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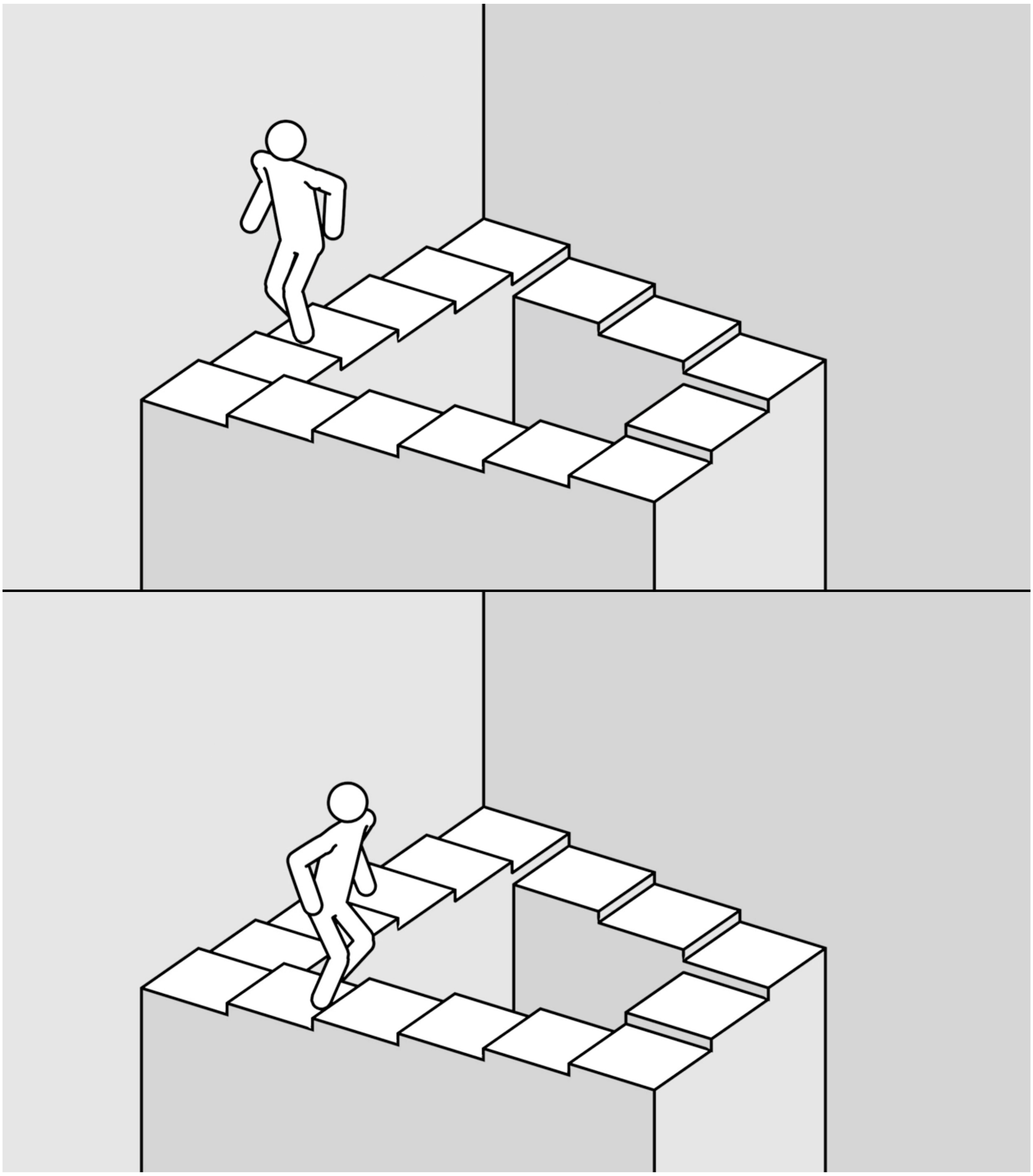
3D and spatial depth today and yesterday

Edited by the Editors at GAME



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Taking space literally

Reconceptualizing the effects of stereoscopic representation on user experience

Recently, cinemas, home theater systems and game consoles have undergone a rapid evolution towards stereoscopic representation with recipients gradually becoming accustomed to these changes. Stereoscopy techniques in most media present two offset images separately to the left and right eye of the viewer (usually with the help of glasses separating both images) resulting in the perception of three-dimensional depth. In contrast to these mass market techniques, true 3D volumetric displays or holograms that display an image in three full dimensions are relatively uncommon. The visual quality and visual comfort of stereoscopic representation is constantly being improved by the industry. Digital games allow for intense experiences with their possibilities to provide visually authentic, life-like 3D environments and interaction with the game world itself and other players. Since the release of the Nintendo Wii in 2005 and later Sony Move as well as Microsoft Kinect (both 2010), modern console games use motion control in addition to the classic gamepad. Both the use of these natural user interfaces (NUIs) and stereoscopic representation determine the user experience (UX) with the system. The rise in popularity of these technologies has led to high expectations regarding an added value in entertainment, immersion, and excitement—especially of 3D games—as both technologies are employed to enable richer and deeper media experiences. For the commercial success of these technologies, the resulting UX has to be enjoyable and strain-free. Because this is not always the case, we have to understand the factors underlying the UX of stereoscopic entertainment media and natural user interfaces to improve it further.

In this paper, we review the current state of user experience research on stereoscopic games and the theoretical frameworks underlying it. We further argue that previous research primarily concentrated on direct effects of stereoscopic representation without considering interaction processes between input and output modalities. More specifically, UX should only be enriched if games enable users to meaningfully map mental representations of input (NUIs) and output (stereoscopic representation) space. We will show how the concept of mental models can account for both information channels and present implications for game studies and game design.

USER EXPERIENCE AND GAMES

There are many different approaches to the concept and measurement of UX in games (Komulainen, Takatalo, Lehtonen & Nyman, 2008). UX is often defined as an umbrella term for all qualitative experiences a user has while interacting with a given product, and it reaches beyond the more task-oriented term usability (for an overview, see Bernhaupt, 2010 or Krahn, 2012). The ISO definition of UX focuses on a "user's perception and responses resulting from the use or anticipated use of a product, system, service or game" (ISO FDIS 9241-210:2010, 2010).

Several other concepts are closely related to UX in games. Terms such as immersion (Murray, 1997; McMahan, 2003), flow (Ciskszentmihalyi, 1975), gameplay (Rollings & Adams, 2003), fun and playability are often used to explain UX from a game design point of view (Bernhaupt, Eckschlager, Tscheligi, 2007), and have been used to evaluate UX. Pietschmann (2009) analyzed further concepts of user experience from other fields of research for their application for UX research, such as presence (Biocca, 1997), cognitive absorption (Agarwal & Karahanna, 2000), gameflow (Sweetser & Wyeth, 2005), engagement (Douglas & Hargadon, 2000), and involvement (Witmer & Singer, 1998). A combined analysis revealed a high degree of consilience that suggests a considerable overlap between the concepts. Due to the multifaceted definition and operationalization of UX, the advancement of theory as well as results suffers from a lack of comparability.

The rise of consumer stereoscopic display technologies poses new challenges to the UX research in games as they claim to increase the visual authenticity. One of the main questions in this context is whether this increased visual authenticity in games automatically leads to an enhanced UX—and if so, what mechanisms exactly constitute this enhanced experience. Another challenge is the measurement of stereoscopic UX in video games.

Describing entertainment experiences based on the concept of (tele)presence has a theoretical and empirical background for the use in the research of interactive media (e.g. Tamborini & Skalski, 2006; Ravaja et al., 2006; Bae et al., 2012). Many studies focused on the measurement of presence, and a broad body of research with questionnaires as well as behavioral and psychophysiological measures exists (for an overview, see Baren & Ijsselsteijn, 2004) that can be employed in the research of UX in stereoscopic games.

EFFECTS OF STEREOSCOPIC REPRESENTATION IN DIFFERENT MEDIA

Stereoscopic displays induce a convergence-accommodation conflict in the user because they present images at a fixed focal length (i.e. the distance to the screen) but vary the object convergence to simulate depth. During the fixation of real world objects both convergence and accommodation are closely linked, but the fixed focal length of a stereoscopic display results in a conflict within our visual system. As a result, viewing stereoscopic images can have negative short-term consequences, including difficulty fusing binocular images and therefore reduced binocular performance (Hiruma, Hashimoto & Takeda, 1996;MacKenzie & Watt, 2010). Consequently, a great deal of research focused on negative effects of stereoscopic displays such as visual discomfort or visual fatigue, and suggested how to avoid them (e.g. Häkkinen, Takatalo, Kilpeläinen, Salmimaa & Nyman, 2009; Tam, Speranza, Yano, Shimono & Ono, 2011; for a review see Lambooij, Ijsselsteijn, Fortuin & Heynderickx, 2009; Rajae-Joordens, 2008 and Howarth, 2011).

These negative effects are part of the concept of simulator sickness (SS) which is established in virtual reality research since the early 1980s (e.g. Frank, Kennedy, Kellogg & McCauley, 1983). It is usually measured via the simulator sickness questionnaire (SSQ; Kennedy, Lane, Berbaum & Lilienthal, 1993). Symptoms of SS have also been identified in studies on stereoscopic gaming. For example, Häkkinen, Pölönen, Takatalo & Nyman (2006) found that after stereoscopic representation of a car racing game, eye strain and disorientation symptoms were significantly elevated compared to non-stereoscopic modes of representation.

However, research also focused on positive effects of stereoscopic representation on UX in different media in order to investigate the industry's claim of enriched UX. Ijsselsteijn, de Ridder, Freeman, Avons & Bowhuis (2001) studied positive and negative aspects in stereoscopic, non-stereoscopic, still, and moving video conditions. In all conditions, a video with a rally car traversing a curved track at high speed was shown to the participants. The results revealed a significant effect of stereoscopic representation on the subjective judgments of presence, but not on vection, involvement, or simulator sickness. However, they concluded that the presence ratings were more affected by image motion than by the stereoscopic effect.

Rajae-Joordens, Langendijk, Wilinski & Heynderickx (2005) reported similar findings: Experienced gamers played the first-person shooter *Quake III: Arena* in a stereoscopic and a non-stereoscopic condition. The participants reported increased presence and engagement in the stereoscopic condition but no symptoms of simulator sickness. The authors concluded that stereoscopic representation elicited more intense, realistic experiences, a er feeling of presence and thus a richer UX. Additionally, several studies found that stereoscopy enhances the user's depth perception and eye-hand coordination in real world scenarios (e.g. McMahan, Gorton, Gresock, McConnell & Bowman, 2006).

STEREOSCOPIC REPRESENTATION DOES NOT AUTOMATICALLY ENHANCE USER EXPERIENCE

Contrary to earlier findings, recent studies found that stereoscopic representation in different media does not automatically improve UX. Takatalo, Kawai, Kaistinen, Nyman & Häkkinen (2011) used a hybrid qualitative-quantitative methodology to assess UX in three display conditions (non-stereoscopic, medium stereo separation, high stereo separation) playing the racing game *Need* *for Speed Underground.* They found that the medium and not the high separation condition yielded the best experiences. The authors concluded that the discomfort of stereoscopic representation (due to limitions of stereoscopic technology) is tolerable in the medium separation condition but diminishes the UX in the high separation condition.

Another study from Sobieraj, Krämer, Engler & Siebert (2011) compared experiences of 2D and 3D cinema audiences of the same movie regarding entertainment, presence and immersion. Results revealed that the stereoscopic condition did increase neither the entertainment experience nor positive emotions or the feeling of presence or immersion.

Elson, van Looy, Vermeulen & van den Bosch (2012) conducted three experiments to investigate the effects of visual presentation on UX. In the first study participants played a platform game (*Sly 2: Band of Thieves*) in standard definition, high definition or 3D condition. In the second study they used a more recent action adventure game (*Uncharted 3: Drake's Deception*) with the same viewing conditions. In their third study, Elson and colleagues, in collaboration with a game developer, created a game that requires spatial information procession (*3D Pong*) and employed the same experimental conditions.

In all three studies the results showed no differences in any variables between the conditions; there was no effect of stereoscopic representation on any measure of UX.

Disparities between studies might be explained by differences in the experimental designs. We already indicated that UX has a broad range of possible measures that might also differ significantly in their sensitivity to stereoscopic representation. Additionally, it is not granted that participants in all studies were provided sufficient time to adapt to the mode of presentation. For the latter case, further longitudinal research is required to assess the user's shifting perception of and thereby adaptation to stereoscopic representation over time. However, the studies reported above indicate that the sole use of stereoscopic representation might not automatically enhance the UX—i.e. the rule of thumb "the more, the better" does not seem to apply here.

MEANINGFUL RELATION OF CONTENT, INPUT, AND OUTPUT

One flaw of research on stereoscopic media is the fact that researchers, due to the notion of an omnibus-effect, often did not focus on the underlying mechanisms, how stereoscopic representation would enrich UX. We argue that the lack of change in UX with stereoscopic representation in previous studies can be explained by the concept of mental interaction models and the related cognitive processes during gameplay. To successfully enrich UX, games have to create a meaningful relation between stereoscopic representation, input modality and the type of task that players have to fulfill. Therefore, we should not consider stereoscopic representation merely as an attribute of games on its own, but as an attribute that is closely tied to other attributes of the medium in which it is implemented.

First, we argue that UX can only be considerably enhanced by stereoscopic representation if users can interact via natural input devices within the same three-dimensional space they visually perceive. The implementation of both technologies facilitates the user's construction of a mental interaction model by mapping the space of the virtual environment to the real space where the player performs actions. Second, this spatial mapping of input and output modalities should only matter if it is relevant to the task users have to fulfill and the according type of action users perform, respectively.

MENTAL MODELS AND THEIR APPLICATIONS

The concept of mental models originates from cognitive psychology and its precursors (e.g. Craik, 1943; Johnson-Laird, 1983) as a means to explain our understanding of different complex entities that we experience, such as situations, processes, and relations between objects[1]. In general, mental models can be regarded as preliminary cognitive schemata that are not yet fully learnt but are under construction. The concept of mental models evolved from the idea that we initially do not fully comprehend perceived entities, but have to construct our understanding through experiences. Therefore, understanding can only be a result of a constant update of a mental model based on new information and the model's prior state.

The general form of a mental model receives information input from two sources. First, when we construct mental models about a new entity, we do not build models from scratch because we implement existing experiences or knowledge from other domains that we deem helpful (top-down processing). When we see a smashed bottle of water next to a table, we assume that some force caused the bottle to move and that gravity let it fall. We could further assume that our cat was the force that initially caused the mess, because she had done so twice already. We thereby systematically draw from previous knowledge (top-down) in order to reconstruct the event via a mental model. Second, mental models are constructed for a specific entity that deviates from similar entities that we referred to in top-down processing. We therefore look for and implement information from specific events itself (bottom-up processing). The fact that the bottle of water is broken and located on the floor next to a table indicates that a specific event has happened, i.e. the bottle dropped. This information caused top-down processing, which relates the event to other situations, such as when things drop from the kitchen table. However, upon further examination of the scene we realize that our son is standing at the other side of the room, ashamedly looking down. This new information causes a major modification of our model (bottom-up), i.e. the causation of the event is substituted. Because mental models are typically constructed over time according to the information available, other relevant prior knowledge and new

1. For a detailed historical overview of the concept of mental models, see Johnson-Laird (2004).

information is implemented into the model to improve its effectiveness with the goal to achieve a good model fit. In our example, we might ask why the son smashed the bottle of water—was it bad luck, because he did not pay attention to the table (bottom-up), or did he again argue with his brother resulting in the accident (top-down)? Both bottom-up and top-down processing are at the core of human cognition and are utilized in every situation that involves perception. Accordingly, both types of processing as well as the construction of mental models as higher cognitive instances are automated processes that do not require conscious processing and only through the combination of both types of processing, mental models can gain accuracy over time.

Mental models serve as a tool allowing for interaction within the real world without initially having to fully understand every element—they allow us to *model* the real world. Once we have an initial model of a given entity, we can make assumptions about possible outcomes of interactions with the entity and test the assumption against the real world outcome. The deviation between predicted and observed outcome serves as an indicator as to whether the mental model suffices or how it can be further improved. This way we can simply simulate our environment with ever-increasing complexity to achieve better understanding. However, mental models are processed in our working memory and are thereby subject to our working memory's processing capacity. Therefore, complexity reaches its limits when the model requires more mental resources than are available. The model is then no longer efficient as a means to simulate our environment. Consequently, simple models that do not rely on detailed parameters allow us to simulate entities despite our cognitive processing limitation. Thus it is important to keep models simple and reduce their complexity to a necessary number of components that can still be handled by our processing capacity.

Within the context of media reception research, a similar concept has been used by Kintsch & van Dijk (1978) to explain a reader's understanding of texts. In this case the amount of available information is limited to the aspects that are mentioned in the text. In order to understand an event the user has to rely on prior knowledge to fill the information gaps within the text. Kintsch & van Dijk argued that readers build a proposition network from textual information and preexisting propositions to represent the situation of a text. The concept of mental models was also applied to film studies (Ohler, 1994) in an effort to explain the viewer's understanding of film narratives, in this case called situation model. As with the case of written texts, movies often do not provide the recipient with all necessary information required to understand events. On the contrary, detective stories often suggest information pieces that recipients implement into their situation model because they deem reasonable, thereby manipulating the recipients understanding of the narrative in order to create suspenseful entertainment experiences (Ohler & Nieding, 1996). Whenever new information becomes available through the detective's investigation, our model is updated.

SPATIAL INFORMATION IN PLAYER-GAME INTERACTION

In our effort to explain effects of stereoscopic representation on UX by a mental interaction model, we first have to define, which information is represented within the model and why the interaction between player and game is an important process for a seemingly mere perceptual phenomenon. Interaction is often described as the fundamental component of the gaming experience (Crawford, 2003; Salen & Zimmermann, 2004; Zimmermann, 2004) that elevates games to a new type of media distinct from books or films. In addition to the narrative that is carried out within the game, we can manipulate the virtual environment to a certain degree in order to advance the narrative[2] by our actions. Through this interaction our perspective on the narrative shifts from an observer to an actor whose actions determine the narratives outcome (Aarseth, 1997).

Interacting with game systems requires at least one channel for each input and output of information. To understand the cognitive prerequisites of interaction models we first have to identify the type of information that is carried within each channel. Second, as we want to understand stereoscopic representation—a *spatial* phenomenon—we have to identify each channel's relation to spatial information.

In terms of input, games provide different types of game controllers, such as gamepads, mouse, keyboard, or motion sensitive controllers. The buttons of a controller are generally linked to a specific action in the game. However, for some actions the mapping between controller and game action is mediated by an additional input layer within the GUI. In the latter case, the action is not activated by a specific button on the controller as the button only executes an action that is linked to some GUI element[3]. To understand the effects of interaction on UX, we should not utilize a simplified definition of interaction between real world action and in-game consequence. Instead, we should analyze each input layer separately as each input action differs in the way it is related to in-game actions. In terms of output, games use several information channels to convey feedback, i.e. visual, auditory, and haptic information. In this paper we focus on visual feedback and, more precisely, on the effects of stereoscopic versus non-stereoscopic representation on the interaction process and thus on UX.

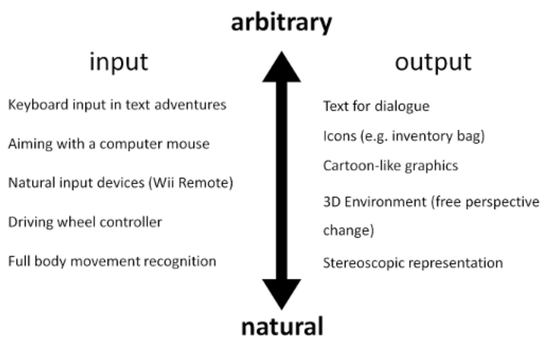

Figure 1 – Continuum of perceived naturalness of input and output information channels in games

2. The term narrative should be understood in its broadest sense here. We regard player action to be part of the narrative, while other authors limit the term narrative to the plot of the game. For a discussion see Juul (2001).

3. As an example a button could be used to let the player *interact* with the environment. This way the button is not responsible for the player opening a door or speaking to a NPC, but the player's selection of a door or an NPC by moving towards it. The interact button then only executes an interaction affordance of a GUI element.

Each information channel that is used in the interaction process can be classified according to its perceived naturalness compared to the real world on a continuum[4] between arbitrary and natural (see figure 1).

Arbitrary input information is common in games and often prevents players from having to input a complex series of button-combinations in order to perform an action. Instead of having to swing a sword and block an opponent's strikes by moving the sword via the gamepad's analog stick, we are given one button for each action. Despite the increased perceptual naturalness of analog stick movements compared to sword movements by mapping the directionality of movement, this type of input would greatly increase input complexity and thereby the game's difficulty. Accordingly, arbitrary input facilitates UX by reducing input complexity, so that the player can perform relevant actions without much effort and can focus his attention on more relevant entities (e.g. strategic decisions). Only recently with modern gaming consoles has technology enabled players of mass marketed games to use input devices with greater naturalness that are sensitive to the player's movement. Although other types of natural input devices have been available before (e.g. steering wheels or microphones), they are only applicable for specific types of action whereas the recent generation of input devices supports a wide range of possible actions.

Nonetheless, input devices such as steering wheels, drum sets or microphones require almost exactly the same movements that are necessary for driving cars, playing drums or singing a song. In this case the motion performed by the player can be transferred directly into the game. However, the more intensely an input device is used for different input actions (e.g. playing tennis or swinging a sword), the more the input information has to be interpreted by the game in order to reach a robust means of interaction.

Because all these movements represent directionality, rotation, acceleration, and speed in a three-dimensional space, this type of input can be regarded as fairly natural according to the degree a game interprets the input information. As a consequence of the increased naturalness of input, players have to focus their attention on the input action itself to a greater degree because they have to coordinate their movements according to the desired consequence in the game. Arbitrary input devices simplify the interaction process by reducing rather complex actions to a single button press. Natural input devices, however, often force the player[5] to perform an action as it should appear in the game. The learning process of an interface is therefore more demanding when we have to learn motoric skills instead of simple button mappings. This sensomotoric experience should result in a very different gameplay experience.

In terms of naturalness of visual output, games usually provide both arbitrary and more natural information. Arbitrary information is used for numerical feedback (e.g. the amount of experience points required to reach the next level) or in the form of symbols that convey relevant game information (e.g. button symbols in quick time events). The degree to which visual output is rendered naturally

4. This continuum has already been reported by Sachs-Hombach (e.g. 2005) to categorize media, especially visual media, according to their perceptual fidelity.

5. It should be mentioned that in some cases the player forces herself, because she overestimates the required accuracy of the controller movement to perform an action in the game. In *Wii Sports Tennis* for example, a simple controller movement is equally successful as a fully exercised service movement.

depends on the respective game: Early game engines were not able to represent game elements realistically. Over the past ten years, however, game engines constantly gained visual fidelity with some games getting close to the visual quality of films. The latter is especially true for games that utilize the first-person perspective, usually allowing free movement and free perspective change. Therefore, visual representation of those games is highly developed in terms of object shape, object movement, texture, and lighting quality, and can be regarded as a highly natural type of representation. Additionally, players gain an impression of the three-dimensional quality of the virtual environment via monocular depth cues, such as object size, perspective, and movement speed while moving around objects. However, they do not fully perceive spatial depth, but utilize monocular depth cues. Only with stereoscopic display technology can players additionally utilize binocular depth cues to perceive actual spatial depth. Games that allow stereoscopic representation can therefore present visual output with a higher visual fidelity than games that merely rely on a three-dimensional virtual game world that is reduced to a two-dimensional representation.

Recent research investigated if this assumed difference in naturalness of output had an effect on UX. The inconclusive results may be a result of at least three circumstances: (1) there is no effect; (2) there are other variables that mediate the effect; or (3) there is no difference in perceived naturalness in the first place. With the help of interaction models, we can explain that prior research might be subject to a combination of (2) and (3): we argue that there is an effect if a given system constructs a meaningful relation between stereoscopic output, natural input and type of task. Therefore, an effect should exist, if a game accounts for a natural type of input and tasks that rely on interaction in a three-dimensional space (2). However, if a game only provides natural input devices and stereoscopic representation, but spatial depth is not relevant to the task a player fulfills, effects of stereoscopic representation should only exist as a short-term sensation due to the new kind of experience. Additionally, it should have no effect in extended gaming sessions, because it is not relevant to the game. In the latter case, other experiences superimpose the impression of spatial depth and stereoscopic representation should be perceived as just as natural as non-stereoscopic representation (3), given that the player is not forced to compare both conditions.

MENTAL MODELS OF INTERACTION AND SPATIAL MAPPING

For stereoscopic representation to positively affect UX, the additional information this technology provides, i.e. binocular spatial depth cues, has to be *relevant* to the gaming experience. Only when spatial depth cues are at the core of the game mechanics can they influence UX in extended gaming sessions. Because interactivity is regarded as the central attribute of digital games, spatial depth cues would have to be relevant to the interaction between player and game. It contains at least two information channels that flow into opposite directions;

therefore, not only should display technology present spatial depth cues, but input devices should also be allowed to spatial depth into the system. However, as spatial depth is not relevant to the gaming experience per se, it should be enforced by the player's tasks. In this case, processing spatial depth information should considerably determine the player's success and thereby focus the player's attention to some extent on spatial depth; it becomes relevant to the way the player interacts with the game.

We argue that whenever players interact with a game for the first time, they construct a mental model of the interaction process because games differ intensely in the way different input actions are linked to specific game events. One might counter that experienced players already possess an elaborated model of how to interact with a game because many games rely on conventional mappings of controller buttons (e.g. analog sticks for movement and perspective control). However, there are still actions that are not subject to conventional controller mapping. Additionally, even if the general functionality of a button is intuitive via its conventionality, the specific outcome as well as the required timing and rhythm of button presses still differ between games. Eventually, players will have to learn basic interaction principles for each game by constructing an interaction model and improve it by game experience. This fact also becomes evident by the tutorial phase that is carried out at the beginning of almost every game, where players learn the basics of game control and game mechanics respectively. In the case of natural input devices, the learning process can become rather difficult, as input action gain complexity because of the required input of motoric action.

Just as other mental models, interaction models are constructed in a combined bottom-up and top-down process, i.e. the model draws from both prior knowledge and experience during gameplay. Experienced players should benefit from interaction models of other games and should therefore learn more quickly during the actual interaction with the game. In addition to controller mappings, interaction models represent at least two other types of information. First, they model the *interaction affordances* of a game, which can be regarded as a set of possible actions that allow the player to manipulate the game world (e.g. moving boxes or turning on a radio). Accordingly, players do not know initially which interaction affordances are present within the game, but have to identify them throughout the game.

Second, because both input and output modalities convey spatial information, the player faces the problem of *multiple spaces* with the gaming environment and the living room being separated from each other. The player would have to understand how the space she is physically located in is related to the space she perceives visually. For example, in *Wii Sports/Tennis* (Nintendo, 2006), both spaces are fairly independent of one another: A forehand swing does not require the player to swing his *racket* from back to front in an upward movement—the player could also just perform a short movement in any direction. Both spaces are not linked one to another; the only information that is gathered from the controller is the amount of acceleration and the timing of a swing. In this scenario spatial depth cues would not be relevant to the interaction and, therefore, not affect the UX. Spatial depth only becomes important when both spaces are closely linked, a state that we refer to as *spatial mapping*. In this case, the game environment becomes part of the player's living room and vice versa, i.e. she is perceptually located within the virtual environment she interacts with, which might be referred to as an intense feeling of spatial presence (e.g. Tamborini & Skalski, 2006). Here, the player's interaction model would suggest that their movements in the real world space are consistent with movements in the virtual world. The extreme state of spatial mapping is presented by the Holodeck technology in *Star Trek: The Next Generation* (Berman, 1987-1994). In this fictional VR, each element of the virtual environment can be interacted with directly. But even real VR installations can achieve a similar perceptual phenomenon, where each set of coordinates of the virtual world is *mapped* to a set of coordinates in the real world. Players can then use natural input to manipulate the object at its actual position. A tennis game could therefore project the ball's position into the space in which the player is located and track their precise movement to determine whether they hit the ball or not. Of course, this high level of spatial mapping would require the game to track the player's head and controller position to display the player's perspective correctly.

Games that provide a high degree of spatial mapping stress the players processing of spatial depth cues as they are relevant to his success and could therefore affect UX quite intensely (see Fig. 2).

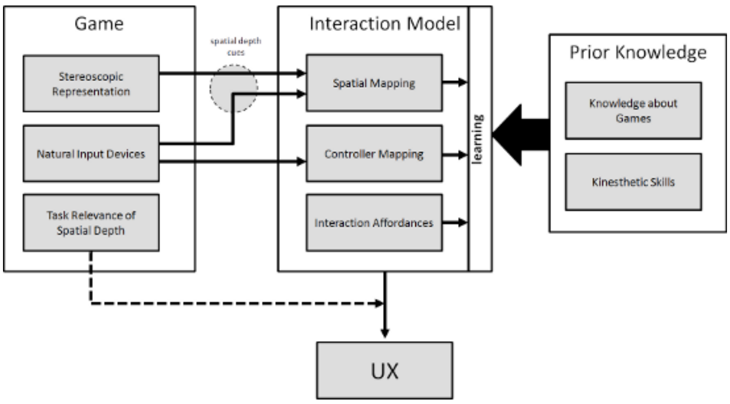

Figure 2 – Construction of the interaction models and their relation to UX

Arguably, only spatial mapping allows natural input devices to reach their full potential: possible input actions can gain a high degree of complexity due to the high spatial resolution the devices track and the spatial validity of the movements in the virtual space as a consequence of spatial mapping. Consequently, the training procedure for the interaction model for this type of input would increase intensely. However, over time players develop automated motor programs in a similar way they learn gear shifting in driving school. These motor programs can trigger complex motor actions that have been trained repeatedly. Once these motor programs have reached a sufficient precision, the player's UX can benefit greatly from the increased complexity of input actions Due to the fact that the player's real actions are responsible for a positive outcome of the game, she experiences a higher degree of perceived self-efficacy (Klimmt & Hartmann, 2006) compared to other games with arbitrary input mappings. Thereby, stereoscopic representation can further improve UX by raising the effectiveness of natural input devices.

DISCUSSION

The rise of new technologies in computer games has always been a mixed blessing, since it always takes a lot of time until the new technology is mastered. Consumers have often been used as test audiences, paying for half-baked products. When 3D graphics first arrived, many games just used it because it was available. But it was not meaningfully implemented into the gameplay and so players did not gain any additional value. A similar observation can be made concerning stereoscopic technology in movies and games for the reasons mentioned above. We argue that with a theoretical understanding and systematic implementation, stereoscopic representation can not only enrich UX, but also deliver new types of entertainment software for the consumer market. To achieve this, the additional information conveyed through stereoscopy (i.e. binocular spatial depth cues) has to be relevant to the tasks users perform within the game. Without implementing spatial information into the game mechanics, stereoscopy will always be just a gimmick without real consequences for UX. Additionally, the mapping of input and output spaces results in a higher degree of self-efficacy of the player and thus can enrich the UX. But in the end, we don't want to discuss what is and is not fun for some players as the spatial mapping allows for other forms of UX that each player does not necessarily perceive as more fun. One reason we play games is to escape our everyday life and to have adventures we cannot have in real life. A high spatial mapping (e.g. in an action game) can be more work then relaxation for the player and may not be in the interest of particular game design concepts. Game designers should therefore use it wisely to make a good game.

To empirically support our argument of spatial mapping, we first need the adequate software products. As stated above, current games do not fulfill this requirement. To create according games, the designers have to consider constraints of the stereoscopic technology as well as user acceptance. However, it is likely that technological parameters have to be adjusted to the given game mechanics or game tasks. An iterative design approach with exhaustive testing is advisable for designers since the balance between content, interaction possibilities and visualization of the gameplay is expected to be delicate. Since complex inputs might overstrain the user, games should, at least at the beginning, require rather simple interactions to successfully enhance gaming experience through the use of stereoscopic representation. For example, the player's task could be the manipulation of one moving object at a time. This kind of gameplay would not only help players to gradually get used to the technology, but it would also facilitate behavioral measures as well as the setting up of experiments with easy manipulation of all relevant parameters of the software.

Given the availability of games suitable for research, it is still not simple to measure the crucial variables because they have yet to be identified. General constructs like UX, presence, immersion and others have shown to be too unfocused or overlapping, and may therefore be considered as covariates, if anything. Even though the aforementioned constructs can somehow be related to the experience during gameplay, we think this issue has to be further specified. We argue that players benefit from games that implement stereoscopic technology if they provide a higher degree of entertainment and amusement compared to games with a comparable gameplay in terms of game tasks and interactions. However, there is not yet a standardized method for measuring the entertainment value of a game. We suggest the proven combination of three methods: self-reporting, observation and psychophysiological measurement. Furthermore, other relevant variables and approaches have to be considered that can influence the UX during gameplay. Previous studies did not take into account that players may gradually get used to the stereoscopic technology during repeated exposure. As a consequence, simulator sickness or other negative effects could disappear or at least be reduced by a large amount. This would cause players to become aware of the benefits of the new technology that may be distracting or bothersome upon the first interaction or short-term usage.

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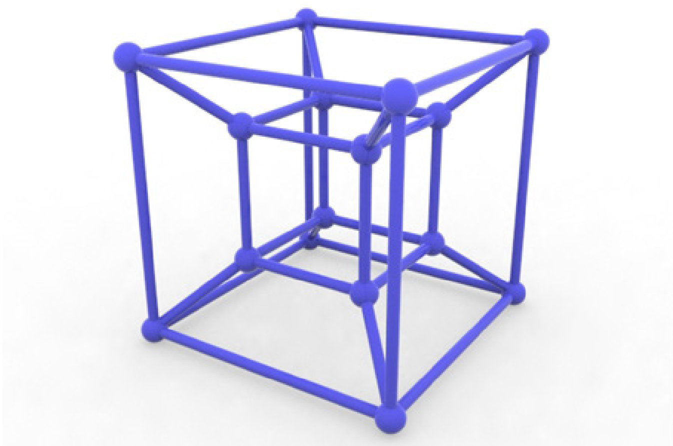
From M.C. Escher to Mass Effect

Impossible spaces and hyper-real worlds in video games.

How can hyper-real worlds be designed and interpreted in a 2D, 2.5D and 3D virtual environment and how will this implementation affect the stereoscopic 3D video games of the future?



Game developers, even during the early years of game design, have always searched for new and interesting ways of creating more elaborate, immersive and realistic environments for their video games.

Even the MUD's (multi-user dungeons), designed in the late 1970s, such as Roy Trubshaw's *MUD1*, implemented such interesting ways of connecting their rooms as teleportation, paving the way for later developers to design and implement interesting and imaginative environments that border on the fantastic or the *Hyper-real*, as we will designate these worlds in this article.

The term Hyper-real is used extensively by philosophers, such as Jean Baudrillard and Umberto Eco; they use the term to distinguish reality from a simulation of reality, especially in cases of technologically advanced societies. In Baudrillard's own words, hyper-reality is a simulation generated "by models of a real without origin or reality" (Baudrillard, 2000, p. 1). In this article, the term "Hyper-real worlds" will be used to describe worlds that are not that much further from what Baudrillard describes. These game worlds, although they have a connection to our reality, architectural structure or geographical coordinates, are definitely un-realistic and without any origin in our world, comprised of fantastic creatures, alien architecture and geometrical and physical impossibilities.

This brings us to the second major topic of discussion for this article: impossible shapes. At this point, we must distinguish between two major categories of impossibilities in video game world design, geometrical/mathematical impossibilities and physical/temporal impossibilities. Even though in the mathematical and physical world, that we live in, space and time co-exist and are interdependent on one another, we have to separate them for the sake of better understanding what is possible and what is not when developing a video game. This separation is dictated by the simple fact that the computer hardware used to design, create and implement these virtual worlds is based on mathematical reasoning and not a physical one. While we will explore, to some extent, the geometrical/mathematical impossibilities in this article, best exemplified by the works of M.C. Escher, Oscar Reutersvärd, Salvador Dalí and Giorgio De Chirico among others, some notes on physical/temporal impossibilities will be given to showcase the possibilities that a developer is offered in order to create a hyper-real virtual world.

Besides exploring how impossible elements can be introduced in 2D, 2.5D and3D game worlds, it is necessary to gain basic knowledge of how the human visual system works in order to better understand the limitations imposed in the design process of game worlds that utilize stereoscopic imagery.

Concluding this article, we will assess what possibilities stereoscopic video games have to offer to potential game developers and the gaming audience and what opportunities these game worlds open up for future technologies that involve video game development.

THE ART OF THE IMPOSSIBLE

Oscar Reutersvärd (1915-2002) is considered to be the father of impossible figures and shapes. During his long career as an artist he created thousands of impossible figures that seemingly *break* the laws of geometry and space. His most famous shape is the impossible triangle which later became more commonly known as The Penrose Triangle.

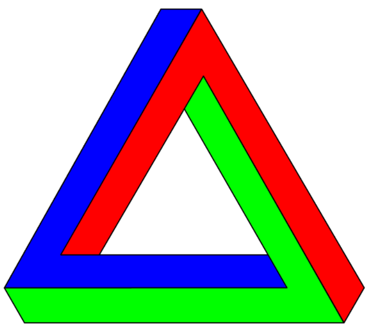


Figure 1 – The Penrose Triangle

M.C. Escher (1898 – 1972) is the major follower of Reutersvärd's artistic perspective. While Reutersvärd dabbled only in designing shapes and objects that transcend the geometrical laws, Escher managed to incorporate these designs into his paintings, creating art–in the process–that transcend the Euclidean laws and also provided the inspiration for later artists and mathematicians–like Roger Penrose and Douglas Hofstadter–to try their own hand in creating impossible figures.

Two painters that could fit into the category of impossible artists are surrealist painters Salvador Dalí (1904-1989) and Giorgio De Chirico (1888-1978). Dalí, as a man with an excessive number of eccentricities, painted the world around him as only a man who claims to remember his birth could. Filled with, mostly, physical and biological impossibilities, his paintings prove to be a challenge for game developers who wish to emulate a world that resembles Dalí's soft physics.

Where Dalí chose to paint physical and biological impossibilities, De Chirico's paintings, on the other hand, though they seemed to be more accurate in the depiction of the real world, have nevertheless their own impossible touch. De Chirico chose to paint his own distorted versions of the world around him in the skewed perspectives offered by different fugue points in the same scene, using flawed perspective to prioritize order of perception.

THE HUMAN PERCEPTION

Visual perception is, perhaps, the most important sense of a human when locomotion and orientation are concerned, since it is not only the sense which enables us to visualize and interpret the world around us but also gives us the largest amount of information to do so. There are some instances when sound and the auditory perception take precedence over the visual system, especially where balance is involved, but the sheer amount of information entered through the visual system makes it the paramount sense when video games are concerned.

Everything about human perception starts with the upright position of the body which enables us to differentiate between front-back and left-right (Tuan, 2001).These positions are extrapolated from the position of the body and they change according to the body's motion in space. The only axes that are relatively static are the top-bottom axes which would only change in case the body finds itself floating in a zero-gravity environment.

Furthermore, depending on the distance from the observer to the object observed, the distance can be differentiated into 3 categories: close-range (up to 5m from object), intermediate range (between 5m and 20m) and long-range (more than 20m) (Granum and Musaeus in Qvortrup et al., 2002, pp. 118-119).

The third most important factor in human perception is the search for landmarks and/or points of interest. According to Tuan (2001), a human cannot look at a scene in general since our eyes will always look for a place or scene to rest upon. Kevin Lynch also individuated landmarks as a defining element to create memorable spaces. This is done consciously (when we deliberately search for a landmark) or unconsciously (when a feature in the horizon is so compelling that it demands our attention).

There are, of course, many more factors that play a role, either major or minor, in the human perception system. Colors, size of objects observed, shapes, perspective, and object motion are only some of them, and even these factors can all be sub-divided into more elaborate and detailed sub-categories.

THE FUNCTIONS OF THE EYES

Anatomically, the part of the brain that controls and is concerned with the reception and interpretation of vision is the visual cortex. This is a very curious function for two reasons.

Firstly, a region that exists on the far back of the brain is responsible for interpreting the visual signals that come from the front of the human head.

Second is the fact that the right cerebral hemisphere of the brain is responsible for the left-hand side of the body, and the left cerebral hemisphere is responsible for the right-hand side. That way, a well-defined map of the left-hand visual field is formed on the right visual cortex and another map is formed of the right-hand visual system on the left visual cortex (Penrose, 2002, pp. 484-485).

Aside from these anatomical details, there are two distinguished features of the eyes that play a prominent role to the way we see and perceive the world around us.

One of these details is that the eye is not the sole organ for perceiving the world around us but only a part of a system that consists of the moving eye, the moving head, the brain and the moving body.

With the above system in mind, we can divide the above into three separate visions: aperture vision, ambient vision and ambulatory vision (Kolstrup in Qvortrup et al., 2002, p. 243).

The above system is utilized and most prominent in FPS (first-person shooter) games such as *Counterstrike*, where quick avatar (body and head) movements and quick eye movement is necessary in order to rise above other players and survive in this fast-paced PvP (player versus payer) video game.

The second feature, the anisotropy of left and right, is mostly overlooked and people are generally only unconsciously aware of it.

Heinrich Wölfflin, an art historian, pointed out that paintings lose their meaning when they are turned into their mirror images. This happens, he realized, because images are *read* by the brain from left to right which, in turn, changes the way they are interpreted when inverted (Arnheim, 2004).Notably, even thoughthis is true for cultures with a left-right scansion of written text, it is not universally true for all humans, but mostly for humans in western cultures. Whether this distinction is biological or cultural is not in the scope of this article to analyse.

Mercedes Gaffron, a psychologist, investigated the phenomenon of the left and right anisotropy in the brain further, and related it to the dominance of the left cerebral cortex, which contains the higher brain functions of speech, writing and reading.

This function has been used extensively in video games to a greater or lesser extent. In almost all video games where the avatar of the player is required to stay alive in order to continue playing the game, the most important aspect of the UI (user interface), arbitrarily the health and possibly the resources of the avatar, are almost always placed on the top left of the screen. Consequently, the rest of the UI is placed in key areas depending on their significance to the player and the game mechanics.

Even in notable exceptions to this pattern we see the dominance of the left-side. In *Dead Space* the entire UI was integrated on the avatar of the player but even in that case we can distinguish the definite dominance of the left side in the way the camera is placed above the right shoulder of the avatar and in the fact that the health of the avatar is placed on his back which, due to camera placement, is on the left side of our visual field.

THE VIRTUAL WORLD OF 2 DIMENSIONS

In the early days of video game design, developers had only a limited amount of tools to work with. The limitations posed by these tools and the hardware that was called to process the final product allowed for only a minor number of shapes to be developed as part of the video game's assets.

Despite this fact, the early MUDs (multi-user dungeons), which were actually text-based video games, represented the first interactive virtual worlds that demonstrated and utilized impossible non-Euclidean spaces in their game world. Lacking a visual representation of the in-game virtual world, they nevertheless paved the way for hyper-real, impossible worlds.

Once the technology was developed so as to include a series of moving images in order to demonstrate the virtual world to the player, hyper-real worlds started becoming more and more elaborate in their representation. The most prominent examples of hyper-real and impossible/non-Euclidean worlds are *Pac-Man* and *Asteroids*. Interestingly, both games featured the exact same non-Euclidean feature, which was also the one offered in the early MUDs of the '70s. This feature enabled the player-controlled avatar (in whatever form) to transcend the space of the designed area of play by exiting from one side of the map and re-appearing on the other side, following only either a designated exit-entrance portal (in the case of *Pac-Man*) or adhering to the momentum of the avatar's movement at the point of exit (in the case of *Asteroids*).

The same teleportation effect was later used in games, such as *Eye of The Beholder II: The Legend of Darkmoon*, in order to create impossible corridors which were also meant as a puzzle for the player to solve, if they wanted to continue on their quest in the game.

Two-dimensional video games were, in fact, ideal for representing and portraying impossible shapes and non-Euclidean environments. Leaving aside text-based games, which left almost all visual representation of the virtual world to the imagination of the player, early video games that utilized moving image sequences to simulate character/avatar movement had the potential to create the most accurately depicted Escher-like environments.

The key factor that contributed to such a fact is the lack of freedom on the part of the player. Just like in an Escher painting, the player of a two-dimensional virtual world is limited in only a fixed viewpoint of the world: the one offered by the two-dimensional image that is demonstrated to them at any given time. They cannot move in a manner that would transcend this limitation any more than a viewer of an Escher painting can take one of the impossible objects that he designed on his hand and rotate it so as to see it from every possible angle.

ISOMETRIC WORLDS: THE LACK OF PERSPECTIVE

During the early 1980s, a new method of representing the virtual world came to being with the introduction of isometric or pseudo-3D environments. These games offered a view of the virtual world that had a very close, but not exact, resemblance to how humans perceive the world around them.

While the term isometric has been dominant in describing games that employ a fixed perspective, it is actually one of three axonometric projections used in video games and industrial design. The other two are diametric and trimetric.

The first game to utilize such a viewpoint was *Zaxxon*, after which many more followed, creating more elaborate and sophisticated worlds that proved to be extremely popular in either isometric or trimetric projections like *Populous*, *Civilization II*, *Diablo* and *Fallout*.

Even in recent years, there are still games that employ these axonometric projections in their viewpoint as the standard. The more recent examples are *StarCraft* and *Diablo III* which both employ a viewpoint that is similar to isometric view although, since it was created and developed in Blizzard's proprietary 3D engine, there is also some hint of true perspective in the game world.

While isometric view provided a more detailed experience for the players, it still remained an artistic construct since humans never experience their surroundings in isometric view but in perspective. Even so, just like their two-dimensional counterparts, isometric video games provided the unique possibility to represent mathematical impossibilities, as depicted in Reutersvärd's and Escher's shapes and paintings. The lack of freedom, on the part of the user-controlled camera, was again the key factor that allowed for such designs to be accurately represented in the game world.

As we will explain later in this article, having a fixed perspective is the only actual way of depicting accurately and approximately the impossible shapes and scenes of Reutersvärd's and Escher's paintings.

THE 3-DIMENSIONAL WORLD

With the advent of 3D software came the emergence of true 3D computer graphics in the video game world. The engines which have been designed by various companies as the main developing tools of current-date video games operate in the same way, and follow in the footsteps of the major 3D software in the market.

Both the 3D software and the various game engines operate on meshes, and utilize cameras and lights to give life to the scene.

A mesh is a collection of triangular (or quadrilateral in some cases) contiguous, non-overlapping faces joined together along their edges. A mesh will consist of three basic elements, called faces, edges and vertices. Modeling of these meshes occurs when we use a computer to implement the mathematical construction of an object, by defining points in a 3-dimensional array, which is based in the X, Y and Z axis of geometrical space or otherwise called, a Cartesian coordinates system. Essentially, a mesh is the visual representation of a mathematical theoretical object in a Cartesian coordinate system.

The most basic of these meshes are the Platonic solids, or as they are more commonly called, *regular polyhedra*. Only five of these meshes can exist in 3-dimensional space and in order of number of faces are: the tetrahedron, the hexahedron (cube), the octahedron, the dodecahedron and the icosahedron. These five are the only meshes in 3-dimensional space that satisfy the very strong restriction of looking exactly the same at every vertex (Banchoff, 1996, p. 91).

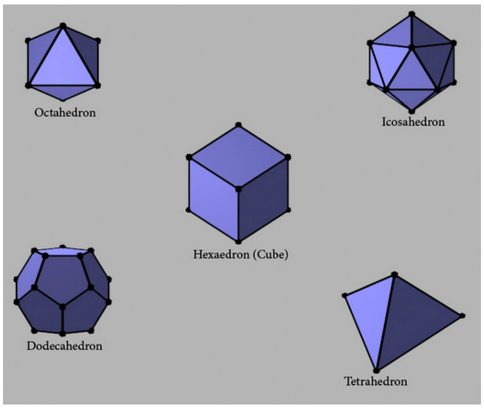


Figure 2 – Platonic Solids

Taking the cube as an example and imposing upon it the Cartesian coordinate system, we can see how it is interpreted, mathematically, in the 3-dimensional virtual world.

As we explained before, a mesh is modeled when the computer implements a mathematical construction of the object, by defining points in the Cartesian coordinates system. In the case of the cube, each vertex is defined that way, with a unique set of coordinates that each correspond to a unique location on the X, Y, and Z axes. Therefore, a cube can also be translated as a group of coordinate sets that have the form (X1, Y1, Z1), (X2, Y2, Z2)……(X8, Y8, Z8), with each set describing the exact position of every vertex of the cube in the Cartesian coordinate system.

Once we try to impose the same mathematical principles on the Penrose triangle, we immediately realize what the problem is. Since the Penrose triangle is a mesh, it is correctly identified as having faces, edges and vertices. The problem starts when we try to identify each vertex as a set of coordinates, corresponding to the 3 axes of the Cartesian coordinates system. What we discover is that each vertex of this object cannot be identified by only 3 specific points. Depending on the face (side) that this vertex belongs to, it will need at least 2 sets of coordinates for its mathematical construction, and in all the cases the coordinates of these sets will have at least one value that is not identical with each other. An example is shown in Figure 3 where we see that point *x* can be interpreted in two different ways, resulting in two different sets of coordinates for the (seemingly) same vertex depending on the viewpoint of the viewer. This means that in order for a Penrose triangle, or any other impossible shape for that matter, to be properly mathematically constructed in a virtual world, it must be done so in a 4-dimensional coordinates system or higher, depending on the object in question. Assuming that such a coordinates system existed, then any impossible object could be translated in the form of (X1, Y1, Z1, V1), (X2, Y2, Z2, V2)……(Xn, Yn, Zn, Vn), with each coordinate corresponding to a specific and unique position in the coordinates system.

The problem then is that a 4-dimensional (or higher) Cartesian coordinate system cannot exist in a 3-dimensional world. The reason for that is that 3D design software is based purely on mathematical and geometrical mechanics and the only way we can visualize objects with more than 3 dimensions is by using imagination and theoretical mathematics, as we will see below.

The best example of this limitation is the process used to create a *Hypercube* or *Tesseract*, a term attributed to C.H. Hinton who in the 1880's wrote an article about the fourth dimension and his own dimensional allegory *An Episode in Flatland* (Banchoff, 1996, p. 115). This theoretical construct is supposed to depict a 4-dimensional cube in 3-dimensional space, virtual or real.

The logic behind creating such a construct starts with a point in space that has 0 dimensions. If we drag the point along the X dimension, we end up with a line, the first shape with a single dimension. By drawing the line along the Y dimension, we end up with a rectangle, the first shape with 2 dimensions. Drawing the rectangle along the Z dimension, we end up with a cube, an object of 3 dimensions. If we wish to go further than that, the only thing that we can do is drawing each vertex of the cube outwards, thus creating a cube inside a cube. But the truth is that this construct is nothing more than a 3-dimensional cube inside a 3-dimensional cube, not a 4-dimensional cube. A 4-dimensional cube, in a 4-dimensional Cartesian coordinate system, should have all its sides equal and all its angles right, and our construct has at least two sides which are not equal and at least two angles which are not right.

In an attempt to impose a new coordinate plane in the typical Cartesian coordinates system, we find that it is impossible to do so without deviating from the mathematical laws of the system. In three-dimensional space, a Cartesian coordinate system is defined by starting with three number lines intersecting at their common origin (0, 0, 0). On the first axis, the points are labeled as (*x*, 0, 0), on the second axis the points are labeled as (0, *y*, 0) and on the third axis the points are labeled as (0, 0, *z*). Thus, the points of a cube, designed in three-dimensional space, with a side length of 1 unit will be labeled:

(0, 0, 0)	(0, 0, 1)
(1, 0, 0)	(1, 0, 1)
(1, 1, 0)	(1, 1, 1)
(0, 1, 0)	(0, 1, 1)

(Banchoff, 1996, pp. 160-161)

Since algebra is practically the same whether we write theorems about one, two, three or four dimensions, we can extrapolate the same method to design a hyper-cube in a four-dimensional Cartesian coordinate system by working backwards.

A hyper-cube will consist of 16 points since it is created by dragging a cube towards a 4^{th} dimension, essentially creating a second cube or a cube inside a cube. In a four-dimensional Cartesian coordinate system the points of a hyper-cube with a side length of 1 unit, will be labeled:

(0, 0, 0, 0)	(1, 0, 0, 0)	(1, 1, 0, 0)	(0, 1, 0, 0)
(0, 0, 1, 0)	(1, 0, 1, 0)	(1, 1, 1, 0)	(0, 1, 1, 0)
(0, 0, 1, 1)	(1, 0, 1, 1)	(1, 1, 1, 1)	(0, 1, 1, 1)
(0, 0, 0, 1)	(1, 0, 0, 1)	(1, 1, 0,1)	(0, 1, 0, 1)

(Banchoff, 1996, p. 162)

Following the information contained in the above table, we arrive at the conclusion that a four-dimensional Cartesian coordinate system should have four number lines intersecting at their common origin (0, 0, 0, 0). The first axis has points labeled as (*x*, 0, 0, 0), the second axis has points labeled as (0, *y*, 0, 0), the third axis has points labeled as (0, 0, *z*, 0), and the fourth axis has points labeled as (0, 0, 0, *v*). Any point within this Cartesian coordinate system is completely determined by the number quadruple (*x, y, z, v*). The problem is that any of the infinite lines that intersect the origin (0, 0, 0) of the three-dimensional Cartesian coordinate system, apart from *x*, *y* and *z*, is completely determined by the number triplet (*x, y, z*) which means that it will never obey the rule of the axis *v* which must have points labeled (0, 0, 0, *v*). Since this rule cannot be obeyed, and therefore, such a line cannot be created, a true fourth-dimensional Cartesian coordinate system can exist only in theory.

So, since it is impossible to create a 4-dimensional coordinates system, how can we, then, create impossible shapes, objects and scenes in a virtual world? The short answer, of course, is: we can't. To find a solution we have to go back and explore the 2D and axonometric relatives of the current video games. There we find the solution for creating an impossible object or scene in a video game using current day technologies: keeping the object or scene in question fixated on a single angle towards the camera. Since all mathematical representations of impossible objects, on a Cartesian coordinate system, rely on being seen from a specific viewpoint, the same trick can be employed when trying to implement such an object into our 3D world. Keeping the object fixated on the correct angle towards the camera/player we keep the illusion of the object intact, for if the player could maneuver around the object, then he would recognize the truth of the object and the illusion would be lost.

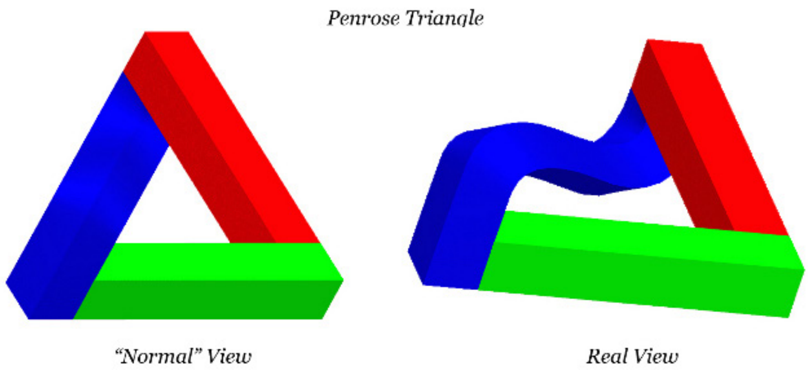


Figure 3 – Tridimensional Penrose Triangle

In this way, we are free to manipulate these objects to any extent so as to make them appear exactly as they were designed by Escher and Reutersvärd.

STEREOSCOPY, THE ROAD TO VIRTUAL REALITY

Stereoscopic video games have already appeared back in 1982 with the game *Sub-Roc 3D*, an arcade game that used a display that delivered different individual images to the player's eyes. Since then, many video game developers have created stereoscopic video games. Some of the most prominent titles in the video game industry are *Duke Nukem 3D*, *Minecraft*, *Batman:Arkham City* and, more recently, *Assassin's Creed III*.

The basic requirement for stereoscopic 3D images is using two cameras to capture left and right eye images. These cameras are positioned in such a way so as to mimic the eye's stereo vision capability by seeing two different angles of the same scene, with only a slight difference. The human brain then will take those two images and create a sense of depth (Shaw, 2011).

Despite the fact that stereoscopy gives a sense of depth and greatly enhances, in some cases, the 3D experience of the viewer/player, it still must obey and conform to the same rules outlined above concerning the design and implementation of 3D objects in a virtual environment.

Since stereoscopy needs two separate cameras to capture the same scene, impossible objects such as the Penrose Triangle will be even more difficult to depict, due to the fact that even if one of the cameras deviates even a little from the 'normal' viewpoint, that allows the object to be seen as impossible, and the illusion of the object is lost.

While stereoscopy is a technique that could provide excellent results for future video games, it will still be unable to represent impossible objects and scenes in a virtual environment.

Even in systems such as the Cave Automatic Virtual Environment (CAVE), which creates the illusion of a seamless virtual space by using projected stereoscopic images from the rear of the interactor, the illusion of an impossible object will be lost should the interactor in the CAVE box be moved to the side or behind, or the viewpoint deviated slightly from the 'normal' viewpoint (Nitsche, 2008, p. 211).

Just as axonometry paved the way for current era 3-dimensional environments in video games, by the same token, stereoscopy will pave the way for future virtual reality environments. But even then, impossible objects will still remain impossible, adhering to the absolute rules of geometry and mathematics since, after all, Virtual Space is a world defined by a universe of coordinates (Nitsche, 2008, p. 191).

CONCLUSIONS

Over the course of this article, we explored the world of 2D, axonometric, 3D and stereoscopic 3D video games in order to better understand the virtual world in which they exist.

As stated in the introduction of this article, separating the dimensions into geometrical, temporal and physical ones was paramount in order to discuss the possibilities offered in a world that is governed by mathematics, geometry and Cartesian coordinates, rather than biological or physical phenomena.

After examining the possibilities offered by current day technologies and their by-products, it is then safe to assume that impossible objects will not be able to exist in a virtual environment, exactly as they are unable to exist in our real 3-dimensional world.

Four hundred years ago Galileo Galilei, using his telescope, saw moons orbiting Jupiter and now, with modern day telescopes scientists can see and observe the presence of Quasars and distant solar systems that exist billions of light years away. The capacity of mankind to exceed its limitations might, one day, revolutionize our ability to realize the wonderful scenes and objects depicted by Escher's paintings or Reutersvärd's "Windows in the Floor."

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IMAGES

Cover Image *(Tesseract)*. Created by A. Petrovits and A. Canossa

Image 1 *(The Penrose Triangle)*. Created by A. Petrovits and A. Canossa

Image 2 *(Regular Polyhedra)*. Created by A. Petrovits and A. Canossa

Image 3A and 3B *(Penrose Triangle Possible 3D Modeling Variations)*. Retrieved from http://www.cs.technion.ac.il/~gershon/EscherForReal/

Image 3C and 3D *(Penrose Triangle Possible 3D Modeling Variations)*. Created by A. Petrovits and A. Canossa

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A new angle on parallel languages

the contribution of visual arts to a vocabulary of graphical projection in video games

It is fair to argue that in the short history of game studies, the concept of *graphical projection* has not been used in all its dimensions. In a way, we might even say that the idea has been systematically overlooked. Therefore, in order to fully express the potential of graphical projection in game studies, we have to properly define the vocabulary used to describe its various forms. Indeed, while the press and gamers have only applied catch-all terms like *top-down view* and *isometric graphics*, researchers need a more robust and complex categorization of each type of projection. My opinion is that a proper use of the language of visual arts will provide a more robust analytical tool for game studies.

The main idea is to use terms in keeping with the traditional perspectives from which they derive. Certainly, I don't want to apply (as a copy-paste) the terms only because they fit into a type of effect of one technology or another, but instead we need to *understand* the principles of each type of projection and find its own application as a video gaming figure of speech. To accomplish this, we have to recognize the historical aspect of the concept of graphical projection and its relation with today's digital imaging.

Out of which tradition—mathematical, scientific or artistic—should we envision graphical projection? As we search through art history for a precise definition, we face a historical and conceptual dead end. Perspective, for instance, has always been torn between its more practical aspects and its more scientific conceptualization. Graphical projection, as a practical concept, answers a defined objective: make visually intelligible a three dimension view on a flat surface. As such, graphical projection is a protocol in which every form has its own rules.

If we take, for example, the principle of Albertian perspective, the fundamental idea was more concerned with creating a working tool to coordinate the space of the frame than an artistic or philosophical concept. Alberti was, above all, a mathematician. Thus, his theory on perspective was predominantly influenced by the optical principles of Euclid. That cold and scientific conception of the principle of vision has had a major impact on Alberti's logic of representation—which, according to Damisch (1987), still dominates certain principles of the current logic of visual representation such as the predetermined viewpoint of the artist and the viewer.

Indeed, Albertian perspective is a mathematical construct as the perception combines the perfect vantage point (of the artist and the viewer) and the vanishing point (where all lines converge). This point, the founding point, is the most important because it guides the viewer (it tells them where to look) and directs all the other points of the picture. Finally, because it only offers a single viewing position, it encodes the visual representation. The visual experience related to this 'mathematical' perspective of Alberti is a spatial relationship dictated by the artist, and not drawn from the *real* laws of physics or the principle of photographic representation. This distinction is important to our current relationship with visual arts which is the mathematization of visual representation by digital technology.

According to Friedberg (2006), the surface of today's screen (computer or television) is divided into several components and functions that we analyze simultaneously, a bit like a cubist painting. Indeed, this particular type of painting, unlike the works of Italian Renaissance using Albertian perspective, simultaneously offers a multitude of views. Also, and perhaps most importantly, cubist painting has fractured the single viewpoint of Albertian perspective and placed disparate objects on the same representational plane. This paradigm of Albertian perspective is nonetheless ingrained in video games and any other situation that requires the simulation of three dimensional space. The visual simulation in video games and its objective (to provide a virtual playground rather than an optimization of a visual space) makes it closer to Italian Renaissance art history than modern art. In this case, our standpoint on perspective is the same as Damisch: it is a paradigm that can pass through and amalgamate history.

THE TWO TYPES OF PROJECTION IN A NUTSHELL

As we discussed a little earlier, perspective has been the principal technique for artists to model their perception. Also, we saw how this form of projection is combined with the idea that visual representation is predetermined as a *mise-en-scène* by the artist (and thus, not by nature). As such, perspective is a great tool for painters to draw attention on a specific element of the representation and not only give an impression of a third dimension. However, there is another form of projection—called parallel projection—that tries to illustrate a third dimension on a flat surface, and one has to know how to differentiate them.

Even though perspective and parallel projections have a similar main objective, as techniques, they are quite different. In parallel projection, lines that are parallel in reality are drawn parallel in the picture; contrary to perspective, there is no foreshortening involved to approximate the vision that an actual human being would have. The main focus in this kind of projection is on the axes between the lines. As we saw, perspective is more about representing the viewpoint than the object it represents. To summarize, perspective projection is using the process of convergence of parallel lines toward one (or more) vanishing point(s) and implies a horizon line. Parallel projection uses the method of projecting straight lines. Therefore, both parallel and perspective projections have their own specific categories with their own specifications.

A GUIDE TO PARALLEL AND PERSPECTIVE PROJECTION

Parallel projection is divided into two categories: pictorial projection and orthographic projection. Orthographic projection is a process derived from the principles of descriptive geometry. However, since it is mainly used in the execution of technical and working drawing, this category will not be used to follow the objective of our study. Pictorial projection tries to represent an object as viewed in an angle so that all three directions (axes) of space will be visible in a single picture. In order to do so, pictorial projections contain some distortion and liberties in the representation of the object.

In pictorial projection, the projected image is drawn according to the parallel lines that make up the grid of represented space, which means that the parallel lines of an object in reality remain parallel in the drawn image. Pictorial projection is divided into two categories: axonometric and oblique projections. What distinguishes the oblique and axonometric projection is their relationship to the projective plane. The projective plane is an extension of the mathematical concept of plane in which two parallel lines can eventually meet at infinity. In other words, the projective plane can be imagined as a two dimensional space where one can project a third dimension using infinite projection points.

Oblique projection is the simplest representation of parallel projection. In oblique projection, one face of the projected object is presented parallel to the projective plane and the lines are drawn at an angle other than 90 degrees. The cavalier perspective and the cabinet projection are the forms most commonly used in oblique projection. The cavalier perspective, despite its name, is not a form of perspective, but a pictorial projection, since the lines that are projected are based on a specific angle and not a vanishing point. The method is more mathematical than artistic: the coordinates of the points x and z of the image are reported in a ratio of 1:1 and the point y is drawn at a specific angle (generally 30 or 45 degrees). The principle is the same for cabinet projection, however, the point y will be drawn in a ratio of 0.5 of its length. Oblique projection is mostly used in technical drawings and illustrations. However, before the advent of 3D, some video games have used this form of projection in the visual aesthetics of their design, such as *Paperboy*, *Sim City* and *Ultima VII*.

Axonometric projection is the method of parallel projection in which the axes of the object represented are not parallel to the projective plane in order to represent all three points of views (x, y and z). Depending on the division of the sum of all three angles forming the axis of the projected object, axonometric projection uses three more specific terms: isometric, dimetric and trimetric projections. Because it is the most common form of axonometric projection, isometric has often taken the role (and the name) of a vast number of other categories of visual representation. However, isometric, as a technique of representation, has its own specific set of rules and visual effects. Indeed, the angles of an isometric projection are always of 30 degrees. The same scale is used on all axes, which meets the actual proportion of the object in all three dimensions. Dimetric projection highlights two of the three axes by making their angles equal. There are therefore two different scales: a scale which is the same for two axes (for example, the axis *x* and *z* for width and depth; and a second one to regulate the third axis, the *y* axis, i.e. the height). Trimetric projection shows the three axes with different values and therefore three different scales, one for each axis. To clarify our point, we could give the examples of *Final Fantasy Tactics* to illustrate isometric projection, *Diablo* for dimetric projection, and *Fallout* for trimetric projection.

As we have seen previously, perspective and parallel projections both have the same main objective: to render a tridimensional view on a flat piece of paper. Indeed, perspective uses its own techniques of illusion to represent as closely as possible the direct view of the artist's eye. These techniques are mainly based on the illusion of depth, and the various techniques include the effect that distant objects are smaller than closer ones. Also, perspective projection implies greater subjectivity and adaptation on account of the artist. It is therefore less mathematical or geometric than parallel perspective, which is based on the degree of the angles between the projected lines. In this sense, perspective projection has two tangents: fundamental and artificial. The fundamental perspective is more based on the use of color to give a sense of depth. For example, chromatic perspective uses the relational effects between colors to achieve depth by using warm foreground colors and cold background colors. Artificial perspective is rather a construction of the pictorial space (like Albertian perspective).

Before the invention of artificial perspective, the coherence of the picture space was established by the existing pictorial conventions (Greek or Egyptian for instance), or by intuition, and was therefore fundamental. From ancient Egypt to ancient Greece, different techniques and various depth cues were used to simulate a third dimension without any mathematical calculations: overlapping objects, a multitude of planes, a color gradient, shadow and light, the *checkerboard* floor so often seen in Dutch paintings of the 17th century such as those of Vermeer and de Hooch, etc. Some of these techniques are still used today to reinforce the simulation of a third dimension in addition to another form of projection in videogames as well as in painting. Artificial perspective dates back to the Renaissance, and is rooted in a mathematical (Ptolemy, Euclid), optical (Alhazen), geometric (Brunelleschi) and physical (Aristotle) basis. Its study was particularly established by the theoretical works of Alberti in *De Pictura* (1435).

Perspective mainly uses the process of convergence of parallel lines toward one or more vanishing points and an implied horizon line that often serves to support those vanishing points. With one vanishing point, the main focus is usually located in front of the viewer and the horizon, at the center of the picture (which recalls railway tracks). Perspective with two vanishing points is typically used to illustrate a pair of parallels (obliques) that converge within the image and away from their respective vanishing points. One can add a third vanishing point to the perspective, usually located either well below or well above the element represented. The three vanishing point perspective is regularly used in technical drawing, but not as much in video gaming.

As we have discussed, perspective and parallel projections do not proceed in the same way to achieve the illusion of three dimensions nor do they have the same visual relation with the object they try to illustrate. While perspective is subject centered and tries to simulate human vision, parallel projection is object centered and tries to simulate the actual physical dimensions of an object independently of any actual view we would have of it. As such, perspective projection, unlike parallel projection, is closer to the concept of human vision (or at least its Euclidean concept). This means that the underlying principle of perspective is the focus on a point (the vanishing point), and all the lines are projecting toward this point. Being closer to the concept of human vision also means appealing to the principle of foreshortening. This principle is recognized by the impression of compression and distortion of the object it represents, related to the perspective since the object is facing the viewer. It was used particularly in the Middle Ages, but we can easily recognize its combination with some technological techniques in video games graphics (like Mode 7 in *F-Zero*).

With the advent of the moving image, other depth effects were matched to projection techniques. First, there is the parallax effect, which corresponds to the way objects move laterally at different speeds depending on the distance which separates them from the viewer. We can easily distinguish the effect by its principle of visual motion: the closer the objects represented in the image are to the viewer, the faster they move. There is also the stereoscopic effect that gives the illusion of depth. To achieve this visual effect, we need two similar images (but with a slight shift) and a technical device that merges these images into one. The stereoscopic effect has been widely researched and used, and should be, if we believe the discourse of advertising papers, the ultimate indicator of technological advance in games, consoles, and among other visual projection industries. However, the success of a console using the principles of stereoscopy have been limited, as evidenced by the recent Nintendo 3DS.

VISUAL PROJECTION IN VIDEO GAMES

As mentioned above, some terms are used more often than others in video game discourse, and this is not just a question of referential accuracy or mere habit, but rather simple resumption semantics. However, now the structure of the different techniques of graphic projection have been developed, it would be appropriate to use the proper semantic terms.

Video game graphics can be presented sideways (side view), from the top (top-down view) or from a straight down view (bird's eye). The side view is often used to simulate the "eye of the beholder". These types of projection are often used in 2D games. Sometimes they deviate slightly from projection rules in order to "add variety and the illusion of depth without the use of scaling" (Koncewicz, 2009) which is a calculation process of shrinking or growing 2D graphics objects (sprites). One of the most famous examples of side view gaming is *Super Mario Bros*. This game is interesting in terms of how it demonstrates that the side view projection is appropriate, thus without using any technique to illustrate depth. Indeed, those types of presentation are not exclusive to parallel or perspective projection. Also, this type of viewpoint frequently uses the parallax effect, which, as mentioned earlier, provides a sense of depth. Good examples of side scrolling games using parallel projection are *Donkey Kong Country 2* and *Prince of Persia*. Some video games using perspective projection are also presented sideways, such as *Friday the 13th*. However, in this videogame, although everything seems to be in two-dimension (like the houses, or the background), there are projected lines that make the interpretation of the depth strange and vague. It is in an effort to create depth in that the two oblique lines in front each house or road implies a distance. But still, because these lines do not correspond to each other to a single vanishing point, it offers a rather odd presentation. Which means that side-scrolling is not infallible to coherence in graphical projection.

The principal problem with other points of view (top-down and bird's eye) and the types of projection is that the angles tend to be confused with one another. We can often see different types of projections in the same frame, which gives a strange perception of the objects or the view represented. For example, in the interior representation in *The Legend of Zelda*, the top-down view offers a simultaneous impression that the player's view is from above and frontal. Indeed, there is a strong one point perspective with a central vanishing point to the character which we see frontally thus the gameplay suggests a side-scrolling motion (which, in that case, the character is moving while laying down). Despite this, this point of view was frequently used in certain types of games because the overhead view often offers the best viewpoint for gameplay. This is particularly the case for role playing games (*Final Fantasy, Dragon Warrior, etc.*), strategy games (*Warcraft*), or construction and management simulation games (*RollerCoaster Tycoon*, *SimCity 2000, etc.*).

As stated before, in parallel projection the relationship between the axes is preferred to the impression of horizon or depth. In an isometric view, the scale of all three dimensions (x, y, z) is the same, and each angle measure 30 degrees. A cube projected isometrically retains its proportions, which means that its width, height and length will be the same size and will contain the same surface area. This type of projection is in fact very difficult to achieve (especially in the older games), and designers prefer to use a dimetric projection. The main difference between an isometric and a dimetric projection is that in the latter, only two out of three angles must respect the equivalence of the axes. For this reason, this type of projection is the most generally used. The most common ratio of angles is 2:1 (for every two pixels on the*x* axis, there is one on the *y* axis). This means that most of the time, an isometric projection is actually dimetric because this combination of pixels does not result in a 30 degree angle. Finally, trimetric projection allows freedom to stylize angles, and therefore graphics, which can result in an atypical game stylization. Since oblique projection has no specific rules concerning the angles of the axes, its aesthetic results in a quite arbitrary scaling of dimensions and proportions. However, as mentioned before, the cavalier perspective and cabinet projection (based on an extension of the sides of an object at an angle of 30 or 45 degree) was used in some games (such as the original *Sim City*).

As suggested at the beginning of this article, with regard to the historical study of graphics in video games, perspective is much more relevant than parallel projection because it is a paradigm that fits better with new technologies within time. Yet, according to Friedberg, the advent of new technologies has broken the single view point of this traditional visual conception. This challenge towards perspective by new technologies is perceived by the recent and rapid reorganization of the layout of images on modern displays. The split screen and multiple screens are two examples of resistance to the dominant visual mode dictated by the paradigm of perspective (single frame/single image). Although certain technologies have changed our relationship to the screen and the way we perceive our visual space, I believe that video games are rather a simulation than an exploration or organization of the screen. Indeed, even though the screen may be divided or include disparate elements in its visual space (such as commands, tools or actions), the main objective of the game will focus on a function of simulation rather than an organization one (like in the case of a cell phone or desktop display). Perspective is therefore an effective and appropriate tool to explore the advent of three dimensionality.

Perspective in 2D games was mainly used to complement the background of the first adventure games. Perspective to a vanishing point facilitated the calculation of the scaling (characters, for example). The environments made of pre-rendered 3D graphics allow the player to occupy any point of view in the environment and the characters therein were resized accordingly. This way the depth was integrated into the gameplay [endnote See the paper in this issue by Dominic Arsenault and Pierre-Marc Côté, Reverse-Engineering Perspective Innovation: An Introduction to Graphical Regimes.]. However, the use of perspective in games in 2D and fixed 3D was not the norm until the advent of real time 3D. The use of perspective was mostly devoted to decorative elements or to the environment.

Games like *Prince of Persia* and *Mortal Kombat* may not have been in actual 3D, but they advanced graphics technologies for video games. The digitized actors that portrayed the in game characters in *Mortal Kombat*, for example, were developed from digitized sprites of real actors, not animated cartoons. However, the multiplicity of characters is not from an equal number of actors, but from the recoloration of sprites. Indeed, some of the characters were based on the same model, but the colors of their attire and their special techniques indicated that they were different (such as Scorpion, Reptile and Sub-Zero). In 1997, *Mortal Kombat 4* led the franchise to three dimensionality by replacing photographic actor models with polygon models from motion capture, thus moving from fixed 3D to *real life* 3D (Elmer-Dewitt, 2001).

Since the advent of polygonal 3D, the use of perspective is almost systematic. However, it is not the fact of having a good graphic rendering or appropriate use of perspective that makes a game a success or a failure of. Although all games use their own projection technique, one has to keep in mind that it is a specification among many others in the theory of video games. Thus the reception, the gameplay, and many other factors still remain to be studied. In this perspective, the vocabulary of graphic projection is not to be taken literally, but should be applied according to the knowledge that game studies has its own history.

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The production of subjects and space in videogames

Despite the dominant view that distinguishes video game space from other spatial representations as navigable space, someone who engages with the screen space of a video game must first and foremost *rest* at an ideal viewing spot in physical space, which is in accord with the requirements of a proper screening. In other words, one's illusory experience of navigable space becomes possible only if one's body in physical space occupies the visual center on which the scenographic arrangement relies in order to function. This type of "spectatorship" (Florenski, 2001, p. 57)[1], which is also central to the form of video games (Rehak, 2003, p. 118), has a long tradition in western mimesis and can be traced back to ancient theatre, in which the visual order relied on principles of Euclidian geometry. Revived during the Renaissance, and further developed with the notion of Cartesian space, this mode of representation, together with its implied spectator position, became the way of seeing in the New Age, and continues today, where it now serves as the basis for graphic rendering technologies in computer-generated imagery, animation, and video games (Taylor, 2003; Graça, 2006, p. 4; Wells, 2006, p. 1).

At the heart of this tradition lies linear perspective, a practice of representation that asks the spectator to remain immobile in front of a stage, and to have a fastened eye that sees what is *brought* to its sight (Florenski, 2001, p. 57). Based on a strong faith in natural sciences that were instrumental in its development, linear perspective is often hailed as the most "naturalistic" and "scientific" method to be used in the visual representation of the world. Rooted in Plato's philosophy, which is known for the "prominence [it] bestows on visual activity, considered to be equal to cognitive activity" (Stoichita, 1997, p. 22), this mode of representation is also believed to reveal the truth (the capacity to reach the "inside") while remaining objective (the capacity of stating the factual from "outside"), a highly problematic duality that has been the subject of much debate in anthropology, especially in the distinction between the *emic*(insider) and the *etic* (outsider) positions in anthropological field research (Harris & Park, 1983, pp. 10–11), and in photography theory, where the status of documentary photography in particular has been strongly questioned with regard to truth and

1. Due to lack of access to an English version of *Inverse Perspective,* all direct quotes and paraphrases from this work of Pavel Florenski have been translated into the English language by myself. I took as a basis the Turkish translation of Florenski's work, which is also mentioned in the bibliography section of this paper. The Turkish version of this book has been translated by Assoc. Dr. Yeşim Tükel, a seasoned translator and scholar with a background in language and translation studies. Tükel's translation was published in 2001 by the Istanbul-based publisher Metis and includes a valuable presentation written by Zeynep Sayın, an acknowledged art scholar from Istanbul, which I have also cited twice for her insightful interpretations of Florenski's thought.

objectivity (La Grange, 2005). The naturalistic effect that can be achieved in this mode of representation is specifically related to its success in self-effacement; that is, its success in managing to render its own form invisible and, through this, its capacity to function as an "engine of affirmation" (Kolker, 1992). Showing similarities to the notion of continuity in cinema, game genres like the first-person shooter have been praised for exactly this kind of fluent, realistic and seamless "direct representation" in which "looking and targeting come together, and the player [is] invited to follow his gun" (Kleijver, cited by Hitchens, 2011). Put in Ryan's (2001a) words, "we experience what is made of information as material" (p. 68). This illusion provides enough ground to be able to state that screen spaces such as interfaces "are ideological, they work to remove themselves from awareness, seeking transparency—or at least inobtrusiveness—as they channel agency into new forms" (Rehak, 2003, p. 122). Lefebvre (1991) also points out this relation of spatial representation to ideology: "What is an ideology without a space to which it refers, a space which it describes, whose vocabulary and links it makes use of, and whose code it embodies?" (p. 40).

As Taylor (2002) has pointed out, "the dominance of linear perspective as a mode of representation has been much interrogated for other forms of pictorial representation, [but] it has not been so for video games" (p. 2). Taylor (2003) further states that "much of the current critical and theoretical literature on new media, including video and computer games, assumes both the conceptual transparency of the video or computer screen and the absolute authority of a rational scientific order." As a result of these assumptions, developers, researchers and players alike tend to equate the underlying models of Euclidean geometry and Cartesian space to real space, and assign images rendered through methods of linear perspective to the status of the tangible, a quality which is often expressed through the terms "realistic" and "navigable." In game development practice, this means that "video games have given implicit priority to unified monocular vision" (Taylor, 2002, p. 2) and that it is a widespread "assum[ption] that the screen is transparent and the player can effectively merge with the game space" (p. 12). However, as an observation of Rehak (2003) clearly reveals, these assumptions of transparency and the player's effective merging with screen space remain problematic: "to sit at a computer and handle mouse and keyboard is to be physically positioned; to misrecognize oneself as the addressee of the screen's discourse is to be interpellated as a subject" (p. 122). Not only the construction of screen space, but also the construction of the broader "stage" in which spectatorship takes place must be therefore regarded as instrumental in "enabling a snug fit between the player and his or her *game-produced subjectivity*" (Rehak, 2003, p. 119). As Martin Heidegger has observed, the world becoming an image is the same as the human being becoming a subject (cited in Sayın, 2001, p. 15). Hence, "producing a coherent space of reception for a viewing subject" is at the same time the "construction of unified subject positions" (Rehak, 2003, p. 119).

Rehak's observations not only capture the mobility/immobility and inside/outside dualities, both of which are central to this model of video game consumption, but they also point into the theoretical direction of psychoanalysis. As Taylor (2003) has pointed out, "the models of subjectivity and agency offered by psychoanalysis provide a way to investigate the relationship of player, player-character and the screen [and to] examine how perspective shapes the field of gaze and the implications of the shaping." Most importantly, Lacanian subject theory has shown that the production of spatial representation and the production of subject is an inseparable moment. This notion of simultaneity is a strong point of departure for reconsidering the abovementioned dualities in our perception of gaming both as players and as game researchers. However, dealing with this topic also requires taking a closer look at the concept of linear perspective as it has been questioned and criticized in architecture, the fine arts, and screen theory. In these fields, we find a number of works that give a critical account of linear perspective, among them studies on inverse perspective which deserve special attention.

THE INVERSAL OF PERSPECTIVE: GAZE, SPACE AND THE SUBJECT

Inverse perspective does not simply refer to a visual style whose most impressive examples were produced during the era of the Byzantine Empire, but it must also be regarded as a conceptual tool in the arsenal of modern art criticism, one that has been used to capture the immersive relationship between a work of art and the looking object, and the aesthetic experience that results from this encounter. Thus, the notion of inverse perspective plays a twofold role in understanding the relationship between the visual construction of ludic spaces and the production of ludic subjects. Firstly, it serves as a radical point of departure to critically approach the philosophies behind the representational strategies applied in contemporary gaming technologies and the mode of consumption that is fostered thereby. On the other hand, it serves as a metaphor that powerfully describes the immersive experience of "being at play" (*in lusio*, illusion), and allows us to relate to Lacanian psychoanalysis, whose theoretical framework has identified several (some of them spatial) misrecognitions (or inversals) that play a role in the production of subjects. Both Lacanian subject theory and the notion of inverse perspective have many common points that are helpful in the interrogation of linear perspective and the type of spectator/subject that it produces. These common points are particularly useful for overcoming the abovementioned dualities, which seems to hamper the attempts to formulate a theory that gives a more accurate account of a player's relation to on-screen representations and/or social spaces.

Linear perspective's claims in regard to naturalism have long been under dispute in other arts. This "wordview" has also been criticized for standing in association with the Cartesian *cogito*, which provides the basis for a subject theory that projects the human as a conscious being guided by reason as it "acts upon" an external world made tangible through the objectively truth-revealing powers of the natural sciences. To its critics, linear perspective is imperialistic (just as the modern rational subject whose "eye" it represents), its goal is "to tame the world, to take it under the control of a notion of space that can be ordered, looked at, invaded and possessed" (Florenski, 2001, p. 57). Rather than being copies identical to the real world, images created based on this method need to be considered as "the result of a complex calculation and coding process" (Graça, 2006, p. 3), of "a mechanical, automated eye" (Florenski, 2001, p. 57) which can render through its schematic order any sight into image, while treating them with equal indifference. Thus it is considered to be a process which cannot simply be regarded as an accurate reproduction of the way the human eye sees, for it lacks a human touch in the first place, but it must be seen as a visual discourse that is the product of a particular moment in history. The claim of representing the world as humans see it, comes even more under dispute when one considers the non-photographic nature of video and computer games, that is, their use of virtual cameras whose "animated camera movements are generated frame by frame imitating their cinematographic equivalents" (Hernandez, 2007, p. 38), a fact which is also indicative of the presence of "an autonomous universe, unfastened from factual existence" (p. 38). However, even if it were a photographic reproduction of the real world rather than a completely invented universe , the artificiality of such realistic rendering would still prevail. This is a fact which, according to Graça (2006), is largely ignored: "scholars deem to disregard that photographed pictures are graphical constructs that can be, and are, used to deceive" (p. 2). Graça continues by stating that "each photographed picture is already the result of a calculation process and, in its very essence, is not the expression of a physical direct human experience of time and space, but rather a visualization" (p. 4). Hence, "it does not correspond to a neutral process of 'copying' physical reality but, instead, is a process of building virtual representations according to a set of precise mathematical rules" (p. 4). Florenski (2001), not only critical of, but also strictly opposed to linear perspective, draws attention to the fact that some devices used in linear perspective drawing do not even require the artist to have an eye, since the artist can construct images without looking at the objects he draws (pp. 105 and 109). This level of mechanization and automation, the separation of hand from eye, and of creativity from realization, seems to stand in stark contrast with artistic views that strive to avoid "becom[ing] part of the production line as a functionary of the technical scheme within the apparatus" (Graça, 2006, p.6) and are against the extensive use of a "technical mechanisms standing between conception and finished work" (p. 5).

Opposed to the alienation of the artist from his work, inverse perspective is a term that has not only been used to emphasize integrity between artist and artifact, body and soul, human and nature, but also between artwork and spectator. In regard to aesthetic experience, this notion starts by suggesting that the viewer is positioned at the vantage point of the gaze of another. This vantage point, which is implied by the visual structure of the artwork itself, intersects with the viewing spot in front of the picture frame (or screen) that the spectator occupies. Through this implied position within the field of gaze, the spectator finds itself as part of extended screen space (Zettl: 1990, p. 134). When the spectator activates the codes of the work, it finds itself "inside and outside of the object at the same time" (Pallasmaa, 2005, p. 13) in an "encompassing field of seeing" (Taylor, 2003) and experiences itself "engaged in reverse perspective, in his/her self-image" (Pallasmaa, 2005, p. 12). In other words, it is not only the image that is exposed to the spectator here, but also the spectator who is exposed to the image: the goal of representation is not simply to give the spectator access to the virtual world, but also to give the virtual world access to the spectator. (Sayın, 2001, p. 16).

Pallasmaa (2005, p. 40) feels the need to refer to psychoanalysis to capture this immersive relationship with space and spatial representations by claiming that there is no body without a place in space, and no space which is not related to the unconscious image of the perceiving self, a connection that is central in the context of our interrogation. According to Taylor (2003), this is due to the gaze dominating the relationship because it is the very structure of this relationship. This is a structure that, according to Clemens (1996), "contradicts logic, for rather than the model preceeding its image, the image preceedes its putative model, that is, the body" (p. 74). It has been attempted more than once to describe this experience of "the looking back of the subject onto itself" (Taylor, 2003) with the metaphor of (divine) light. For example Byzantine icons are said to "take into their light the eye that looks at them (…) the light rays do not run from the eye to the image, but from the image to the eye" (Sayın, 2001, p. 16). Interestingly, Lacan too speaks of such light when he describes gaze: "it looked at me at the *level of the point of light*, the point at which everything that looks at me is *simulated*". He continues to explain this experience of inverse raytracing as "the reduction of the subject to object in the field of gaze" (cited by Taylor, 2003).

While the notion of inverse perspective seems to put forward a quite unified vision in regard to aesthetic experience, one in which the spectator and the artefact become inseparable, in game studies the inside/out duality remains an important figure in attempts to capture the relationship between player, avatar and screen space. Game researchers often maintain a distinction between an outsider position that acts "upon" the world and an insider position that acts "within" the world, or they put a player's relationship to game space as a half inside/half outside position: "one is in the world, but not of the world" (Aarseth, 2001, p. 5). The problem is often put as one of directness or indirectness; for example the FPS genre is regarded as enabling "direct agency," whereas other genres, such as the so-called god game, are regarded as involving the player "indirectly." Classifications of game space and player point-of-view (for example Ryan, 2001b; and Aarseth, Smedstad and Sunnana, 2003) are also marked by this duality, where camera distance and angle are regarded as measures of insiderness or outsiderness. Further related to this duality is the notion of embodiment, in which, depending on whether the player is associated to an in-game representation (for example an avatar) or not, the player is regarded as "disembodied" and therefore outside because of no "corresponding pair of eyes" in the game space (Poole, cited by Taylor, 2003). Finally, there is a form of this inside/out duality which perceives the player's relation to game space similar to a *rite of passage*, in which the player is thought of as an outsider who has to work his way through the interface in order to enter the game and turn into an insider. Here, the interface is regarded as both physical (part of the real world, faced externally, and screening out the player) and virtual (an envelope that wraps and contains the fictional world and the player). The inside/outside duality seems to be a major obstacle in capturing the experience of being at play, which is immersive and unified regardless of point-of-view, that is, the distance to and angle from which one perceives events and other existents, and regardless of the impossibilities that the representations suggest as being true. All these indicate that it is a pivotal task to formulate an approach that goes beyond the inside/outside duality and explains that rather than a move from outside in, both space and subject are brought simultaneously into existence within the field of gaze.

SUTURE AND THE PRODUCTION OF SUBJECT AND SPACE IN THE FIELD OF GAZE

A key concept that proves to be helpful here is *suture*, a condition "by which spectators are 'stitched into' the signifying chain through edits that articulate a plentitude of observed space to an observing character" (Rehak, 2003, p. 122). Rehak (2003) cites Silverman saying that "the operation of suture is successful at the moment the viewing subject says 'Yes, that's me' or 'That's what I see'." (p. 122). We know from our own gaming experiences that, regardless of point-of-view, presence or absence of avatarial in-game representation, and the degree of manipulation of the game world that is allowed to the player, we said "Yes, that's me" and "That's what I see" many times, on the broadest imaginable palette of games from all genres, and throughout an inexhaustive variety of mechanics, controls and interfaces. This situation indicates that identification, that is, "the transformation that takes place in the subject when it *assumes* an image" (Lacan, cited by Taylor, 2003), is a much more radical condition of "counting as one" than is perceived by the approaches that are built around the inside/outside duality. This fact is also stated by Lefebvre (1991) who observes that "representational spaces (…) need obey no rules of consistency or cohesiveness" (p. 41). He points out the arbitrariness of representations (and therefore the subject positions produced by them) by asking "what does it mean for example to ask whether perspective is true or false?" In the end, "all representations of space are abstract" and are "subordinate to their own logic" (p. 41). Florenski (2001, pp. 114-115) also points up this fact when he says that

> representation is always signification (…) to ask whether a representation is natural or attempts a style makes no sense (…) one can only ask whether the applied style attempts to be naturalistic. Style is the inescapable nature of all repesentations.

This is another way of expressing that identification can take place under the weirdest configurations of visual style and spatial order, since they are all perceived as natural within their own style, and a spectator is therefore always ready to live up to the variety in which they may come.

Clemens (1996) draws attention to this active and performative nature of identification and states that it is by no means a simple registration of fact, but rather having the simultaneous status of cutting and suturing through which the human "identifies itself as a delimitable being-in-the-world, [and as] one object among others" (p. 73). This simultaneous status of cutting and suturing is closely related to the way the body, including the eye (or seeing) gets caught into the semantic web of the ludic discourse. As Zizek (1992, p. 21) explains, central in grasping this process is Lacan's distinction between drive and demand. The central thought here is that in the symbolic order, the division of bodies into zones is not determined biologically, but through discourse. Hence, body parts or zones are marked not by their position within the human anatomy, but through the way they got themselves caught into the semantic web of the symbolic order. The body and its drives are rendered through the symbolic so as to be inscribed with varying sets of gestures, substances, values and replacement parts. Since the satisfaction of drives can only be attempted through this rendered body, Lacan uses the capital letter D, standing for Demand, which is how he calls such rendered drives.

It was probably Bernard Suits (1978) who included the notion of demand for the first time into a definition of play, saying that it is an activity "where the rules prohibit more efficient in favor of less efficient means" (p. 34), which is another way of expressing that players must satisfy drive through the way in which the game has reconfigured their body and the world within which they act. A term that may be useful to address such operations of demand on the eye (or seeing) is *game view* (Schreiber and Brathwaite, 2009, pp. 25-26). However, it is important not to mistake perceptual view for the broader field of gaze, since gaze is not simply perceptual view, but rather an order that constructs an artificial point-of-view and then naturalizes it as if it were perceptual view (the world presented as if it were "someone's perception of it"). Hence, subjectivity is produced through a broader field of gaze that is "a structure of seeing" (Rehak, 2003, p. 119) and simulates an artificial view as if it were a perceptual view. In other words, "That's me" (subject in space) and "That's what I see" (spatial representation misrecognized as perceptual view) are both produced by the field of gaze, equally artificial but interdependent in the maintenance of their naturalizations.

It appears obligatory to consider ludic spaces from such a demand perspective then. Rapoport (1979) points out the importance of semantic webs in the differentiation of space into place so as to "indicate that [we] are *here* rather than *there*" (p. 3). In other words, the making of place is the marking of space, it is the "ordering of the environment by abstracting and creating schemata" (p. 3) and the "purpose of structuring space and time is to organize and structure communication" (p. 9). Hence, we do not speak of a "random assembly of things [but of the] expression of *domains*" (p. 9). According to Lefebvre (1991), this is "logico-epistemological space, the space of social practice" (pp. 11-12), which is underlied by "codifications produced along with the space corresponding to them" (p. 17). These codes must be regarded as "part of a practical relationship, (…) part of an interaction between 'subjects' and their space and surroundings" (pp. 17). This "appropriated space" (p. 31), which is the connotative sum of physical and mental space, is then where subject and place, both being products of the same codification, come into mutual existence.

Interfaces, too, can be seen from this perspective. Following Flanagan's (2006) observation that "interfaces are abstractions that can be said to describe an underlying topology of the self" (p. 312), it appears that they embody the semantic web that we are caught in at exactly the moment we start to interact with them. However, we need to take into account that it is not merely the interface itself that re-skins the player, since the interface must be regarded as a re-skinned body/space, too. The relation between player and interface/screen space must be seen as an encounter of two skins/bodies caught simultaneously into varying but mutually accessible architectures of the *same* semantic web. But where is this semantic web then to be found? As Flanagan (2006, p. 315) explains,

> the equivalent to skin and its markings lies in code, in programming. Computer programming provides the ultimate map, for it is both a language with its symbolic representations, and itself a body, a place where language transcends representation and becomes action.

The program reskins both of these participants with different but by both participants mutually and meaningfully recognized zones. With meaningfully recognized zones, I mean to say that the demand of a subject always involves a certain vision of the demand of the other, because ultimately, the reskinning of bodies is also an act of inscribing gaze (the demand of the other) onto each other's skins. Running against each other in order to satisfy their demands, intercourse between the two subjects interface and player will only take place if the conditions put forward by the semantic web are met, that is, the confronted subjects must negotiate the satisfaction of their demands in a way recognized by the semantic web that produced them. What is recognized as a valid exchange changes, of course, from game to game. This broader framework of valid exchange, which re-skins both player and interface simultaneously, also explains in particular why, as long as the contrivance or appropriation is successful, a player can identify with any type of visual representation of presence within ludic space, be it through subjective camera, side-view, top-view, in-game avatars, or all of them at once, since the player's subjectivity and the interface are constructed as each other's mirror reflections: they see each other in each other.

The fundamental importance of semantic webs in the re-zoning of bodies and spaces indicates that one must see a condition of the semiotic type here, one that doesn't simply turn inside or outside based on camera distance or angle, but one which allows it to assume any kind of position as a property of the self, and this is exactly what suture achieves: to be as is. One assumes the image, despite its radical otherness; the properties of the image one assumes come second. It may come across as striking to realize how old this particular notion of "counting as one" is: the verb assume is etymologically rooted in the latin *sum*(to be, to amount to), and *esse* (being), from which also the word essence derives. The connection to the word essence is interesting because it lays bare a complex, almost tautological aspect of this kind of presence: A being whose ontological basis is founded onto itself, as is exemplified in the way God answers Moses' call for providing an identity: *Ego sum, cui sum;* "I am who I am." This is the biblical *Yahveh*, the name of God, a being whose characteristic property consists of being. In short: God *is*. On another account, this is also the essence of the narcissistic condition, in which one assumes one's own shadow reflection (*imaginis umbra*) in order to erect an image of one's self so as to gain a substance and a proper name: "That's me" (Stoichita, 1997, pp. 32-33). In other words, one maintains a self-image on the basis of an image that has been mistaken for the self. In the case of ludic identification, we could say that the sum we talk about is a *connotative sum* (a self-image): that between a signifier (the human borrowed by the game from the real world) and a signified (the logical and semantic form of the game). This allows us to draw the conclusion that being a player is to count oneself as the position produced by, and taken in, in symbolic space, and that through this, one has become a *sign*.

How does a human find itself reduced (or, if you prefer, elevated) to a sign, to a game-generated subject within ludic space? An explanation to this is given in one of Roland Barthes' (1991) early studies that is concerned with myth as speech. Myth as speech, according to Barthes, borrows the signs from a first order language (which could be any token of reality—a human for example—that has been already rendered into a sign by other discourses), and strips them from their already existing signifieds, thereby turning them into empty forms (signifiers), and associates them then with the set of signifieds of its own symbolic order (p. 113). This operation of discourse on discourse, which Gregory Bateson (1983, pp. 315-316) defines as meta-communication, renders the invaded objects into metaphor, and causes them to shift on a vertical axis, into a different logical state (a different set of rules that govern a productive articulation of its own kind), one which radically alters the meaning and capacity of every contrived object or action. This can be said to apply to games too, since games recruit already existing signs as to give them functions as signifiers in their own systems. Games can be then partly defined as *second-order languages that recruit the signs of first-order languages as their signifiers*. As soon as the signs of the first order language are dislocated by the operations of the second order language, they retreat into the state of being signifiers in the latter (1991, p. 113). The important aspect here is that through its borrowing, the signifier-turned-sign gains a double sense: it is simultaneously a sign in a first order language, and a signifier (associated with the signifieds) in the game's second-order language. Through the borrowing and association with the signifieds, the borrowed sign becomes rooted into the realm of the game so as to express meaning in terms of the logical form by which it has been invaded. For example, the game of football utilizes real humans, real-world physics (such as gravity), and real objects (a ball, a framework made of wood), all of which could be considered as already having meaning in the real world (thus, being sign systems, or first order languages), and uses them as the empty forms (signifiers) of its secondary order language by filling them with its own logical form (signifieds). The logical form redefines and reconfigures the emptied signs so as to make them functional in the fictional universe of the game, thereby also enabling the ludic signification process. Humans, physics and objects that have been borrowed are still real to some extent; however, humans only gain functionality by pretending not to have any hands, and gravity has gained new functionalities by being put into the service of the fictional universe of the game. In other words, what has been borrowed from reality is not exactly the same as with what has been given back (Barthes, 1991, p. 124). As Malaby (2007, p. 96) has stated, we must speak of "contrived contingency" here: the utilized elements acquire new meaning through their subordination to the definitions and delineations of the ludic discourse. Real properties and real actions of real humans and processes no longer denote what they used to denote, because "when it becomes form, the meaning leaves the contingency behind" (Barthes, 1991, p. 116).

It can therefore be said that through the rendering of first-order languages into metaphor, *games invent one world scheme in terms of another.* The invented world scheme must be regarded as the knowledge about a certain truth that was outside our perception until its inception through the ludic call. Despite the materiality of the utilized beings and objects, we do not deal with empirical facts here anymore, but with symbolic values put into circulation by ludic discourse. To consider these values as half real-half fiction, half inside-half outside, means that one assigns substance to what has become form, thereby seeing empirical facts in what is signification, and a causal chain of real events in what is a system of values (Barthes, 1991, p. 130). Indeed, to the player, a game seems to be stripped from the motivations that created it and is consumed with a sense of logic, as if the signified were set up by the signifier, and as if the image led us naturally to the concept, which results in one seeing an inductive system in what is actually a sign system (Barthes, 1991, p. 130). This complex process of the naturalization of the artificial is achieved by a human's submission to several interrelated orders of misrecognition. The next section deals with these misrecognitions.

THE COMPASS OF DISORIENTATION

In a paper on the concept of misrecognition in psychoanalysis, Clemens (1996) provides us with what he has named a "compass of disorientation". Here he lists eight orders of misrecognition (see Table 1) through which Lacanian theory explains the production of subjects. Each of the misrecognitions are also matched with equivalent figures of speech in rhetoric, something which immediately brings into one's mind the notion of procedural rhetoric in Ian Bogost's (2007) work on persuasive games. Clemens (1996) draws attention to the fact that "for Lacan, it is precisely rhetoric that attempts to ground being" (p. 81).

Mis-Rec.	Rhetorical Figure	Figure Description	Psychoanalytical Description	Corresponding Player Phrase
1st	*Metaphor*	Treating an object as if it were another object	Seeing one's image "over there" as if it were "over here"	"That's me"
2nd	*Synechdoche*	Substitution of a part for a whole	Mistaking one's own fragmentation for an unified self	"It functions"
3rd	*Prosopopoeia*	Anthropomorphism	Misrecognition of the image as human, despite the fact that it is an artefact	"It's alive"
4th	*Prolepsis*	Anticipation ofthe future	The mistaking of a promise for an already accom-plished fact or possible manifesta-tion	"I am..."
5th	*Metalepsis*	Trope of a trope	Miscrecognition of the status of this promise, which is actually a promise of a promise	"...was, and will be"
6th	*Antithesis*	Counter-proposi-tion that denotes a direct contrast to the original proposition	A misrecognition that proceeds by inverting the image's significance and value	"I'm the reason"
7th	*Catachresis*	Misnaming	The misrecognition of the stage as stage.	"This pretends to be a game, but it can't fool me: this is a game"
8th	*Irony*	Incongruity between the implied and literal meaning	The misrecognition of the entire scene as if it takes place, despite its impossi-bility. Everything transpires precisely because of its non-existence.	"Impossible, there-fore."

Table 1 – The compass of disorientation: eight orders of misrecognition briefly described and tagged with corresponding figures of speech.

Clemens (1996) describes the first misrecognition, metaphor, as primarily spatial (p. 74). It is a stationary transport in which "one is caught up in the lure of spatial identification" and one sees "one's image over *there* as if it were over *here"* (p. 74). Bateson (1983, pp. 316-318) explains this as the effect of meta-communication, since a game frames the relationship between objects anew and causes an inversal similar to figure-ground inversals in optical illusions. Objects shift into a new logical state and no longer denote what they used to denote. Besides, what they now denote is something fictional. Barthes (1991), as already mentioned, explains this inversal as a second-order language dislocationg the signs of a first-order language so as to make them work under its own signification chain. Indeed, all myth is metaphor.

The second misrecognition is the "mistaking of one's own fragmentation for a unified self" (Clemens, 1996, p. 74). It is based on an "overlooking of the external, material support of one's image" (the stage, the surface), something which allows us to say that the produced identity of the subject is sort of a "non-existing prosthesis that helps one to stand up straight within oneself" (Clemens, 1996, p. 74). Interestingly, this notion of a support that enables one to stand erect, can be traced back to the term *colossus*, which expresses the erection of something living and persistent inside the twin-image (Stoichita, 1997, p. 20), that is, to turn the flat (not only in the sense of being two-dimensional, but also as in "lying flat on the nose") image into a clay figure or erect *statua* (statue) by filling it with substance and thereby giving it three-dimensionality (pp. 16-17).

The third misrecognition "illicitly renders the inhuman human, by giving a face to a thing" (Clemens, 1996, pp. 74-75). This is primarily to repeat in an image what has been lost, or simpler, to animate the dead, something which according to Stoichita (1997, p. 20) marks the birth of the tradition of western mimesis and is the main motif behind the long story of image as placeholder.

The fourth and fifth misrecognitions are related to time rather than space, because they are about a promise, or more precisely, about the promise of a promise that is misrecognized as an "already accomplished fact or possible manifestation" (Clemens, 1996, p. 75). According to Stoichita (1997, p. 21), this is a defining property of images (or representations), because their primary impact is to point at their own time, the time in which they exist, and thereby cause the setup of a time outside of the flow of time. Here, the image is not just a projection in the visual sense, but also in the mental/cognitive and temporal sense: it comes from the future, and makes one think "to already be" (*This is me, here, now*), which is "a prefiguration of power linked with the symbolic [and] governed by a strange temporal structure, that of the already/not-yet" (Clemens, 1996, p. 75). This is maintained by a doubled illusion: not only are the screen images we see and which make us assume an image of the self, illusions, but also this very image of the self-caused by these images is an illusion. Hence, what is misrecognized as presence is the projection of a ghost of a ghost, of a future of a future, "something that might never receive actualization" (p. 75): *This is me, here, now,* is then an illusion of the finest sort. And it leads to the sixth misrecognition: "one mistakes what the promise holds out" and as a result, "apparition is greeted with jubilation" (p. 75). But what is greeted with jubilation is not only to be a ghost, but to be a ghost in the machine, since what seems like being in power is only to function as a gear in the machine, that is, the interpellated subject carries the system on its back, while it thinks to sit on top of it. In other words, the subject "inverts the image's significance and value" (pp. 75-76.) and perceives as a privileged position what is just one of the countless functions that need to be performed for the system to reproduce itself, including its carriage-subjects.

The two final misrecognitions, catachresis and irony, require a bit of a special treatment, because they relate to how the whole stage is misrecognized. The misrecognition of the stage as stage is a very interesting one, because one is aware of its status of fiction but nevertheless proceeds as if it were not. The staging occurs, but ultimately cannot be grasped. This, in the final analysis, leads to irony, because everything takes places despite its impossibility (Clemens, 1996, pp. 76 and 80). Clemens goes on to say that "this is not a fantasy in the sense of wishful thinking or of an absurd or offensive content, but rather an empty and fractured frame that is organized according to eminent logical exigencies, and devolves from logic running against its own limits" (p. 80). Such "disappearance of the initial cause from the mechanical field that it founds" (Copjec, cited by Clemens, 1996, p. 80), has been addressed with terms such as naturalization and non-knowledge. Barthes describes both as essential aspects of mythmaking, aspects that can also be said to apply to games: when the game's invitation to join its unique signification process finds us in our individuality, the game, which is after all a historical artefact, appears to us as if it were natural, that is, as if it were the most logical thing for it to spring out of contingency the way it sprung (Barthes, 1991, pp. 123-124). The ludic call presents the game's existents and events as though they were magical items that feel as if they have been created solely for us, in exactly the moment of our encounter with them (p. 123). This is the result of the successful contrivance between the object that has been borrowed from the first order language and the logic of the second order language. Barthes (1991) describes this contrivance as a turnstile that puts into motion the dual sense of the signifier-turned-sign: we can no longer distinguish between the *sign as meaning* (its state in the first order language), and the *sign as empty form* (its state as the signifier in the second order language) (pp. 113-119 and 121), and it is exactly this state of not being able to distinguish between these two states that generates the irresistible magic that makes the call of the game so powerful. This mechanism is central to the production of the ludic subject: "player" neither stands for the real human (outside), nor for the abstraction that the concept puts forward as a role (inside); it is the inability to distinguish between the two, between the inside and outside, something which causes one to take on a position that is non-existent (symbolic).

This condition of standing on a ground that exists solely because of its non-existence must be overcome by the subject with a sort of a non-knowledge.

In order to maintain the illusion of agency, it is thus central that the subject remains unaware of the fact that the source of its capacity is not in itself, but that it is produced by the position which it holds within the symbolic order (Zizek, 1992, p. 29). Instead it must experience the fact of being a product of ludic discourse in a way that allows it to find its produced self as truth. This becomes possible through what Lacan calls the *answer of the real*, a defining moment in our encounter with discourse, which sets up the illusion that we have been always already there as we are. According to Zizek (1992), the answer of the real can be regarded as the repetition of the phallic gesture of the symbolic order in response to a loss of reality (p. 29). In the case of games, this is a response to the sudden thrownness into the alien game world. In order to transform the resulting utter impotence of this thrownness into its opposite, agency, the player must find a way that allows it to take on responsibility in the sudden appearance of this ludic reality: it needs a *token of truth* that suppresses the arbitrary nature of its presence and confirms its faith into being a unique and omnipotent subject (p. 30). In other words, it needs an event, "the experience of being influenced, of a connexion" (Wittgenstein, 1953, p. 71e) that allows it to re-inscribe itself into what it believes to be a causal chain of events that respond to its demands and manipulations—"'the experience of the because" (p. 72e). A typical example for this is the "A-ha, see? I did it!" moment, when one uses the controls of a game for the first time and manages to make something happen. When the player's action accidentally produces an event, the playing human, perceives this accident as the success of its own communication: it put a demand into circulation and its demand has been answered (Zizek, 1992, p 31). Zizek states:

> For things to have meaning, this meaning must be confirmed by some contingent piece of the real that can be read as a "sign." The very word sign, in opposition to the arbitrary mark, pertains to the "answer of the real": the "sign" is given by the thing itself, it indicates that at least at a certain point, the abyss separating the real from the symbolic network has been crossed, i.e. that the real itself has complied with the signifier's appeal. (p.32)

He further states that it is only through non-knowledge that this successful misunderstanding establishes the psychic reality that allows for a meaningful encounter with a number of naturalized entities (pp. 33-34). Hence, game-produced subjectivity must be experienced as an *immediate quality of one's individual presence*—the "purest crystal," as Wittgenstein calls it (1953, p. 44e)—and not as being maintained by the performative act that produces it as such. In other words, for the player, the *as if* is, and can only be, *real.*

CONCLUSION

As I have pointed out in this paper, the field of game studies has yet to develop a unified player theory which has the capacity to explain the complex relations between player, game space and visual representation. I have drawn particular attention to the points of that made repeated failure in this regard due to a prevailing inside/outside duality that seems to create confusion in locating the player's position within the mixed field of physical and virtual space. This confusion has in particular to do with a failure to recognize a player's status as spectator, who, as opposed to the idea that he navigates through space, rests at a fixed point in physical space so as to obey a scenographic arrangement that makes the staging of such navigation possible.

This article also attempts to overcome the aforementioned duality by interrogating the notion of linear perspective. To do so, I use the notion of inverse perspective, a concept that does not only refer to a certain mode of representation, but also to a certain philosophy in art criticism. This philosophy emphasizes a highly unified and immersive relationship between spectator and artwork. Based on the framework that this philosophy puts forward, and especially around the notion of (divine) light, I have established a connection to the concept of gaze and to the theoretical framework of psychoanalysis.

Based on the earlier works of game studies scholars who attempted to use Lacanian psychoanalyses, in particular Bob Rehak and Laurie Taylor, I have used interpretations of Lacan's theory and some of his central concepts, such as Demand, in order to shed light on the complex relationship between player, space and gaze. The point that I emphasize here is that player and space are simultaneously produced and mutually dependent constructions within the broader field of gaze. This is a condition that is difficult to capture with approaches built around an inside/outside duality, since we need to take into account the symbolic order as the fundamental ground on which subjectivity and space are constructed. Such an approach suggests that reference to real physical space must be suspended to some extent in order to deal with the problem of subjectivity in a thorough way.

In order to deal with the production of subjectivity itself in a detailed way, I have used Justin Clemens' "compass of disorientation" and discussed several of the orders of misrecognition which he puts forward. In my discussion, I have made particular use of the works of Roland Barthes, Victor Stoichita, and Slavoj Zizek. I hope that I have thereby been able to make a contribution to the understanding of how a game produces subjects that assign the status of the real to the "as if." I believe that in the future we need to see more studies that attempt to overcome the prevailing inside/outside duality, especially studies that emphasize the simultaneity of the production of ludic space and ludic subjects.

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Reverse-engineering graphical innovation

An introduction to graphical regimes

Technological innovation in the video games industry is a rich area of research that has barely been explored as of yet. [1]. Gamers are always clamoring for novelty and a remedy to the oft-decried "sequelitis" that "plagues" the industry, while game publishers and platform holders secretly plan a next-gen platform to capture the ever-shifting market. In this light, the importance of graphics cannot be understated, as it is usually taken for granted in game historiography that "[g]ame graphics were, and to a large extent still are, the main criteria by which advancing video game technology is benchmarked" (Wolf, 2003, p.53). This formulation, however, needs to be expanded and broken down if we want to truly capture the reasons for success and innovation in the games industry. One key aspect to be factored into the equation is that gamers are sophisticated and literate enough to look beyond the mere graphics "coating", and seek new gameplay opportunities.

To extricate the complex interlocking of graphics, technology and innovation will require us to articulate the interdependent uses and discourses surrounding the notion of *graphics* in games. Working around Kline, Dyer-Witheford & De Peuter's (2003) model of the game industry as the interaction of three circuits—technology, marketing and culture—we will make terminological and conceptual distinctions that will help clarify the roles played by graphics, innovation, technologies and aesthetics in games. Although we agree with Andrew Hutchison, who "explicitly highlights the important co-dependence [of] game aesthetics [as] the combination of the audio-visual rendering aspects *and* gameplay and narrative/fictional aspects of a game experience" (2008), our approach is to take this statement as a starting point and to deconstruct this co-dependence in order to analytically identify the properties of each half and understand how and when they can form a whole.

DISTINGUISHING FUNCTIONAL AND AESTHETIC INNOVATION

Studying innovation in video games is a tricky proposition because it threatens to confuse distinct sets of issues [2]. As Ian Bogost argued, the design of video games can be understood as a practice that straddles the *functional* and *aesthet-*

1. See Arsenault, Côté, Larochelle and Lebel's paper *Graphical Technologies, Innovation and Aesthetics in the Video Game Industry: A Case Study of the Shift from 2D to 3D Graphics in the 1990s*, also in this issue, for more on the study of innovation in the games industry

2. See Arsenault, 2009, for a discussion of game innovation in the context of game genres *ic* dimensions: "Video games are software, but they are not meant to serve the same function as spreadsheets. They are not tools that provide a specific and solitary end, but experiences that spark ideas and proffer sensations." (2008, p.1) Conceivably, innovation can occur on both of these levels. But this does not mean these two types of innovation are of the same kind.

Functional innovation is a somewhat straightforward matter: a game franchise may automate tiresome processes (by auto-saving or auto-mapping a gamer's progress, providing a *fast travel* option, or automatically managing supplies efficiently unless the gamer wants to give customized orders), add more simulational complexity (such as line changes and stamina meters in sports games), or offer new modes of play (for instance, the Practice Mode in *Killer Instinct*). Functional innovation is often thought of as teleologic, but in truth has no such pre-established, absolute direction to follow. It advances through reiteration, each new game largely repeating its precursors' successes while pitching a couple of new ideas to "revise" the set "schema," in the words of art historian E. H. Gombrich's schema and correction theory (1960). Even on the functional level, then, a certain kind of game culture is established.

Aesthetic innovation may at first glance seem like either an oxymoron or a tautology. If we postulate that the aesthetic phenomenon is linked to originality and uniqueness, then any aesthetic component of a game is always by default an innovation; conversely, by definition no aesthetic proposition can be inscribed in a straight teleologic line with an earlier proposition because it would then fall under the functional dimension. Yet in any given game design, form follows both function and the cultural criterion of a satisfying media experience that stands between a wealth of existing artifacts and a horizon of promises yet to be actualized. A new game is thus both a new idea to be explored through an original experience, and a reassessment of past explorations of related experiences. As aesthetically unique as it may appear, no game springs forth from a designer's mind untouched by the larger gaming culture: the historical context is an unavoidable part of the equation. Aesthetic innovation, then, can be thought of as Hans R. Jauss' aesthetic variation, which is the degree to which a given work differs from our expectations and manages to surprise us by positioning itself in the margins, or in another space entirely, from the horizon of expectations (1982). Functional innovation can be seen as a small step or a leap forward along a trajectory; aesthetic innovation is a small step or a leap sideways, in another direction.

CIRCUMSCRIBING TECHNOLOGICAL INNOVATION

The nature of video games as technological constructs (and subjected to Moore's law that processors double in power every two years) makes any investigation of innovation seem inherently technology-driven. And technology *can* and *does* influence a number of innovations: auto-mapping, for example, requires additional data storage. Hardware advances in game console generations provide ever more computational power, more buttons on game controllers, higher graphical resolutions, etc. But many innovations cannot be charted up to technology. *Killer Instinct*'s Practice Mode, for instance, is in fact much easier to implement than its standard fighting mode, as it consists of letting an opponent stand still waiting to be beaten up forever, with no artificial intelligence, damage calculation or timer rules to be dealt with. Hence both functional and aesthetic innovations hinge on genre and media conventions, which are socio-cultural habits largely independent from questions of technology.

Technology is only one term in the broader equation of game innovation, and it often functions as a *facilitating agent,* rather than a necessary cause, for many innovations. A technological innovation opens a field of possibilities in the technological circuit. The possible must be understood here in the philosophical tradition of the actual and the virtual. For Gilles Deleuze (1966), the virtual is opposed to the actual (rather than the real): it represents an open field that contains everything needed for an event or a thing to actually take form, but it is already *real* insofar as the real always holds, in itself, a part of virtuality, of differentiation. By contrast, the possible is a realm that is conceptualized in some form as independent from the real; a possibility is a set of definite preconditions for existence that have already been met, so that the only thing left is for it to be realized.

Applying these concepts to game innovation and technology, we would claim that technological innovation may carve out a part of the virtual and move it into the domain of the possible. This was the case with the ray casting technique employed by id Software for *Wolfenstein 3D* (1992), which simulates tridimensionality out of 2D bitmap sprites. Their methods for doing so could have been actualized earlier, as the principles behind them stem from the virtualities of programming, visual rendering and data treatment. When they started licensing their engines as technologies, the subsequent game developers who worked on them did not operate from the virtual, but from the possibilities which this engine allowed them. (They could, of course, add unexpected features to the engine from the unactualized virtualities of reality, just as id had done before them).

Technological innovation thus acts as a pole of attraction for game developers by breaking down the infinity of the virtual and delimiting a set of possibles from which they can easily work. This intersects with what Nelson & Winter (1982) have identified as a technological trajectory, a natural way for technologies to evolve based on the exploitation of latent economies and optimization (such as increasing hard drive sizes, faster processing, more dedicated graphical memory, etc.). Importantly, the trajectory develops in accordance with the larger technological regime, as Marsili's summary of the research on innovation and technological regimes show:

> A "technological regime" (Nelson & Winter 1982, Winter 1984) or "technological paradigm" (Dosi, 1982) defines the nature of technology according to a knowledge

> based theory of production (Rosenberg, 1976). Innovation is viewed as a problem-solving activity drawing upon knowledge bases that are stored in routines (Nelson & Winter, 1982). Accordingly, the technology is represented as a technological paradigm defining "a pattern of solution to selected technological problems based on selected principles derived from natural sciences and selected material technologies" (Dosi, 1982). In a similar way, a technological regime defines the particular knowledge environment where firm problem-solving activities take place (Winter, 1984) (1999, p.3).

The successive techniques and technologies used to materialize a given game idea, which partially depends on the graphical regime, are to be considered as forming a technological regime: *Quake*'s (1996) full-3D implementation of virtual environments and actors is a new way of solving the problem of providing a first-person shooting experience, just as *Doom*'s (1992) binary space partitioning was an answer to *Wolfenstein 3D*'s ray casting, itself an answer to *Maze War*'s (1973) step-based approach to 3D space (Arsenault, 2009), etc.

VIDEOGAME INNOVATION AND TECHNOLOGICAL NOVELTY

Returning to Wolf's claim that game graphics serve as a benchmarking tool for new technologies (Wolf, 2003), we must add a crucial dimension to the statement. If graphics act as a conceptual interface linking consumers with the underlying, invisible technologies, we must also integrate separately the *usages* that are made of these technologies. This means that graphics, in and of themselves, have an indirect and limited impact on a game or console's success. 16-bit graphics were not enough to bring success to the TurboGrafx-16 in America because many of its early games did not exploit the new graphical capabilities of the console to expand the range of possible game experiences. The separation of technologies and usages allows us to relativize the classic video game marketing claims, which have historically heavily emphasized graphical fidelity, with ever more on-screen colors and background layers, higher resolutions, sprite sizes and polygonal counts, more advanced shading effects, etc. These are all accounted for as technological trajectories, but innovation does not always rely on technological advances. This is why Nelson & Winter (1982) distinguish the technological trajectory from the trajectory of innovation: an innovative product invites reiterations and incremental refinements, which can develop into its own trajectory regardless of technological progress or stagnation. Isabelle Raynauld has shown how a new technology's appearance always constitutes a promise to consumers as well (2003); in the case of video game graphical technologies, that promise could be said to imply more than just "prettier" graphics, and rather promise new play experiences through new modes of representation.

In other words, the technological trajectory must be coupled with an interesting trajectory of innovation, that is, a renewing of game forms and possibilities of action for players. Nowhere is this more evident than during the launch of a new game console, where the launch title games become the privileged vessels of all three circuits of marketing, technology and culture, as they are tasked with demonstrating the possibilities of the hardware, keeping alive the promises of the new technology, and regulating the horizon of expectations of gamers. This was the case with the Super NES' special Mode 7 graphics, a form of planar projection that could render a 2D bird's eye view image in pseudo-3D by foreshortening the pixels up to a horizon line. Two of the SNES' launch titles illustrated this convergence of technological and innovation trajectories, albeit differently. *Pilotwings* (1990) showcased the potential for Mode 7 to bring about new types of gameplay and opened up a novel trajectory of innovation, while *F-Zero* (1990), though quite content with providing a classic racing game experience, took that innovation trajectory to a new level of visual details and smooth scrolling animation. This dual discourse from Nintendo (the platform holder) managed to attract both kinds of game developers: those favoring conservative refinements along the existing innovation trajectories, and those more adventurous developers that wanted to push new innovation trajectories.

Framing innovation as a facilitating agent and pole of attraction for game developers allows us to simultaneously treat technology with the importance it is due, but also to envision innovation outside of technology. There is legitimate cause for a relativistic approach of its importance in our understanding of the medium. This is precisely where *graphical regimes* are helpful to us, as they can account for continuities and ruptures in visual forms of gameplay that transcend technology as a material imperative. In other words, we believe that the essential feature of new graphical technologies is to cement new graphical regimes, as in innovative ways of viewing and—more importantly—of playing. The term "cementing" is not chosen lightly. If we are to postulate an essential continuity of forms that is independent from particular technologies (at least to some degree), then we must replace all images of newness and metaphors of appearance, emergence and birth by metaphors of cementing and coalescence. In this view, a technology seldom introduces newness that springs out of a materialistic "big bang" that creates matter out of nothingness, but rather articulates or reshapes some primal matter and elements that were already present.

THE SYNERGISTIC FORMS BETWEEN GRAPHICS AND GAMEPLAY: GRAPHICAL REGIMES

The graphical regime is to be understood as the junction point between gameplay and graphics: it is defined as *the imaging of gameplay and the gameplay of the image*, independently of the technological graphical capabilities or limitations. As such, it serves to describe the range of affordances that the game creators open or close for the player as a result of visual configurations. For instance, even though *Starcraft 2* (2012) is powered by real-time polygonal 3D graphics, its creators did not allow the player to freely move the virtual camera anywhere they wanted, staying true to the graphical regime of the top-down view that had characterized its classic predecessor. The same conservatism transpired through *Donkey Kong Country* (1994) and *Killer Instinct*'s integration of cutting-edge pre-rendered 3D modeling and animation technology into classic 2D fighting and platforming gameplay. A graphical technology may not translate into new modes or affordances of gameplay if it is not accompanied by a corresponding change in graphical regime. To further clarify, the graphical regime is a qualitative descriptor of video game artifacts.

The first task for any new concept is to interrogate the medium anew. In our specific case, we have moved away from a technologically-driven view of video game history and instead envision it according to the ways in which the imagery can be mobilized to enhance or transform gameplay and, reversely, the ways in which the game allows for interactivity with the visual elements of play experiences. Can the player alter the image's framing, point of view, and visibility of distance or layers? How much and how often is he or she in control of the virtual camera? Are the user's interactions with the image a crucial aspect in the game's structure, or more of a secondary addition to meaningful play?

Aside from acting as descriptive statements, graphical regimes can help to highlight complex aesthetic effects, such as the Scarecrow's nightmare sequences in *Batman: Arkham Asylum* (2009), where gameplay is reduced from the usual 3D exploration to a 2D side-scrolling view. In the context of this action game, the brutal reduction in the gamer's control over the camera positioning quite literally puts the player under the villain's graphical regime (an ongoing metaphor throughout the entire narrative).

Keeping this interrogative stance, it can be very instructive to consider the phenomenon of video game remakes. What kind of added value can be gained from enhancing a classic game's visual characteristics? The Playstation Portable (PSP) release of the PC Engine's *Castlevania: Rondo of Blood* (1993) can provide us with an example. The decline of its original platform has significantly reduced the game's accessibility, long desired by fans of the series. The resulting offer to this demand was *Dracula X Chronicles* (2007), a polygonal 3D version of *Rondo of Blood* that ran contrary to the visual strategy taken by the 1997 *Symphony of the Night* (also included in the package as unlockable content). In terms of graphical regime, nothing is changed: the player's relationship and stance adopted toward the game space is bound to the classical sidescroller, allowing no action to alter anything on the Z-axis. The same graphical regime characterizes Jordan Mechner's *Karateka* (1984) and *Prince of Persia* (1989), independently of the perspectivist graphics they feature: though the ground is pictured with depth cues, the player still moves along a single horizontal line[3]. Graphically, these appear to be pseudo-3D spaces, but this depth is not implemented in gameplay, unlike in *Double Dragon* (1987) and other beat 'em ups.

So far, we have presented the graphical regime as an analytical tool that allows us to link together games that use different technologies or techniques to achieve a similar way of playing and viewing, so to speak, from the point of view of an analyst or gamer. As a metaphor for political control, it always implies a game creator somehow constricting a gamer with imperial authority. Understanding the deployment of graphical regimes then requires us to focus on the pole of creation as much as reception. To this end, we would like to propose a new distinction into the model of relationships between innovation, technology and graphics, from the perspective of a game's creators: the concept and process of *mise-en-image*.

GRAPHICS AS A DESIGN PREOCCUPATION: DEFINING THE PROCESS OF MISE-EN-IMAGE

Looking at the situation from the point of view of game creators requires us to historically situate the rhetorical importance of graphics, which is always relative to the state of affairs of the industry at a given moment. While Kline *et al.*'s model can be used as a flat sheet mapping of the industrial arena, in actuality the birth of an individual video game artifact always occurs within a certain hierarchical configuration of the circuits, in a constant dynamic of *initiatives* and *adaptative responses.* Nevertheless, what matters for videogame creators (in spite of the historically numerous marketing efforts to give credits to graphics alone) is the way in which a given interactive pattern of input and feedback is visualized by the interacting player. In certain cases, the designer may start with a gameplay concept, and then struggle to implement it through a corresponding visualization concept: here, a particular model of what "playing a game", or of what "a game of such-and-such kind" should be acts as the starting point, which means that it is the cultural circuit that takes the initiative, while the technology and marketing must adapt and respond to sustain this initiative. The creative effort to build such a relationship can be accurately synthesized as *mise-en-image,* akin to the *mise-en-scène* by which a director struggles to implement a dramatic script through a corresponding visualization for the camera or the stage. Of course, this process can start with an initial choice of favored visual pattern, but what really matters is that in both cases, *vision* and *gameplay* must be articulated according to aesthetic and technical considerations. This articulation is an irreducible preoccupation of game imagery. In our understanding, the choice of a *graphical style* of representation is separated from those of gameplay and vision, even though the three aspects are intertwined in the play experience as a whole. A short quasi-caricatural table of features will clearly illustrate the differences between what we term graphical style and vision, which follow the same split between the dimensions of functionality and aesthetics that we traced at the beginning of this paper. Graphical style is what we commonly mean by visual aesthetics, while vision refers to the functional aspects of graphics:

3. It is worth noting, in passing, that *Karateka* is a rather rare example of a 1D game on the gameplay level: the player progresses forward or walks back, without being able to move along the Z-axis from the foreground to the background, nor jumping on the Y-axis.

Graphical style	Vision
Surface level cosmetic polish	Point of view and perspective on the game world
Visual realism (number of colors, resolution, ...)	Scale and angle of camera shots
Spectacular visual effects (lens flares, motion blur, parallax scrolling, ...)	Display of gameplay elements (draw distance, number of sprites on screen, ...)
"Eye candy" with stuttering gameplay	"Bare-bones" graphics at 60 frames per second
Incremental graphical technological improvements (the TurboGrafx-16 graphics processor)	Innovative graphical technological improvements (Nintendo's Mode 7 graphics and Super FX chip on the SNES)

While an innovation in the technological circuit can open new possibilities on one or more of these creative processes, the medium's history also shows that many games have expanded the possibilities of interaction beyond what their technology allowed at face value. Consider, in this light, the already mentioned cases of the beat 'em up subgenre of action games exemplified by *Double Dragon*, which offered a playfield with navigable depth even though actions were performed on a single line on the horizontal x-axis, or the ray casting technique which projected a tridimensional perspectivist space out of 2D bitmap graphics in *Wolfenstein 3D*. That determined individuals can push forward new game experiences even before their facilitation by new technology suggests a continuation of the 'hacker' culture famously responsible for the birth of the 1961 *Spacewar!*. But even for spectacular technical innovations, the question remains as to their actual effect on gameplay. As the *mise-en-image* is a process that ties representation to interaction, it is always a way to construct both game space itself and the point of view, which is crucial to the graphical regime's influence on visual feedback. As Michael Nitsche pointed out: "One has to explore the interaction and the media that present it. Any concentration on either presentation or functionality but not both would destroy the holistic principle of spatial experience" (2008, p.8).

In other words, our vision cannot be reduced to simply mechanistic considerations. Gameplay is not an activity that follows reductionist, abstracted choice-and-payoff grids from game theory, but is the actualization of an experience predetermined to some degree by the game's designer(s). Thinking in terms of game mechanics can only inform us about the gameplay or simulational logic dimension of games, but we must not discard the other components that shape the user experience as a whole. A robot might play *Doom* in the same way whether it is looking at it through the map screen or the first-person point of view[4], but then a robot would play *Doom* without any screen connected to the computer anyway. This goes along with Juul's statement that "games that are formally equivalent can be experienced completely differently" (2005, p.52).

Steve Swink's concept of "game feel" also provides a good framework to account for the complexities of the play experience, and relativizes the part played

4. See Nitsche, 2005: "*Doom* (id Software Ltd., 1993), the seminal First Person Shooter (FPS) provides a vectorized 2D map overview. The view is not merely representational as players stay in control of the avatar and can explore the world further" (p. 2).

by graphics by telling us that "the point is to convey the physical properties of objects through their motion and interaction. Any effect that enhances the impression that the game world has its own self consistent physics is fair game" (Swink, 2007, p.4). Even visual polish, according to Swink, does not depend on graphical enhancement, but has in fact more to do with the coherence of the various technical choices that are made to tie a given game's imagery to corresponding rhythms and contexts of gameplay, a distinction championed by our chosen term *mise-en-image*.

Of course, if we imagine a game like *Star Fox* (1993) on the Super Nintendo without polygonal graphics—perhaps with the then-paradigmatic Mode 7 foreshortened scrolling spaces and 2D sprites—we dramatically alter the ride that the game offers. Indeed, it would probably be more akin to HAL Laboratory's 1991 release *Hyperzone*. Tridimensional real time rendering not only brought a heightened precision for spatial simulation on the technical dimension of graphics, but also transformed possibilities for visual "polish" on an aesthetic dimension.

Star Fox remains a good example here, albeit in a negative form, since the Super FX chip's features famously premiered by the cartridge did *not* include a lot of visual refinement. What would *Star Fox* be, as an overall gaming experience, with particle effects, texture mapping, and dynamic lighting? An argument could be made that *Star Fox 64* (1997) is already a significantly different experience, even as it reiterates most of its 16 bit predecessor's graphical regime and gameplay mechanics. Nevertheless, the concept of graphical regime invites us to treat the SNES and the Nintendo 64 titles as a continuity of forms and to claim that *Hyperzone* differs more from them than them between themselves, again relativizing the importance of material platforms and hardware.

Graphical style, of course, has its part to play. As much as we argue to limit its potential role as a component in the confusing golden lamb of "graphics" in videogame terminology, we must acknowledge that it is always a part of any gaming experience. This is complicated by the fact that it is not impossible to find examples of games where the graphical aesthetics (the graphical style outside any functional considerations) are in direct connection with their proposed gameplay aesthetics. In Frédérick Raynal's 1992 *Alone in the Dark*, the objects available for interaction are visually highlighted as they are polygonal objects—like the protagonist and creatures—in an environment that is entirely pre-rendered with a markedly different visual style.

Such contrasts are also of prime importance when playing *Mirror's Edge* (2008), a first person *parkour*action game where the usable objects are highlighted with a bright red over the monochromatic white of the environment. Here, the choices regarding the sensory stimuli of the screen's surface work in synergy with the *mise-en-image* to indirectly influence the pacing of gameplay by explicitly distinguishing a plane of interaction possibilities from a plane of non manipulable *décor* for the player, giving him a clear line to follow. Graphical resolution can also become a central gameplay preoccupation if we were to imagine two different video game adaptations of the *Where's Waldo?* books, one in 256 x 322 pixels and the other in 1920 x 1080; surely the resolution here would transcend mere questions of style and render the search significantly easier or harder.

THEORY GOING 3D: BEYOND UNIDIMENSIONAL GAMEPLAY AND GRAPHICS

Our investigation of the relations between innovation, technology, graphics and gameplay can open new areas of inquiry that have yet to be charted out. For example, a significant problem with any discussion concerning the videogame image lies in the inherent hybridity of the visual flux that games present us: imaginary diegetic spaces, themselves often a complex composite of real time and pre-rendered polygons, 2D graphic overlays, video sequences and/or still photographs, are often presented as coexistent with non-diegetic game menus, interface items and abstract or iconic symbols representing more complex diegetic elements. How can we circumscribe the *mise-en-image*, i.e. the interaction of gameplay and image, in a game like *Final Fantasy Tactics* (1997), where an important part of playing the game happens within menus rather than in the spatial projection of the fictional world? As much as we separate the different aspects of games and recognize them as multidimensional artifacts, we also need to move away from global, totalizing descriptive statements that attempt to circumscribe given games in their totality, for the good reason that our games are not only multidimensional (a multiplicity of levels which we could conceivably chart out in simple 2D graphs), but these dimensions are proteiform and multilayered, such that we must also account for their inherent hybridity or dynamically shifting expressions.

These considerations invite us to stop treating gameplay as the sole or exclusive focus of scholarly efforts to arrive at an essential ontological heart of "gameness," isolated from other aspects. Even though gameplay might be conceived as the heart of games or even of game studies, a heart is still organically linked to other components of the body. In the same way, we need to analyze gameplay as a relational entity linked to the other aspects of video games, just as we have studied the gameplay/image symbiotic unit here. A future study could investigate the relationship between gameplay, vision and control. It would be interesting to study games like *Super Paper Mario* (2007) and *Metroid: Other M* (2010), where the player is tasked with actively shifting between different graphical regimes, in order to trace lines of continuity and innovation along this axis. When Capcom's 2001 *Ace Attorney* series, originally released on the Game Boy Advance, was remade in 2005 for the Nintendo DS, the dual display screens of the DS allowed a more immediate access to in game data, which is a central aspect of these games. As *Wired*journalist Chris Kohler wrote:

> the quickie ports of these games to the Nintendo DS just a few years later might have been seen as a cheap cash-in were it not for the fact the DS' array of innovative features were perfect for the genre. I can't imagine playing these games without using the touch controls to investigate rooms and flip through menus, or without checking my case evidence on a separate screen while reading a witness' testimony (2011).

The notion of graphical regimes permits a new look at video game history and an appropriate theoretical framework for accurately describing and analyzing the contributions of agents in the technological and cultural circuits while avoiding the exuberant discourses on innovation from the marketing circuit.

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Polygons and practice in Skies of Arcadia

This paper features research carried out at the Victoria and Albert Museum into the design history of Sega's 2000 Dreamcast title, *Skies of Arcadia* (released in Japan as *Eternal Arcadia*). It was released by Overworks, a subsidiary of Sega, at an interesting point in Japanese computer game history. A new generation of video game consoles was in its infancy, and much speculation in the industry surrounded how networked gaming and large, open, tridimensional game worlds would change game design in the years ahead.

Skies of Arcadia is a game about sky pirates, set in a world where islands and continents float in the sky. I became interested in this game because it was praised in critical reviews for the real sense of place in its visual design. It is a Japanese Role Playing Game (JRPG), meaning that gameplay focuses on exploring a series of spaces and defeating enemies in turn-based, probabilistic battles using a system similar to that established by tabletop games such as *Dungeons & Dragons*.

This research is based on interviews with the producer Shuntaro Tanaka and lead designer Toshiyuki Mukaiyama, user reviews submitted online over the past 10 plus years, and historically informed design analysis. It is grounded in a broader study of the networks of production and consumption that surrounded and co-produced the Dreamcast as a cultural phenomenon, technological agent and played experience.

Through design analysis, oral history and archival research, in this paper I will complicate notions of tridimensionality by placing a three dimensional RPG in a broader network of sociotechnical relationships. Tridimensionality is not a trick of technology; it is a collaborative practice between player, designer and console.

HISTORIOGRAPHY

Video game architecture and space design has been treated in depth by researchers in game studies and game design practice, but little work has been carried out into the history of video games from the perspective of their inner spaces.

Steffen Walz's *Space Time Play* (Borries, Walz & Böttger, 2007) and *Towards a Ludic Architecture*(Walz, 2010) provided the basis for a spatially oriented games criticism and design theory in the late 2000s. These two works provide a survey of architectural perspectives on gaming and ludic perspectives on architecture; theoretical sketches are complimented by taxonomies of spatial organisation in games and brief reviews of how games have used space in their design. They are extremely useful theoretical works, but as with game studies more generally, there has been no attempt to trace the socio-technical history of network relations that brought changes in video game space design into being. For a text targeted at design theorists and designers in training, this is not a serious flaw.

However, just as historical study is an important way of building citizenship in state schools, a greater understanding of the causes of design change and stagnation in the games industry over its history so far can help developers, critics and players to better understand how change could happen in the future. The technologically determinist account of video game design history suggested by the introduction to *Space Time Play*, whereby changes in the dimensionality and spatiality of games are caused by advances in hardware, puts developers and players in a passive role as the subjects of technology's ever progressing march into the future. I would argue, inspired by Bruno Latour's "Actor Network Theory" methodology (Latour, 2005) that design change occurs as part of a larger network of historical forces, a network in which all participants, both human and non-human, are actors with some degree of agency.

HISTORY

Tridimensionality had been a profitable gimmick in arcade gaming since the 1980s, but in the early 1990s, when Sony began building hype for the PlayStation, it became a major selling point for big publishers. Business analyst Nicholas Lovell recalled in an interview that the demos for the PlayStation, particularly tridimensional games such as *Ridge Racer*, gave the video games industry generally a new legitimacy as the enhanced legibility brought on by more advanced graphics technology made it conceivable that games could be understood and played by a broader audience (Lovell, 2012). The next generation of consoles—Dreamcast, GameCube and PlayStation 2 —competed heavily on the basis of their capacity for tridimensional graphics.

Skies of Arcadia was developed in-house by Sega to demonstrate the 3D graphics processing capabilities of the Dreamcast, and to give Sega an offering in the growing market for Japanese RPGs. The Dreamcast hardware, including its 3D graphics processor, is and was understood by most human actors in the network from a technologically determinist standpoint; the hardware would bring in the customers, inspire game developers, and enable new approaches to game design.

Shuntaro Tanaka was the director of *Skies of Arcadia* [1]. His own sense of direction in the project seems to have come from two main sources: firstly, his communication with his seniors in the company and the hardware division of Sega; and secondly, his perception of what the target demographic would enjoy based on existing cultural products.

1. Reflecting the international presence of Sega and other games companies, in this paper I refer to game designers at Sega and elsewhere with Anglicised name order—that is, family name last, as opposed to the Japanese custom of putting the family name first. This follows the convention in English-language gaming media, and it is how the individuals concerned refer to themselves around English-speaking people.

One case where direction came from above was in recognising the importance of the game as a product that would demonstrate the hardware capabilities of Sega's new console. Tanaka heard from the hardware division that the Dreamcast would provide unprecedented graphics processing power, and that Sega's consoles needed a large-scale RPG to rival *Final Fantasy* or *Dragon Quest*, (Tanaka & Mukaiyama, 2011) both of which ran on Sony's PlayStation. By 1999 RPGs were perceived to be a very profitable genre; the Nikkei Weekly conjectured that it "could revive the games industry" off the back of the 17.88 million units of *Final Fantasy* games shipped by Square by the time *Final Fantasy VIII* was released (*Arcade, home games to be compatible*, 1999). Sega was suffering significant commercial and financial problems due to the perceived failure of their previous console, the Saturn, so they needed the Dreamcast to be a major success.

On world design (sekaikan), Tanaka's direction came from other cultural products that were held in high esteem, such as the anime films of Hayao Miyazaki. This quotation of familiar images and products was well-received by fans:

> When I was a child, big warships and the Metal Max series [2] left a deep impression on me. If you liked this sort of thing too, you'd enjoy this game. (Nanjayo, 2007)

When interviewed, games developers working in the late 1990s seemed ambivalent towards Sword and Sorcery themed RPGs. While the roots of the game genre lie in *Dungeons & Dragons* tabletop RPGs, Japanese RPGs had been drifting away from these origins in the 1990s, most notably in the *Final Fantasy* series, which had introduced elements from Japanese myth and legend, and cyberpunk aesthetics. A graphic designer for Vagrant's Story, released in 2000, said with a note of pride that he "wasn't familiar with the sword and sorcery look," so his enemy character designs looked unconventional and fresh (Studio Bentstuff, 2000, p. 487).

Tanaka reported that the original RPG that Mukaiyama had been working on for the Sega Saturn was to be a traditional sword and sorcery themed game. Once Tanaka joined the team he introduced the new theme of sky pirates, and the team began to work towards the game that would become *Skies of Arcadia*. He said that there were many reasons for this choice of theme, and highlighted two particularly important factors. One was his belief that a game world inspired by Miyazaki's *Laputa: Castle in the Sky*would appeal to the target demographic of teenagers and "people who like anime and manga." Implicitly, sword and sorcery themed worlds did not hold the same appeal. In addition, he believed that the theme would make it possible to show off the polygon 3D capabilities of the Dreamcast, since airships could view landmasses from any angle (Tanaka & Mukaiyama, 2012).

Coeval with the push to demonstrate the new hardware features of a next generation console was perhaps the notion that a next generation game should push frontiers artistically as well as technologically. Therefore, the game world did not have to be just large enough and three-dimensional enough to impress players, but it also had to have a refreshing setting to garner real attention.

2. An RPG series for Nintendo consoles that featured vehicle combat.

The turbulence and power games of an age of empires and piracy may have been evocative of the exciting state of the industry in the late 1990s, as game designers looked forwards to a new age of networked, fully three-dimensional, open worlds for virtual roleplaying. This was a time when many game designers were developing new technologies and skills in anticipation of the next generation of games. Perhaps this was analogous to the new world mythos of empire and piracy. This optimistic sense of being on the cusp of a brave new cyberworld would have been supported by the euphoria of massive economic growth in the software and IT industries during the dot com boom.

One common issue that arises in retrospective interviews with game developers working in the late 1990s is whether the team possessed, from the outset, the skills required to make games for the next generation of consoles, and how they trained in those skills if they were lacking. The interviews I will quote below show that it was uncommon for Japanese companies to headhunt expert designers and programmers who could bring a new skillset to the studio. Instead, employees would remain on the payroll even while working on projects that would never make it to market, in order to develop the skills required to make later, high budget titles. This was the case with *Skies of Arcadia*, as Shuntaro Tanaka explained in our interview:

> We didn't have any experience of making large-scale RPGs, [3] […] I hadn't come in yet, but Mukaiyama was there from the start, and at that time [the console was] Sega Saturn. So for two years they were working with the Saturn. They still weren't able to make anything out of it when Sega announced that [the console] wouldn't be Saturn, but they were releasing some [new] hardware. It turned out that they were going to release the Dreamcast, so the plan changed—they weren't going to make it in time for the Saturn, so they [decided] to make a game for the Dreamcast. I came in shortly after that, and since it was to be the Dreamcast, the hopes for the game and the story totally changed, so we started from scratch and it took another two years after that. (Tanaka & Mukaiyama, 2000)

Tanaka's previous work had been in Sega's tactical RPG and dating sim [4]franchise Sakura Taisen, and he was brought into the project when the switch to the Dreamcast was announced. From there on, any experience in gameplay development gained by the existing team from their two-year attempt to create a large-scale RPG was applied to a new project, with Tanaka as creative director. Rather than hire someone from outside with prior experience in large-scale RPGs, Sega made use of the talent it already had in-house.

Retrospectively, developers are prone to describing projects that led to published games as though they too were training exercises, perhaps particularly if they were not high-budget titles within large franchises bringing in huge revenue for the company. Matsuno recalls that although it was made for the PlayStation, *Vagrant's Story* was made with a view to building the 3D polygon design skills that would be required to make next-generation games on the PlayStation 2.

3. The term large-scale was used in this interview to refer to games such as *Final Fantasy* and *Dragon Quest*, as opposed to tactical RPGs or smaller RPGs such as *Pokémon*.

4. A note on genres: tactical RPGs focus on the location and deployment of troops in a field, whereas standard RPGs focus on the combat actions of a small party of characters. Dating sims are dialogue-driven games that provide players with a series of multiple-choice decisions about what to say and do in an attempt to win the affections of the characters.

> We figured it would be the last game we make for the PlayStation. After that, we would shift to next-generation consoles such as PS2, Dolphin [later known as Gamecube] and Dreamcast. So we thought rather than make a 2D game, we should get a 3D game under our belts. For this game, we gathered together a lot of people who had worked in 2D games, so Vagrant's Story was the first time they had built up the know-how for polygon 3D games, for both graphics and programming. That was our starting point for the project. (Studio Bentstuff, 2000, p. 8)

Matsuno later worked on *Final Fantasy XII*, and introduced to the franchise stylistic themes he had developed in *Vagrant's Story*. Other members of the design and planning teams also attested to the fact that the biggest challenge in making *Vagrant's Story* was developing skills in 3D real-time graphics.

> Personally, I was interested in what we would actually be able to create graphically. A lot of people working on this game had been making games since way back. I wondered what they would be able to do when we were making graphics for the PlayStation. By gaining some know-how in that area, we might be able to further advance real-time graphics when hardware capacities go up a notch with the PlayStation 2. [...] This was the first game I had made in full polygons, and I realised that everything I had learned making 2D games would still help me. Expressing things in very few polygons, reducing the number of colours to increase processing times, things like that had us using the same skills that they were using when they made dot images for the Super Famicom. For example, even with the PlayStation 2, there will still be limitations on memory and processing capacity, so at the end of the day what determines the quality of our work is our prior experience. (Studio Bentstuff, 2000, p. 487)

The suggestion here is that by developing an advanced game within the technical limitations of the PlayStation, they would be better equipped to make maximum use of the superior hardware capabilities of the PlayStation 2 in later games with larger budgets and greater expectations, such as *Final Fantasy XII*. When it came to 3D polygon-based design, there was a similar sense of being on the cusp of a great technological leap, but the designers interviewed focused on the ways in which their existing skills allowed them to make this jump successfully.

> Everyone made polygon models and also made dot images, and I think that's how we were able to make a game like this. In the end, when it came to character expressions and scenery, we were making those polygons using the same techniques that people working with dot images had always used... I like to have technical constraints... drawing something in three dots that you would have drawn in ten... without technical constraints, it's not as interesting. (Studio Bentstuff, 2000, p. 41)

Skies of Arcadia has a very similar backstory. The 3D polygon-based aesthetic that Tanaka first worked on here was later applied to his more commercially successful project, *Valkyria Chronicles* (2008). Clearly, at both Sega and Square at the end of the 1990s, there was a sense that polygon-based 3D worlds would be very significant for future games development, so projects were taken on that would allow design teams to build up the necessary skills. At Square, the skills developed while working on *Vagrant's Story* were put to use in *Final Fantasy XII*, and at Sega a similar training process led from *Skies of Arcadia* to *Valkyria Chronicles*.

This offers one answer to the question of significance with relation to 3D graphics technology—technically significant games trained developers in the skills required to make later games that become prolific.

DESIGN ANALYSIS

In this design analysis, I will demonstrate that *Skies of Arcadia* was not just designed to showcase hardware, but that verticality was used in architectural designs for narrative effect, constituting a historically-situated "narrative architecture" following the game design theory of Henry Jenkins (2004). Tridimensionality emerged as a narrative and experiential practice, rather than a technological flourish.

Skies of Arcadia is a game-world made entirely from polygons, with no use of background images to give an illusion of perspective projection on a flat plane. A world made of polygons is three-dimensional from a visual point of view, but the control degrees of freedom can range from one—for example, if the game world were to automatically move past the character, and the player could control only whether to jump or duck—up to six in, for example, a helicopter simulator in which the players could control movement along three axes and the tilt, roll and yaw of the vehicle itself. In *Skies*, players are only able to move on-screen characters along a maximum of two degrees of freedom at any given time; while on foot they can move the character forwards and back, right and left, and while on a ladder or pole players can only move the character up and down. So the world is three-dimensional, but the control degrees of freedom are no greater than can be achieved in a two-dimensional game-world. Players are also sometimes able to move the camera along another two degrees of freedom: up and down, and left and right.

This is common for RPGs, and could be compared with action games such as games from the *Tomb Raider* franchise, which typically give the players six control degrees of freedom: the playable character Lara Croft can be moved forwards and back, left and right, up and down (by jumping, crouching, climbing and falling), oriented right, left, up and down to face different directions, and even made to turn upside down by cartwheeling (Core Design, 1996). This is a key differentiator between RPG and action gameplay, and makes different demands on the player's skill.

This shows that tridimensionality was not just a question of using a graphics card to create game worlds made of polygons. It was also important to consider the interaction design in the game mechanics: the control degrees of freedom given over to the player affected the extent to which a game felt tridimensional.

TOWN AND DUNGEON

In order to draw attention to the polygon tridimensionality of the game and, by extension, to the graphical capabilities of the Dreamcast itself, *Skies of Arcadia*'s architectural designs created dynamic topologies to permit movement along the vertical plane without increasing the control degrees of freedom.

Pirate Isle, the home of the main characters, is an example of a town map where the ground elevation is arranged almost as a corkscrew; the lowest part of the island is an underground secret base, which contains three floor levels that are scaled by a variety of ladders, ramps and poles. A door from the underground base leads to the outer edge of the island, where a path circles up and around the outside to the main village buildings and further up and around to the top floor of the windmill. The buildings and windmill are both connected to a wooden mezzanine that leads upwards to two separate, small islands; one acts as a jetty for small ships, the other is used as a lookout post. This is one of the earliest areas accessed in the game, and it demonstrates the tridimensionality of the game world very clearly through architectural verticality.

Horteka is a rainforest island which also employs wooden mezzanines, in combination with zipwires, poles and ladders, to navigate between straw huts and treehouses. Poles and zipwires are particularly well designed for demonstrating the tridimensionality of the space in terms of depth. Movement down them is smooth and dynamic, and foreground elements such as leaves and branches briefly move past the camera to emphasise proximity and distance.

Shrine Island is arranged as three concentric circles; the outermost circle contains a lake, and is joined to the inner two circles via a long, narrow path. This narrow path leads towards the large structure of the shrine itself, which looms ever closer towards the camera as the player pushes the character forwards. Another concentric circle leads around the shrine, but access has been cut off by debris, forcing players to access the building through imposing doors. All of this emphasises the scale and volume of the building.

SKY AND SHIPS

The tridimensionality of the sky maps, across which the player-character must travel in a ship in order to get between the floating islands that house towns and dungeons, allows players to move along three degrees of freedom. The gameplay features of the sky map require skillful maneuvering of the ship, particularly when attempting to catch fish as they swim through the sky by flying directly into them. While the first ships piloted in the game do not feel conspicuously slow to respond, there is a significant change in ease of response when the characters come into possession of the Delphinus. The Little Jack, the ship featured in the first half of the game, responds too slowly to follow fish that have swum behind the ship. The Delphinus, however, can spin around very rapidly, making it possible to catch fish with greater speed and accuracy than before.

The simulation of control systems was an interesting issue for Dreamcast games at the time. *Sega GT* (Sega, 2000), a racing game made by Sega, used the processing power of the Dreamcast to offer supposedly realistic simulations of the experience of driving the models of sports car offered by the game. This notion of realistic simulation was taken further with the release of steering wheel controllers for the Dreamcast. The notion was that core features such as steering response, acceleration, brake speed etc. were accurately transferred into algorithmic properties of the cars featured in the software and then fed back haptically into the controllers.

In *Sega GT* and other racing games, player progress is rewarded by unlocking more advanced cars and more challenging and exciting tracks. The goal of the game is to win races with inferior cars in order to be able to participate in better races with faster, more responsive cars. These games distil the challenge-reward mechanism of game design in a much simpler form than the sprawling, multi-layered gameplay of RPGs. A variety of challenges are made available to players, designed to feel difficult but achievable; players select a challenge, and if they complete it they win more challenges and more tools that they can use to complete those challenges. An important factor here is the player's sense of agency in their choice not only of challenges, but of which rewards to apply to solve the individual problems posed by each challenge.

Of course, the flying ships of *Skies of Arcadia* were not designed to be realistic simulations of what it would be like to sail a ship in open air. However, a similar logic of technical impressiveness regarding the air ships in *Skies of Arcadia* was applied to the sports cars in *Gran Turismo*; quick response times were impressive features designed to wow the players and serve as a reward for progress in the game.

The technology said to determine the capabilities of ships in the game world are able to be installed as interchangeable hardware of the ship itself. Different cannons can be bought or won and used to increase attack power in battle. Other hardware allows the ship to sail through reefs of rock or sky walls. Here, the same logic that is seen in racing games is again applied to the ships of *Skies of Arcadia*; players are rewarded for their success in ship battles with superior hardware, and they then have the choice of which hardware to install before attempting the next challenge. This same logic applies to the games console itself; the value of technological commodities is arguably promoted here through gameplay performance.

The tridimensionality of *Skies of Arcadia* is not simply a natural result of the construction of the world from polygons, nor can it be summed up as the number of control degrees of freedom. More complex issues of game design make the game feel more three-dimensional than previous RPGs, which allowed a similar number of degrees of freedom despite being rendered partly from flat images, such as *Final Fantasy VII* and *VIII* (Square, 1997; Square, 1999). The ability to traverse the sky in an airship gives players three control degrees of freedom and allows the world to be viewed from any angle. The architectural design of the game world arranges passable space and impassable structures to create pockets that emphasize movement around structures rather than across the two-dimensional ground plane. Varying ground elevation and the inclusion of ladders and poles highlights the three-dimensionality of structures through player movement, as does the manipulation of viewer sense of scale.

VERTICALITY AND NARRATIVE

A 3D platform game released by Sega one year after *Skies of Arcadia*, *Super Monkey Ball* distinguished itself by its emphasis on the vertical dimension. Level design played on pillars and castle turrets to visually highlight verticality, gameplay introduced falling as either a failure or a short-cut to success, and the optical distortion of its wide-angle view further added to the sense of near-free fall (Johansson, 2007). In *Skies of Arcadia*, verticality is skillfully employed in architecture to emphasise the tridimensionality of the game-world and contribute to game narrative.

Height is mobilised in architectural design to narrativise the political differences between civilisations in terms of character agency. Under benevolent regimes such as Pirate Isle and the rainforest land of Horteka, it is easy to travel vertically by climbing ladders and poles. More controlling regimes such as Valua restrict the characters' movements, particularly along the vertical dimension. Valua is divided into the upper and lower city, and the upper city is restricted to only those of a higher social class. Forbidden routes through Valua are achieved via the underground catacombs, which are populated by monsters that the characters must fight in order to pass through. The use of underground architecture for subversive action is established on Pirate Isle, where all buildings and objects that relate to piratical activity are located in a secret underground base.

This equation of height with power lends itself to a reading of Arcadia's architecture as panoptic. In some ways this is true. Valua features many electric searchlights that glare down on the characters from above, at one stage in the game actually posing a real threat as being caught in the searchlight generates a battle with a set of deceptively powerful robots. The sixth civilisation's location in upper sky above the rest of the world is reflective of their aloofness and ultimate power to destroy the rest of the world in an instant if they see fit. However, both in terms of the storyline and the game's artificial intelligence, there is actually nobody behind the searchlight watching the characters. They are able to spend the whole game travelling the world freely, and when they do run into Valua they fight ship to ship as equals. A great deal of the power held by the enemy forces is not a result of their height, but of their technological power. So, while architectural height does contribute to an awareness of control and aggression, this is only in conjunction with the theme of technology, weaponisation and geographical power.

CONCLUSION

This paper has taken *Skies of Arcadia* as an example to look at tridimensionality in its networked historical moment. With the release of the Dreamcast and the in-house development of games such as *Skies*, Sega was pursuing tridimensionality as a strategy in hardware, business, design and staff skilling. Tridimensionality affected games as a business proposition, a design challenge and a craft skill.

The need to promote the Dreamcast and offer something unique and progressive also influenced the scenario design; floating islands and sky pirates allowed the game to demonstrate not just tridimensionality but also artistic novelty, while harking back to Miyazaki's nostalgic anime. Business imperatives and the possibilities introduced by new hardware were not the only determinants of tridimensional space design; tridimensionality also served the game's narrative architecture.

The nature of tridimensionality goes beyond the construction of a game-world from polygons. The number of control degrees of freedom available to the player affect how tridimensional a game is from the point of view of interaction. When the number of control degrees of freedom was limited, architectural design introduced tridimensional interaction without making extra demands on players' skill.

Design strategies that constructed tridimensional spatial challenges were not simply dependent on polygonal graphics technology. Level design strategies created paths of movement in three-dimensions, and players' operation of the game brought that movement into force. Tridimensionality was a collaborative product of technology, business, design and player interaction.

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Graphical technologies, innovation and aesthetics in the video game industry

A case study of the shift from 2d to 3d graphics in the 1990s

For a decade now, game studies have steadily progressed and covered ever more ground in the fields of humanities, arts and culture. An important dimension of video games, however, is still left unaccounted for: the dynamics of innovation in the games industry. Searching for *innovation* in the Title and Keyword fields of the Digital Games Research Association (DiGRA) digital library returns only 8 papers out of the 618 entries. This is all the more surprising given that the 2009 DiGRA conference was titled *Breaking New Ground: Innovation in Games, Play, Practice and Theory*. There seems to be a clear lack of research on innovation, which this project aims to remedy to a degree. A few Game Innovation Labs exist in universities in the U.S.A. (at the University of Southern California and at New York University, for instance), but they are spaces of practice where games are designed and developed. Theoretical research on innovation is limited, but existing. A research seminar on game innovation, initiated by the GAIN (GAmes and INnovation) project led by Annakaisa Kultima at the University of Tampere, stated in its call for papers that "we know relatively little about the innovation processes that take place within the industry, [and] the bulk of the influential work on games and innovation is found in practically oriented guidebooks authored by experienced games industry experts" (Game Research Lab, 2011). The GAIN project has provided the most extensive writings on theorizing innovation in the games industry and game design process, along with the annual international Games Innovation Conference, which has been running since 2009.

The present project aims to unravel the links between graphical technologies and innovation in the games industry and in gamer culture by focusing on a specific historical corpus: the transition from 2D to 3D graphics in the 1990s. This transition is of the utmost importance in video game history because it conflates two different issues, which analysis and research will distillate: innovation in graphical technologies, in the capacity to represent and implement tridimensional game spaces, and in types of gameplay. From a research and disciplinary standpoint, rooting this study in the graphical dimension of gameplay allows for interesting and fruitful interdisciplinary explorations of art history and film studies approaches; moreover, it makes a strong case for the shortcomings of any single disciplinary framework, and for the importance of game studies to establish itself as an academic discipline of its own.

BEYOND THE SUPERFICIAL: FRAMING GRAPHICS AND MATERIAL CULTURE

From game reviews in specialized magazines to general newspaper articles on the games industry, marketing claims, advertisements, and interviews with game developers, it seems that everything that revolves around video games ties into larger issues of technology. id Software, makers of the infamous *Doom* (1993), were pioneers in developing graphical technology to the point where most of their business came from selling their proprietary technology to other video game developers (Kushner, 2003). Popular game magazines from the 1990s featured elaborate comparisons of megahertz, RAM and ROM or number of on-screen colors, sprites or background layers between Nintendo's Super NES and Sega's Genesis consoles, and dedicated whole articles to the benefits of CD-ROM technology, Full-Motion Video (FMV), pre-rendered 3D graphics, or some special software technique or hardware configuration that allowed spectacular visual effects.

The Sega Genesis console had the terms "16-BIT" and "HIGH DEFINITION GRAPHICS" centrally embossed on its very hardware. When the TurboGrafx-16 console attempted to topple Nintendo's NES, it launched the "bit wars," claiming that the NES was an 8-bit console, while the TG-16 was 16-bit, and hence more technologically advanced. This argument backfired when it was discovered that in fact, the TG-16 had a 16- bit graphics processor, coupled to a Central Processing Unit (CPU) that was only 8-bit. This goes to show the level of technical expertise and literacy that was put forth by the games industry and its culture, and also the need for conducting a rigorous historical study. None of the various websites and articles that treat this topic (including Herman, 2008, for a single example among others) detail how and when the 8-bit nature of the TG-16 was discovered, or who called it out. More importantly, as the failures of the TurboGrafx-16, NeoGeo, CD-i and other consoles proved, technology alone cannot make a platform successful. Why then do we find such a strong focus on this subject in various video game publications?

The hypothesis upon which this part of the research rests, and that this project will allow to test and refine, is that technology does influence the success of a game platform, but in an indirect and limited way. More precisely, it has to affect graphical capabilities to have an impact on the public, but only in a certain, precise way: its graphical innovations must be geared towards new modes of gameplay, rather than simply upgrading the fidelity, resolution, or "polish effects" that graphics can provide. We wholeheartedly agree with Michael Nitsche (2008) that "it is time to move away from graphics that function as 'eye-candy' that remains largely unused in actual gameplay" (p. 6), and are similarly irritated by those graphics engines which "offer little to no development of their original interactive features. They concentrate predominantly on improved performance of 3D graphics. Visual detail has become the fetish of some game developers who entered into a kind of space race to the most advanced presentation form" (pp. 71-72). Our irritation does not come from any prescriptive position on what and how games "should" be, but is epistemological: these technical innovations run the risk (and, in our view, have already done so to some degree) of reducing graphics to a qualitative surface layer, thereby clouding the vital role that they play in shaping the gameplay.

TECHNOLOGY IN PLATFORM WARS

While the significance of graphical technologies and innovation cannot be understated for the games industry as a whole, it is of paramount importance when considering platforms — notably, the release of new game consoles. Ultimately, a platform is only as strong as its library of games on offer. While console manufacturers make games themselves, a broad and sustained selection of genres and titles can only be achieved by resorting to third-party developers. By developing games themselves, they contribute to making the platform ever more appealing to consumers, which creates a positive feedback loop that results in ever more adopters. But the problem lies in the very first moments of a new platform's life, when little to no third-party support exists and must be built from the ground up.

In this crucial stage, technology acts as a pole of attraction for game developers by delimiting a technological trajectory (Nelson & Winter, 1982), a natural orientation for technological changes to follow according to the demands and realities of a given environment. To claim that graphics are important in promoting video games is self-evident, as Mark J. P. Wolf observed: "The number of games available for a given system was one consideration for system buyers, along with graphical complexity. Game graphics were, and to a large extent still are, the main criteria by which advancing video game technology is benchmarked" (Wolf, 2003, p. 53). Hence graphics, when envisioned in the context of technological innovation, are more than eye candy: they act as a conceptual interface that allows consumers (and, to a lesser extent, developers) to see the underlying, invisible technologies. But this technological trajectory must be coupled with a trajectory of innovation, which the platform stakeholders themselves will set by developing games that revolve around the idea of demonstrating the possibilities which their technology affords.

In this context, Nintendo's abundance of mosaic effects, scaling and rotation, and scrolling background layers in *Super Mario World* can be read as a means to demonstrate the strengths of the Super NES platform for other developers interested in traditional games, while titles such as *F-Zero* and *Pilotwings* showcased the console's unique Mode 7 graphical perspective in order to stir experimentation in other directions. The production of these games (as well as other flagship titles, such as Sega's *Sonic the Hedgehog* or id Software's *Doom* and *Quake*) cannot be thought of as simply providing entertainment to its consumers. Instead, these games become rhetorical devices in themselves, parts of a wider discourse from technology stakeholders that attempt to seduce and convince third-party game developers and consumers to choose their own technology over that of competitors.

The composite image presented in Mode 7 in F-Zero. From top-left to bottom-right: 1) the natural view of the aerial 2D plane; 2) the deployment of Mode7 perspective effect by foreshortening the pixels at the top of the screen; 3) the 2D plane projected up to a horizon line, without the skyline background image; 4) the skyline image without the 2D plane projection; 5) the final, composite image with all layers.

While all game platforms have historically employed graphics as a rhetorical device supporting claims of technological superiority, the 1990s period is particularly relevant for this study because it featured a common goal that each platform aspired to: the "conquest of the third dimension". In this regard, the Super NES console (1991-1997) holds a determining spot, and deserves the lion's share of the research efforts because it offers several hardware and software innovations. The Super NES had a built-in capacity to display four background layers, each of them being able to scroll at variable speeds. This set an innovation trajectory for video game creators to take a cue from traditional film animation and implement parallax scrolling (the movement of different background layers at different speeds to simulate a depth of field that increases the perceptual illusion of perspective). The Super NES' most interesting contribution to the conquest of the third dimension, however, is its special (and much-touted in discourse) mode 7 graphics, a form of planar projection that can render a 2D bird's eye view image in pseudo-3D by foreshortening the pixels up to a horizon line, with the rest of the frame being occupied by another background layer (such as a skyline). Over the mode 7 playfield, the 2D sprites (individual movable objects) are superimposed and scaled according to distance.

TECHNOLOGICAL INNOVATION AND TECHNIQUES

The nature of video games as technological constructs (and subjected to Moore's law that processors double in power every two years) makes any investigation of innovation seem inherently technology-driven. Even in fixed, standardized platforms like the Super NES, some manufacturers resorted to external processing chips added in particular game cartridges. For example, Nintendo used a Super FX chip in *Star Fox* to compute real-time 3D polygons (again with much fanfare, the game's box itself reading "Revolutionary Super FX Micro Chip Creates Special Effects Like Never Before!"), while Capcom included in *Mega Man X2* a C4 chip to integrate 3D wireframe meshes in their 2D platform game. Quite significantly, the back of the box's very first bullet-point feature reads, "Enhanced realism and 3-D effects with the new CAPCOM C4 graphics chip!" These are the most high-profile examples of technologies that aim to bridge the 2D-3D gap; others are doubtless waiting to be found, as we discovered, shuffling through an issue of *Electronic Gaming Monthly*, the existence of a Sega Virtua Processor chip meant as a riposte to Nintendo's Super FX chip (which fared much worse, having been used only once in *Virtua Racer*).

Through its competing platforms and their varying technological promises, the 1990s offer a unique window into the various processes of innovation. This includes the fact that many innovations cannot be attributed to technology, but are instead dependent on *techniques*. An innovation comes through techniques (often in programming) when a novel usage of a given, established technology is made. This is the case for games which managed to include a form of parallax scrolling prior to the presence of multiple background layers (see *Star Wars: The Empire Strikes Back* on the Atari 2600, or *Joe & Mac* and *Metal Storm* on the NES), or the various ways which game developers used to represent a tridimensional game space using bidimensional graphics and different depth cues and perspective effects. Examples could be enumerated *ad libitum*, but we only need to think of games from the beat 'em up genre (such as *Double Dragon* and *Streets of Rage*) that offered a playfield with navigable depth, even though actions were still performed on the horizontal x-axis only: fighting moves could not hit targets positioned a single step nearer or farther on the z-axis.

Perhaps the most famous graphical techniques came from id Software's *Wolfenstein 3D* and *Doom*; John Carmack's ingenious computing skills allowed the developer (and those game developers who licensed their engine) to create fully navigable tridimensional game spaces before the technology of

3D accelerated graphics cards streamlined the process and made it viable to resort to polygons. The success of the raycasting technique at work in both of these games is important for four reasons: first, it explicitly shows the need to distinguish between techniques and technologies; second, it illustrates the two global models of innovation (reiteration, which follows progressive additions and revisions, and innovation itself, which is thought of as a more radical break from established forms and conventions); third, it stands as the point of departure of a trajectory of innovation, before the wave of new 3D-focused hardware opens a technological trajectory; finally, it calls attention to the need to trace a common filiation between games that concretize a given gameplay mechanic (such as the treatment of space), independently of the technical or technological means through which they do so. The concept of graphical regimes, which we are developing as part of this research project, stems from this necessity[1].

TRIGGER: TECHNOLOGY / REITERATION / INNOVATION / GRAPHICS / GENRES / EVOLUTION / REGIMES

Arsenault has shown (2009, 2011) how video game genre is a driving factor in the development of innovation. In this light, Nintendo's Super NES can be said to favor reiteration across already-proven genres, such as platform games, turn-based role-playing games (RPGs), and 2D action/adventures, integrating its graphical technological innovations into these reiterations of familiar gameplay aesthetics. *Super Mario World* is representative this approach: whether by placing trees in the foreground to occlude the playing field, or by having Mario climbing on fences and using revolving doors to move from the second to the third background layer, seamlessly transiting from the front to the back of the fences and vice-versa to avoid or to hit the Koopas that he meets, the graphical capabilities of the Super NES console were not simply used to woo the target audience with images that were impressive in themselves, but were the starting point of new explorations in form — albeit very limited explorations that stick close to a well-known formula. Nuances must be made, though, since clearly some SNES games experimented with innovative control schemes, gameplay mechanics, or spatial treatment; but many of the new gameplay possibilities were integrated at first as specific parts or alternative modes in the context of a larger, more traditional game type. For example, while Mode 7 graphics were used as a key game mechanic in the original *S.O.S.* (1994), where a side-scrolling game environment literally revolves around the player-character to open or block possibilities for spatial navigation, that idea was first introduced in stage 4-2 of *Super Castlevania IV* (1991).

The importance of generic templates in game design, which Ernest Adams (2009) attributes to Nintendo's draconian policies with the NES platform that dominated the 1985- 1990 period, reached its apex during the 1990s on the Super NES. Meanwhile, bolstered by new technologies such as CD-ROM storage and real-time polygon-based rendering, the personal computer and Sega's Genesis/Sega-CD hardware engage in experimentation through a number

1. See the paper in this issue by Dominic Arsenault and Pierre-Marc Côté, *Reverse-Engineering Perspective Innovation: An Introduction to Graphical Regimes*.

of new genres: full motion video (FMV) games with digitized footage, 3D action/adventures, and the ubiquitous first-person shooter (FPS), which is a genre that perfectly espouses a technological trajectory (of 3D accelerated graphics cards and general computing power) with little radical innovation (aside from the *Doom* spark that launched it).

https://youtu.be/DpoE4FsxdPs

The research will allow us to determine under what conditions a new technology can lead to new visual aesthetics, but also of new gameplay propositions (graphical regimes), and how these factors interact with other forces such as marketing imperatives or generic formulae. These findings will allow us to better contextualize, revise and enhance diverse statements on innovation, such as Matthieu Letourneux's explanation that games can be created according to a specific genre to lessen the financial risks of production (in Genvo, pp. 39-40), Chris Bateman's opinion that "[r]efinement of design is as valuable a process as raw originality. Sequels serve an important role in the development of games, and one quite separate from the occasional ground-breaking games" (Bateman, 2003), and Thomas Apperley's belief that "[t]he expectation is that the stability of genre will be tempered by innovation; this innovation may be technical, not necessarily stylistic" (Apperley, 2006, p. 9).

AN ACADEMIC PARALLAX: THE CASE FOR CROSS-PERSPECTIVE ANALYSIS

The academic framework of this project is strongly related to art history and theories of visual perception. When looking at the various video game technologies and their associated discourses throughout the transition from 2D to 3D, one is struck by the resurgence of techniques, debates and philosophies that have marked art history. This leads us to a thesis, largely developed by Edmond Couchot (1988, 1991): for all its ontological novelty, computer-generated imagery (particularly in the case of the video game) presents itself as an extension of already-existing visual media history. For instance, Henry Jenkins (2004) situated the side-scrolling perspective of the platform game among the older tradition of Japanese map scrolls. Isometric and axonometric perspectives in games like *Final Fantasy Tactics* have eschewed perceptual realism (and notably accurate depth perception) in favor of providing a Cartesian view of space in its exact measurements and angles.

This leads us to one of our biggest challenges in tackling the question of graphical representation of game spaces: bridging our understanding of video game graphical technologies and the myriad ways in which they depict visual signs, which are articulated in a hybrid, dynamic visual flux during the gameplay experience, with the descriptive and analytical vocabularies developed in other disciplines, for other more linear objects [2]. Games present themselves to us as a motley configuration of tridimensional spatial depictions with depth cues and a vanishing point, static bidimensional backdrops or skylines (sometimes projected on a hemispheric dome to make up "virtual skies"), objects

2. Audrey Larochelle's contribution to this issue, *A new angle on parallel languages: the contribution of visual arts to a vocabulary of graphical projection in video games*, focuses extensively of this subject.

highlighted with glowing edges, parallax effects in bidimensional background layers, superimposed textual layers of menu items or dialogues, etc. If we ever hope to make sense of video games as complex visual objects, we need to adopt a broader view and import and adapt tools, vocabulary and methods from a variety of disciplines with both exacting rigor and creative flexibility, including graphical projection, architectural and technical drawing, art history and perspective, philosophy, animated film, photography, and so on.

This becomes readily apparent when we consider graphical techniques such as raycasting, used by id Software in *Wolfenstein 3D*: from the player's position on a 2D map, rays are traced in the direction in which he is looking, and when these rays hit a wall or an object, the computer draws the object at an appropriate scale (based on distance) in perspective projection. This technological resurgence of Plato and Euclid's belief that rays of light (or fire) emanated from our eyes and lit the objects upon which we gazed can appear surprising, but further highlights the need to situate these techniques and technologies in a much broader history. The same applies to the distinction between game spaces represented in perspective, and those game worlds which are rendered in parallel projection. In the first case, we are reproducing the world as we perceive it (or as we would, anyway); in the second case, we are depicting the object as it is in actuality, parallel lines never intersecting in the object's material structure. Plato's view that we should represent objects as they are in truth, and not in the way we perceive them, could have been formulated — all philosophical considerations set aside — as a game design principle for strategy and management games, where the exact representation of space as a dimensional grid of possible movement is to be valued over any sort of subjective view that would immerse the gamer in the fictional world "as if he was there". *Sid Meier's Civilization*, *Sim City* and *Warcraft: Orcs & Humans* may tell the player, through the fictional *mise-en-scène* that they are an emperor, a mayor or an army leader, respectively, but they clearly consider that role as an abstraction in their *mise-en-image*: no actual human being could have the free-roaming, disembodied view of space that the player is afforded in those games. This is radically opposed to such innovations as the multiple background layers that allow parallax effects in 16-bit game consoles, a digital remediation of the Disney multiplane camera used in animated film to simulate the human impression of depth.

METHODOLOGY AND STATE OF RESEARCH

The project's theoretical framework is composed of texts from art history, psychology and philosophy on perspective and perception, and video game history and genre theory. A number of factual and basic information sources, such as reference works, will be consulted as well, in order to get a firm grasp on a number of concepts from related disciplines such as animated film, technical drawing, and technological innovation in industries.

As the first year of the project comes to a close, we can say that, so far, we have reviewed a high number of discursive materials in order to identify common recurring tropes and types of discourses regarding graphics, technologies and innovation. These materials include the most popular gaming magazines from the time period: *Electronic Gaming Monthly, Nintendo Power, Game Informer, GamePro, Official U.S. PlayStation Magazine, PC Games, Video Games and Computer Entertainment*, and *Sega Visions*, as well as a number of particular guides and books, such as the *Super NES Players Guide*. We have also begun identifying games to form a corpus of study. These may be interesting because they pioneered a graphical technique or technology, or because they integrated new graphical effects in classic game genres and structures. A number of games will provide some examples: Super NES titles *F-Zero, Pilotwings*, the *Super Star Wars* trilogy, and *Super Mario Kart* for their extensive usage of Mode 7 graphics; *Mega Man X2* and *Mega Man X3* for integrating 3D wireframe graphics using a special chip; *Out of this World* and *Flashback: The Quest for Identity* for integrating polygons into 2D platforming games; *Star Fox, Stunt Race FX* and *Virtua Racing* (on the Sega Genesis platform) for their inclusion of 3D polygons computed with special chips on 2D consoles; *Castlevania: Symphony of the Night* as an example of a 2D game on Sony's predominantly-3D PlayStation console, that featured 3D effects for certain magic spells and background graphics; a few games for Nintendo's failed Virtual Boy portable console, that featured stereoscopic graphics in an evident bid for the conquest of the third dimension; *Alone in the Dark* as a prime example of early 3D games, where the settings and backgrounds are painted in static camera views and 3D polygons are superimposed over them; *Wolfenstein 3D, Doom* and *Quake* for their respective uses of raycasting, polygonal walls and floors, and full-3D characters and objects. We have identified 65 such games so far, but the list will undoubtedly grow to include peripheral titles on a monthly basis.

We have also looked at a high number of game boxes and manuals of the games from this period in search of mentions of techniques and technologies used in the games, as an important relay of material culture. In the coming year, these paratextual statements will be analyzed and filed in a public database on the Ludiciné website (www.ludicine.ca) according to the grounds on which the arguments are made (hardware technology, novel techniques or unique choices), the nature of the claims regarding the current state of similar games or genres (increased complexity, increased graphical fidelity, innovative approach to gameplay) and the larger interests they serve (stimulating interest in the game, selling the platform behind it, undermining competitors), etc. The descriptors will undoubtedly change and expand as the team encounters more and more of these discourses. The database will also grow as the team also reads and files various theoretical works on perspective, art history and technology, game studies and genre, and map the technological innovations identified in discourse onto the larger history of visual media and digital media ontology.

Ultimately, the bulk of the theoretical work will go towards a system of descriptors for the composite visual mediation at work in video games. We have begun this work and while we cannot share our preliminary working hypotheses and system developed so far, we can say with confidence that the current 3-year project will not be enough to devise a system of descriptors that can account for the plurality of ways in which graphics can depict space and represent game events in any game type. We will have to settle for a partial system optimized toward our needs of articulating the transition from 2D to 3D graphics, and leave the vast peripheral questions and objects for future research.

The research project's main contribution will reside in a monograph on the Super NES console for the MIT Press' *Platform Studies* series, for which work has already begun. This publication will benefit the field of game studies as the Super NES is an important milestone in video game history, and the monograph, like the research project out of which it is born, addresses the larger question of the video game industry's seeming over-reliance on graphics and technology, as well as the medium's specificities and, perhaps more importantly, its ties to older traditions and debates in art history and visual media.

Furthermore, it is expected that a typology of graphical and generic innovation will be of interest not only to game studies researchers, but also to the games industry and academic game development communities, and could help to instigate new projects of experimentation.

Until then, we welcome any and all feedback and suggestions from like-minded researchers, whether on games, books or papers, conferences, magazines, advertisements, interviews with industry people, theoretical concepts or disciplinary approaches, etc. And we would like to thank the FQRSC (*Fonds de recherche Québec – Société et Culture* / Quebec Fund for Research – Society and Culture) for funding this project, and the editors of G|A|M|E for putting up an issue on such a timely question!

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Digital aesthetic forms between cinema and television:

The need for new research directions

A. Twentieth [1] century visual conventions — organized by a competitive collusion between cinema and television — did not survive the multiple forms and applications of digital media that put into play the multiplication of screens, the differentiation of production practices and processes of diffusion, and the rise of audience participative experiences.

The brilliant paradigm of "remediation" (Bolter & Grusin, 1999), applied to twentieth century media, was rooted only in the first phase of the digital era when Web 2.0 and beyond were merely remote perspectives. It is clear, then, that this paradigm does not suffice to understand what happened next. In 2001, Lev Manovich described a strict link between media arts and new modes of fruition typical of cinema spectators and video game players such as in the antithetical *Doom* and *Myst*, the former characterized by a "breathtaking pace", the latter on the contrary absolutely "slow" (pp. 213-218). Seven years later, he defined, in *Software Takes Command*, the cultural supremacy of software and remix technologies over other forms that compose the digital audiovisual landscape (Manovich, 2008). Henry Jenkins also underlined the rising role of crowdsourcing in production, diffusion and participation in the audiovisual field. Moreover, the subtitle of his famous *Convergence Culture*, "Where old and new media collide", strongly implies the competitive aspect of grassroots productions (Jenkins, 2007).

In the last decade, most cinema and television scholars have assimilated both the theories of Manovich and Jenkins. However, a new phase is at hand, and it became clear in the technological and cultural limit regarding the appreciation of grassroots products. In fact, when they are presented to a mainstream public, conscious of all the entertaining sophistications, and not to a motivated, niche one, problems arise. Mainstream cinema and television acquire state of the art digital technologies through expensive investments, increasing the level of visual conventions: augmented reality, enhanced vision, full HD, 3D.

1. Enrico Menduni, Antonio Catolfi, paper presented at Consulta Universitaria del Cinema annual Conference: *En sortant du cinéma. Gli studi di cinema oltre in cinema*, Università Roma Tre, Aula Magna, July 5, 2012. Enrico Menduni wrote the first paragraph, Antonio Catolfi wrote the second paragraph. Both authors revised and approved the entire text.

After the initial enthusiasm for user-generated contents (UGCs), the twentieth century structures of media industry managed to come back, first of all with television: pay TV, pay per view with non-linear fruition, and HD. This high grade vision quality, along with the point of view of the spectator, became crucial elements. A certain aesthetic of definition pervades the television medium, starting more or less around 2005 with the widespread diffusion of large, flat screens and broadband internet connections that allows a wider and more detailed signal [2].

Cinema in particular responded to the success of mash-up practices and UGCs highlighted by Jenkins, introducing new sophisticated techniques such as digital 3D and HD. Digital 3D does not share anything with the primordial 3D or with the one that emerged around 1950, both very expensive and almost impossible to fully integrate in the market. In these years, CinemaScope technology prevailed because it simply widened the image anamorphically rather than creating any kind of difficulty for investors, workers and technicians.

Other experiences of 3D perception could be found several years before contemporary media. If we consider the point of view and the visual perspective of the observer as key points, we can start referring to the monocular Reinassance perspective: the "window on the world" of Leon Battista Alberti. Masaccio [3] has been the first painter to adopt this principle.

Between 1425 and 1427 he frescoed a big Trinity (667 x 317 cm) at the S. Maria Novella Cathedral in Florence. Characters are presented as statues on different planes of an elaborate architectonic structure. Perspective rules assume a unique observer, placed in a central position in front of the painting, external to it but capable of interpreting it through senses and reason. The painting becomes a window through which one can have the sensation of seeing an actual space.

Caravaggio, Mantegna and other Italian painters of the sixteenth century apply the perspective that avoids the original position, based on a central point of view for the observer. They build oblique frames, from the bottom or from the sides of the scene. They do not try to support the frontal observer vision, instead proposing unconventional points of view closer to anamorphosis. One of the main features of these original perspective structures is that they are part of a cold, rational technology. It is absolutely unemotional, neither inclusive nor participative, and it requires a distant observer that does not feel part of the representation.

B. During the period of Baroque style, architecture, sculpture and painting instead cooperated to constitute a tridimensional effect capable of involving the observer — who we can now call "spectator" — making him feel inside the representation. The Baroque building is projected to reach this inclusive, immersive and illusory effect. Sant'Ignazio Curch's roof in Rome, work of the Jesuit painter Andrea Pozzo (1685), presents the Triumph of Sant'Ignazio inside an illusory building that ends in a sky populated by Saints and Beatified. The ideal point of view to view this work of art is a marked spot on the aisle floor.

2. It is interesting to note that the American cutting-edge television system has been based, throughout the twentieth century, on NTSC technology, a standard developed in 1941 with fewer lines and lower quality compared to the European standard. The low quality of vision has never been considered an issue in establishing an effective and popular connection with the American audience.

3. Tommaso di Ser Giovanni di Simone, 1401-1428.

The perspective representation became a painting canon, and this form passed on to photography, for example in this 1952 photo by Henri Cartier-Bresson in the Italian town of Scanno.

Stereoscopy, allowing an efficient view of the third dimension, started to be used near 1900, in particular for group images and landscapes, such as this 1890 photo by Fuhrmann.

Photography then handed down perspective rules to cinema, and cinema in turn passed them on to television.

Television never indulged in aesthetics very much because of its low resolution images, its smaller display, and its transmission of free content. Before the digital era, only one technical upgrade convinced the public to buy a new television set even if the one possessed was not broken: colour. All the others innovations—for example analogic high definition—never managed to reach that goal. Digital technology applied in distribution (DBS) created the pay per view system in the last decade of the twentieth century, not only offering widespread channels and a telephonic billing system, but also an efficient means of disseminating high valued specific contents to the mainstream public, creating niches for which they would be inclined to pay. . It is at this time that the quality of images started to be considered as a key factor. As we have already seen, these tendencies were fully stabilized around 2005, with broadband and flat screens, and they created a dominant cultural form for a scopic regime forged through over a century of mechanically reproduced images. Contemporary 3D recycles only the concept of stereoscopic shooting that brings the spectator inside the frame, an idea that moves the camera inside the character, dragging the audience in the story.

Cinematographic 3D is today not only an applied technology, it is also a tool for authors. Tim Burton's *Alicein Wonderland* combines two different experiences and neatly merges them: on the one, hand live acting; on the other, motion capture.

3D digital films are stratified composite images or, more precisely, a stratification in which it is possible to elaborate singular images. For Manovich, "The new media of 3D computer animation has 'eaten up' the dominant media of the industrial age – lens-based photo, film and video recording" (Manovich, 2008, p. 134). Images are no longer "time-based" but instead "composition-based" and "object oriented".

In *Hugo*, Martin Scorsese uses a level of 3D absolutely functional to the imaginary tale. In this film, and in Wim Wenders' *Pina*, the spectator is not immersed within the world but into the character.

3D technology is used in these films as a real tool to explore the characters' psychologies. Directors figuratively accompany the audience inside the characters.

In *Pina*, the camera is not external; the shooting is the character. Technocrane and Steadicam movements alternate with a naturalness that resembles the real dancing practices of professional dancers.

Some cinematographic authors, however, did not realize that these evolutions changed production modes. Video games instead, when used as a source by films, have a crucial role. Platforms like the Nintendo Wii or tools like Microsoft Kinect for the Xbox 360 create real immersive perspectives for the players/spectators, with gyroscopes and kinetic sensors that read and translate their movements on the screen [4].

If 3D interests filmmakers such as Scorsese, Wenders and Burton, then it is no longer merely a blockbuster attraction. New aesthetic forms arise, circulating between cinema, TV and video, and delineate the visual and communicative landscape of this century. Digital 3D offers a new aesthetic convention through stereoscopy and binocular vision, above all genetically different from everything we have seen before. This topic is not yet a central one either in cinema or in television studies.

Our conclusion is that it is no longer possible to study media using the instruments of the past century. We must enlarge our horizons to study these new forms of total convergence. In the future, a multidisciplinary approach is needed in order to hypothesize new research directions, at least to consider the increasingly immersive visual conventions and cultures. In fact, these tend to create a scopic regime in which spectators, or perhaps only a part of them, "dive" inside the audiovisual content, stepping completely inside the story.

4. Wii interprets the player's gestures through the movements of its remote used by the player. Kinect mounts two infrared cameras that stereoscopically read the actions in front of them.

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