# Game Mechanics: Describing Computer-Augmented Games in Terms of Interaction

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**Abstract.** We report how new types of games can be created using the possibilities of embedded computing, sensors, new output devices and ad-hoc wireless networks while keeping characteristics from traditional non-computerized games. Applying both a technological and use-oriented research approach, we identified a number of new interaction acts made possible by the new technology. These are described using game mechanics, a concept developed by the game design community. The identified mechanics, together with examples of games using them, are described as well as the benefits and limitations of using the game mechanic concept.

## 1 Introduction

During the last twenty years computer games have become a major industry. The estimated 2002 sales of computer, console and handheld games in Western Europe and North America is $12.8 billion, compared with $9.6 billion in 2001. The top 5 best selling PC games in 2001 sold over 1 200 000 copies each in the US, UK, France and Germany combined, with slightly larger sales for PS2 games [25]. Clearly, computer-based games are a very popular form of entertainment, but they have also suffered from various kinds of critiques; that they increase aggressive behavior, promote sedentary lives, increase the risk of obesity, portray sexist worldviews, and that they show simplified and shallow versions of reality. True or not, there is a risk that if computer based games take over the gaming sphere completely, qualities primarily found in other types of games will be lost, e.g. the intense social interaction when playing a board game together.

The evolution of computer games has been geared towards making maximum use of the hardware which has been available. Small, cheap and embedded computers are ubiquitous today; there are microprocessors in cars, video recorders, toasters and even toys. In many cases, these microprocessors get input via various sensors and react on this. Thus, one could imagine that the game industry, which is seen as having

innovation as its prime criteria for success, would explore how these new technologies could be used to create novel forms of gameplay. However, the game industry has become a very large and competitive market which rarely ventures from established game genres or brands. During 2001, 19 of the 20 best selling games in the US were either sequels or brand-based (e.g. Pokémon or Harry Potter) or both [10], the exception being Halo which was published by Microsoft. This leads to a situation where the game industry may stagnate in terms of game styles rather than grow with the computer industry into new areas of use (although mobile phone games emulate old computer games).

The aim of our research has been to explore how new types of games can be created using the possibilities of embedded computing, sensors, new output devices and ad-hoc wireless networks. One intention has been to focus on computer-augmented games that keep most of the characteristics from traditional games, i.e. social interactivity, co-location, and the tactile and visual qualities of such games. By doing this, we hope to show how the benefits of computer games, e.g. the possibility to display and manage information, and to add simultaneous and continuous action, can be added to traditional games. This opens up for new interaction styles, both in-between players and between the players and the game itself.

Our research approach has its basis in two perspectives: one technological and one use-oriented. In the two following sections we describe and motivate the particular points of departure taken within each perspective in order to provide a background for our chosen method which is described thereafter. An exposition of computer-augmented games and the game mechanics used in them follows and the paper concludes with a discussion about the use of game mechanics as well as planned future work.

## 2 Ubiquitous Computing

Many fields of research related to computers are applicable to games, e.g. artificial intelligence, scientific visualization, robotics and techniques for network communication. However, these do not focus upon our primary interest: the interaction between humans and computers and the computer mediation of human communication through natural and already established interfaces. These aspects have primarily been explored within *ubiquitous computing* [30], which looks at the use of embedded computer technology to support users activities wherever and whenever it is needed, and *tangible interfaces* [12] which take ubiquitous computing yet another step, promoting that user interfaces to computers should not be digital, but physical; one should be able to manipulate data in computers by manipulating physical objects.

The emphasis both approaches put on adapting computer technology to the fundamental activity it supports without disrupting existing habits made them natural areas to ground the technological aspects of our research.

### 2.1 Suitable Technologies

During the years that research has been conducted within ubiquitous computing and tangible interfaces a view has emerged that computational power needs to be quiet and calm; disappearing completely into the background so that users can focus solely on the activity the computer system should support [31]. An easy way to avoid the inherent features of personal computers or game consoles is to start with a device that satisfies the minimum requirements of computational power. Looking at the kind of calculations used in traditional games these can in nearly all cases be solved by using a microcontroller, a one-chip computer. The small size and low power consumption of these devices makes it possible to embed them, including their power source, within small objects.

Regardless of the computational device used to enable a new form of gaming, the technology used to enable interaction can be divided into input or output technologies. An alternative to everyday input devices such as keyboards, mice, joysticks, etc. is the use of sensors to collect data. This makes the system more autonomous, and can free the user from tedious input tasks, e.g. not having to log on to a computer if biosensors are used. Sensors can for example be used to detect presence of, or changes in, light, sound, electromagnetic fields, ultrasound, bending, acceleration, proximity, pressure, or movement. Of special interest in this context are *RFID* (Radio Frequency ID) techniques which can read and change digital data.

Similarly, there are numerous ways to display or transfer output: light emitting diodes, small lamps, liquid crystal displays, lasers, loudspeakers, motors, heating coil etc. We refer readers to the related work found in the references for details.

## 3 Ludology

Within the field of research on games, *Ludology*, most available work describes the historical development of games or focus on developing taxonomies of different game types (c.f. [24] for both examples and a description of other taxonomies). They do not typically address the question of designing new games, especially not new games utilizing novel technologies.

When studying computer games, recent research has focused on the understanding of how new technology can be used to support games or entertainment. This has been accomplished by applying the approaches, theories and methods from narrative fields such as literature, theatre, film etc. (c.f. [7], [15], [17], [21], [23], and [29]). However, this research has focused solely on computer games, rather than games in general. Further, the parent mediums have a strong focus on supporting experience, rather than interactivity, which is of greater importance in traditional games.

Since we wanted to focus on traditional games, and thus also on interaction rather than narration, none of the approaches above would be suitable for our work. Therefore, there was no obvious theoretical foundation for the research we wished to perform. Fortunately, game designers and interest groups have describes the various

interaction acts possible in games using the concept of *game mechanics*. This provided us with a valid starting point which could also possibly ease the communication of our findings to practitioners.

### 3.1 A Terminology for Describing Interaction within Games: Mechanics

A game mechanic is 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. The mechanic trading, for example, simply states that during the game, players have the possibility to trade with each others. What they may trade, and how, and when, is stated in the specific rules for each game using this mechanic. Other examples of game mechanics include bidding, negotiation, story-telling, roll and move, and role-playing.

Evidence of the use of mechanics is abundant. For example, Boardgamegeek [5], a board game website with over 500 000 hits per month uses the mechanics as one element to categorize the over 3800 games that are reviewed, described and discussed at the site. As of September 2002, the site lists more than 40 distinct mechanics. Computer game designers also frequently use mechanics, or sometimes its equivalent mechanism, but the meaning of the term does not seem to have been strictly defined within this area – it can be used both in the same way it is used for board games and within technical programming contexts; overall it seems to be used in its most general sense.

## 4 Method

Having the intention to explore new types of games breaking away from the view of computer games, we chose as our method to start studying interaction in traditional games and then to explore how they could be enhanced in different ways using computer technology.

### 4.1 Initial Technology and Application Survey

When investigating the technologies available to enhance games, we found that researchers within ubiquitous computing had used games as a way to explore various research issues. Although their aim was different from ours, we concluded that these researchers would be interested in participating in events exploring the merger of games and ubiquitous computing. Thus, the workshop “Designing Ubiquitous Computing Games” was organized during the UbiComp 2001 conference to explore various aspects of the subject, including how to capture, display and/or blur physical, social and virtual environments. The papers presented at the workshop later formed the basis for a special issue on ubiquitous computing, to which additional research projects were submitted [18]. These events produced a large collection of possible technologies together with examples of actual implementations of games using them.

Armed with this material, two additional events were arranged. The first one was a one-week research atelier with the aim to create game concepts using ubiquitous computers [4]. It gathered researchers from within Europe that during the given timeframe produced a number of different result: *the Guild*, a concept of technology supporting undercover live role-playing in urban environments; *the SpyGame*, a partially working prototype of an espionage game based around a sensor-equipped suitcase; and *Multi Monster Madness*, an intelligent collectible card game system plus the game *the Hatchery* which used the system. The second event, "Build your own board game", was a rule-writing contest at a gaming convention (GothCon XXVII, 2002). It evolved around a prototype game system called *the MarbleGame*; a board game with a computer-controlled surface. The contest explored how computer qualities affect game design, and the results provided a significant part of a Master thesis on computer-augmented board games [19].

### 4.2 Identification and Analysis of Game Mechanics

Our first structured work to identify new mechanics applicable to computer-augmented games focused on board game mechanics. The starting point was to examine existing mechanics to see which were suitable for computer enhancement. To simplify this task, a brief taxonomy of existing mechanics was created. The collection of mechanics was then expanded by examining existing computer augmented games. The found mechanics were then analyzed in terms of how they could be used as tools for design, analysis and constructive discussion.

## 5 An Exposition of Computer-Augmented Games

A couple of commercial attempts to introduce computerized board games occurred in the 1980ies. Besides numerous clones of chess computers the prime examples are *Stop Thief* (Parker Brothers 1979) and *Dark Tower* (Milton Bradley 1981). In the two latter games, computational power was used to randomize events and to hide and reveal information. Computerized toys (c.f. Barney the talking Dinosaur, the Furby, Lego's Mindstorm System, Sony's Aibo) have been introduced to the market during the late 1990ies and several of these toys are programmed to let them play simple games such peek-a-boo or hide and seek with their owner. Recently, commercial companies have launched games that are played continuously using various digital mediums, c.f. Botfighters (It's Alive 2000) and Majestic (Electronic Arts 2001).

However, most computer-augmented games have been developed within academia. In the following sections we give a brief overview of such games that use computers but do not conform to the traditional characteristics of computer games. They have been obtained from literature searches or from contributions to the workshops or journals described above, and have been chosen since they exemplify different ways to computer-enhance games, as well as the new game mechanics this technology provides. The examples have also been selected because of their strong

focus on creating playable games rather than testing technologies (for the latter see e.g. [16]). For further examples and technical details, see the references, as well as the workshop “Funology: designing enjoyment” [22] and its related work.

### 5.1 Virtual Reality and Mixed Reality Games

These games rely on high-precision body tracking and see-through head-mounted displays. The *MIND-WARPING* system [27] is a fighting game where one player places physical game pieces depicting monsters onto a projected board, whereas the other player plays the game in a VR-environment, fighting these superimposed monsters with gestures. Other similar games include *AR2 Hockey*, *AquaGauntlet*, and *RV-Border Guards* (all described in [28]) which superimpose computer-rendered game elements on the players’ physical environment. *Touch-Space* [6] also superimposes game elements but switches between a virtual and semi-virtual world.

### 5.2 Tile-based Games

Gorbet et al. [9] created the *Triangles* interface which, among other things, was used as a storytelling device for children. By combining the triangles, that in this case depicted characters and places from the Cinderella story, children could hear different aspects of the story. Mandryk et al. [20] created *False Prophets* which uses a computer-augmented board game together with handheld computers to create a game that requires non-mediated social interaction between the players. Computation is used to provide private information to the handheld devices, and to create an action-for-energy system that frees the players from traditional turn-taking.

### 5.3 Location-based and Proximity-based Games

Several projects have explored how to use location information to enhance computer games. *Can You See Me Now?* [8] features two kinds of players: some play online using avatars, moving the avatars across a map of the city while other players roam the actual city, chasing the avatars using handheld computers (PDAs) that inform them about the avatars’ whereabouts. *Pirates!* [3] is a multi-player PDA-based game using radio-based proximity sensors to detect proximity to other players or ‘islands’ in the game. *Pervasive Clue* [26] is a pervasive mystery game in the form of a Live Action Role-playing game, where some clues are provided with sensing technology. *Finding Mister X* [1] equips people with sensor-collecting PDAs, the objective being to identify a specific player given only that person’s sensor data.

*PingPongPlus* [13] introduces the concept of Computer-Supported Cooperative Play (CSCP) in which traditional games and sports are merged, transformed and augmented. Several augmented variants of Ping Pong were created using a sound based tracking system and a ceiling-mounted projector.

### 5.4 Biofeedback Games

These games use input from biosensors attached to players to influence the game, meaning that body control is a critical element of the game. Examples include *Brainball* [11], where players' brainwaves guide a ball towards the opposing goal, and *Relax-to-Win* [2], where relaxation is required to win a race.

## 6 Identified Mechanics

The descriptions of the identified mechanics below are short in line with the use among designers of traditional games, although we have added examples from the games we have encountered or designed. Due to space constraints not all mechanics are fully described; unusual mechanics or those that can be seen as being contained within other mechanics are listed in the end of the section. In some cases mechanics have been identified without having any games that exemplify them; these are included as they may be of use in future game designs.

### 6.1 Computerized Clues

The computer controls the distribution of clues in the game so that players may be uninformed of the source, reliability, etc. of any clue as well as when the clues will be disclosed. Examples include False Prophets, Finding Mister X, and Pervasive Clue.

### 6.2 Espionage

Players can get information about another player's resources, but the computer regulates the level of accuracy of the information. Examples include False Prophets and the SpyGame.

### 6.3 Pervasive Gaming

The game is played continuously even if intertwined with daily activities such as working or sleeping. Examples include the SpyGame, Botfighters, and Majestic.

### 6.4 Superimposed Game World

The game is superimposed on a physical environment which is still inhabited by non-players. Players and non-players have different worldviews but all can unrestrictedly interact with each other. Examples include Can You See Me Now?, Pirates! and Pervasive Clue.

### 6.5 Secret Partnerships

Players are divided in teams without knowing with whom, this possibly being a substantial part of the game. Examples include False Prophets and the SpyGame.

### 6.6 Body-Mapped Avatar

As in sports, players' bodies are their primary loci of game interaction but, unlike sports, the consequences of gameplay affect players' avatars instead of their physical bodies. Examples include Pirates!, Can You See Me Now?, AR2 Hockey, RV-Border Guards, AquaGauntlet and Touch-Space.

### 6.7 Player-Undecidable Conditions

The computer keeps track of conditions which are very hard, or impossible, for players to decide the state of, and the computer uses this information to steer gameplay. For example, a game may end when the total used of a resource exceeds a certain value and it is difficult for players to communicate one's own use to other players. Examples include Stop Thief, the SpyGame, and Multi Monster Madness.

### 6.8 Encouraged Face-to-Face Information Exchange

The game makes it impossible for players geographically separated to share information through the game medium in order encourage players to physically meet. Examples include Pirates!, Pervasive Clue and False Prophets.

### 6.9 Implicit Player Input

Players affect the course of the game by sending input to biosensors attached to them, meaning that a critical element of the game is body control. Examples include Brainball and Relax-To-Win.

### 6.10 Additional Mechanics

Examples of additional mechanics identified include Anonymous Trading, Active Board (examples include PingPongPlus and the Hatchery), Complex Commodities Prizes, Complex Phenomena, Active Dice, Active Surfaces (examples include the Marble Game and the Hatchery), Active Tiles (examples include Triangles), and Secret Bidding. (see [19] for descriptions of most of these). However, we are convinced that numerous others can be found by conducting further investigation.

## 7 Discussion

The games designed as part of the conducted workshops etc. can be seen as successful in that they all need computational power to work, which shows that it is possible to enhance traditional games with computer and/or sensor technology. However, basically all the games can be transformed to "pure" computer games while retaining most of their rules and mechanics. Still, this would probably result in the loss of at least one of the factors we regard to be significant, namely social interactivity, co-location or the tactile and visual qualities.

### 7.1 Using Mechanics in Game Design

Mechanics can be regarded as a way to summarize game rules, and are often used to categorize games, e.g. a “trading game” or a “bidding game”. However, mechanics often have effects not explicitly described, typically how they affect the experience of the game and the interaction between players. For example, pervasive games can potentially change the interpretation of nearly all activities in players’ lives. These effects, hardly ever a part of the descriptions, can make it difficult to use game mechanics per se as design tools when designing a game, even though extensive knowledge about them can help.

Nevertheless, the *concept* of mechanics, i.e. that a game can be regarded as an entity put together by a number of smaller components, can be very useful. During the design process it can make it easier to consider the game’s overall design, achieving an insight how different parts influence each other.

Discussing game design in terms of mechanics also makes it relatively easy to comment on or analyze an ongoing design, even if problems and relations to other mechanics have to be clarified. This comes partly from the fact that mechanics are not elaborate or precisely defined but also because they are incomplete in the sense that they are do not constitute parts of a structured framework. Thus how they relate to each other is not publicly discussed, e.g. how the negative effects of one mechanic may be balanced by another.

### 7.2 Returning to Computer Games

Most of the mechanics identified can easily be used in computer games played on PCs and game consoles. However, one can question how easy it would have been to isolate and define them without starting from the game mechanics of traditional games. In one way, the starting point of traditional games may have opened up for a new approach to looking at computer games; a way that allows computer-based games and non-computerized games to more easily be compared with each other since instances from both categories can be described using the same terms and concepts.

## 8 Future Work

Our work on mechanics, as well as discussions with designers of various kinds of games, has led us to believe that the game design community lacks a structural framework of mechanic-like concepts. There seems to be a need for this, since an absence of methods and terminology applicable to game design makes it hard or impossible to discuss and analyze games, game design and game design processes in an appropriate way. We intend to explore a possible solution to this problem by expanding Kreimeier’s [14] concept of *game design patterns* for computer games, regarding them as the next generation of game mechanics applicable to any type of game. A game design pattern is a formal description of a general problem that occurs

in more than one game and the solution to that problem. The pattern is described in terms of relations to other existing patterns. Where mechanics describe solutions, patterns denominate problems, methods and solutions. Although being more expressive and structured than mechanics, the use of game patterns has yet to be adopted by the various game designer communities. We believe this is a task more suited for researchers rather than developers due to the amount of time required to collect, describe and relate the patterns.

Although the pattern concept is not extensively used among game designers, it exists within architecture and object-oriented programming, the latter being close at hand to the computer game industry, which could provide a way to ease communication between programmers and game designers.

We plan to create structural framework in which we describe and relate game patterns, thus providing a richer description of the design space of games. These patterns will not only be based upon game mechanics for traditional games, since the extensive background work that has been conducted throughout the last year has prepared us for analyzing mechanics in any kind of game. One step in this process has already been taken; the workshop "Computer Game Design Patterns" at the Computer Games and Digital Cultures conference in Tampere, Finland, 2002, which brought together researchers and designers interested in the game design process to present and discuss concepts of game design patterns. A second, ongoing step is to interview prominent game designers (from both traditional game design and computer game design) to collect information about how successful game designers express concepts of game design.

Another intention is to design more computer-augmented games in order to test design methods, validate the structural framework of game patterns, and carry out extensive play testing of such games. We are currently working on *MyTheme*, a storytelling game for non-storytellers (sic!) based on physical play cards, as well as supervising *Kid Cards*, a collectible smart card game for children, and *PhotoPhone Entertainment*, a collection of games and entertainment for mobile phones equipped with digital cameras.

## 9 Conclusion

We have identified a number of game mechanics for computer-augmented games that increase the vocabulary of mechanics developed by game designers. Game mechanics has allowed us to identify, design and analyze the design space of games that make use of sensors, novel output devices and non-PC computer technology. Basing the research on a terminology developed by game designers and hobbyist allowed us to examine a wide variety of game genres and formats; making it possible to focus on the interaction acts found in games rather than on aspects of story-telling, technical systems, or social impact. Further, game mechanics enabled the analysis of both

traditional games and computer games using the same concepts and doing this in a fashion which can be communicated to designers as well as researchers.

However, the non-academic origin of mechanics was found to have caused some weaknesses; they were neither precisely defined nor put in relation to each other in a structured fashion. In addition, the game mechanics were purely descriptive, providing little support for design processes by not containing information about consequences of using a mechanic or how to apply a mechanic to a partly-developed concept. We have identified a possible successor in game design patterns which support relationship information, consequence analysis and implementation strategies.

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