# The Case for Computer-Augmented Games

## Using computers to support and not dictate gameplay

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### Abstract

In this article we introduce and explore the concept of Computer-Augmented Games – the use of computer technology to provide support or tools for gaming activities rather than use the technology as the complete mediating platform. Several examples of these games are presented and placed in a design space using a multi-dimensional typology of games approach. Based on this, possible future directions for using computers to support gameplay are discussed.

### Keywords

Computer-Augmented Games, Game Design, Multi-dimensional Typology of Games

### Introduction

Computers have become an integral part of many people's lives, including to shape their leisure and entertainment. Nowhere is this perhaps more obvious than in the case of games; computers and gaming consoles lets millions of people play in a multitude of forms, often with each other over networks and in many cases exploring large detailed fictional worlds.

That computers are so often used to encase or mediate games has a long history. The early computer pioneers have documented research interests in games, and the first computers were often used for games (Björk 2013). While the motivation for this often was to try and create AI players for particular games – which allowed them to be played alone – the introduction of computational power brought other advantages. Rules could be enacted and enforced by the computer, and this allowed players to adopt a trial-and-error style of learning games. By maintaining the game state, the computer could make it easier to setup and store away ongoing game instances, and with the development of computer networks people could play and game with people at far off locations. With the development of computer graphics and sound, virtual worlds could be visualized in high fidelity.

With all these advantages, one could almost believe that the use of traditional games would have declined. However, even if today the video game industry is the commercially strongest game industry, it is easy to find thriving examples of other types of games. The hobby-game site boardgamegeek lists over 1000 board games and expansions released in 2012 alone (www.boardgamegeek.com). While below their peak in the 1980s, *Tabletop Roleplaying Games* (TRPGs – see e.g. Fine 1983 or Bowman 2010) continue to be published in new editions (see Peterson 2012 for the history of this type of games). *Live Action Role-Playing* (LARPs – see e.g. Stenros & Montola 2010) is becoming a more and more established form of gaming and several large scale crossmedia events have used this as part of the interaction offered (e.g. Waern & Denward 2009; Stenros *et al.* 2011). Further, the recent popularity of *mimetic interfaces* (Juul 2010) provided by the Wii, Kinect, and PlayStation Move show that people are interested in game experiences other than those provided by the “standard” platform provided by video games. Evidently, people still play and enjoy a wide variety of games. Looking closer at the advantages offered by computers for gaming, several of these seem to come with limitations that can be seen as disadvantages. That the computer can enforce rules lessens the workload for players in updating the game state but at the same time makes it difficult to change or add rules to suit the social context, or quickly create example game states to explain the game for novice players. Scripted narration and well-crafted visual and audio material can effectively be presented by computers but make it more difficult for players to be creative within these areas.

In this article we argue that there exists a larger design space for harnessing the potential affordances of computers for games. While we would argue that computers are today mostly used to encase and mediate games, we describe the concept of *Computer-Augmented Games (CAGs)*; games that utilize computational power to provide support or tools for the gaming activity rather than use it as the complete mediating platform.

First we look at a number of different cases that we believe straddle the divide between the traditional video game and the traditional "non-video" game; usually by augmenting one or more existing games, but also some which are more like hybrids. We then describe six CAGs whose design, implementation, and deployment we have been involved in. From these cases – as well as from archetypical board-, computer, role-playing, and live-action role-playing games – we extrapolate a number of design features that are available to game designers. Using the method suggested by the *multi-dimensional typology of games model* (Elverdam & Aarseth 2007), these are used to describe a novel part of the design space of games. Concluding, we make some observations regarding CAGs and other types of games and the different use niches they can occupy.

## Related Work

While this paper builds upon the design experience gained during several game design projects, the CAGs presented later have been informed by many earlier research contributions in the intersection between games and computer technology. Two examples that clearly fit within our definition of CAGs is *False Prophets* (Mandryk *et al.* 2002) and the *Stars platform* (Magerkurth *et al.* 2004). Both of these introduce new computer systems to support gameplay and provide new functionality to support the face-to-face context of board games. The designers of *Stars* also explicitly mention potential pitfalls of moving "a lot of game elements into the virtual domain" (p. 76) and do not create computerized die to maintain the social dimension of die rolling (Fine 1983). However, to provide a fuller understanding of CAGs, we in the following position them with examples that use computers for novel gameplay but are neither CAGs nor "ordinary" video games.

Many of the early computer pioneers did explore the playing of traditional games such as Tic-Tac-Toe, Nim, and Chess (Björk 2013). However, access to the game states were only available through interfaces that ensured following the formal rules either because they were intended for commercial use or because this made the actual practical construction easier from an engineering perspective. We regard these types of games as *Computer-Mediated Games* (CMGs) in that a computer system encases the game state and acts as a gatekeeper for which actions are possible, only allowing actions that are part of the formal rules of the game. As such, most current video games are CMGs.

A noteworthy step towards moving the focus and control of games from being within the computer was taken by Ishii *et al.* (1999) through the concept of *Computer-Supported Cooperative Play* (CSCP). They saw the use of computers together with various input and output technologies as a way not to mediate an activity but instead to "encompass both the augmentation and transformation of sports and games" (Ishii *et al.*, 1999). Using the dimensions of augmentation|transformation and competition|collaboration, they presented a two-dimensional design space for CSCP together with seven applications (including the "application" of unmodified ping-pong). While CSCP has been used to understand online gaming (Wadley *et al.* 2003), Ishii *et al.* saw the term as a way of exploring "athletic-tangible interfaces" (1999) and this aspect has been carried on by later work on *exertion interfaces* that support "sports over a distance" (Mueller *et al.* 2007). Although our concept of CAGs overlaps with CSCP and exertion interfaces, it is significantly more inclusive in the types of games it considers, as there is no requirement that players' physical prowess affect the activity (c.f. Ishii *et al.* 1999).

Another relevant approach is *pervasive games* (Magerkurth *et al.* 2005). Taking the basis in the ideas of ubiquitous computing (Weiser

1991) and pervasive computing (Dordick 1998), these types of games use computers together with sensors and actuators to create gameplay that is "no longer confined to the virtual domain of the computer, but integrate the physical and social aspects of the real world." (p. 2). Many of these make use of *augmented reality* (Mackay 1998), e.g. MIND-WARPING (Starner *et al.* 2000), the Touch-Space system (Cheok *et al* 2002), AR Tankwar (Nilsen & Looser 2005), and TARBoard (Lee *et al.* 2005). While these point towards intriguing new gameplay possibilities, all but TARBoard fall within the category of CMGs since the systems mediate all gameplay.

From the perspective of how games can provide play in a multitude of locations, McGonigal introduces a categorization that redefines ubicomp games, pervasive games, and ubiquitous games (McGonigal 2006). Montola (2005) and Montola *et al*. (2009) gives a different meaning to pervasive games that is closer to McGonigal's ubiquitous games, stating that the defining characteristic is that they expand when one can play from a social, spatial or temporal perspective. While many of the games mentioned in this section make use of computers, Montola (2005) uses the game *Killer: The Game of Assassination* to show that pervasive games do not need to use computers at all. McGonigal's categories rely more clearly on technology in that they all describe approaches that make it possible to play games in different kinds of situations. Although this can be a result of augmenting a game with computers, it is not the defining characteristic, and in this sense CAGs can be seen as a more inclusive term.

## Cases

Our understanding of CAGs has been developed over several years of experimental game design research. In the following, we provide descriptions of some of these projects. While some of the games described in the previous section could have been used as examples, we use games where we have either been directly involved in the design or worked in a supervisory capacity, and therefore have detailed insight into the underlying design processes and goals.

Case: Wizard's Apprentice (ACE 2006)

The design goal behind *Wizard's Apprentice* (Peitz *et al.* 2006) was to explore how computer technology could support two distinctly different target audiences in playing a board game together. The two audiences were a) people interested in playing the game but in need of some help to play, and b) single individuals who were perhaps not that interested in playing but rather in providing said help. The typical user case being a group of children and a supervising parent. The game starts with gameplay being directed for the most part by the single individual, but as gameplay progresses this individual is needed less and less. This is themed as a wizard trying to save a fantasy kingdom by sending his or her apprentices to solve quests which become progressively more difficult and require longer journeys. The physical components needed to play *Wizard's Apprentice* consisted of a sensor-augmented board, a laptop, and several custom-made tokens (a die, miniatures, and control markers) with embedded RFID-tags.

*Wizard's Apprentice* does not check that any of the players are following the rules even if the system can detect when players move to story locations and has a sensor for detecting the result of die rolls. Instead players have to jointly enforce the rules and decide when and if exceptions can be made. This allows for rerolls and simply deciding what result one wants as long as all those present agree. An added bonus of this is that setting up game state examples and events is simplified.

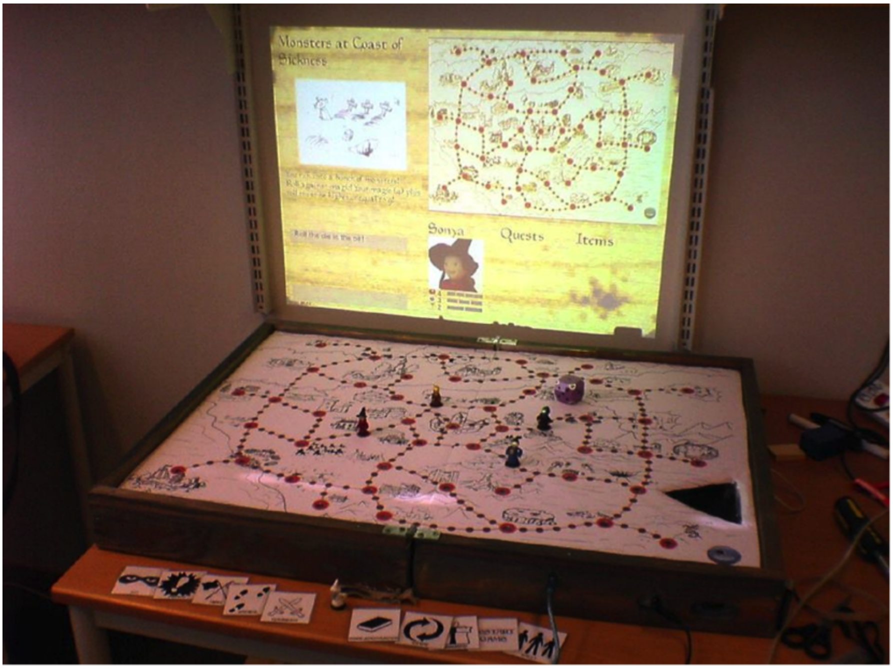


*Figure 1: The Wizard's Apprentice game board, sometime after the first turn.*

Case: M.I.G.

*Mobile Intelligence Game* (*M.I.G.*) is a commercial quiz game similar to *Trivial Pursuit* (Haney & Abbot 1979). The iPhone version of the game was developed as a master thesis (Göransson & Landin 2009) and has since then also been released on Android Market (*M.I.G.* will in the text refer to these versions unless stated otherwise). Based on observations of people playing the original *M.I.G.*, the designers of the computerized version explored the possibilities of automating bookkeeping and rule enactment, compared to letting players do these things manually. While some advantages to automation were found, primarily less more seamless interaction, many disadvantages were also found. First, the automatic approach was vulnerable to unintentional interactions and needed a manual mode to correct the effects of these. Second, a big social disadvantage was found in that interaction "takes place between the user and the device instead of between user and user" (p. 30). In contrast, the manual allowed freedom in the social interaction of explaining the game in that one person could "teach the other players to play the game by freely showing the different parts of the game, exactly as when explaining the physical game in the real world" (p. 30). Given these arguments, the iPhone version was implemented with the manual approach as this put "[t]he user, and not the device, is in control of the game and the flow." (p. 30)


*Figure 2: The main interface for the computerized version of M.I.G.*

The *M.I.G.* application provides a simulated environment that contains all game components needed to play the game. Players can freely move between rolling the dice, marking score, and interacting with the deck of questions. The players are free to ignore rules in the same fashion one could do with a physical copy of the game (e.g. to avoid having questions one has already used), and themselves decide if an answer is correct.

### Case: Undercurrents

*Undercurrents* (Bergström *et al.* 2010) is a web-based tool that augments TRPGs. The GM and all players use individual laptops or tablet computers to send messages and images. This replaces the hand-written notes normally used, which come with several inherent weaknesses, such as writing time, legibility, and that it is visible who is sending a message to whom. The system also gave the players the ability to take notes and access a wiki with information about the game world.

The design goals of *Undercurrents* was to make peripheral and secondary tasks of TRPGs easier. None are strictly necessary but done without *Undercurrents* or other aids they are likely to cause some disruption or inconsistent role-playing. However, introducing computers could easily be distracting, so care was taken to make the interface subtle and not support activities that would disrupt the role-playing focus.

*Figure 3: Players and game master engaged in tabletop role-playing using the Undercurrents system.*

### Case: Tisch

*Tisch* is an application developed for the Microsoft Pixelsense table[1] to provide support for board and role-playing games (Hartelius *et al.* 2012). Based upon an analysis of the general challenges to these

1. The table version used during the development of Tisch was named Microsoft Surface,

activities, the *Tisch* system was designed to reduce excise (Cooper and Reimann, 2003) while allowing house rules and support both improvisation and advance preparation. Further, the principle of *Calm Technology* (Weiser & Brown 1996) was a design goal in order to avoid distractions from the main gaming activity, and as a corollary of this came the objectives of having *Social Adaptability* (Björk *et al.* 2007) and low *Social Weight* (Toney *et. al.* 2002).

The basic functionality of *Tisch* is to provide an interactive map which several people can use simultaneously with their fingers and custom tokens. While a game master (GM) can prepare maps in advance, redrawing parts or adding details can be done on-the-fly. The system supports both rapid transitions between scenes as well as gradual exploration. The state can be saved between game sessions to help and special modes provide tools to measure distances or determine line of sight. In addition, the system can help keep track of the order in which characters act as well as some visual features such as lighting and day|night cycles.

but has since changed as the trademark Surface has been transferred to Microsoft's tablet computers.

*Figure 4: Play testers using Tisch to battle it out in an (not so) abandoned farmyard.*

Case: Monitor Celestra

*Monitor Celestra* (Berättelsefrämjandet 2013) was an ambitious three-day LARP taking place in early 2013 with a Swedish museum-destroyer standing in as the spaceship Celestra. The game was enhanced with a plethora of computer systems and custom-built hardware, providing communication between the players and between the players and the GMs, a soundscape, and the means of controlling the ship in a virtual space. Real-time game masters provided some of the game's logic and coordinated the players.

While the system calculated ship and torpedo movement, sensor signatures and set off some sounds automatically, the state of the support system could be manipulated by the GMs at will, and they provided the majority of the content and logic in real time. Thus, the GMs were free to change events "behind the scenes" to better suit the game's narrative and enter new elements to the ongoing story based on the players' actions.

*Figure 5: Helm console aboard the Celestra. Image: John-Paul Bichard.*

Case: Voidship Concordia Pilot

The *Voidship Concordia Pilot* (VCP) LARP (Bergström *et. al.* 2013) was the precursor for a planned later game and tested methods and design concepts. Just like in *Monitor Celestra*, technological systems were used hand in hand with traditional LARP to enrich the experience and develop a sense of a wider (fictional) world stretching beyond the stage, as well as providing the players with affordances generally unavailable in a traditional LARP. The game system generally built on what was learned during work with *Monitor Celestra*, but scaled back on many levels; replacing custom-built hardware with commercial-off-the-shelf solutions and reducing automation. Instead, gameplay was developed further, with even greater emphasis on making it possible to add content in real-time.

Just like in *Monitor Celestra*, the player characters were in command of a ship, but this time only the command centre was “on stage”, and the rest of the ship simulated virtually. From there, the players controlled the ship using voice commands instead of consoles. The computer-augmented part of the game consisted of two parts – one that kept track of the movement of the ship and other objects in the fictional space (but left all other logic to the GM, such as object collisions, damage, etc), and one used to control entities within the ship, such as the players’ troops and agents. An additional computer was used to control the soundscape, providing sound effects and ambience. This setup meant more work for the GMs (there was almost as many GMs and support personnel as there were players), but greatly increased flexibility.

*Figure 6: Players from VCP discussing strategy in front of the plotting table – one of the game's display screens can be seen in the background.*

## Dimensions of Computer-Augmented Games

While the games and systems we have described above provide examples of what CAGs can be, they do not in themselves point out other possible support computers could lend to a game. To do this some form of framework is needed where the examples can be positioned, but even more importantly, where the spaces in between (and beyond) them can be made explicit. This has been done earlier by game researchers wanting to understand the structural forms of games; specifically through defining dimensions that attribute the presence or absence of specific game elements in games (Aarseth *et al.* 2003; Elverdam & Aarseth 2007). In this context game elements should be understood not only as tangible elements but also abstract features, e.g., pace, representation, and teleology. Further, elements do not have to do directly with what is being interacted with during gameplay but can be any part of the game artifact that one wishes to study, so an alternative descriptor may be "design features". Through using these dimensions, a *multi-dimensional typology of games* is possible, which defines a design space with the extreme points of all dimensions as the outer bounds. Examined games occupy specific places in this space based on what values they have for each dimension, and this allows them to be compared to each other easily – close proximity indicate more similarities. That dimensions can be added, removed, or changed is argued to be an advantage since parts can be used to explore specific aspects of games without compromising the general model. The *Game Ontology Project* (Zagal *et al.* 2005) has a similar perspective, even saying "[o]ur goal is not to classify games according to their characteristics and/or mechanics [...], but to describe the design space of games" (p. 2), but does not elaborate on this further.

During the work with the cases described above, we identified several game elements related to CAGs. Through a brainstorming session several of these were flagged for possible use in this context, and further reduced by discarding those that did not look interesting for more than one game, or produced a (more or less) clear-cut dimension. This reduced batch was then applied to the aforementioned games, and presented to several other researchers for feedback and commentary. After said feedback had been applied, we felt that the remaining dimensions were adequate enough for our purposes.

In line with the methodology of the multi-dimensional typology of games, we below outline these dimensions which can serve as expansions to the original typology. These are then used in the next section to analyze the cases described above as well as relate to archetypical examples of several types of games. The reason for aligning more with the multi-dimensional typology rather than the game ontology project was its flexibility; the identified dimensions can be used without regards to an existing hierarchy which would not have been possible using the game ontology project. This allowed for an iterative, explorative approach where candidates could be added to test their viability without causing inconsistencies or conflicts with other identified game elements. Many of the dimensions we identify overlap at least in part with each other, and in some cases the dimensions have been perceived to be non-orthogonal, i.e. where movement in one dimension likely will cause movement in another.

Note that for games with human GMs, e.g. TRPGs and some LARPs (including both LARPs presented in this article), we view these GMs as players, since our perspective is primarily related to how computers or humans handle various aspects of games. Also, when we talk about changing aspects of the game, we do so from a perspective of doing so from "outside" the game, i.e. not as part of regular gameplay.

#### "Player-agreed" vs. "Artefact-encased" game logic

In this dimension we find the difference between games where the game logic is held in collective agreement between the players, and where it is held by the game artefact itself. On the extreme end of the spectrum we have child's play, both "free" and more formalized (blind man's bluff, hide-and-seek, see e.g. Hughes 1983), then board games where the artefact provides the explicit rules but they are held collectively by the players during play (e.g. *Agricola*, Rosenberg 2007), and at the other end of the spectrum, traditional video games where the artefact takes care of all game logic for the player (e.g. *Grand Theft Auto V*, Benzies & Sarwar 2013).

#### "Limited" vs. "Rich" audiovisual content

One thing that differentiates different types of games is the ability to access audiovisual content, which can help visualize aspects of the game such as the game state and/or the game world, further the narrative of the game, or simply improve the audiovisual aesthetical experience. On one end we find games where the game world is held entirely in the participants imagination (e.g. tabletop role-playing without props or visual aids), on the other end immersive virtual environments such as the CAVE (Cruz & Neira 1992) and LARPs. Somewhere in the middle are board games with added AV content, such as *Space Alert* (Chvátil 2008).

#### "Fluid" vs. "Fixed" game content

The ease with which game content is added; both during play and between sessions, comprise a dimension. On one end of this scale we find collaborative storytelling games (*Universalis*, Holmes & Mazza 2002), where a player is relatively free to come up with new content during play, after which comes "creative" board games (e.g. *Dixit*, Roubira 2010). "Sandbox-style" games (e.g. *Minecraft*, Person 2009), where players create content but are restricted in which elements to use, come somewhere in the middle and traditional video games are placed in the other end.

#### "Manual" vs. "Automatized" excise

Excise denotes the amount of work required by the players to maintain and update the game state. At one end of this dimension we find high excise board games such as *The Campaign for North Africa* (Berg 1979), low-excise board games such as *Settlers of Catan* (Teuber 1995) can be found in the middle, and games where computers perform large amounts of updates as part of simulations, e.g. *Europa Universalis IV* (Andersson, 2013), are found in the other end. Note that this dimension relates to several others – more work done by the computer often means more logic controlled by the computer, for example.

### "Low-effort" vs. "High-effort" modification of rules

How easy it is to modify the game rules, both during games and between games, make up another dimension. This takes into account both the amount of modification possible and how easy it is to perform the modification. Storytelling games such as *Universalis* are on one end (usually requiring only a change of the common agreement), followed by most board games such as *Space Alert* and *Dixit* (which also might require an adjustment of the game materials), then "mod-ready" video games such as *Europa Universalis IV* and *Sid Meier's Civilization IV* (Johnson 2005), followed by video games which lets you change game rules via options (e.g. *Silent Hunter III*, Lazar 2005) and arcade games on the other end.

### "Low-effort" vs. "High-effort" modification of game state

The possibility of modifying the game state is viewed as a separate design feature from the modifying rules or game content because it points to different use scenarios; e.g. when the game state can be modified to let someone "take back" a bad move, explain the game by providing examples, or correcting an error made earlier. On one end we have board games such as *Space Alert* and *Dixit* which lets you modify the game state at will, usually because it is necessary for you as a player to update the game-state as well (i.e., being in the manual part of the excise dimension), somewhere in the middle are video games with a "god mode" editor (such as *Sim Earth*, Wright 1990) and on the other end arcade games.

### "Unlimited" vs. "Constrained" action space

Games differ greatly when it comes to the number of actions players can perform. On one hand we have storytelling games where only the players' imaginations are the limit (e.g. most tabletop role-playing games), then comes live-action role-playing games (LARPs), where the players' character basically can do as much as the players; on the other end of the spectrum we have "open world" video games (e.g. *Fallout: New Vegas*, Sawyer *et al*. 2010) next to more restricted “follow the path” video games (e.g. *Leisure Suit Larry*, Lowe & Crowe 1987). Tabletop miniature games, wargames, and “eurostyle” board games are all in the middle, but clearly distinguishable as separate points.

### “Low” vs. “High” Tangibility

With tangible interfaces we mean the number, quality and scope of tangible objects players can interact with as part of gameplay. This differs greatly between games, and has been researched before, see e.g. (Ullmer & Ishii 2000). The spectrum has the traditional video game on one end and LARPs on the other, games with tangible interfaces such as *Dance Dance Revolution*, (Wada & Yoshida 2001), board games (e.g. Campaign for North Africa), and miniature games (e.g. *Warhammer 40.00*0, Priestley et. al. 1998) in the middle. While one does not necessarily consider traditional video games as having tangible interfaces, the use of a game controller or a mouse and keyboard do provide tangible experiences even if they are the same for all games using those interfaces. Note also that traditional pen-and-paper role-playing games belong on the “video game end” of the scale, unless augmented with tangible props such as miniatures and handouts.

### Exploring the Design Space of CAGs

The diagram below illustrates where the CAGs mentioned in this article fall on the above spectrums, as well as “archetypical” examples for modern video games (aVG), board games (aBG), tabletop role-playing games (aTRPG) and live-action role-playing games (aLARP). These were chosen to provide additional data points and comparisons. *Grand Theft Auto V* was chosen as aVG to represent the open world freedom found in many current video games. *Agricola* serves as an example of modern mechanics-driven board games. *Call of Cthulhu* (Petersen 1981) serves as an example of TRPGs that have a strong GM role and is representative for many other systems. *Krigshjärta* (Föreningen Krighsjärta 2013) is a prototypical example of an immersive and inclusive LARP that takes place over several days in a rural fantasy setting. It is however important to stress that these were chosen to represent categories of games; while this could have been done by adding several examples from each category this would have cluttered the diagram and decreased its readability without adding much in terms of information.

Unlike both the multi-dimensional typology and game ontology project, we considered the dimensions to be continuous. This avoids having a requirement to create hard dichotomies or enumerations of possible values and instead be able to focus on the relative differences. While this is similar to the synthesized dimensions Aarseth produced using correspondence analysis in the work that informed the multi-dimensional typology (1997, p. 67-75), our choice of focusing on relative positions rather than exact values make our values less suitable for clustering analysis (besides Aarseth's original work, see Peitz & Björk 2007, and Dahlskog *et al.* 2009 for examples of this related to games). We present these games using *parallel coordinates*. This visualization technique was original developed in the 19th century (Maurice d'Ocagne 1885) but popularized by Inselberg (1985).

We do not want to suggest that positions given for the games should be taken too literally. This is due to several reasons. First, the extreme points of each dimension are typically difficult to exactly or meaningfully pinpoint, making the possible range imprecise. Second, providing a deterministic way to measure the game features for the different game types presented here is non-trivial. Even so, we argue that judging the games positions to each other can be done reliably and these suggested positions serve a useful purpose in that they allow relative comparisons.

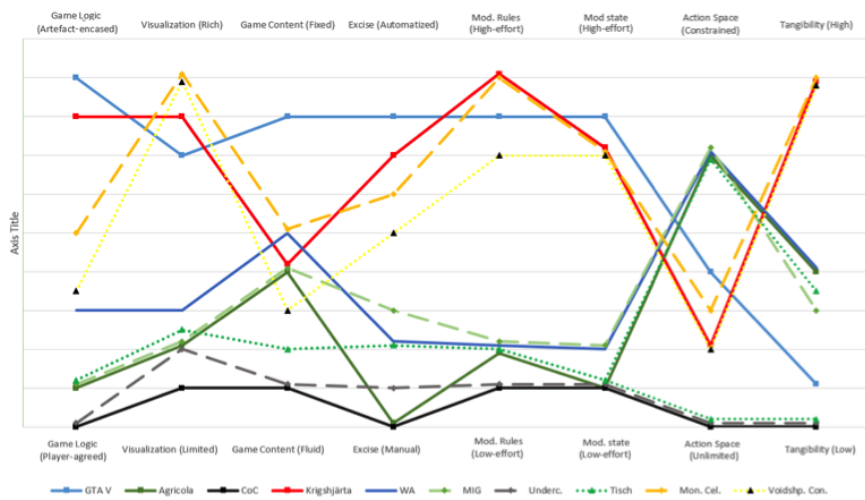


*Figure 7: The position of all example games in the various dimensions.*

To avoid possible misrepresentations it is important to note that the polarities of the scale have been selected so that the archetypical TRPG, *Call of Cthulhu*, is along the bottom of the diagram. This creates a rather uniform line for this game but also for the aVG, *GTA V* except for the two last dimensions. The presented polarities were chosen since they minimized intersections between the most extreme examples (the archetypical TRPG, *Undercurrents*, and the archetypical CG) and other examples, thereby making the diagram somewhat easier to read. The line for *Tisch* deserves an extra note since it bifurcates for the action space and tangibility dimensions; this is simply because *Tisch* can support both board games and role-playing games. Since *Tisch* does not change the number of gameplay actions available, using it means that players have the same action space as the supported game and the tangibility is only slightly affected if used with the aBG *Agricola*. Beyond these basic comments, the diagram help points out a number of observations regarding how CAGs influence gameplay.

First, looking at the board games examples one can see that the lines for *Agricola, M.I.G.,* and *Wizard's Apprentice* closely follow each other. As a system using RFID-tags and a computer to keep track of a hidden game state as well as player progress, it is not surprising that *Wizard's Apprentice* is closer to the video game example than *Agricola* is; the exception being that it has as limited actions for players as other board games. The design intention of *M.I.G.* to put players in control can be seen in that it follows closely to *Agricola*; it retains the flexibility of board games while reducing excise since setting up and storing away the game is trivial. That shuffling the card deck is done simply by shaking the phone also reduces excise but reduces the possibility to change the game state since one cannot rearrange the deck (one can however freely browse through it). Naturally, having all game components represented on a screen lowers tangibility but since the smartphone needs to be passed between players *M.I.G.* still retains some tangible aspect.

Second, looking at the role-playing games, *Tisch* and *Undercurrents* also closely follow the chosen example of a TRPG. *Undercurrents* adds some possibilities for audiovisual content and makes some actions less cumbersome but otherwise doesn't affect the role-playing activity it is used with. *Tisch* is more blatantly a computer system which can be seen in how it positions closer to video games (and *Wizard's Apprentice*), the exception being action space and tangibility which it does not affect at all. That *Tisch* positions itself between the board game and TRPG example regarding game content is not a compromise value; adding content requires more effort than for TRPGs since in these they can simply be announced through performative utterances, while expanding the playable area or making it detailed is simplified by the drawing functionality of *Tisch* compared to a traditional board game. *Tisch* helps both board games and TRPG in setting up and taking down game states between sessions as well as providing measuring tools; this gives it the lower excise value than the games it supports.

Finally, looking at the systems supporting LARPs, both *Monitor Celestra* and *VCP* introduced whole new features compared to traditional LARPs, which is reflected in the greater discrepancies between their respective scales. *Monitor Celestra* was significantly more automated than *VCP*, leading both to less excise and flexibility.

It also had more dedicated hardware for changing the game state (buttons, levers and switches instead of verbal commands), increasing tangibility.

Generalizing, the CAGs that have automated excise have made it more difficult to add game content or modify rules. *M.I.G.* is an exception to this, arguably due to the quiz game not being complex in terms of game element manipulation. In contrast, *Monitor Celestra* and *VCP* increased the possibilities for GMs at the expense of more excise compared to the archetypical LARP. This may be an indication that designs need to consider the level of excise and the possibility of game content and modification together, but can also be a challenge for future research on CAGs. Similarly, increasing the possibility for visualization seems to be related to difficulties of adding new content. Besides these comments about CAGs, the diagram does point to the somewhat unintuitive point that regarding the explored dimensions, LARPs have more in common with videogames than with TRPGs. The basic reason for this is that LARPs for many purposes make use of reality as the “game engine” and this causes similar limitations to changing the game rules and -state as for most video games.

## Discussion

The design space introduced above aims at helping in the understanding of what possibilities computational technologies offers for games beyond that which players can access currently. On a whole, CAGs and the dimensions presented in this article are not intended as normative guidelines for design. Instead, they allow the mapping of a design space where a multitude of gameplay experiences are possible in the interplay between different points on the scales, which can be used to more precisely define and describe design goals. So far, CAGs have mostly been about reducing excise, or providing additional capabilities without increasing excise to unreasonable levels; it is however not difficult to imagine other types of games. As a thought-experiment, the “perfect” CAG would push against the endpoints of the scales by having automatically executed but entirely modifiable rules, rich visualization capabilities, the ability to add content on-the-fly, an unlimited action space, and complete tactility. While such a game may seem a farfetched fantasy, this has already been conceptualized in Murray's *Hamlet on the Holodeck* (1997).

Even if the positions can be read literally, one can also find some open spaces in the presented diagram. These can be seen as potential area for future explorations of novel ways of using computers for gameplay purposes. How this can be done is rather straightforward for CAGs supporting board games, TRPGs, and LARPs given the cases presented, but the same approach can be applied to video games. For example, the dimensions regarding control of game logic and the possibility of modifying rules or game states have most examples near the extremes (*Monitor Celestra* and *Voidship Concordia Pilot* being the exceptions). Video games can rather easily move towards the middle areas by either simply avoid protecting data or implementing a "simulation layer" that allows manipulation of game elements as if they were physical elements (as *M.I.G.* does for a quiz game). While this may not suit all video games, the concept of CAGs and the diagram help make possible design features explicit so they can be included in design discussions. As another example, the tangibility dimension makes visible the lower level of tactile interaction in video games compared to board games, LARPs and CAGs that support these. *Skylanders: Spyro's Adventure* (Toys for Bob 2011) can be seen as a step in adding tangibility to video games but the diagram shows that many more steps can be taken in this direction.

We believe that the dimensions presented here are not the final set of dimensions to be used to understand CAGs but should rather be seen as a starting point for more detailed studies of the topic. Like Aarseth and his collaborators have updated which dimensions they use (c.f. Aarseth *et al.* 2007 and Elverdam & Aarseth, 2007), we believe that further research on CAGs will suggest new dimensions and modifications to those suggested in this text. In fact, several dimensions were discarded in the process of formulating those presented in this article, mainly because none of the presented cases addressed these dimensions in any significant manner. One of these was whether one could learn the game in a "trial-and-error" manner while playing the game, as is possible with most typical video games, but impossible with most board games (i.e. you have to know at least the core rules before play begins). Another was rules transparency – if it is possible to see and understand the underlying mechanics of the game, as in a typical board game, or if these are opaque, as in a video game with a physics engine, for example. The latter dimension is also complicated by the fact that rules transparency is not always a design goal. A dimension that was suggested during the process is whether the game can visualize possible future game-states based on a proposed move, in order to facilitate mastering of the game. Combined with the "trial-and-error learning" dimension suggested above, it is possible that future CAG projects can operate on a scale where they will help players learn and master complicated games quicker, through this making them available to a wider audience.

Finally, we believe that the dimensions presented here have feasibility for game research more generally. They provide a perspective of how games are presented, enforced, and encased through their materiality. The expanded the multi-dimensional topology can for example help distinguish between various forms of LARPs; e.g. examine the hypothesis that vampire-based LARPs (e.g. *Minds Eye Theatre*, Woodworth 2005) are more similar to TRGPs than other LARPs are because of their need to have rules for supernatural powers.

## Conclusions

In this paper we have introduced the concept of *Computer-Augmented Games* and given several examples of how this allows computer technology to support gaming and playing activities without dictating exactly how they should be done or encasing the rules or content. Through a number of identified dimensions, we have presented a design space which points out new technology-based possibilities for all types of games as well as offering to be a theoretical tool for game research.

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