From Euclidean Space to Albertian Gaze : Traditions of Visual Representation in Games Beyond the Surface

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ABSTRACT
In this paper, we examine the two highly relevant traditions of the simulation of space, and the simulation of the gaze, to develop an art history approach to video games rooted in the relationship of a gamer to the visual and play space implemented in the game through its surface and diegetic spaces. Parallel projection and perspective are both examined from their philosophical roots in Greek antiquity to their technological implementation in 2D game engines; the many techniques employed to simulate a third dimension out of the bidimensional surface of the screen (namely parallax scrolling, occlusion, depth cues and ray casting) help influence the player's engagement with the game space, and his positioning on the continuum opposing contemplative immersion and interactive engagement. We finally present an original model of Axial-Spatial Play to account for the mapping of diegetic and surface spaces in 2D video games.

Keywords
Space, perspective, parallel projection, visual aesthetics, video game history

INTRODUCTION
As we go through art history for concepts that could relate to graphics in video games, we are facing very different forms of historical and conceptual representations. Selecting an appropriate analytical frame is challenging for multiple reasons, one of them being the surface hybridity of the video game image. The screen routinely features a visual representation of a fictional world, often with various interface elements being overlaid, sometimes with menu, dialogue or inventory screens popping up, and the occasional

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window, split-screen or picture-in-picture of a second viewpoint on the diegetic world. According to Friedberg (2006), the surface of today's screen (in all the various forms in which video games are displayed) is divided into several components and functions that are gazed at simultaneously. The author compares this division with modern art, especially cubist painting, because we can have access to a great variety of information in a single plane. The plane can be understood as a two-dimensional (physical) space and one can project a third dimension and create a three-dimensional (visual) space using various techniques and conventions; this is called the projective plane.

Modern art has fractured the single viewpoint that was established as the hallmark of perspective projection in favor of abstract, multivalent or non-representational spaces. This could seem to make modern art a good basis for the study of the video game image, but in reality the fragmentation of the screen surface does not reflect on every visual aspect of the game: in a very large number of cases, video games visually project a fictional world which the player, through a character, can explore, and this world is represented through a single, unitary visual framework. If we are to examine how video games depict spaces and fictional worlds, we thus need to go beyond the 2D surface of the physical screen, which is fragmentary in nature and can be studied through the theoretical developments brought about by modern art, and reach out for additional visual traditions. For all their modern surface hybridity, by and large, video games present us with spaces through typical and conservative visual techniques and traditions such as perspective.

The Italian Renaissance has cemented the means of achieving rigorous perspective since Alberti, among others, has codified a series of mathematical relationships and geometrical operations in his treatise *De Pictura.* As modern real-time polygonal 3D video games aim for immersion in simulated space, the paradigm of perspective now sees widespread use. But that was not always the case; earlier and current-day 2D video games draw on a wealth of other visual traditions, of which we need to be aware if we want to make sense of video game graphics as a whole. What we want to stress here is that the real-time polygonal 3D spaces that appeared during the 1990s and have come to represent almost the entirety of the AAA video game production follows only a certain paradigm of the image when considered as a whole, and that 2D video games depict their in-game spaces by resorting to very different visual traditions that encompass multiple graphical modes, beyond perspective.

Perspective projection falls under the larger scope of graphical projection, which answers, as a practical concept, to a defined objective: making a three-dimensional reality visually intelligible on a two-dimensional surface. As such, graphical projection is a protocol that includes various methods of spatial representation, and we will focus here on two very different traditions that create particular types of relationship with the image and space in video games: perspective and parallel projection.

Figure 1: Railroads in perspective and parallel projection.

PERSPECTIVE: THE SIMULATION OF THE GAZE

Ever since Euclid's *Optica*, the angle of viewing has been recognized as an important part of an object's appearance to a viewing subject. An object or natural feature that has a rectangular or square shape will not appear rectangular or square if it is seen from a long distance, or viewed from a pronounced angle: this is the basis of perspective. The lines that make up an object might be parallel or perpendicular in the object's physical structure, but will be perceived as converging given a sufficient viewing distance or angle. Railroad tracks, as depicted above, provide the classic illustration of this phenomenon.

Alberti's contribution to perspective, based on Alhazen's *Book of Optics*, has been to turn a largely intuitive practice into a rigorously developed method. Where an individual painter's impressions of depth resulted in many competing pictural techniques fraught with minor or major inconsistencies, the mathematical and geometrical principles at the heart of Albertian perspective provided a working method for the systematic coordination of the space of the frame (or the screen) in depicting space. In Alberti's view, the beauty of nature reside in the harmony and regularity of its forms, justifying the use of a mathematical method in order to remain faithful to its divine geometry. This allows us to reposition Albertian perspective as being fundamentally not so much an artistic principle, but more of a mathematical and geometrical method that serves a function, even though it has been extensively used throughout art history. In other words, perspective is an enabling device that functionally allows, through a rationalized method founded in mathematics and geometry, the expression of an artist's vision in accordance with a specific goal: representing a scene or a space as if the viewer of the painting was directly witnessing the scene.

However, Alberti method (linear perspective) is not to be confused with perspective projection tools (as the grid or the camera obscura) which allowed artists to 'visually' paint depth from their own observations rather than having to rigorously calculate it. The use of such tools was a prominent feature of Dutch paintings, which, by this method, was extending the Italian tradition and its use of Alberti's perspective. According to Svetlana

Alpers in The Art of Describing (1985) Italian art sits on a tradition of ancient treaties and texts while Nordic art, such as Dutch art, takes root following the craftsmen tradition. According to Alpers, the Dutch visual culture - a term she borrows from Michael Baxandall - is closely linked to the camera obscura, which is, for the author, fundamentally opposed to the principles of linear perspective theorized by Alberti and developed in Italy. However, while the two are very different in their techniques, some visual aspects are similar. The marble checkerboard floor is a very good example illustrated in both traditions. Many paintings from the Renaissance feature preeminent checkerboard floor patterns, which were popular in their own right by virtue of architectural practices, but also served the function of establishing an artist's mastery of "correct" perspective as a method of accurately rendering geometrically and architecturally sound spaces. This logic of representation of the viewer's gaze implies a predetermined viewpoint of the artist and the viewer, and is still, according to Damisch (1987), the current logic of visual representation.

Figure 2: An example of erroneous perspectival depth cues from *Wrath of the Black Manta* (AI Co. 1989). Note the non-converging checkerboard floor tiles, non-angled shadow in the top-left corner, overlong shadows from the suspended side platforms, and disproportioned door in the back.

Because perspective offers a single predetermined viewpoint to construct the gaze, it also encodes the visual representation as a point of view on the world, rather than a rigorous detailing of its physical properties as seen in maps or architectural drawings. Perspective simulates a gaze that is directed on the world, rather than the world itself. From this point of view, perspective is the perfect method for any artist (in the broadest sense that includes video game designers) to structure the representation and draw attention on some of its specific elements. This motivates the "window" analogy, laid out by Friedberg and discussed earlier, which comes up time and again when discussing the ideal of transparency or visual immersion. This immersion rendered by Friedberg's "window" is not an extension of our own immediate reality, but rather provides an access to a virtual world, not unlike the doors in Pixar's *Monsters Inc.* (Docter, 2001) which offer the creatures access to the human world, and in line with Étienne Souriau's 1953 remark that the cinema screen must be understood as a door: "I say a door, and not a window. By the mind and by the meaning, we enter this universe." (Souriau 1953, p.11)

While the principle of perspective is prevalent throughout a large portion of Western art history and is also very appropriate for the study of a large tradition in the imagery of video games, the logic of the simulation of the gaze cannot account for a significant part of video games that draw from other, non-perspectivist traditions of visual representation.

PARALLEL PROJECTION: THE SIMULATION OF THE SPACE

While perspective uses the principle of the convergence of lines toward a single point, in the tradition of parallel projection the lines that are parallel in a given object's physical properties are drawn parallel in the picture as well. Thus the main focus is not the gaze one turns on the world, or a perception of the space or objects contained within, but a reconstitution of that object's physical properties through a drawing that is explanatory (we may use the term "descriptive", as in descriptive geometry) more than illusionistic. Where perspective simulates a gaze turned on space, parallel projection simulates the space itself.

Parallel projection can be subdivided into many different techniques. Pictorials form the most common type, owing in part to the ease with which they can be created. A pictorial parallel projection is simply an image drawn from some angle that allows all three directions (axes) of the space to be represented in a single view, without any more complex or rigorous requirements. They are essentially the most basic and intuitive form of parallel projections, and they naturally contain some distortion and liberties taken in the representation of the object. Before the advent of rigorous perspective, namely through Alberti's work, many painters proceeded intuitively and ended up featuring objects with pictorial parallel projection. To summarize, the projected image is drawn in accordance with its axes and angles, which means that the parallel lines of an object in reality will remain parallel in the picture. Aside from this condition, every technique has its own name and specifications.

Figure 3: Gentile da Fabriano's 1423 *Presentation in the Temple* (left) and Pietro Lorenzetti's 1320 *Entry of Christ into Jerusalem* (right), two examples of pictorial line parallelism without a geometrical basis.

The simplest form of parallel pictorials is oblique projection. In this technique, one face of the represented object is always parallel to the projective plane (and thus to the viewer) and all the other lines are drawn at an approximate angle (any other than 90 degrees). Cavalier and cabinet projections are two types of oblique projections that follow some mathematical guidelines. They both trace parallel lines at a specific angle (generally 30 or 45 degrees), with cavalier projection rendering depth faithfully according to the object's exact measurements. This generally results in overly deep images that do not correspond to how we would perceive the represented objects in reality. Cabinet projection seeks to correct this flaw by cutting the object's actual depth value in half; it essentially functions as an easier and more cost-effective way of achieving a limited perspective effect while preserving the object's proportions.

In video games, oblique projection has been used before the advent of 3D graphics in the visual aesthetics of games such as *Paperboy* (Atari 1984), the original *SimCity* (Maxis 1989) and *Ultima IV: Quest of the Avatar* (Origin Systems 1985). It is plain to see that through all these representations, the depth of the game objects and game spaces may be approximated, but the visuals still strive to establish a coherent game space.

Figure 4: Cabinet projection in *Paperboy* (left) and top-down oblique projection in *Ultima IV* (right): two examples of visual representations taking liberties.

From the naïveté and spontaneousness of oblique pictorials through the rigorous line lengths and proportions of the cabinet and cavalier projections, we go a step further away from the simulation of the gaze and toward the simulation of space with the more rigorous axonometric projections. As with oblique projection, all three axes (*X*, *Y* and *Z*) and thus dimensions of the represented objects are made visible from a single viewpoint. The difference is that the game-world is not offered to us from the front as a flat surface on one of its dimensions, but from an angle. Thus axonometric projections are somewhat less skewed toward considering one of the game space's dimensions as being central and the others ancillary, and they go further in their geometrical partitioning of space: while cabinet and cavalier projections systematized the lines' lengths and proportions, axonometric projections do the same with the angles at which the three axes are drawn. They can be subdivided into three categories: isometric, dimetric and trimetric projections.

The term *isometric* has been mistakenly used among the video game fans, press and designers as a general category, alternatively taken as "axonometric" or even worse, "pictorials", instead of its proper, narrower sense as a sub-type of axonometric projection. An isometric representation uses angles of a single scale (*iso* as "same" or "equal", and *metron* as "meter" or "measure") between all three axes, which are separated by 60 degrees each. In dimetric projection, two meters are used: one for two of the three dimensions, and a second meter for the third axis. Finally, trimetric projection uses a different scale for each of the axes, resulting in a more slanted appearance. The visual aesthetics of *Ultima VIII* (Origin Systems 1994) use true isometry, *Diablo* (Blizzard Entertainment 1996) dimetric projection, and *Fallout* (Interplay Entertainment 1997) trimetric projection. As with many decisions made in the context of game production, the point of view is largely rooted in technical exigencies. An article on the Giant Bomb website details some of the rationale behind the usage of dimetric axonometric projection in video games:

> When the isometric perspective is used in a lower resolution video game or artwork in which individual pixels are pronounced or visible, the traditional angle of 30 degrees from the horizontal is usually substituted with an angle of 26.6 degrees. 26.6 degrees produces a line that has a uniform 1:2 pixel ratio that follows a neat pattern whereas 30 degrees causes a line to be generated which is visually less appealing and appears jagged.
>
> For this reason, most artwork described as "isometric" in video games is actually a form of dimetric projection because only two of its three axes appear equally foreshortened. (Giant Bomb, 2013)

Figure 5: Rigorous isometry in *Ultima VIII: Pagan* (Origin Systems 1994) (left), dimetric projection in *Diablo* (center) and a rare case of trimetric projection in *Fallout* (right).

POINT OF VIEW AND PROJECTION AS DESIGN CHOICES

As we can understand, perspective and parallel projection (with its different techniques) offer different ways to structure or give the illusion of space, and therefore each method has a specific visual relationship with the objects they illustrate. While perspective is subject-centered and tries to simulate human vision, parallel projection is object-centered and tries to simulate the actual physicality of an object in its representation, beyond any view we could have of it. As such, if perspective is closer to the spatial structure of the gaze, parallel projection is closer to the spatial structure of the object. Consequently, both concepts emphasize a central aspect (subject or object) through the instrumentalization of the other: each one models both space and sight, but in varying objectives and interests.

Even though he, like Plato and Aristotle, believed in the emission theory of light, (according to which our eyes emit rays of light that make the world visible), Euclid had understood that our perception of the world is skewed. This is in part due to the conical shape of our eyes, which “emit” (or, as it turns out under the intromission model of light and perception later detailed by Alhazen), “receive”) light from a range of hemispherical angles, thereby causing visual artifacts that get more pronounced the further an object is situated from us (since the angular spread of our “lines of perception” increases in constant measurements). Euclid’s explanation accounts for the many perspectival effects that occur in human vision and that are imitated in the illusionistic perspective tradition of visual representation, such as the convergence of parallel lines, foreshortening, chromatic blurring of distant objects, etc. Perspective does not faithfully reflect the world as it is, but the somewhat distorted human vision that is laid on it.

Flash-forward to the 20th century and we find the same opposition between the subjective gaze and the objective space being staged in video games, although with increasingly complex questions interwoven throughout. As the video game image is a result of computation and graphical rendering (and particularly so in its early days of graphical abstraction), it has been largely treated through mathematics, geometry and graphical projection. As a sort of technical default, early video game images were, by and large, non-perspectivist in nature, favoring the overhead, top-down, or side-scrolling points of view and their associated parallel projections. As schematic graphical representations evolved into more advanced pictorials, in no small part due to the development of hardware and graphical technologies, the innately bidimensional graphics progressively integrated more perspectival effects, such as scrolling backgrounds, multiple scrolling background layers, and eventually background layers scrolling at different speeds (causing an effect known as parallax, where objects situated closer to the observer have more pronounced spatial displacement than objects farther away). The rise of real-time polygonal 3D graphics eventually cemented perspective as the new technological default point of view.

This broad and, needless to say, greatly oversimplified overview of the history of video game graphics is not meant to provide a teleological and technofetishistic account of "progress" toward the achievement of illusionism, but rather to point out that while technological hurdles may have restricted some early games from rendering their game spaces in perspective projection, there is more at stake than simple technology, as a number of games continue to be produced in parallel or axonometric projection even today. *Bastion* and *Shadowrun Returns* provide some recent examples, and it is worth mentioning that the latter offers the player the choice to alter "projection mode" in the game's settings. When "perspective" mode is selected, the top and bottom of the image are squashed and stretched during rendering. While this does provide a limited perspective effect, such a game must still be understood as belonging to the tradition of parallel projection. Other games like *Diablo* offer a similar choice, but we would illustrate the method through a particularly exaggerated example from *Knights of Xentar* (ELF Corporation, 1991):

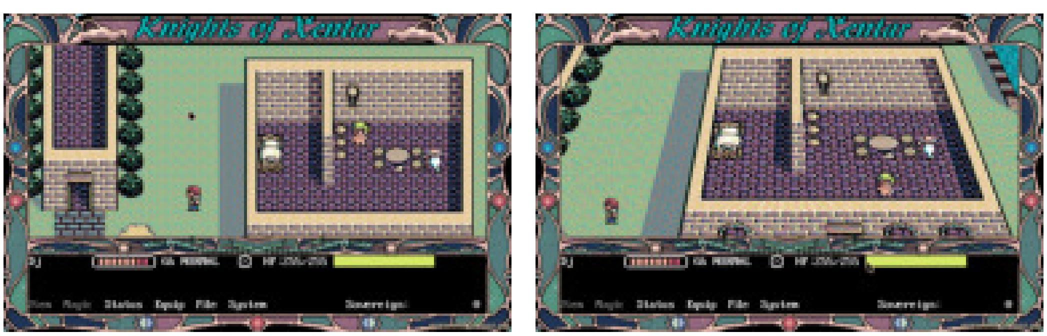

Figure 6: Enabling perspective projection, known as "3D mode" in *Knights of Xentar*, does not fundamentally alter the game space or gameplay.

Therefore, we will focus on showing how the choice of graphical projection is deliberately made in accordance with different types of gameplay that are achieved through particular spatial dynamics. For example, parallel projection in games such as *SimCity 4* (Maxis 2003) calls for a managerial relationship with the space, the player occupying a non-position resolutely *outside* the game space. *SimCity 4* (and more generally, the entire series) does not attempt to convey what the player would see if he were to gaze down on his city while floating up above; the image is drawn in parallel projection according to the exact angles and measurements of the space and game objects so that the player can plan and develop his city efficiently, with mathematical precision. *SimCity* simulates a city in an ideal space, instead of an actual gaze turned on a city. Many games use perspective projection instead, as in *Red Dead Redemption* (Rockstar 2010), because it invites an immersive stance toward the game space, and gameplay revolves around exploring and inhabiting that space rather than managing it from a removed position.

As should be apparent, the choice of a visual concept in video games is rarely done for the purpose of subscribing to an artistic or philosophical visual tradition, but mainly for functional considerations. The design of a game can also be motivated by a technical economy of the game implementation, or the desire to reach a specific genre clientele by imitation of similar games in the video game tradition. Parallel projection, for instance, alleviates the need for objects to scale according to distance, and to recede up to the horizon line, which makes it easy to show multiple instantiations of a given terrain or construction in a tileset space; at the same time, it evokes a prior tradition of management, simulation and strategy games such as *SimCity* and *Sid Meier's Civilization* (MicroProse 1990).

Figure 7: Managing a railroad in *SimCity 4* (left), and traveling on one in *Red Dead Redemption* (right) call for different visualization strategies.

A FORESHORTENED HISTORY OF GAME GRAPHICS THROUGH THE ASP MODEL

We will propose a bit of new terminology, and an accompanying conceptual model, in order to frame our history of video game graphics. Inspired by Wolf (2008), we want to study 2D games in particular by partitioning the gameplay according to the axes of either the screen surface (treated as a projection plane) or the perceptual impressions of the represented fictional space, the *diegesis*. We borrow this term from a certain tradition of narratology in the sense typically attributed to French filmologist Étienne Souriau, to designate the world in which the represented events take place, and not in the sense of an opposition between *diegesis* and *mimesis* as modes of communication roughly corresponding to the telling/showing opposition (see Boillat, 2009 for an in-depth discussion of the topic). Our model of Axial-Spatial Play (ASP) allows us to chart diverse relationships between space and play across the axes of the screen surface and of the game world. These two play spaces can each use their own axes, whether explicitly or implicitly.

To illustrate using a few canonical cases, the typical side-scrolling platform game involves X-Y surface play, the player being tasked with maneuvering his character on the screen's bidimensional surface in order to avoid pits and obstacles. The diegetic space formed by the parallel projection, however, is not an X-Y space, but a Y-Z space; we are not being shown a fictional world as if we were gazing down at a cross-section cut of it, but are being presented a space whose third dimension cannot be worked out in any meaningful way; the characters are not moving sideways left and right, but forward and backward in a world where there is no lateral axis, like a narrow strip where occasional cardboard cutout background elements are being put up on one of their sides, as figure 8 shows using screenshots from Wong and Laatsch's 2011 *First Person Mario* short animated film:

Figure 8: the tridimensional diegetic space of *Super Mario Bros.* (Nintendo 1983) inferred by Wong and Laatsch (2011), from the original game displayed as a transparent insert in the top-left corner of the right-hand picture.

Games represented from a top-down point of view similarly present X-Y surface play, but transposed into an X-Z space. Moving a character left and up might then be transposed as them moving forward and sideways. The Y axis may be totally absent from the gameplay, but is often featured implicitly using various strategies. In *The Legend of Zelda* (Nintendo 1986), for instance, Link may use a ladder or a raft to carry himself over rivers and water; though he may not interact with the Y dimension in any complex way (by striking foes from atop higher ground, for instance), that dimension is incorporated implicitly.

Perspective and tridimensionality may be integrated in games with varying degrees of interactivity. The lowest of these may be found in 2D games with largely decorative perspective, mostly present in backdrops that are not part of the playable space itself. As the difference between the original NES edition of *Super Mario Bros. 3* (Nintendo 1988) and its re-release on the *Super Mario All-Stars* (Nintendo 1993) SNES cartridge illustrates, the impression of depth conveyed by the shading of the background details has no bearing on the actual gameplay experience: both games still feature the exact same X-Y surface play, the added diegetic X-space being completely implicit and having no bearing on the gamer's actions.

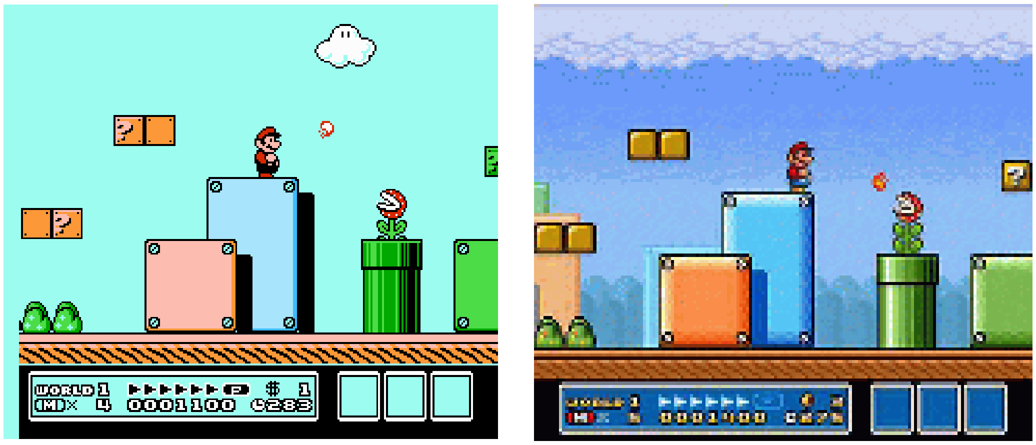

Figure 9: Decorative or cosmetic usage of perspective in the *Super Mario All-Stars* implementation of *Super Mario Bros. 3* (right). Depth cues provide more of a fictional Z-space, but do not add anything to the gameplay beyond the original game (left).

The usage of multiple graphical layers is one of the key techniques to represent depth in 2D side-scrolling games. As the Super NES and Sega Genesis both offered independently scrolling layers, perspective would appear more and more often through the parallax scrolling effect, which is done by making each background layer scroll more slowly as they extend further away from the viewpoint. This creates an implied surface Z-space (and implied diegetic X-space) entirely from the variations among surface X-distance between diegetic objects. The effect simulates the experience of gazing at a scene or objects while moving laterally. In *Mortal Kombat* (Midway Games 1992) for example, additional folds of the diegetic space in Goro's Lair are revealed through the viewpoint's lateral translation as it follows the movement of the combatants.

Figure 10: Parallax scrolling in *Mortal Kombat.* Notice how the surface X-distance between the arches in the immediate and farther background varies as the fighters move about, due to their different scrolling speeds. The eyes glowing in the dark also come slightly closer to the back arch's right end between the first and second images.

A more interactive usage of perspective consists in integrating the multiple background layers into the gameplay itself. This is done brilliantly in some cases, such as in *Super Mario World* (Nintendo 1990). In Iggy Koopa's castle, Mario can cling to and climb a giant grating hanging from the ceiling. Enemy koopa troopas start to appear on this grating as well, both next to Mario and on the other side, across Mario. The gamer can then punch these koopas across the grating, and punch some integrated revolving doors to flip Mario around both sides of the grating. Here the gamer is invited to engage in some implied Z-axis surface play to interact with the game's implicit diegetic X-space, rather than merely gazing at the implied surface Z-space and imagining an implied diegetic X-space.

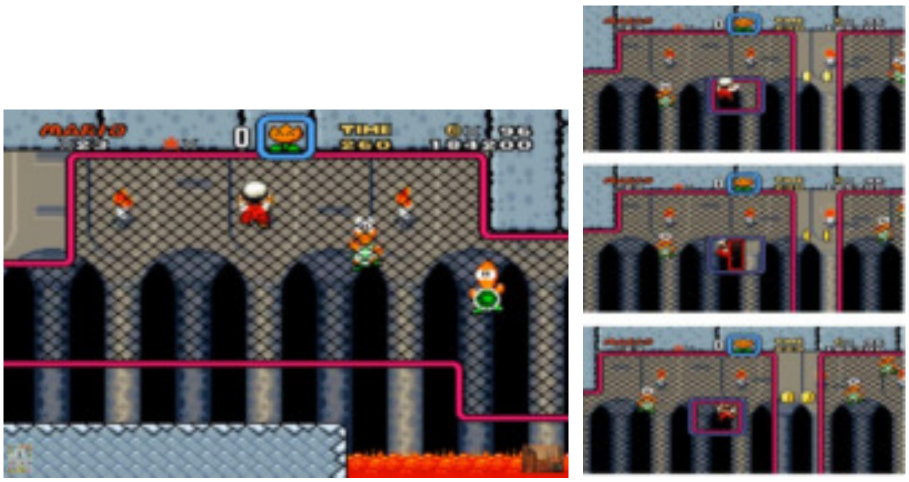

Figure 11: The hanging grating in *Super Mario World* allows the player to interact with the implicit surface Z-space to explore the implicit diegetic X-space.

A step up from the visual representation of depth is to provide some means, however limited, to navigate it more directly than in the layered approach, making the X-dimension of diegetic space explicit rather than implicit. One of the earliest ways of achieving such a result could be found in the beat'em all genre, with games such as *Double Dragon* (Technôs Japan 1988). The spatial structure of these games could be said to feature an explicit X-Z diegetic playfield space, with the X-axis being projected on the Y (vertical) axis of the X-Y surface space of the screen; as gamers move their characters up on the screen, they are led to imagine their characters receding farther away from the viewpoint. The diegetic Y-axis is often minimized to the fact that characters can jump, or fall down in pits. Where the playfield in parallel projection ends on the surface Y-axis, a backdrop usually presented in perspective projection stretches out across the upper region of the screen, and is typically made up of city buildings or a skyline carefully orchestrated depth cues to stimulate an immersive gaze into a coherent-looking space. The juxtaposition of elements in parallel and perspective projections can lead to many hybrid situations. For instance, figure 12 shows a back street from *Double Dragon* (NES version), where the angle of projection to the picture plane is inverted amidst the level, thus creating a strong perspective effect.

Figure 12: Spatial montage showing a misplaced perspectival effect in *Double Dragon*. As the gamer progresses from left to right and the screen reveals the scene, the angle of parallel projection, which had been kept the same since the beginning of the level, is mirrored. All depth lines in the scene nevertheless stay parallel.

When we start to actively interpret the technical aspects of the visuals to decode and mentally recreate an actual space from the visual representation, it does not take much time to recognize that something is off. But this effect, while completely opposed to the general spatial structure, still does not pop out to one who is not paying much attention to that kind of details. Whereas Albertian perspective treats the visual space as an immersive device, parallel projection uses the visual space as a navigational structure in the Euclidean logic of accurately simulating dimensional space, in service of the interactivity offered to the gamer. In this view, the bimodal visual representation of space in many video games from the late 8-bit and 16-bit era acts as a mechanism for negotiating the conflicting needs of immersion and interactivity.

GAME SPACES BEYOND THE SURFACE

Before we turn to the games more closely associated with 3D gameplay, it is worth pausing to reflect on the construction of game spaces and how they are relevant to players. As Michael Nitsche (2008) points out, in games "possibilities of engagement are directly built into the spatial structure". Therefore, "a possibility space describes the options made available to the player through spatial conditions at a given moment in the game experience" (Nitsche 2008, p.189). But this adequation will benefit from deeper scrutiny. Following the work on video games and fiction by Jesper Juul (2005), video games are both play-spaces to be explored with interactivity, and they typically also present a fictional world that stretches beyond the interactive aspects. Some aspects of the fictional world are simulated through computation processes and thus form a part of the gameplay, but some other aspects cannot be affected by the player's actions. Juul identified a "level of abstraction" (2007) that acts as a contact point between the purely fictional non-interactive elements of a game, and its interactive fictional elements (which he terms simulated or virtual). This model reaches its limit, according to Juul, when considering space in video games: "Space in video games is special because video games mostly take place in a space, and because the space usually is part of the fiction of the game, *and* is implemented in the rules." (Juul 2007)

Nonetheless, spatial inconsistencies in video games are not perceived as such as long as the fictional world and the rules remain consistent. As such, spatial (and graphical) inconsistencies are not systematically identified or, if so, they are not seen as obstacles or problems in relation to the gameplay; to paraphrase Edward Branigan's claim originally expressed regarding film, "*no critic uses the term 'camera' to refer to a piece of equipment*. Rather, critics speak of the camera in the ways most helpful to his or her interpretive and evaluative projects." (Branigan 2006, p.201) There is little doubt that most gamers have never really paused to reflect on the spatial structure in side-scrolling platform or beat'em all games, as that is not useful to their project, which instrumentalizes perception and interpretation for the execution of the actions required by the game, as Eskelinen and Tronstad remarked: "in games we have to interpret in order to be able to configure, and proceed from the beginning to the winning or some other situation." (Eskelinen and Tronstad, 2003, p.197) Our examples of the Super NES port of *Super Mario Bros. 3* and *Wrath of the Black Manta*, where one succeeds and the other fails in achieving a working perspective effect, have shown that the configurative practice of gameplay operates from the visual cues but does not treat them as an end in themselves.

While perspective may be employed in decorative or auxiliary functions in many 2D games, it plays a vital role in the interactive experience of games focused on tridimensional play. One of the landmark titles in that respect, *Wolfenstein 3D* (id Software, 1992), employed foreshortening and scaling extensively for its "ray casting" technique. In a weird turn of events, ray casting happens to function as a literal incarnation of the principles of emission theory laid out by Euclid; the player-character occupies a certain position on a 2D overhead map of the game space, and rays of perception are being traced straight out from his position, in a conic shape. As the rays hit various objects or walls in the environment, they each contribute one vertical column of pixels to make up the picture; the computer checks how far the ray has traveled before hitting an object, and then displays a vertical slice of that object at an appropriate scale and vertical distance based on the foundations of perspective (objects that are farther away appear smaller and higher on the Y-axis, closer to the horizon line).

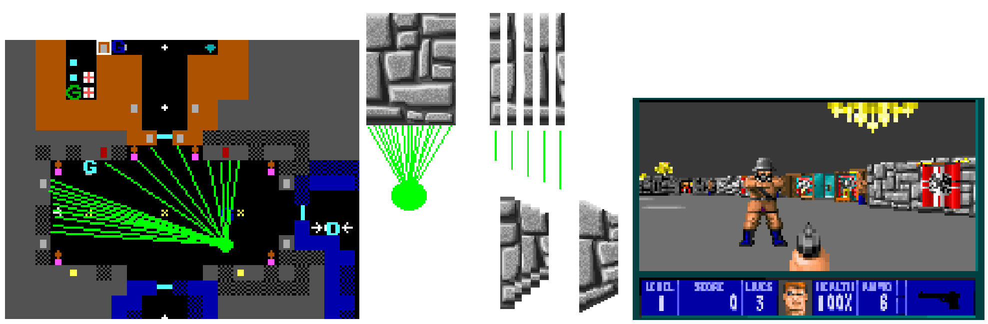

Figure 13: Perspectival rendering of space using *Wolfenstein 3D*'s "ray casting" technique.

The player emits green "rays of perception" from his position, in a 90-degree angle field of view. The game then retrieves the corresponding graphical object (in this case a grey wall) from the game data, measures the distance traveled by each ray, and enlarges or shrinks that column of pixels before displaying it. As the two bottom-center wall faces in figure 13 show, having more rays traveling out and thinner pixel columns results in a smoother picture. More importantly, aside from the technical details involved, *Wolfenstein 3D* perhaps best illustrates the need to separate the space of the rules from the visual space projected to the gamer. The computational space of the pure game rules in *Wolfenstein 3D* is a 2D overhead map. There is literally no diegetic Y-axis; no stairs, no vertical aiming, and no looking up and down. The X-Z diegetic space gains an implied Y axis entirely by the visual projection on the X-Y surface space, which itself feeds on the diegetic space to gain an implied Z-axis. The experiential space offered to the gamer is tridimensional thanks to the perspective projection – even if in truth, there is no actual ceiling and floor implemented in the game rules, but merely a shaded background orchestrated to look like them.

This provides a strong argument for maintaining Juul's level of abstraction even in the case of video game space. The case of real-time polygonal 3D graphics may perhaps appear to be the most "unabstractable", since they truly simulate a space through a set of specified object dimensions instead of approximating it through techniques of illusion. But even there, things are not so straightforward. The 3D polygons used in creating a video game world do not have real physical substance, but are merely visually displayed objects. Their immaterial nature allows them to intersect and pass through one another without hindrances; hence, sculpting a 3D model world does not by itself result in a navigable space or physically sound world. The hundreds and thousands of polygons that make up a detailed 3D character or object must be doubled with invisible polygons that make up a considerably simplified "collision box" or "bounding box", which the programming will use to manage the positions of objects and prevent any unauthorized collisions – namely, to save characters and objects from falling through the floors or going through walls. Almost every game in real-time polygonal 3D functions on this principle of complex visuals supplemented by simple, invisible bounding boxes used to track movements and regulate collisions, and almost every game will have, somewhere, an odd edge left protruding beyond its collision box. These slight divergences will cause various anomalies, such as a character's hand brushing through a wall.

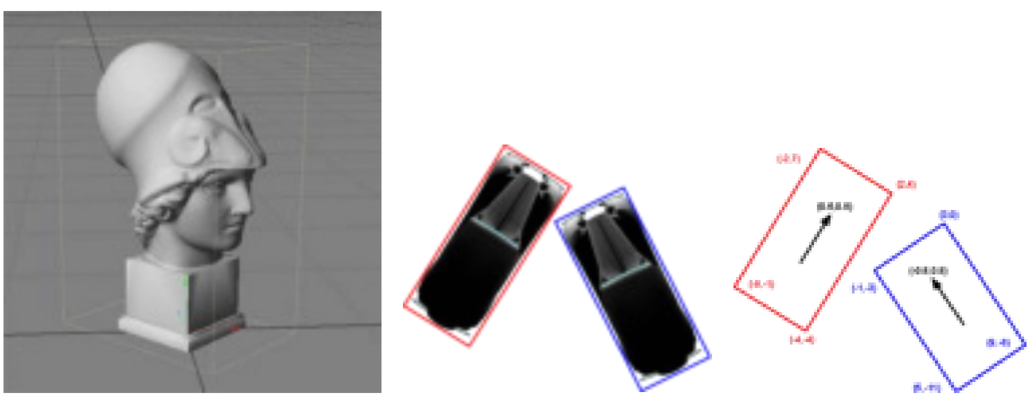

Figure 14: on the left, a 3D model and its bounding box (image by "Maksim", courtesy of Wikimedia Commons); in the center, two cars colliding and their bounding boxes; on the right, the abstracted pure-rules "cars" as computed by a collision detection algorithm (Baker, 2012).

These mismatches highlight the layer of abstraction present in 3D game spaces: the game's fictional world is rendered through a visual space made of highly detailed polygons and textures, but the space actually implemented in the game's rules is composed of entirely invisible collision boxes simplified to correspond to the rough shapes of objects.

CONCLUSION: BEYOND SIMULATION?

As we have suggested earlier in this paper, projection techniques are relevant to theorize some aspects regarding the historical study of visual representation in video games. Indeed, even though the screen may be divided or include disparate elements in its visual space (such as commands, tools or actions) and thus break the single viewpoint (Friedberg, 2006), the main objective of a game (its *project*, to use Branigan's term cited earlier) will focus on functions of simulation or immersion rather than in the concrete organization and management of information (as in the case of a cell phone or desktop work environment). Perspective is therefore an effective and appropriate tool to explore the advent of tridimensionality.

The appearance of polygonal 3D graphics can be understood in the same light as photography and the film camera; in Edmond Couchot's view (1998), these devices brought machine automatisms, i.e. they automated some operations that were traditionally performed by individual artists through techniques and methods for the construction of proper perspective. Likewise, polygonal graphics can automate all the viewing operations that fall under the scope of perspective; one only has to stage the objects and determine an angle and lighting for the shot to produce what would have required extra sketches and drawings in the form of graphical sprites for 2D video games.

That said, the perspectivist automatisms brought by polygonal 3D graphics do not signify the end of all alternative possibilities. The two spatial structures of perspective and parallel projection are still being used in both 2D and 3D video games, mainly for gameplay purposes since they immediately place a focus on either the gaze or the space. Moreover, the opposition cannot be reduced simply to graphical technologies, with the illusionistic tradition of refined perspective thanks to 3D polygons on one side, and parallel projection de-emphasizing the immersive gaze through 2D sprites on the other; the advent of polygonal 3D graphics did not happen overnight, and a number of games feature hybrid combinations of pre-rendered 3D polygons, real-time 3D, 2D sprites, text or number boxes, 2D icons, and so on. The hybrid, composite nature of the video game image, both through its surface and diegetic spaces, constitutes a promising area for future research.

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