely balanced halves of gaming (to progress) and playing (to be present).

5 Conclusion

In this article I have tried to construct a conceptual framework to assist in the design and interpretation of pervasive games and pervasive gaming. In many ways, the pervasive games paradigm transcends traditional computer gaming: its epistemology or molecular experience must be built into the ontology or atomic structure of the game map itself; a certain sense of openness, fuzziness, and uncertainty clings to pervasive gaming; and the complexity of game states and state functions dramatically increases once a system necessarily made up of tangibility and random interaction with physical objects is tied to the virtual control apparatus. Although truly pervasive games and current augmented or mixed reality games often overlap - the virtual/real diametric, the blend of tangible, information, and accessibility space - the essential characteristics of pervasive games is still the focus on *embedded* (or simply physical) technology. In this respect we could call a pervasive game a mobile, context aware, location-based game.

A great many challenges await us in the field of post-screen gaming. On the analytical side, it may be rewarding to think of PG in terms of axes, key units, and space modalities, as I have suggested in this context. On the phenomenological side I think it would be a good idea to consider the implications of the intentional juxtaposition of play-space and game-space in pervasive gameplay; such considerations might also serve as a “test” in the continuous pursuit of a tightly balanced game-play. It is nice to be out in the open while playing. And yet one should carefully try to control some of the contingent elements in the socio-physical environment and somehow pre-arrange them in the determinacy of the rule system. On the technological side, it may be equally rewarding to focus on the field of adaptronics in computer game design when trying to bring 'life' and other modes of self-configuration and adaptation into play – or, rather, game-play.

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