

Preserving Video Games

Through Its Textual and Contextual Components

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Proper preservation of video games requires equal attention to the textual and contextual components. Because the texts and contexts of video games are more tightly intertwined than other types of preserved content, failing to preserve both aspects fundamentally neuters any preservation efforts. This thesis problematizes video game preservation by exploring the text and contextual components and how they relate.

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Introduction

Video games are important. While they certainly have had their fair share of detractors, it would be difficult to successfully argue that video games are still a small fringe entertainment medium. Video games are so ubiquitous right now that they are no longer being dismissed by scholars and archivists alike. In international academic circles, they have aroused the interest of researchers. Academic journals, such as *Game Studies: The International Journal of Computer Game Research*, have started to emerge as a part of academia formally known as Game Studies¹. Video games are also significant economically; the consumer market for video games is extremely profitable. The revenue of video games has even been reported to have surpassed the motion picture industry in some markets, such as in the UK (Rosenberg 2009).

Nevertheless, video games are often treated as inferior to other forms of expression and their legitimacy has been contentiously fought over, especially within the last half decade. The Pulitzer Prize winning film critic, Roger Ebert, dismissed video games outright by writing that “video games can never be art” (Ebert 2010). Taking a completely different stance, the US Supreme Court remarked in June 27, 2011 that “Like the protected books, plays and movies that preceded them, video games communicate ideas — and even social messages — through many familiar literary devices (such as characters, dialogue, plot and music) and through features distinctive to the medium (such as the player’s interaction with the virtual world [...]) That suffices to confer First Amendment protection” (Liptak 2011).

¹ Game Studies does not study video games exclusively. In the history of Game Studies, academics have also looked at more traditional games. However, the popularity of the study has exploded in recent years with a focus in studying video games academically.

The consumer habits of this content do not help its reputation. It has been argued that video games have the shortest shelf life² of any media (Steele 2006) and there is the subtle bitter taste of futurism with the way video games are consumed as the newest technological developments are heavily marketed to distinguish themselves from older products. In other words, better technology brings in bigger revenue and often leaves older titles in the dust.

Because of this attitude of video game disposability, someone needs to start taking an active role to preserve video games for future generations. A handful of high profile archives, such as the US Library of Congress (Library of Congress 2006) and the National Media Museum in the UK (National Media Museum n.d.) have expressed an interest in including video games into their archives. But video games, like other time-based media works, are very different from traditional media found in archives today.

The Head of Time-based Media Conservation at Tate, Pip Laurenson, described the problem with traditional approaches is that they reflect a narrower definition of conservation. Conservation by this narrower definition is the “means by which the original and true nature of an object is maintained and the means by which the true nature of an object is preserved”. (Laurenson, *Authenticity, Change and Loss in the Conservation of Time-Based Media Installations* 2006). She explains that this narrow definition of conservation is antiquated, as it comes from the 18th century view of aesthetics that there is “an independence to works of art

² There are some exceptions to this. Unlike brick-and-mortar shops, a few online digital distribution companies such as Steam and GOG.com are examples of video game sales with a long-tail. However, as this only applies to PC games, this is more of an exception to the rule. For more about these digital distribution companies, see the “Modern Trends that Lead to New Problems with Future Preservation Efforts” chapter.

as ends in themselves” (Laurenson, *Authenticity, Change and Loss in the Conservation of Time-Based Media Installations* 2006).

According to Laurenson, the conservation of autographic art (paintings and sculpture) is suited for traditional conservation framework. However, allographic art, works that were performed (musical or theatrical), is not suited for a traditional conservation framework because this type of artwork is not made up of a unique physical object. While the traditional conservation of art has persisted, the art world has not. Modern time-based works, such as video, sound, or electronic games, are not based on 18th century aesthetics. Instead, they are installed and are like allographic art. They have been described by Laurenson as fitting somewhere between sculpture and performance. They do not suit this narrow definition of conservation because the works of art are not necessarily self-contained physical object with inherent aesthetic properties. For this reason, conservation has to be redefined in order to remain relevant for time-based works. The definition Laurenson provides broadens the duties to maintaining the history of the meaning of the conservation object. “Their identity is defined by a cluster of work-defining properties which will include the artist's instructions, artist approved installations intended to act as models, an understanding of the context in which they were made and the willingness and ability of those acting as custodians of the work to be sensitive in the realisation of a good installation” (Laurenson, *Authenticity, Change and Loss in the Conservation of Time-Based Media Installations* 2006). Only through understanding a works identity can the conservation of time-based work be relevant.

As Laurenson explains, works can be 'thinly' or 'thickly' specified. "In time-based media installations, 'thickly' specified works are works where the artist has specified the qualities of the work and its presentation as precisely as possible" (Laurenson, *Authenticity, Change and Loss in the Conservation of Time-Based Media Installations* 2006). The more thickly specified the more specific the requirements are to recreating the work. In cinema, it is important to know the operating procedures of 35mm film. The frame speed and reel order are 'thickly' specified however the exact model and make of the contemporaneous 35mm projector used is less so. Knowing the order of the film reels and how fast it was projected, one can recreate the context and remain true to the work without having to locate a 1915 projector to present D.W. Griffith's *The Birth of a Nation*. Video games differentiate themselves in that their contexts are way more 'thickly' specified than cinema.

What makes video games special is that *not only are the texts and the contexts of video games so closely linked, the text and context are, at the same time, fundamentally discrete*. While preservation and presentation are often intertwined with the archival efforts of other modern media (i.e. magnetic and photochemical media), never has the integration been this tight before and 'thickly' specified. This tight dynamic between the text and the context is unique to video games and other digital based new media and it is for this very reason that I argue equal efforts needs to be made in order to preserve the text and the context of video games. If the balance between these aspects is not given equal attention, the dynamic is lost and the preservation is fundamentally neutered.

Intentions

In this study, I dissect video games to better explain how they can be preserved for the long term. In doing so, I intend to problematize what it truly means to archive video games appropriately. The goal here is not to provide objective solutions on how to archive games because deciding archival policy is pragmatic and necessarily subjective. After all, the views of archivists can vary greatly. Instead, I hope to achieve something broader by identifying the most important issues at hand in the framework stated above. This way one can have a better understanding of what is needed in order to effectively preserve video games. In other words, I want to identify salient aspects of preservation, rather than prescribe preservation techniques. As explained in the final chapter, the problems preserving games prior to 2003 are completely different and thus the main focus here is on games prior to the adoption of broadband internet and internet based digital rights management.

This study is split into four chapters. The first chapter discusses the text and the context of video games and discusses what is at stake. This is followed by a chapter about preserving the context of video games and exploring the concept of emulation. The third chapter examines preservation of game text. The final chapter touches on new trends that video game companies are currently implementing. These will introduce additional problems for future preservation efforts. In problematizing, one can seek an understanding of the importance of preserving the dynamic of the text and context of video games.

Chapter 1: What Is Video Game Preservation and Why Should we Bother?

A Growing Interest

In 2006, the US Library of Congress produced a press release declaring that leading producers of commercial content in digital formats, including video games, stated that they were “keenly interested in the preservation of their digital materials for archival and other purposes.” This press release concluded that the Library of Congress would be creating an initiative called, “Preserving Creative America” to help aid in preservation efforts of this type of content (Library of Congress 2006). This news found its way on to the popular high-profile video game news blogs including Gamasutra, Game Politics, and Kotaku. By no means was the Library of Congress taking the very first steps toward video game preservation, but their position made mainstream headlines. Interest in video game preservation did not sparkle and fade with the news coverage of this press release; it increased. Today, interest in video game preservation has never been higher in the western world. In 2011, two panels were reserved for covering video game preservation at GDC³ (Game Developers Conference) in the United States. In Europe, the 2011 Magis - Gorizia International Film Studies Spring School Conference in Italy discussed the archive’s relationship to video games as one of their primary foci. This growing interest is also reflected in the formation of IGDA (International Game Developers Association).

This brings up three important questions. First, why do video games deserve attention for preservation? Second, if they do, what exactly does that imply? Third, what does video

³ The 2011 GDC took place on February 28th to March 4th in San Francisco, California. GDC is an expo designed for game developers. Workshops and presentations are offered to attendees. Game engines such as Epic’s Unreal Engine and 3rd party development tools such as SpeedTree [sic] are marketed to the attendees of the convention. GDC was setup to promote education within developers and foster networking within the industry rather than as a marketing tool like E3 (Electronic Entertainment Expo) and with few exceptions, this is not usually a place where upcoming games are advertised or marketed.

game preservation even mean? This chapter attempts to cover these topics and deal with the “whys” and “whats” of video game preservation.

Why Archive?

Why should anything be preserved and archived – including video games? The expressed goals of archives and the purpose of their collections can hardly be described as unified. Some archives have been used for the legal protection of commerce, such as the Library of Congress. Since 1846, the US Library of Congress has been a repository for books and pamphlets, protecting the creative works of copyright holders (Library of Congress 2006). On the other hand, the goals of the Cinémathèque Française film archive are considerably different. Instead of protecting copyright holders, the goals of the Cinémathèque Française have always been focused on the art objects themselves. This archive has been described as more “museological” in nature (Mannoni 2006, 274) because of their heavy emphasis on presenting their collections to the public. Archive goals can vary wildly.

But what does the historical record say about the earliest archives? Unfortunately, stimuli behind the earliest archives are rather vague and the first known archival literature only goes back a 100 years. The 1898 literature, Manual for the Arrangement and Description of Archives, known informally as “The Dutch Manual,” focused on the nature and treatment of governmental records but had little to say about curation and the selection process (Cook 1997, 20-21). Fortunately, 24 years after The Dutch Manual was published, a more helpful book was written; it clearly expressed reasons for archives. It was written by Sir Hilary Jenkinson and entitled, A Manual of Archive Administration. It described the archives and archival records in terms of evidence. (Jenkinson, A Manual of Archive Administration Including the Problems of

War Archives and Archive Making 1922). Jenkinson saw archives as holders of evidence as they were “correctives of the more or less ex parte statements of contemporary or later commentators on events” (Jenkinson, *Reflections of an Archivist* 1944, 356). While, the goals of both the Library of Congress and the Cinémathèque Française are vastly different, they both share this idea put forth by Jenkinson. In both cases, they are archiving because their holdings are evidence of something. Hence the question; are video games evidence? If they are evidence, what can we say that video games are evidence of? To answer this question, one must consider the ontology of video games.

The Value of Video Games

In the limited academic literature on video game preservation, a common theme is validation of video games in the following form: “Video games are ____.” University of Colorado, Colorado Springs professor of game design and game studies, Devin Monnens has written about games and justified them in terms of history, property, design, art, and culture (Monnens, *Why are Games Worth Preserving?* 2009). One could argue that the archiving of video games could provide evidence for all of these characteristics listed by Monnens. The archiving video games simply because they are evidence may be valid, yet, it is a rather limited approach. A better reason to archive has been postulated. Zach Vowell, a Digital Archivist at The University of Texas at Austin, has expanded on Monnens and wrote that, games are fun (Vowell 2009). One might quickly dismiss this as insignificant; yet it is important to consider that video games are not just valued by academics and copyright holders. Video games do significantly entertain many people.

The Current Status of Video Games

One might ask if there is any urgency. As it is, the funding of cultural organizations is presently reflecting the global economic recession. There are already designated funds reserved for preservation of other media, such as books, film, and audio recordings. While the number of early films lost is shocking in its own right⁴, the fact of the matter is that if something is not done soon, early video games could easily suffer this same fate. It would be naïve to think that because of modern technology and the rise of valuable information exchanged on the internet, the relatively new video game medium would receive more careful treatment by consumers.

One might wonder how much has already been lost. Paul Gooding of the BBC Sports Library and Melissa Terras of the University College London performed a relatively small survey to try to quantify the current state of loss of video games. Concluding from the small sample of 50 games⁵ for the Atari 2600⁶ searched for by the study, some games could already be

⁴ It is easier to rationalize film preservation because so much of our early film history is already lost forever and all available money is needed to limit and reduce any more damage from happening. The amount that has been lost is no small matter. In fact, the common estimate lists that 90% of American silent films and 50% of sound films before 1950 are already lost and missing (Kehr 2010).

⁵ I was unable to find a verified total of the number of games produced for the Atari 2600. I only was able to find an estimate on the internet of 418 games. The reasoning for this can be found at the following weblink. (<http://www.atariage.com/forums/blog/279/entry-5704-how-many-atari-2600-games-are-there-answer-418/>)

⁶ However, at closer inspection, one will find that this study is fundamentally flawed at being truly representative of the big picture in terms of video game loss. The survey targeted exclusively games produced for the Atari 2600, which was one of the more popular video game console systems from the late 1970 through the 1980s (Guttenbrunner, Digital Preservation of Console Video Games 2007, 8). Because this survey chooses to focus on a popular console, the conclusions which can be drawn from the data are rather limited. At most this could be seen as a “best case scenario”. What about PC games or games from other consoles which were not as popular as the Atari 2600? While more comprehensive research in this area could prove useful, this was currently the only research dedicated to quantifying video game loss that could be located.

considered lost. According to their report, 12 of these games on their list could already not be located in a physical form⁷ in an archive or from eBay (Gooding and Terras 2008, 29).

The loss of games is not the only problem. There are not enough authoritative references for the documentation of existing video games. Much frustration has been expressed in academic literature concerning the lack of trustworthy sources for research. This includes from Gooding & Terras who explicitly stated in their report that, “One of the most difficult elements of compiling these results was tracking down reliable resources” (Gooding and Terras 2008, 33). There has been much concern voiced by academics about the prospect of user-submitted information websites, such as Wikipedia, as the main source of video game research. It is not just academics who realize this. In an article from the mainstream magazine, Wired UK, Mark Brown, concludes that “while cataloging gaming history is a vitally important move for this culture or art form, and Wikipedia makes a very valiant contribution, the site can’t be held accountable as the singular destination for gaming archeology” (Brown 2011). Other alternatives to Wikipedia exist online for video game information such as Gamespot, Giantbomb, IGN, Mobygames, etc. However, these websites have the same or similar problems as Wikipedia. While they all contain a plethora of information, they are predominately comprised of user submissions; thus, the reliability of this information can easily be called into question. Therefore, not only are “video games as objects” in danger, but the current state of the information related to video games stands on very thin ice. Hence the big question: Who should an archive serve?

⁷ While not all of these games could be found in physical forms. All games were reported by Gooding & Terras to be available as ROM images on the internet.

Archiving video games would indeed prove useful for academics. If academics had access to video game related materials carefully archived, they would have better sources for research. One might ask, however, if archiving exclusively for academics limits the full potential of the archives.

Consider game archive designed to serve the general public as well. Video games are not exclusively an academic interest. They are also part of social history. One should not ignore the significance of video games as entertainment. For the people have fond personal memories of games that they played decades previously. Archiving games for general public could assure it that its cultural history is not going to be officially discounted and lost to neglect. Sadly, this type of archive can be challenging when it comes to providing public access. Many video game companies have taken to threatening legal actions indicating that they do not like having their intellectual property⁸ made easily available. Abandonware websites such as Home of the Underdogs⁹ received many “Cease and Desist” letters between 1999 and 2000 (Cummins 2009) before scaling back and eventually disbanding. However, not all efforts made by digital archives have been as turbulent as this. The Digital Game Archive (DiGA), for example, has avoided legal problems by working with licensees directly. On their website they claim that “all games, made accessible by DiGA, have been released by their respective license holders for the purposes of private and scientific use.” In the same paragraph they state that, “the cooperation of the license holders are not only crucial but also encouraging: the industry seems to begin to accept

⁸ Because video games are such a relatively young medium, no copyright on a video game have outlived their expiration date. Therefore, very few commercially released games have entered the public domain.

⁹ The original website Home of the Underdogs is no longer in existence. The original was shut down in 2006. There are now at least two different websites that have attempted to pick up where the original website left off. These websites have used the same name but this should in no way be confused with the original.

its share of responsibility in the concerted effort to preserve our digital culture” (DiGA e.V. 2011).

Some in the video game industry have recognized that they could benefit from archiving video games. If an organization were to archive with these companies in mind, legal documentation could be prepared as has been done by the Library of Congress for written material for a century. However, if an archive is established to benefit corporations, one might inquire about archive independence and control. Where do the responsibilities of this kind of archive lay? Are the archives in control or is it the hand (the video game companies) that feeds it?

What Should Be Preserved?

What is required in order to truly preserve video games? As Laurenson pointed out, traditional conservation means are ill-suited for time-based media (Laurenson, Authenticity, Change and Loss in the Conservation of Time-Based Media Installations 2006). Simply storing video game data is a case of not seeing the forest for the trees. Having a game without being able to play it is as good as having a book whose cover is sealed shut and cannot be physically opened. The texts and contexts of video games are so closely linked and yet fundamentally discrete so a better approach may be to split the task of preserving video games into their textual and their contextual components.

The Text

What is the “text” of video games? Perhaps the most obvious interpretation of the text is the video game itself. Unfortunately, saving games is more complicated than just placing

video games in boxes in a vault. Not all the original carriers of this data are designed for long term storage (See Chapter 3: Data Loss).

Text Fragmentation

Document and film archives deal with the “problem of the original.” Video games can exist in multiple versions. PC games are often refined with software patches that update performance or increase the content. While less common in console games, current generation consoles are starting to release patches for their games as well. With each patch, a different version of the game text is created, thus fragmenting the text.

Similar to cinema, video games are not always released in the exact same form worldwide. Sometimes the reason for this fragmentation is commercially driven, such as is affected through the process of localization. Localization is more than just simply translating a game into a different language. In the localization process, significant rewrites are made to match local cultural values with the region the game is published in. Hence, a game produced in the United States would not likely be localized for French Canadian consumers. While the language is certainly different, the culture may not be different enough to cause alienation. The term, localization, is often associated with the Japanese publisher, Square Enix, as Japanese developed games are sold to a western audience.

“Japanese companies including Square Enix have successfully created such cross-culture products, and have incorporated this style into business practices, such as Square Enix’s subsidiaries Square Enix USA and Square Enix Europe. However, this fusion or ‘easy migration’ is not a totalizing system. Distinctions still remain between the games that Square Enix produces for the Japanese market, and those that successfully sell abroad. Those products destined for global consumption are carefully localized, to ensure that their international flavor is not too foreign for non-Japanese tastes” (Consalvo 2006, 120).

Sometimes the development of different versions is more politically driven.

Programmers of the game, *Left 4 Dead 2*, were forced to edit the content of their game when it was “refused classification” by the Australian Classification Board on the grounds that the game “contains violence that is high in impact and is therefore unsuitable for persons aged under 18 to play” (Wildgoose 2009). In any case, persons preserving video games must take into account the multitude of different versions a single title could have.

The Level of Importance

What should be the focus of treatment of the text of video games? After all, it is tempting to go after the most popular and extraordinary games¹⁰. However, a history of successes tells only a part of the picture. For every success, there are many failures. There are even more which fall somewhere between. It is not only the disasters and the mundane that can easily be overlooked for preservation. Should games like *Custer’s Revenge* be preserved? In this infamous Atari 2600 game, produced by the company Mystique, a player would control a naked and fully sexually aroused General Custer¹¹. This player would have to dodge flying arrows and reach the right side of the screen in order to perform questionably consensual intercourse with a naked Indian tied to a post. *Custer’s Revenge* has been recognized since its release as being controversial for depicting rape in a video game despite the game’s creator, Joel Miller, claiming that “He’s seducing her, but she’s a willing participant” (Associated Press

¹⁰ When I was an undergraduate student, a film history lecturer, Michael Z. Newman, once explained something that made a strong impression on me. He argued that ordinary films are just as important as extraordinary ones when it came to understanding the history of film. I strongly feel that this concept should also be applied for video games.

¹¹ General Armstrong Custer was a real life American general from the American Civil War. To this day, he is a controversial historical figure in American history. He is most known for fighting American Indians in the American Indian Wars, where he was defeated and died at the Battle of the Little Bighorn. This battle has become more commonly known as Custer’s last stand.

1982). So should games like *Custer's Revenge* be preserved? We have to ask if embarrassing games like this should receive the same attention as the big budget Triple-A games such as the *Wolfenstein 3D's* or the *Halo's* of video game history.

The Context

The texts are only one side of the proverbial coin for preservation. After all, as Zach Vowell eloquently stated it, “the stuff of game history encompasses far more than the games themselves” (Vowell 2009, 12). What about preserving the contexts of video games? On the most primary level, the context for video games is everything needed to execute the games code such as a console or a computer. For example, the simplest context for Sonic the Hedgehog is the Sega Genesis. The outer context can be used to understand how the game was originally played; for example, having the original bundled gamepads or knowing what type of projection was typically used. The even more outlying levels of context are also helpful to understanding the game. They include paratexts (box covers, manuals) advertisement flyers, news and trade-journal articles, and social networks built up around the text. All of these are part of the context because they help make sense of the game.

Hardware as Context

Perhaps the most obvious and crucial interpretation of the context of the game texts is the machines that play them. With this way of thinking, consoles could be seen as the Ying to console games Yang.

Not all video games are produced for consoles. What about games produced for personal computers? Preserving video games for the console is a double edged sword as they

are more 'thickly' specified than computer games, making them closer to sculpture than performance. On one side, you have the same quality of execution on all machines. There is no flexibility in the specification on a NES (Nintendo Entertainment System). Every NES unit produced by Nintendo featured a Ricoh 2A03 processor, which was based on the NMOS 6502 processor (Diskin 2004). Combine this unified processor, the same amount of system memory, and other technical specifications and you have a unified and 'thickly' specified experience for all users and all games. This means that any emulation of this context has a set of exact goals and guidelines to aspire to and very little interpretation is needed.

On the other hand, games were also produced for personal computers which, to this day, are anything but unified and thus more 'thinly' specified. One could even argue that the philosophy behind personal computers is a sense of choice over unification. What this means for computer games is that the experience that one person had could be different than another person with different hardware. This change in experience could be due to a number of variables, including hard drive speed, optical drive speed, or RAM size. All could dramatically affect how long one would have to wait for the next level to load or how smooth video playback would be. Also, the CPU and GPU clock speeds could affect how many graphical and performance bells and whistles could be turned on while maintaining a playable frame rate. Different hardware could even affect the way a game looks and sounds because different GPU chips render graphics slightly different¹² and different MIDI synthesizers could render the game music with completely different instrumentation based on the audio samples loaded into

¹² The differences between the major GPU chip manufactures, mainly ATI and NVidia, are much less obvious today but in the early 2000s, these differences were much more dramatic.

memory. What does this mean for preserving the contexts of PC games? On one hand, there is no one official game standard for how these games should perform as they are more ‘thinly’ specified than their console counterparts. Instead, there the specified qualities that describe the context in the form of “minimum requirements” and “suggested requirements”. On the other hand, what does this mean for emulation? Do these ‘thinly’ specified qualities mean that emulating is acceptable if the result is within an accepted range, or does it mean that proper emulation needs to cover all the variables? More about emulation is covered in depth in a separate chapter (see Chapter 2: Emulation and other Preservation Strategies.)

Peripheral Items as Context

The context of video games does not stop with the devices that play them. There is much more that surrounds video games in the periphery that is integral to understanding their history. This is not simply just about the hardware peripherals, from the common Sony DualShock [sic] controller, to the bizarre Nintendo Power Glove. Also important are the game boxes and manuals, company memos and press releases, magazines, newspapers and journals, as well as commercial advertisements, promotional paraphernalia from trade shows (also known as “swag”) and relics of fan clubs and social networks. The list goes on. While these items might have limited use on their own, they can “add up to a highly detailed history of the industry and the medium it is built around” (Ruggill and McAllister 2009). The problem is trying to decide what is important enough to save which is something that a curator will have to decide based on their budget and capabilities.

Chapter 2: Emulation and Other Preservation Strategies

Perhaps the most exciting frontier for video game preservation strategies right now is that of emulation. There is certainly a lot of discussion about using emulation as a way to protect the legacy of video game history and it is not just from archivists or other specialists in the preservation field¹³. Newspapers, such as The New York Times (Lubell 2003), have published articles discussing emulation. It might be beneficial to take a closer look at emulators and emulation in this chapter. Prerequisite to a true understanding of how emulation could be used for the preservation of video games is a sense of perspective. This chapter describes strategies for preserving the context of video games, including that of emulation.

The Problems of Using Traditional Methods to Preserve Video Games

Major efforts must be made in preserving both the texts as well as the contexts of video games. Stacking game ROM-cartridges, CD/DVD discs, or 2.5"/3.25" floppy disks does not suffice short and long term preservation. Even where original physical media is not susceptible to data loss over time, digital data is useless without a means to access or interpret it in a meaningful way. Even when compiled code is extracted from the carrier, the efforts are futile in the absence of an appropriate machine to interpret and present the data. The result is like having a manuscript in an unknown language. Just as the text of the game is important, the context of the machine is equally so. Unfortunately, saving hardware is not a completely satisfactory solution for the long term because "console video game systems are usually built

¹³ Personal Note: I even had a personal discussion with an individual in a bar in Amsterdam in the summer of 2010 who wanted to express his opinions about my research. He argued that emulation is all that we need to save the video games of his youth which he reminisced over so fondly.

from custom manufactured parts which cannot be replaced once broken” (Becker, et al. 2008, 3).

A course of action for video game preservation should be based on the objectives of the preservation program as Laurenson explains that the identity of time-based works defined by a cluster of work-defining properties (Laurenson, Authenticity, Change and Loss in the Conservation of Time-Based Media Installations 2006). Unfortunately, most of these properties cannot easily be obtained from a single artist as often hundreds of people might have worked collaboratively on one game. What particular facets of video games warrant attention? Instead, a more general approach is needed in the absence of a single artist’s instructions. In their paper, Becker, Guttenbrunner, Kehrberg, and Rauber suggest that there are three significant properties that are crucial to the essence of video games. They are the visual aspects (often referred to as the graphics, or the video), the audible aspects (often thought of in terms of sound effects and music), and the interactive characteristics (Becker, et al. 2008, 4). Both the visual and the auditory aspects can be empirically tested, but interactive characteristics involve considerable subjectivity. With respect to these dimensions, how might video games be preserved?

Approaches to Prolonging the Life of Video Games

Becker, Guttenbrunner, Kehrberg, and Rauber suggest several approaches to video games preservation which address these textual and contextual facets.

Backwards Compatibility

The first objective they explore is *backwards compatibility*¹⁴. It has for some time been valued by computer operating systems and a select number of video game consoles as a marketing point (Finn 2002, 51). With backwards compatibility, a device can execute not only applications/games built for it but also software designed for earlier versions of its platform. Unfortunately, backwards compatibility is limited to the scope of commercial choices insofar as only platform owners can choose to implement it. Yet, it is a successful commercial model as exemplified by current versions of the Microsoft Windows operating systems. Much software built for Windows XP can still be executed in Windows 7. Backwards compatibility is becoming an important feature found on the console side as well. The Microsoft Xbox 360 can play some of the original Xbox games and the Sony PlayStation 2 is reported to play all of the original PlayStation games (Guttenbrunner, Digital Preservation of Console Video Games 2007, 22)¹⁵. While backwards compatibility is valuable as a new systems feature, it is a limited preservation solution for preservation because it critically relies on developer initiative. The consequent preservation of software written for a given platform is thus tied to corporate wellbeing and market share.

Porting

Guttenbrunner, Kehrberg, and Rauber suggest what they refer to as utilization of source ports. This involves the recompilation of original source code for a platform other than that for

¹⁴ Editorial note from technical fact checker, David Schneider: Backwards compatibility is an encompassing term for emulation/simulation. It is what emulation or simulation achieve. The Wii has backwards compatibility because it has GameCube hardware in it (hardware emulation? Well not totally since it IS a GameCube). The (current gen) PS3 has backwards compatibility because of software simulation of a PS2.

¹⁵ Strangely enough, the PlayStation 3 originally was able to play games from both previous PlayStation systems but a later redesign of the PlayStation 3 hardware, removed the functionality (Falcone 2009). This is most likely due to Sony reducing the production costs of the hardware.

which it was originally written. Porting has been commercially successful in the release of multiplatform games and rereleases. Consider the game Doom. It was originally programmed for MS-DOS but has been ported to many different platforms including the iOS operating system¹⁶. However this solution is not very practical for preservation purposes. Even if the original code is accessible, adaptable modifications might prove necessary for program compatibility with the alternative platform¹⁷. This can be tedious and excessively expensive.

Other Approaches

Becker, Guttenbrunner, Kehrberg, and Rauber also propose both the Museum Approach and the Print-to-Paper Approach. The former maintains original text and context. Active efforts are focused on maintaining the working order of the associated hardware. This may not be practical for the long-term because, as previously mentioned, the components produced for video game systems often cannot be replaced (Becker, et al. 2008, 3). The Print-to-Paper Approach involves the archiving of static (recorded) screenshots and gameplay video footage. This would provide an excellent reproduction of the visual and the auditory characteristics, but such an approach cannot satisfactorily preserve the interactive characteristics of the games. To the extent that video games are uniquely defined by their interactive characteristics, this approach is in itself rather incomplete.

Emulation

The most discussed strategy for video game preservation is emulation. Some clarification is in order. Emulation should not be confused with simulation.

¹⁶ iOS is the operating system which Apple's recent line of mobile devices use, including the iPod Touch, the iPhone, and the iPad.

¹⁷ Editorial note from technical fact checker, David Schneider: Code that doesn't make use of system calls will be easy to recompile for an architecture/OS that it was not initially designed for. Well designed code is much easier to "port" than poorly designed or uses lots of "cute tricks" that make it specific to a version of software/hardware.

A History of Emulation

Early use of the word emulation in reference to computers dates back to the early 1960s. IBM was looking for a way to assure their customers that existing business programs would continue to work on the company's latest computer models. IBM's engineers came up with an approach: the process of simulation.

“Simulation, whereby one processor could be made to imitate a second, was a well-proved technique. A simulator program running on the first processor could read as data an application program written for the second, examining instructions one by one and interpreting the implications in terms of instructions that the first processor would immediately execute. The first processor's memory contained not only the simulator program but also areas used to represent registers and memory of the other. The area representing the other processor's memory was initially loaded with the application program. Then one of the simulator's subroutines would fetch an instruction from simulated memory, analyze the instruction, load simulated registers, and then branch to another subroutine designed to simulate execution of the given instruction. The procedure was repeated for succeeding instructions. Because many instructions had to be executed by the simulating processor for every instruction that was simulated, program execution by simulation was normally slow . ” (Pugh 1991, 159)

This process spared their customers the costly translation process of modifying their code (Tucker 1965, 753). However, the tradeoff was paid by the program's performance instead. Programs run through this simulation process often ran much slower than on the original machine. Emulation was investigated as a means to surmount degraded performance.

It is reported that the word emulator was first coined by Larry M. Moss in the 1960s in the context of work that he and Stuart G. Tucker did on computer simulations for IBM. In their work, Moss and Tucker rewrote and replaced different parts of the simulation with native code, resulting in an increase of performance that was between five to ten times faster than with simulation (Tucker 1965, 753). Because this approach was significantly different than previous attempts with simulation, it is said that Larry M Moss suggested the word emulation be used

instead of simulation because the root of the word, emulation, “goes beyond the notion of imitate to embrace Equal or Excel” (Pugh 1991, 161).

In previous approaches, a simulation would mimic the old machine as a whole and for this reason it would be very slow. With this new approach of emulation, the process would mimic the CPU/chip hardware. However, this means that a firmware image would be required from the original machine in order to function. For example, if one were to emulate a pocket calculator, one could not use the multiplication functions of it unless the assembly code¹⁸ of these functions had been included with the emulation. In essence, emulators execute assembly code but they need the firmware of the original device to be successful. Simulators mimic a device as a whole and do not require the firmware¹⁹ of the device but run much slower.

The Negative Connotation of Emulation

While emulation was originally developed to increase the lifespan of computer software, emulation is often discussed today within the same breath as video game piracy. With the evolution of easy internet file sharing over the last 10 to 15 years, a large number of websites surfaced on the internet providing “ROM images²⁰” for discontinued video game

¹⁸ Assembly code is a low-level computer language (Higher level languages resemble English more where lower level languages provide less abstractions from the computer operations) which is used to communicate with a given CPU architecture.

¹⁹ Firmware is a small set of software, often stored on a separate memory location on a PCB, which usually contains basic instructions for the operations of the hardware. The possible instructions found inside a firmware could be as simple as how a computer reacts to the pressing of a power button on a computer or how to securely transmit encrypted video through a data cable. A firmware is designed to be fixed and is not easily editable. The only way data in a firmware can be altered is with a complete replacement which can only be done by physically removing the memory chip, or a process called “flashing the firmware/BIOS.”

²⁰ A ROM Image is a set of data ripped from a ROM. However, it is more than the data divorced from a physical container. A ROM image is special because, not only does it include the data, it retains the memory location for all data for the storage device. If you simply copy the contents of a CD-ROM on to another one, the location of the files may be stored at different locations on the disc than the original. However if you were to make an image of the same CD and produce another CD from that image, the result would be produce a byte-for-byte replication of the original.

consoles (Costikyan 2000). Alongside numerous “ROM sites,” emulators were developed for personal computers through reverse engineering of the firmware of video game consoles. The ROM/Emulator business suggested a culture of “Wild West” lawlessness. Without obtaining legal consent from copyright holders, these “ROM sites” hosted ROM images of various console games. Anybody with an internet connection could download the ROM image of *Super Mario Brothers* and play it on their computer without payment of royalties or other fees to the Nintendo Corporation. Consequently, the use of the term emulator within the video game industry has been met with a great deal of hostility.

This distribution of commercial ROM images is unquestionably an act of digital piracy, but what about the legality of the emulators? The answer for this is not straightforward because, as stated earlier, an emulator requires the appropriate firmware to run the software so these instructions need to come from somewhere. In the USA, firmware is given the same copyright protection as software and is treated as literary works (Douma 2002, 79) and it is thus protected under law from unauthorized duplication. To evade legal action, many emulators require the use of a separate firmware file, not included in their official distribution.

The Current Status of Console Emulation

Today, programs are being developed to emulate generations of game hardware, however progress made on emulating the sixth generation of consoles and beyond has provided quite a challenge to programmers. A handful of programs claim that they are able to emulate the PlayStation 2. But these emulators do not actually run all games as claimed. And many perform with unacceptable speed and include an unfortunate cargo of artifacts. A few

attempts were made to emulate the original Microsoft Xbox, and those projects have remained mostly dormant for the better part of a decade²¹.

Emulators for Preservation

While emulation can prove useful to people wanting to play old video games, a question remains. Can emulation be useful in the preservation of video games? To answer this, one must articulate requirements for a viable preservation strategy.

Is it desirable to maintain an exact parity of original game text and context? An emulator can excel at providing an environment to view the text of the video game when the original hardware is either no longer available or too fragile to operate. On the other hand, even if emulation code is perfectly translated for presentation in another environment, the context is changed. Video game consoles characteristically require hooking up a machine to a television set. Console specific controllers are used to operate the game console. If someone were to play *Super Mario Brothers* on a computer using an emulator, they would most likely be using a computer keyboard instead of an official NES gamepad²². No code can be written into an emulator which can preserve the tactile feel of a gamepad.

Can an emulator provide satisfactory long term access to the text of video games? Emulators do allow the running of software on machines presently available. A personal computer is arguably easier to maintain than an orphaned device built with proprietary components. On the other hand, when a program (such as an emulator) is compiled, it is

²¹ The Xbox emulation project, CXBX, has not released a new version since 2003 (Caustik 2003).

²² Note: Most modern consoles use USB (Xbox 360 and PlayStation 3) or Bluetooth (Nintendo Wii is Bluetooth only) or both to connect. This means that these original controllers can be directly connected to an emulator as long as the hardware also has USB or Bluetooth. Older controllers with proprietary connections still can be used, provided a first-party or third-party adapter has been produced such as RetroZone's adapter which allows the original Nintendo Entertainment System controller to connect to a USB device (Farivar 2006).

transformed into machine code that is specific to new machine host²³. Microsoft programs Microsoft Word using Windows specific code. For this reason, one cannot natively run the latest version of Microsoft Word on an Apple Mac or Linux. When an emulator is compiled, the capability of that emulator is frozen.

When hardware or operating systems are upgraded -- such as going from Windows XP to Vista or switching from an x86 chip to a 64-bit processor -- the ability to execute, as well as the stability of the software in the new environment is uncertain²⁴. However, one cannot always simply recompile old code with a new compiler. Code must be written in a particular language. When programmers plan ahead, they can try to program in a style which will be supported subsequent compilation on different operating systems and architectures. Examples of this include software that works the same on a Mac and a Windows machine. However, anticipation of future platform requirements is necessarily limited. Sometimes code has to endure the process of major rewrites in order to be recompiled. A recent example of this is the slow transition from 32-bit to 64-bit software. The German pro audio software company, Celemony Software released a 32-bit version of their audio software, Melodyne Editor, in November of 2009 (Lewin 2009). It was not until October of 2010 before the company felt comfortable enough with their new code to release their 64-bit version (Celemony Software GmbH 2010). If an emulator were to be used as a way to provide long term access to old video

²³ Editorial note from technical fact checker, David Schneider: [A program] is compiled for a specific architecture (x86, x86-64, SPARC, MIPS, ARM, etc) OSes come into play when you are programming and using specific OS APIs and/or System Calls. eg browsing the file structure in Linux is different than Windows. And that is a trivial example compared to graphics and/or audio.

²⁴ Editorial note from technical fact checker, David Schneider: Changing software can break compatibility because APIs changes, but is not necessarily going to break. Changing architecture will require a recompile since machine code will have to change or memory offsets.

games, it would have to be an active project or it would suffer the same fate as the context it is trying to preserve.

Emulation Variables

How flexible does emulation need to be? As noted in chapter one, video game consoles provide a mostly uniform hardware environment. In other words, a SNES produced in 1991 will have more-or-less the same hardware components²⁵ as one produced in 1999. This is true for the majority of consoles prior to the present generation. The original Sony PlayStation and the PlayStation 2 provided updates to the system firmware which were included with their hardware revisions. The current generation of consoles, presently referred to as the “seventh-generation”, have complicated this. The motherboards on the Microsoft Xbox 360, the Nintendo Wii, and the Sony PlayStation 3 have an EEPROM memory chip to provide a flashable firmware. This allows for easy updates to the firmware so that the manufacturer can make modifications which either provides improvements in performance, increased stability, or even lock out security flaws²⁶. Hence, with a single video game console, there are many different subtle revisions²⁷ that could alter the performance of a game. This variability in consoles can be especially daunting when one considers that the current generation of video game systems has had significant revisions throughout the life of the hardware (not to mention different SKUs of

²⁵ There can be minor variations in the components used. As part vendors change, these parts may slightly differ but the changes are so minor that they can be neglected.

²⁶ Perhaps the most controversial reason for these updates is related to stopping unsigned code. These updates can be used to lock out access to pirated games and homebrew software (unlicensed programs). The current business model for video games console producers is to produce a machine as cheap as possible (including selling the hardware initially at a loss) and making their entire profit from first-party software and the licensing fees and royalties from third-party publishers. If a game is pirated on the internet, it hurts not only the game publisher but the console manufacture as well because they do not receive royalties on games not legally purchased. Updates to firmware make it more difficult for people to play these pirated games.

²⁷ Some games even require that the most modern firmware is installed on the console and will not run until an update is performed.

the same console being offered at the same time). For example, The Microsoft Xbox 360 launched with two models on November 2005 (Richtel 2005). Microsoft sold a Pro version (included at 20 GB hard drive) and a Core version (no hard drive). Since its release, Microsoft has released different models with different specifications. Later revisions provided HDMI output and larger hard drives. Furthermore, Microsoft redesigned the motherboards (Terdiman 2008). In December 2010, Microsoft was implementing its sixth motherboard revision. What was once seemed to be a “thickly” specified context by default, has become a more complex issue because of the new variables added to the context. The differences in performance might seem minimal but when considering future emulations of these systems, one should consider the range of experiences²⁸.

Case Study: Dioscuri

Do emulators offer a viable preservation strategy for video games? The absence of a simple answer does not mean emulation is not worth further investigation. Currently, a project is underway to construct an emulator for the application of preservation by addressing these aforementioned problems.

History

According to its website, Dioscuri, is an open source project developed by the Koninklijke Bibliotheek, Nationaal Archief of the Netherlands and the company Tessella Support Services plc. It was commenced in 2004 to address digital preservation in a way as to ensure that interactive applications (like games and similar digital objects) would remain accessible for the long term (Koninklijke Bibliotheek, Nationaal Archief, Planets, KEEP 2007). The project has

²⁸ This is not even including the various first and third-party peripherals. Both Microsoft and Sony have both released camera/motion controllers during the 2010 holiday season.

sought to build its emulator in such a manner as to overcome the problems found in most emulators which undermine their value for preservation.

Compatibility

To avoid compiler-based problems introduced, Dioscuri aims at working around them altogether. Instead of using a compiled programming language such as C or C++, Dioscuri is programmed in Java. Java is different than C and C++ because it is an interpreted language. Instead of compiling, a program written in Java runs inside a JVM (Java Virtual Machine). The JVM works like a mini-operating system that runs within a host operating system. This means that any program written in Java code is compatible with any device that has a JVM installed. Accordingly, to run all applications written in Java, only a JVM would have to be compiled for the host device. In other words, if you want to play a version of solitaire written in Java on any machine, install a JVM on that machine. Because the Dioscuri program is written in an interpretive language, it should benefit from wide and long term compatibility. Yet, while the Java language is open source, the JVM is not. The company, Oracle, is the sole steward of the JVM, which bought the developer, Sun Microsystems, in April of 2009 (Oracle 2009). Attempts have been made to produce an alternative JVM, but presently only Sun /Oracle can produce a true and official Java Virtual Machine for any given device²⁹. Hence the vulnerability of related preservation work in the event that Oracle were to discontinue support of the JVM for certain environments or altogether. Another problem with Java programming relates to its practical performance. Because Java is an interpretive language and all code has to be run through a JVM

²⁹ For more information: read The Java Trap <http://www.gnu.org/philosophy/java-trap.html>

interpretive layer, there is a significant level of overhead that affects the program's runtime performance. To put this in perspective, in a recent test, a compiled C program ran two-to-six times faster than the Java programmed equivalent (Cherrystone Software Labs Inc 2010).

Modularity

Another aspect of the Dioscuri emulator useful for preservation is that is its modularity. This property addresses 'thinly' specified contexts because of varying computer hardware specifications. Because this emulation is modular, any software can be emulated with different virtual hardware combinations and settings and provide a range for 'thinly' specified video game contexts. Its design allows one to machine-specifically configure (i.e. CPU, graphics card, RAM, etc) the emulated machine.

Limitations of Dioscuri

The project is early in development and the options are currently somewhat limited. Also, Dioscuri is a PC only emulator and it does not attempt to emulate dedicated video game consoles of older or newer generations. The Dioscuri emulator is a step in the right direction for using emulation as a preservation strategy for video games but it is not yet ready to be used seriously for this purpose.

Until extensive progress is made on emulation, one might have to make a number of concessions and use an emulator not designed for preservation to access the older games. As one of the founders of emulation described his work, "[emulation] is not a solution to all conversion problems, but it should be a significant tool" (Tucker 1965, 753). Likewise, emulation might not be the answer to all our problems with preserving video games. Nevertheless, it might be the most effective tool for preventing the otherwise inevitable. Saving

video game hardware is okay for a museum model of preservation, but it simply is not practical for the long term. Emulation is not a “magic bullet” for video game preservation but it appears to be a promising tool. It may be the best one presently available.

Chapter 3: Data Loss

Because of the efforts taken by film archivists, many films from the last century have been saved from being lost from history. Under the proper environmental conditions, archivists have been able to keep these cinematic artifacts in useful condition for generations. However, video game media is a different story entirely. Instead, it has proven to be exceptionally problematic for long term preservation even when placed under the best possible conditions. This chapter focuses on the problems found in the typical physical media used for distributing video games and in doing so it attempts to explain why traditional archival storage methods are insufficient to preserve video games.

There is no such thing as an analog video game because video games are digital by their very nature and thus exist only in digital media formats. From the arcades of the 1970s to the present, digital storage being used to hold game data could be broken into three distinctive categories: ROM³⁰/Solid State³¹, magnetic, and optical media. With each of these aforementioned categories, problems exist that affect the lifespan of the data. While the specific nature of these problems varies by category, none were designed for longevity.

³⁰ ROM stands for Read Only Memory. True ROM data is a type of data storage that can only be written to once. After this has happened, the data cannot be erased or overwritten.

³¹ Solid state memory contains no moving parts in which the data is stored. Modern examples of solid state memory includes the USB sticks (aka USB Thumb stick, USB Key, Pen drive) or camera memory sticks (eg CompactFlash, SmartMedia, or MicroSD)

ROM Media

Perhaps the earliest and most iconic category of console gaming is that of the ROM cartridge. Nearly every console from the 1980s through the mid-1990s³² used ROM cartridges to distribute their games. Fortunately, while “the ultimate lifespan of masked ROM cartridges is unknown, [...] it is possible that some cartridge-based games will last longer than the copyrights associated with them” (Monnens, *Losing Digital Game History: Bit by Bit 2009*, 4). This does pertain to the other types of media. A variant on traditional ROM storage, EPROM, is less durable. “EPROM cartridges store data by charging electrons inside the chip; over time, these charges will slowly leak through the chip insulation, causing irretrievable loss of information.” Because of this, it is estimated that EPROMs can last up to 25 years (Monnens, *Losing Digital Game History: Bit by Bit 2009*, 4).

Magnetic Media

While magnetic based media was not used in gaming consoles, it was the primary method of storage for computer games in the form of 3.5” and 5.25” floppy disks until the rise of the CD-ROM in the mid-1990s. It was the only way in which games were distributed for more than a decade. Many PC games can only be found on floppy disks. Unfortunately, magnetic media has been recognized as the most likely to suffer from data loss within a short period of time. A report from the University of Massachusetts Amherst concluded that “with moderate care, most magnetic media will last for 10 years” but only “with special storage and handling, digital magnetic tape formats can reliably store information for 30 years or more.” (Gilbert 1998).

³² These consoles that utilized ROM storage include but are not limited to The Nintendo Entertainment System , The Super Nintendo Entertainment System, Nintendo 64, Sega Master System, Sega Genesis, and Atari 2600

Optical Media

Optical media, on the other hand, can be found in both modern day computers and video game consoles alike. Except for handheld gaming devices³³, just about every game console from the last 15 years from Sega Dreamcast, every Sony PlayStation, and both generations of Microsoft Xbox, has used an optical disc to distribute games. On the PC side, optical media was adopted even earlier. As it was the biggest selling video game in history until 2002 (Walker 2002), the popularity of the 1993 CD-ROM only game, *Myst*, could be seen as the impetus that pushed the optical drive to dominance on PCs. Unfortunately, the lifespan of this disc based media is ultimately dubious. In a research report released by the US Library of Congress, the library found that “depending on susceptibility, wear, and environment, various layers of a CD may undergo oxidation, hydrolysis or mechanical stress, leading to damage (variously described as “rot” or “pin holes” or “mirroring”, etc.)” (Library of Congress 2009). However, the estimates for the life of a CD is unknown and estimates range widely from anywhere from 30 to 100 years (Blau 2006).

From these observations it might be concluded that maintaining content on the original digital carriers will not suffice long term preservation. What else can be done? If video game data is to survive it must be excised from its original carrier. This can be done by ripping (copying) the data on to a disk image.

³³ Every handheld portable gaming console has used one form of solid state cartridge or another with the exception of the first generation Sony PlayStation Portable (PSP). Every generation of the Gameboy and DS produced by Nintendo has used a cartridge including their newest system, the Nintendo 3DS. Other handhelds such as the Sega Game Gear and Atari Lynx have also used cartridge media. The Sony PSP used an enclosed optical disc called a Universal Media Disc (UMD) to contain their games for distribution. This is a rarity and early press reports suggest that Sony has dropped this optical disc format for a solid state cartridge in their upcoming next generation of the PSP (Sony Computer Entertainment Inc. 2011).

Long Term Data Storage

However, once the data has been copied from original carriers, the problem of storing this data remains. Fortunately, unlike digitized scans of film at 4K resolution, video game data is relatively small and manageable. With a few exceptions, most games have been limited to a single piece of media. 3.5" floppy disks could hold no more than 2.88 MB of data. The largest official game released for the NES was Kirby's Adventure which required only 6 MB total storage capacity (racketboy [sic] 2007). Because of this limitation, an entire collection of games released could fit a single dual layer DVD. But as already noted, there are problems with storing on optical media. What are the alternatives?

A major problem with storing on normal hard drives is that, hard drives are prone to eventual failure. The UNESCO guidelines state that magnetic hard drives have an expected usable life of only 5 years (UNESCU 2003). For this reason, storing on a single hard drive is not a very good long term strategy. There are at least two options. First is to initiate a more fluid style of migration strategy where the data is constantly moving from one hard drive to the next. This would prevent the data from being lost due to a single hard drive failure. The insurance of the data can be secured by using checksum technology and a RAID 1 hard drive setup which creates data redundancy. In addition, one may use solid state instead of magnetic hard drives. Solid state drives have no moving parts and thus are not prone to the same failures of magnetic drives. On the other hand, these drives are exponentially more expensive and have a theoretically limited number of times that such a drive can be written to. This is less of a problem for long term storage because, even when a solid state drive can no longer be written to, the data on it can still be accessed.

To summarize, the media used to distribute games was not developed for long term preservation. Thus, in order to preserve the video game content, one must separate it from its content holder to prevent its loss. Once the video game data is isolated, decisions are required concerning data storage and management.

Chapter 4: Current Trends in Video Game Development and Distribution Presenting New Problems for Preservation

It is fitting here to look toward the future. While it is tempting for preservation efforts to focus heavily on older games, it is also important to understand that video game development evolves and it is thus subject to change. For this reason, there should be an awareness of trends found in modern video game development and distribution because many of these new trends can be problematic for future preservation efforts. This is very important because the problems produced by these trends are unprecedented and far more difficult to overcome for long term preservation than the problems found with preserving the games a decade old or older. Hence, to better understand the future challenges, a brief review is presented.

Digital Distribution and Online Activation

In 2003, the Valve Corporation launched their online video game store, Steam (Valve Corporation 2003). By downloading the Steam client software, anybody with a credit card, a Windows PC, and an internet connection could purchase Windows games digitally³⁴. Through the Steam client, these games automatically download and install themselves directly to a computer. When a game is purchased through Steam, the purchaser is thereby granted a license to unlimited downloads (provided the availability of an internet connection). The game is then only accessible through Steam client software and only while the authorized user is logged in. Any games distributed exclusively on Steam (e.g. *Audiosurf* & *Shattered Horizon*) are reliant on the continuity of Valve's business activity. If the Valve Corporation were to go

³⁴ Valve initially started for Microsoft Windows only but on April 12th 2011, it became also available to Apple computers as well (Valve 2011).

bankrupt (worst case scenario), taking servers offline, the games would be rendered inaccessible to affected Valve customers. Because of Valve's software encryption, the games, even if stored on a local computer, would remain inaccessible³⁵.

Similarly, the Apple's iTunes App Store presents an interesting case. Games produced for any iOS device can only be purchased using Apple's iTunes store. Once a game is purchased on iTunes, game files can be backed up on a local computer without access to the internet. However, these games can only be run on an Apple iOS device that has been authenticated with the same account as the game purchased.

The use of online activation is not exclusive to Steam and iTunes. It is becoming increasingly prevalent for games -- especially for PC. Companies that implement online activation have justified it pursuant to digital piracy mitigation (Chalk 2010). To run a game, a host computer might have to contact an activation server on the internet in order to unlock the game (Sony DADC Global Home 2009). The implementation of activation software might entail nothing more than being run the first time the game is installed or as frequently as every 10 minutes. What is likely to occur when user interest in the game wanes to the extent that it is no longer economical for the company to maintain the activation servers? Companies may have no obligation to provide this service indefinitely or provide an alternative way of unlocking the

³⁵ It is possible to access these games using Steam's "off-line mode." However, this mode only works with games that have already been activated online once with the given computer, not to mention this service has had a history of being temperamental.

game after they are shutdown³⁶. The increasingly prevalent and hazardous trend of online activation makes preservation (without code alteration) especially challenging.

Downloadable-Only Content

Another trend found in modern game development is the utilizing of downloadable content (DLC). In this scenario, game publishers provide premium content that can be purchased in addition to a base game. With DLC, extra content, such as extra game levels or in-game items, can be purchased to extend or enhance the enjoyment of the game. As the name suggests, this content is exclusively acquired from the Internet, whether it is downloaded from Microsoft's Xbox Marketplace, Valve's Steam store, or elsewhere. As with the activation server and the online distribution situations hitherto mentioned, these servers, once turned off, no longer provide access to content. DLC is often heavily encrypted; there remains thus no convenient means of backup storage.

Dynamic Advertising

Finally, mention should be made of a trend which could be inadvertently overlooked. While actually commercial products have been advertised within video games for a while, the recent implementation of dynamic advertising systems has become increasingly prevalent. The example of a recent (large budget) game which includes dynamic advertising might be considered. In October of 2008, the roadside billboards in the car racing game *Burnout: Paradise* changed to a presidential campaign advertisement for Barack Obama in 10 states in the US (Sinclair 208). While advertising is often seen as a nuisance by many consumers, this in-

³⁶ Anybody who bought the game, *Prey*, from the online store, Triton, were fortunate when Triton went out of business because the original publisher of the game, 3D Realms offered free retail discs to those who had bought them. (Siegler 2006) This was out of courtesy rather than out of legal obligation so it is an exception instead of the rule..

game advertising is indeed part of the game. It also provides a challenge to preservation efforts. If the game was played after these advertisement servers were shut down, the billboards would either appear to be blank or have a generic fake advertisement in their place. Seeing advertisements is not desired by all game players. Yet, dynamic advertising is a part of contemporary video games and it will continue to provide a challenge to preservation³⁷.

These worrisome trends relate essentially only to recently published games and for this reason are unlikely to affect the preservation efforts of games produced before 2000. But it remains important not only to understand the problems of old video game preservation; it is also important to anticipate the possible nature of emergent problems.

³⁷ Personal Note: It must be noted here that I am not explicitly advocating for saving individual ads. I am only stating that because of the dynamic nature of these ads, the presentation will not be the same for people who play these games in the future. It is true that the advertisements found in television reruns are most likely not the same ads that were broadcasted originally. However, what makes advertising in video games different than television is that ads in video games are often part of the diegesis.

Conclusion

The age of cinema started little more than one century ago. In recent decades, a video game age has emerged. Many early films were not widely recognized as preservation-worthy until it was too late. It is presently estimated that most early cinema is lost forever. The video game is now indeed one of the dominate forms of entertainment in North America, Europe and parts of East Asia. However, video games are too often treated as disposable entertainment; for this reason many early video games are on the threshold of meeting the same fate as early films, if they have not already met it. Whether in response to interests cultural, academic, or economic, to the extent that video games are important to a large and diverse population, preservation is an intelligent and socially responsible course of action.

As video games are time-based media, one must move away from the narrow definition of conservation because they have little to do with 18th century views of art as Laurensen suggested. Attention must be balanced wisely between text and context because they are closely integrated in video games. The hardware which video games are played has not been standardized. The text of the game, *God of War 2*, for instance, can only be used within the context of the Sony PlayStation 2. Furthermore, game consoles are constantly and rapidly changing. Something can be done to preserve the game context. Yet, maintaining the mechanical operations of original console hardware is a tenuous approach at best. Because original contexts are impossible to maintain in perpetuity, emulation has been suggested as a possible solution to extend the life of the context. However, emulation has serious practical limitations. It is more of a replacement of the original context than preservation. Nevertheless,

as Laurensen stated “The reference state of object of the work has been replaced by the concept of the identity of the work which describes everything that needs to be persevered in order to prevent the loss of something of value” (Laurensen, Presentation of Authenticity, change and loss in the conservation of time-based media works of art 2006). Still, emulation, limitations notwithstanding may presently exist as the best tool for maintaining the games identity when the original context is too fragile or otherwise not available.

Ultimately, no preservation can ever be considered flawless, vis-à-vis the natural, ultimate certainty of entropy. Arguably, nothing cultural can be preserved forever. Therefore, informed preservation efforts will identify the extent to which they will work to preserve the identity of what they value. The defining properties must be determined and thus difficult compromises are to be expected. It may not be possible to preserve a context of the sofa cushions in living rooms in which a video game was played. It may be practically impossible to fully preserve the tactile sensation of the original controllers or the locations in which arcade and console video games were played. Yet, documentation and metadata can be composed pursuant to preserving to some extent some of the less tangibly preservable.

In a nutshell, actions should be taken now to preserve video games—especially because they are so uniquely susceptible to loss. Even in the best of conditions, original carriers of video games have fleeting lives. If efforts are to be made to protect these important artifacts, they should be made forthwith! There is so much about to be lost.

Bibliography

- National Media Museum. "National New Media Collection." *National Media Museum*. n.d.
<http://www.nationalmediamuseum.org.uk/Collection/NewMedia> (accessed April 16, 2011).
- Associated Press. "Atari Trying to Halt X-Rated Video Games." *Ocala Star-Banner*, October 17, 1982: 8B.
- Becker, Christoph, Mark Guttenbrunner, Carmen Kehrberg, and Andreas Rauber. "Evaluating Strategies for the Preservation of Console Video Games." *International Conference on Preservation of Digital Objects (iPRES 2008)*. London, UK, 2008.
- Blau, John. "Storage expert warns of short life span for burned CDs." *Computerworld*. January 10, 2006.
http://www.computerworld.com/s/article/107607/Storage_expert_warns_of_short_life_span_for_burned_CDs (accessed April 2, 2011).
- Brown, Mark. "Should Wikipedia Be Responsible for Gaming's History?" *Wired*. January 16, 2011.
<http://www.wired.com/gamelife/2011/01/wikipedia-gaming-history/> (accessed February 26, 2011).
- Card, James. "Silent Film Speed." *Image*, October 1955: 55-56.
- Caustik. *Cxbx, The Xbox Emulator -> News*. September 2, 2003. <http://www.caustik.com/cxbx/> (accessed December 27, 2010).
- Celemony Software GmbH. "Melodyne Update 1.2 with 64-bit and more." *Celemony*. October 27, 2010.
http://www.celemony.com/cms/fileadmin/press/docs/1010_PR_MelodyneUpdate_1.2_en.rtf
(accessed January 8, 2011).
- Chalk, Andy. "Ubisoft Details New Anti-Piracy Plan." *The Escapist*. January 26, 2010.
<http://www.escapistmagazine.com/news/view/97778-Ubisoft-Details-New-Anti-Piracy-Plan>
(accessed April 17, 2011).
- Cherrystone Software Labs Inc. "Algorithmic Performance Comparison Between C, C++, Java and C# Programming Languages: A Performance Comparison of Programming Languages." *Cherrystone Software Labs*. August 28, 2010.
<http://www.cherrystonesoftware.com/doc/AlgorithmicPerformance.pdf> (accessed December 28, 2010).
- Consalvo, Mia. "Console video games and global corporations : Creating a hybrid culture." *New Media & Society*, February 2006: 117-137.
- Cook, Terry. "What is Past is Prologue: A History of Archival Ideas Since 1898, and the Future Paradigm Shift." *Archivaria*, 1997: 17-63.
- Costikyan, Greg. "ESSAY; New Front in the Copyright Wars: Out-of-Print Computer Games." *New York Times*, May 18, 2000: 11.

- Cummins, Rob. "Interview with the Underdogs." *Review With Extreme Prejudice*. July 8, 2009.
http://www.reviewwithextremeprejudice.com/?page_id=49 (accessed October 31, 2010).
- DiGA e.V. "What is DiGA e.V." *The Digital Game Archive*. 2011.
<http://www.digitalgamearchive.org/diga.php> (accessed February 26, 2011).
- Diskin, Patrick. *Nintendo Entertainment System Documentation*. Unpublished, 2004.
- Douma, Eric. "Fair Use and Misuse: Two Guards at the Intersection of Copyrights and Trade Secret Rights Held in Software and Firmware." *IDEA: The Journal of Law and Technology*, 2002: 37-92.
- Ebert, Roger. "Video Games Can Never Be Art." *Roger Ebert's Journal*. April 16, 2010.
http://blogs.suntimes.com/ebert/2010/04/video_games_can_never_be_art.html (accessed April 16, 2011).
- Falcone, John P. "PS3 Slim: Everything you need to know." *CNET News*. August 19, 2009.
http://news.cnet.com/8301-17938_105-10313110-1.html (accessed December 4, 2010).
- Farivar, Cyrus. "RetroZone Intros NES, SNES Controller Adapters." *Engadget*. November 30, 2006.
<http://www.engadget.com/2006/11/30/retrozone-intros-nes-snes-controller-adapters/>
 (accessed January 8, 2011).
- Finn, Mark. "Console Games in the Age of Convergence." *Proceedings of Computer Games and Digital Cultures Conference*. Tampere, Finland: Tampere University Press, 2002. 45-58.
- Game Preservation SIG. *Game Preservation SIG/Contribution*. November 6, 2011.
http://wiki.igda.org/Game_Preservation_SIG/Contributions.
- Gilbert, Michael W. "Digital Media Life Expectancy and Care." *University of Massachusetts Office of Information Technologies*, 1998.
- Gooding, Paul, and Melissa Terras. "'Grand Theft Archive': A Quantitative Analysis of the State of Computer Game Preservation." *The International Journal of Digital Curation* 3, no. 2 (2008): 19-41.
- Guttenbrunner, Mark. *Digital Preservation of Console Video Games*. Vienna: Technischen Universität Wien, 2007.
- Guttenbrunner, Mark. *Digital Preservation of Console Video Games*. Vienna: Vienna University of Technology, 2007.
- Jenkinson, Hilary. *A Manual of Archive Administration Including the Problems of War Archives and Archive Making*. Oxford: Clarendon Press, 1922.
- Jenkinson, Hilary. "Reflections of an Archivist." *Contemporary Review*, no. 165 (Jan./June 1944): 355-361.

- Kehr, Dave. "Film Riches, Cleaned Up for Posterity." *The New York Times*, October 15, 2010: 2.
- Koninklijke Bibliotheek, Nationaal Archief, Planets, KEEP. *Frequently Asked Questions (FAQ)*. 2007. <http://dioscuri.sourceforge.net/faq.html> (accessed December 28, 2010).
- Laurenson, Pip. "Authenticity, Change and Loss in the Conservation of Time-Based Media Installations." *TATE*. 2006. <http://www.tate.org.uk/research/tateresearch/tatepapers/06autumn/laurenson.htm> (accessed October 26, 2011).
- . "Presentation of Authenticity, change and loss in the conservation of time-based media works of art." *Inside-installations*. May 11, 2006. http://www.inside-installations.org/project/detail.php?r_id=241&ct=maastricht.
- Lewin, James. "Celemony Melodyne Editor Now Available." *Sonic State*. November 17, 2009. <http://www.sonicstate.com/news/2009/11/17/celemony-melodyne-editor-now-available/> (accessed January 8, 2011).
- Library of Congress. *CD-ROM Longevity Research*. The Library of Congress, 2009.
- . "Library Holds Strategy Session on "Preserving Creative America"." *Library of Congress*. April 19, 2006. <http://www.loc.gov/today/pr/2006/06-096.html> (accessed February 12, 2011).
- . "The Library of Congress, 1800-1992." *Library of Congress*. March 30, 2006. <http://www.loc.gov/loc/legacy/loc.html> (accessed July 21, 2011).
- Liptak, Adam. "Minors Can Buy Violent Games, Justices Decide." *The New York Times*, June 28, 2011: A1.
- Lubell, Sam. "Bringing the Oldies To Modern Gamers." *The New York Times*, January 30, 2003.
- Mannoni, Laurent. "Henri Langlois and the Henri Langlois and the." *Film History: An International Journal*, 2006: 274-287.
- Mission*. n.d. <http://www.cah.utexas.edu/projects/videogamearchive/mission.php> (accessed November 6, 2011).
- Monnens, Devin. "Losing Digital Game History: Bit by Bit." In *Before It's Too Late: A Digital Game Preservation White Paper*, by Devin Monnens, Andrew Armstrong, Judd Ruggill, Ken McAllister and Zach Vowell, 3-8. 2009.
- Monnens, Devin. "Why are Games Worth Preserving?" In *Before It's Too Late: A Digital Game Preservation White Paper*, by Devin Monnens, Andrew Armstrong, Judd Ruggill, Ken McAllister and Zach Vowell, edited by Henry Lowood, 9-11. 2009.
- Online Archive of California. *Guide to the Stephen M. Cabrinety Collection in the History of Microcomputing, ca. 1975-1995*. n.d. <http://www.oac.cdlib.org/findaid/ark:/13030/kt529018f2> (accessed November 6, 2011).

- Oracle. "Oracle Buys Sun." *Oracle*. April 20, 2009. <http://www.oracle.com/us/corporate/press/018363> (accessed January 8, 2011).
- Pugh, Emerson W. "A Unified Product Line." In *IBM's 360 and Early 370 Systems*, by Emerson W Pugh, 157-164. The MIT Press, 1991.
- racketboy [sic]. "The Games That Pushed The Limits Of The NES." *Racket BOY*. December 12, 2007. <http://www.racketboy.com/retro/nintendo/nes/2007/12/best-nes-graphics-sound.html> (accessed April 3, 2011).
- Richtel, Matt. "New Xbox Goes on Sale at Midnight. Good Luck." *The New York Times*, November 21, 2005: 6.
- Rosenberg, Dave. "Video games outsell movies in U.K." *Cnet News*. December 31, 2009. http://news.cnet.com/8301-13846_3-10423150-62.html (accessed April 16, 2011).
- Ruggill, Judd, and Ken McAllister. "What if We Do Nothing?" In *Before It's Too Late: A Digital Game Preservation White Paper*, by Devin Monnens, Andrew Armstrong, Judd Ruggill, Ken McAllister and Zach Vowell, 16-19. 2009.
- Siegler, Joe. "Prey Update for Triton Customers." *3D Realms*. October 10, 2006. http://www.3drealms.com/news/2006/10/prey_update_for_triton.html (accessed August 14, 2011).
- Sinclair, Brendan. "Obama campaigns in Burnout, 17 other games." *Gamespot*. October 14, 2008. <http://www.gamespot.com/news/6199379.html> (accessed April 10, 2011).
- Sony Computer Entertainment Inc. "Sony Computer Entertainment Announces Its Next Generation Portable Entertainment System." *Sony Computer Entertainment Inc*. January 27, 2011. http://www.scei.co.jp/corporate/release/110127a_e.html (accessed April 9, 2011).
- Sony DADC Global Home. "SecuROM™ Product Activation: License information - Activation/Revocation." *SecuROM™*. 2009. https://support.securom.com/faq_pa.html#2.1 (accessed April 17, 2011).
- Steele, Max. "A Marginal Business." *The Escapist*. January 3, 2006. http://www.escapistmagazine.com/articles/view/issues/issue_26/159-A-Marginal-Business (accessed April 16, 2011).
- Terdiman, Daniel. "New Xbox 360 motherboards could mean fewer crashes." *CNET News*. September 30, 2008. http://news.cnet.com/8301-13772_3-10054436-52.html (accessed January 8, 2011).
- Tucker, S. G. "Emulation of Large Systems." *Communications of the ACM*, December 1965: 753 -761.
- UNESCO. *Guidelines for the Preervation of Digital Heritage*. United Nations Educational, Scientific and Cultural Organization, 2003.

- Valve Corporation. "Steam Client Released." *Steam*. September 12, 2003.
<http://store.steampowered.com/news/183/> (accessed April 10, 2011).
- Valve. "Steam for the Mac Released." *Steam*. May 12, 2011.
<http://store.steampowered.com/news/3818/> (accessed July 25, 2011).
- Vowell, Zach. "What Constitutes History?" In *Before It's Too Late: A Digital Game Preservation White Paper*, by Devin Monnens, Andrew Armstrong, Judd Ruggill, Ken McAllister, Zach Vowell and Rachel Donahue, 12-15. 2009.
- Walker, Trey. "The Sims overtakes Myst." *Gamespot*. March 22, 2002.
http://www.gamespot.com/pc/strategy/simslivinlarge/news_2857556.html (accessed April 0, 2011).
- Wildgoose, David. *Valve Appealing, Editing Left 4 Dead 2 for Aussie Classification*. October 7, 2009.
<http://www.kotaku.com.au/2009/10/valve-appealing-editing-left-4-dead-2-for-aussie-classification/> (accessed February 27, 2011).

Appendix 1: List of Video Game Examples:

Game Title	Original Release Date*	Developer*	Publisher*	Platform(s)*	Pages Mentioned
Audiosurf	February 2008	Dylan Fitterer	NA	Windows	p.37
Burnout: Paradise	January 2008	Criterion Games	Electronic Arts	PS3, Xbox 360, Windows	p.39
Custer's Revenge	October 1982	Mystique	Mystique	Atari 2600	pp.14-15
God of War 2	March 2007	SCE Studios Santa Monica	Sony Computer Entertainment	PS2	p.41
Halo: Combat Evolved	November 2001	Bungie	Microsoft Game Studios	Xbox, Windows, Mac OS X, Xbox 360	p.15
Kirby's Adventure	March 1993	HAL Laboratory	Nintendo	Nintendo Entertainment System, Game Boy Advance	P.35
Left 4 Dead 2	November 2009	Valve Corporation	Valve Corporation	Windows, Xbox 360	p.14
Myst	September 1993	Cyan	Brøderbund	Mac OS, Saturn, Windows, Jaguar CD, 3DO, CD-i, PlayStation, AmigaOS, PSP, Nintendo DS, iOS	p.34
Prey	July 2006	Human Head Studios	2K Games	Windows, Xbox 360, Mac OS X, Linux	p.39
Shattered Horizon	November 2009	Futuremark Games Studio	Futuremark Games Studio	Windows	p.37
Super Mario Brothers	September 1985	Nintendo Creative Department	Nintendo	Nintendo Entertainment System, Family Computer Disk System, Super Nintendo Entertainment System, Game Boy Color, Game Boy Advance,	p.24 & p.25
Wolfenstein 3D	May 1992	id Software	Apogee Software	MS-DOS, Mac, Amiga 1200, Apple IIGS, Acorn Archimedes, NEC PC-9801, SNES, Jaguar, GBA, 3DO, Windows Mobile, iOS, PlayStation Network, Xbox Live Arcade, Nintendo 3DS	p.15

* Source Wikipedia (Accessed on July 27 2011)

Appendix 2: List of Video Game Consoles Mentioned:

Console Name	Manufacturer*	Original Release Date*	Discontinued Date*	Pages Mentioned*
Atari 2600	Atari, Inc.	October 1977	January 1992	pp.9 & 14
Dreamcast	Sega	November 1998	March 2001	p.34
Master System	Sega	October 1985	1998	p.33
Mega Drive (aka Sega Genesis)	Sega	October 1988	1997	p.33
Nintendo Entertainment System	Nintendo	July 1983	September 2003	pp.16 & 35
Super Nintendo Entertainment System	Nintendo	November 1990	September 2003	p.27
PlayStation	Sony Computer Entertainment	December 1994	March 2006	pp. 27 & 34
PlayStation 2	Sony Computer Entertainment	March 2000	Still available	pp.20, 24, 27, 34, & 41
PlayStation 3	Sony Computer Entertainment	November 2006	Still available	pp.27 & 34
PlayStation Portable	Sony Computer Entertainment	December 2004	Still available	p.34
Wii	Nintendo	November 2006	Still available	pp.20, 25
Xbox	Microsoft	November 2001	2006	pp.25 & 34
Xbox 360	Microsoft	November 2005	Still available	pp.20, 27, 28

* Source Wikipedia (Accessed on July 27 2011)

Appendix 3: Glossary

Abandonware	Similar to orphan works, abandonware is software that distribution and support has been discontinued and current copyright holder is unclear. The legality of abandonware is a grey area.
Abandonware websites	Websites that hosts abandonware software. The legality of abandonware websites is a grey area.
Audio Samples	Analog audio that has been converted into a digital audio format. Often used with audio synthesizer technology where a single digital recording of a music instrument would be played back at different speeds to produce different musical pitches.
Australian Classification Board*	<p>"The Australian Classification Board is a statutory classification body formed by the Australian Government which classifies films, video games and publications for exhibition, sale or hire in Australia since its establishment in 1970." - From Wikipedia entry (Accessed on July 29, 2011)</p> <p>The board has been infamous for effectively banning games with mature content because the classification system lacked a classification category for mature audiences. This is in the process of receiving an overhaul.</p>
Backwards Compatibility	The ability of previous versions of hardware or software to operate within more modern platforms and environments.
C	Popular low-level programming language.
C++	Popular low-level programming language. Based on C but included Object-Oriented coding capabilities.
Checksum*	"A checksum or hash sum is a fixed-size datum computed from an arbitrary block of digital data for the purpose of detecting accidental errors that may have been introduced during its transmission or storage" - From Wikipedia entry (Accessed on July 29, 2011)
Compile	The process of using a compiler to translate programming code into another language, such as machine specific code.
Console	See Game Console
CPU	The Central Processing Unit is the mathematical center of the computer. Often compared to the human brain.
Digital Game Archive	Internet archive which focuses on video games. www.digitalgamearchive.org
Emulation	Interpreting machine code from one device on another device by mimicking CPU/chip hardware
Emulator	A program that operates some form of emulation.
Firmware*	"In electronic systems and computing, firmware is a term often used to denote the fixed, usually rather small, programs and/or data structures that internally control various electronic devices." - From Wikipedia entry (Accessed on July 29, 2011)
Gamasutra	An Internet portal for the business side of video games. It is notable for its news and job posting services.
Game Console	Single purpose hardware devices designed primarily to play video games. Often closed source
Game Developers Conference*	"The largest annual gathering of professional video game developers, focusing on learning, inspiration, and networking. The event comprises of an expo, networking events, awards shows such as the Independent Games Festival and the Game Developers Choice Awards, and a variety of tutorials, lectures, and roundtables by industry professionals on game-related topics covering programming, design, audio, production, business and management, and visual arts." - From Wikipedia entry (Accessed on July 29, 2011)
Game Politics	Internet blog dedicated to news articles that cover political interaction with video games. www.gamepolitics.com
Game Studies*	"Game studies or the new modern term "gaming theory" is the discipline of studying games, their design, players, and their role in society and culture more broadly." - From Wikipedia entry (Accessed on July 29, 2011)
GDC	See Game Developers Conference
GPU	Graphical Processing Unit. Dedicated chip designed for graphics processing. Often engineered for high parallel processing efficiency
Graphics Card	Expansion card for GPU. See GPU
Hard Drive*	"a non-volatile, random access digital data storage device. It features rotating rigid platters on a motor-driven spindle within a protective enclosure. Data is magnetically read from and written to the platter by read/write heads that float on a film of air above the platters." - From Wikipedia entry (Accessed on July 29, 2011)
Hardware	Physical mechanical devices.
Home of the Underdogs	Popular and heavily controversial abandonware website. Now defunct.
International Game Developers Association*	"professional society for over 10,000 video and computer game developers worldwide" - From Wikipedia entry (Accessed on July 29, 2011)
Java	Interpretive object-oriented programming language. Notable for its good compatibility but poor memory management and slower performance.
Java Virtual Machine	Closed source virtual machine that interprets Java code into machine code at runtime.
Kotaku	Web Blog focused on video games. Owned by Gawker Media. www.kotaku.com
Localization	The process of translating a product to a different market or region.
Machine code*	"System of instructions and data executed directly by a computer's central processing unit." - From Wikipedia entry (Accessed on July 29, 2011)
Magis - Gorizia International Film Studies Spring School Conference	Annual film studies PHD conference located in Gorizia, Italy.
Open-Source Software	Computer software, where the source code is made accessible by the developer for the purpose of allowing anybody to improve on it..
Operating System*	"software, consisting of programs and data, that runs on computers, manages computer hardware resources, and provides common services for execution of various application software" - From Wikipedia entry (Accessed on July 29, 2011)

Optical Drive	"disk drive that uses laser light or electromagnetic waves near the light spectrum as part of the process of reading or writing data to or from optical discs." - From Wikipedia entry (Accessed on July 29, 2011)
Patch	See Software Patch
PC/Personal Computer	Consumer or general-use computer.
Port	Modifying the source code of a program so that it can be compiled for a different hardware environment
Problem of the Original	Controversial topic in film preservation. Deals with complicated nature of authenticity.
Processor	See CPU
RAID*	"a technology that provides increased storage functions and reliability through redundancy." - From Wikipedia entry (Accessed on July 29, 2011)
RAM	Random Access Memory. Can be thought of as an equivalent to short term and working memory in the human brain but for computers.
ROM	Read Only Memory. Type of digital memory storage that was often used to distribute video games. Notable for its durability and quick access speed
ROM Images	Abstracted data storage. Includes data and data location.
ROM Site	A website that provides access to ROM data. Often this ROM data is of video games. The legality of ROM sites is a grey area.
Simulation	Interpreting machine code from one device on another device by mimicking the original device as a whole on the new device
Software	Set of nonphysical instructions which are executed by a computer.
Software Patch	A software modification that fixes or improves a program. Also can add features to an existing program.
Swag	Promotional (often free) gifts given out to potential customers or distributors to increase awareness of a new or upcoming product. Often distributed at trade shows and conventions. Examples include: Posters, T-shirts, and key chains
Video Game Console	See Game Console

* Source Wikipedia (Accessed on July 28 2011)