

Serious Games for and as Cultural Heritage

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Abstract. Contemporary methods of preserving cultural heritage rely highly on digitization and archiving as foundations for developing various virtual heritage applications. During last two decades, video games proved to be an interactive visual media able to incorporate virtual heritage in amazing and highly appealing ways. At the same time, each video game represents a valuable artifact reflecting technological, socioeconomic and historical issues of its creation. Therefore, video games are an essential and integrated part of modern cultural heritage and themselves need preservation efforts. The present paper discusses video games as a modern tool for presenting cultural heritage by integrating art, storytelling and digital technology. It focuses on both entertainment games and serious games for cultural heritage and provides some illustrative examples of such games with discussing their approach and novelty. On the other hand, video games are viewed as interactive artifacts that are a valuable part of the modern cultural heritage, which requires specific efforts for their preservation together with technological platforms and gaming environment.

Keywords: video games, cultural heritage, entertainment, serious games.

1 Introduction

In the last decades, institutions developed many initiatives for digitizing cultural heritage objects worldwide [1] such as archaeological, architectural, sculptural, fine arts and other artifacts with a universal value for the mankind. Beside such tangible cultural artifacts [2], intangible cultural heritage such as traditions, events, expressions, knowledge and skills [3] are also objects of digitization. Much effort was put into creating appropriate standards for metadata descriptions [4] and using them in collections and archives of digitized records. Digitized records of intangible cultural objects were used for producing realistic 3D models and applications as so-called virtual heritage recreating their contemporary or ancient view [5]. Virtual environment often includes augmented reality allowing users to interact with the 3D models using real objects in real time [6], by means of registering virtual images with the real world.

By recreating artifacts of tangible cultural heritage such as ruins, cities and monuments, virtual environments and applications provide high level of user immersion. They allow visitors to walk and to navigate through virtual 3D spaces but lack ade-

quate interactive features expected by their users [7]. On the other hand, virtual and augmented reality environments recreate tangible cultural and historical objects but not intangible elements of cultural heritage like traditional rituals, events, legends and skills [8]. This is reason to look for a more interactive and dynamic visual media, which is capable to use existing 3D recreation of habitations, buildings and interior but adds to them interactive interfaces sufficient for reproduction of intangible cultural elements.

Digital games appear to be exactly such a visual media able to recreate both tangible and intangible cultural artifacts in a highly interactive and dynamic way. They provide a powerful and increasing appeal and engagement for all user ages by possessing an integrated form of fun and play [9]. Prensky [10] explains their high attractiveness by defining twelve structural elements typical for any game and their effect on the player, as follows:

1. form of fun—provides enjoyment and pleasure;
2. form of play—gives intense and passionate involvement;
3. rules—determine structure of the play;
4. goals—provide motivation;
5. interactivity—leads to learning by doing;
6. adaptivity—provides flow;
7. outcomes and feedback—serve as a basis for learning;
8. win states—provides ego gratification;
9. conflicts, competition, challenges and opposition—give more adrenaline;
10. problem solving—sparks players' creativity;
11. interaction—gives social groups;
12. narrative (story) and its representation—both serve as a source of emotional experience before, during and after gameplay.

Digital games have progressed a lot since their invention in the early seventies of the last century until today. Unlike the first digital games oriented to textual content and representation, modern games exploit 2D and 3D video technologies and extensively use multimedia content [9]. Thus, modern digital games are predominantly video games and, thus, when speaking about digital games and their overall impact people mean exactly video games.

Playing both entertainment and serious video games has proven benefits for the cognitive (like enhanced attention, creativity and problem-solving skills), motivational (developing beliefs about intelligence and abilities, persistence to failures and learning by failure), emotional (flow experience, mood management and adaptive emotional regulation skills), and social (pro-social behavior and civic engagement) behavior and skills of the player [11]. These benefits, together with their interactivity and high social penetration, make video games a powerful tool for presentation and popularization of cultural heritage. On other hand, video games are part of the digital heritage, though not explicitly named within the UNESCO 'Charter on the Preservation of Digital Heritage' [12], therefore their preservation should be planned and implemented together with their technological platforms and necessary gaming environment.

This article discusses video games as a high-impact visual media useful for cultural heritage preservation by integrating art, storytelling and digital technology. It introduces entertainment games and describes their character and main features. Next, it discusses how these two groups of video games are used for cultural heritage and gives some examples of such games. In addition, the article shows what type of action should be taken in terms of preservation of video games as an important part of the modern digital heritage and contemporary human culture in global aspect. Finally, the paper discusses technological, artistic and socio-economic challenges posed to modern video games for cultural heritage.

2 Modern Video Games

There are many approaches to embrace existing genres of digital games and to order them into an appropriate classification. A game genre should concentrate “*on the types of interactions that are available in the game, as distinct from the visual iconography*” [13]. Many classifications propose discrete types of games, without organizing them into a dimensional continuum. Unlike the discrete classification, other approaches try to organize game genres with a dimensional space. Vosen [14] proposed a three-dimensional game classification space defined by competitiveness, interactivity, and physical location. The author distinguished three possible confrontations of game types:

- competitive versus noncompetitive games;
- interactive versus non-interactive games;
- physical versus non-physical games.

Other dimensions (categories) for classification of video games were proposed by Apperley [13], namely:

- platforms—hardware systems used for playing the game; vary from personal computers, game consoles like Microsoft Xbox, Nintendo Wii U, or Sony PlayStation 2;
- playing mode—multi- or single-player;
- milieu—describes the visual type of a video game; can be science fiction, fantasy, horror, etc

Additionally, some other categories could be added to the above list, such as:

- distribution—paid or free;
- openness—games with open code or not;
- mod’s—modified games with altered content than the original release;
- linear vs. non-linear gameplay—while linear gameplay provides fixed sequence of challenges stated to the player, nonlinear gameplay poses challenges that can be completed in different sequences;

- progressive vs emergent gameplay—some games (like ‘The Sims’¹) do not have a story structure planned in advance and thus offer emergent gameplay [15].

In general, there are two main classes of modern video games today, naturally formed through the decades—entertainment and serious games.

2.1 Entertainment Video Games

Entertainment games (or games for fun) are digital games created with the chief intent to amuse their players. The most fresh view of the entertainment game taxonomy currently available at the game market is provided by the Entertainment Software Association (ESA) within their last issue of ‘Essential Facts About the Computer and Video Game’ [16]. Fig. 1 below presents a view of distribution of best-selling video game genres by units sold for 2014.

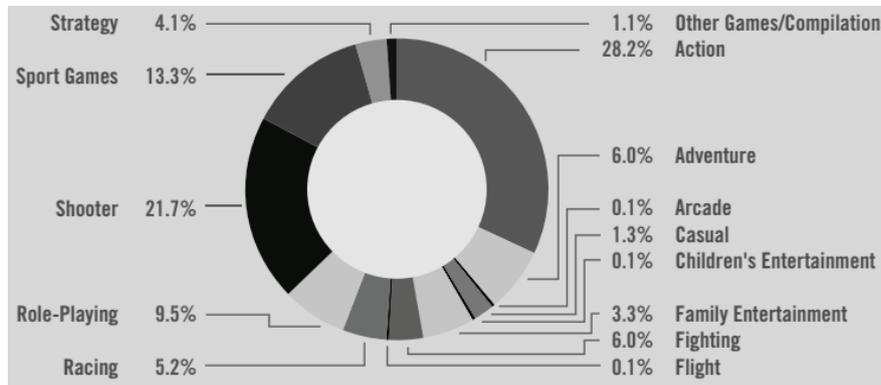


Fig. 1. Distribution of best-selling video games genres by units sold for 2014 [16].

Note that fig.1 does not present real popularity rates of existing video games, because it pictures only relative shares of game sales but does not show indexes of free and indie games played on Web. Nevertheless, according to this distribution, the following types of entertainment video games (ordered from most to less popular) can be listed:

- Action games—includes action-intensive games where players have to go through obstacles of various types in restricted time. The challenge can be increased step-wise according to the progression of the player requiring more and more accuracy, fast reflexes and other skills. The Pong game (a ball-and-paddle game) was the first action game [17] developed in 1972 on a home console. Another famous action game was ‘Pac-Man’ released as arcade game in 1980 and modified many times since its creation [18]. Platform games (platformers) like Nintendo's ‘Super Mario Bros’ and its public domain clone ‘Infinite Mario Bros’ [19] are the most popular

¹ <https://www.youtube.com/user/TheSims>

action game, where players start to travel between different types of platforms (often generated dynamically) by jumping from one to another.

- Shooter games (or shooters)—represent various types of combat with guns, missiles, knives, and weapons. While ‘Wolfenstein 3D’² was released for DOS in 1992, ‘Doom’³ was the first multi-layer shooter game at the market. Depending on the camera perspective, there may be first person shooters (FPS), third person shooters (the camera perspective shows the player character at a distance in 3D space), and 2D shooter games (with a camera perspective over a 2D space).
- Sport games—based on simulation of playing traditional sports like football or tennis. Popular examples of sport games are ‘Madden’⁴ and FIFA ‘Soccer’⁵.
- Role-playing games (RPG)—the RPG genre is especially important for the game industry thanks to its attractiveness to the games society, which is explained by its character transformations that the character goes through [13]. The character evolves within a role fantasy world (like that one of ‘Dungeons & Dragons’⁶) with strictly defined parameters.
- Fighting games—the genre includes hundreds of one-on-one combat games, where combats can be of various types but usually between two characters player against player or player against a non-player character (NPC) controlled by the computer. Among the first ring fighting games were ‘Heavyweight Boxing’ and ‘Greatest Heavyweights’⁷ (by Sega), released respectively in 1976 and 1994 with great success.
- Adventure games—the first computer games in the seventies of the last century were adventure games. Such games provide a gameplay with various adventures, whereupon the player is asked to solve puzzles in order to proceed with the story. Although adventure games attract people who do not usually play games, their popularity slows down after the great success of ‘Myst’⁸.
- Racing games—include races mainly with cars⁹ but also with rockets, motorcycles, bicycles and horses.
- Strategy games—require strategic play whose evolution “*comes from a combination of knowing the various options available and being able to correctly value them within the game context*” [13]. The genre includes real time strategy (RTS) and turn-based strategy (TBS) games. Strategy games such as Sid Meier's ‘Civilization’¹⁰ are also known as 4X games (from eXplore, eXpand, eXploit and eXterminate).
- Family entertainment games—various games to be played at home by all the family.

² <http://3d.wolfenstein.com/>

³ <https://www.youtube.com/watch?v=nnaPB30oKQM>

⁴ <https://www.youtube.com/watch?v=nUiBJy150rg>

⁵ <https://www.youtube.com/watch?v=siVeBCaYeko>

⁶ <https://www.youtube.com/watch?v=9gneSq8Xbzw>

⁷ <https://www.youtube.com/watch?v=aj4ofGicDYQ>

⁸ <https://www.youtube.com/watch?v=buM-y61RkIo>

⁹ <http://www.gametop.com/category/car-racing.html>

¹⁰ <https://www.youtube.com/watch?v=yEl9kl2Aluw>

- Other types of games (with shares less than 2%)—casual games, flight simulators, board games, etc.

2.2 Serious Video Games

The genres presented concern only entertainment game industry producing games for fun. In contrast with them, serious games (SGs), also called applied games or games with purpose, are designed with a special intent different than pure entertainment [9]. There are many existing definitions of SG but perhaps the most summarizing and appropriate are these two, as follows:

- SGs provide a “*mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives*” [20];
- SGs refer to a broad range of video games “*produced, marketed, or used for purposes other than pure entertainment; these include, but are not limited to, educational computer games, edutainment and advertainment*” as far as “*health games and political games*” [21]. The authors also underline that theoretically any video game can be viewed as a SG depending on the players’ perception of the gaming experiences.

Several taxonomies of SGs have been proposed but the most detailed one appears to be Sawyer and Smith’s [22]. Their SGs taxonomy has two dimensions:

- content dimension of SGs—includes games for health, advergaming (advertising games used for marketing), games for training, for education, for science and research, production, and games as work;
- sectoral dimension of SGs: government & NGO, defense, healthcare, marketing & communications, education, corporate, industry.

However, even such broad taxonomies may not be exhaustive. For example, missing are political games such as ‘Darfur is Dying’ [21] which are intended to provoke a change of the player’s viewpoint. Another missing sector is that one of games for cultural heritage [23] including cultural content, narratives and tasks by means of virtual and augmented reality techniques [6, 20].

Many of the categories defined by Sawyer and Smith [22] can be divided in sub-categories. For example, Egenfeldt-Nielsen et al [21] outline three sub-categories of educational serious games:

- edutainment—games like ‘PowerUp’,¹¹
- commercial entertainment titles used for education—such as ‘The Sims’;¹²
- research-based educational games—special educational SG like ‘Global Conflicts: Palestine’.¹³

¹¹ <http://www.powerupthegame.org/>

¹² <https://www.youtube.com/user/TheSims>

Although all are video games, entertainment games and SG have essential differences. Susi et al [24] summarize these differences regarding four criteria: task vs. rich experience, focus, simulations, and communication (Table 1). It is important to underline that pedagogy should be an implicit but not the main component of any SGs because if a SG is no fun while played it will be no game at all [20].

Serious games gained a great popularity in the beginning of this century and proved their effectiveness in many case studies [24]. As summarized by Anderson et al. [23], their main strengths are in “*communication, visual expression of information, collaboration mechanisms, interactivity and entertainment*”. However, the initial enthusiasm slowed down during past eight because of some inflated expectations and limitations of serious games. First at all, SGs have some pedagogical limitations. As Brisson et al. [25] noted recently, SGs have to provide answers to two general problems: (1) to what level SG support and promote learning effectiveness and efficacy, and (2) how to support the pedagogically-driven design of SG by relating content (knowledge plus game mechanics) and players’ experiential context to learning goals.

Second, SGs suffer from significantly lower performance and audio-visual quality compared to the entertainment game, which naturally creates less fun during gameplay. And last but not least—SGs have a much higher price and require greater time than other technologically enhanced leaning methods.

Table 1. Differences between entertainment games and SG [24].

Criterion\Games	Serious games	Entertainment games
Task vs. rich experience	Problem solving in focus	Rich experiences preferred
Focus	Important elements of learning	Fun
Simulations	Assumptions necessary for workable simulations	Simplified simulation processes
Communication	Should reflect natural (non-perfect) communication	Communication is often perfect

Methodological research questions and expectations to SG were well formulated by Mayer et al [26] as follows:

- requirements and design principles for a comprehensive social methodology for SG evaluation;
- extent of SG contribution to technology advanced learning;
- main factors contributing to an effective game-based learning;
- level and conditions for transferring learning through games to the practice.

The same methodological issues remain valid for the area of serious video games cultural heritage as well.

¹³ <https://www.youtube.com/watch?v=0bxmX0YeYUY>

3 Video Games for Cultural Heritage

Unlike other traditional media, video games are capable to deepen our understanding and feelings of cultural heritage in a very interactive way. Salen and Zimmerman [27] stated that all video games always somehow reflect human culture because they are "*objects produced and played within culture at large*", however, "*not all games manifest transformative cultural play to actually transform culture*". Therefore, when discussing video games for cultural heritage, we have to consider both entertainment and serious games.

3.1 Entertainment Video Games for Cultural Heritage

Many existing commercial entertainment video games can be used for non-leisure purposes, including presenting cultural heritage [23]. Most belong to the so-called documentary games [28] depicting realistically past historical events such as battles and wars. Though they are developed as games for fun, they can be used for educational purposes thanks to their historical accuracy and realism. Some examples of documentary games are ‘History Line: 1914-1918’ (Blue Byte, 1992)—one of the earliest turn-based strategy games presenting battles dating back to the First World War; ‘Great Battles of Rome’ (Slitherine Strategies, 2007)—an entertainment video game mixing interactive 3D real-time tactics of actual battles with documentary information; and ‘Napoleon: Total War’ (Creative Assembly, 2010), providing immersive historical setting enriched with important information about real events.

Granström [29] conducted a study aiming at identifying key elements incorporated in virtual heritage applications and analyzing their occurrence in four renowned entertainment video games. In a literature review of 22 surveys and research articles about virtual heritage environments, she found 17 important key elements, as follows:

- Interactivity—“*ability to affect, use or communicate with something or someone in a digital or virtual environment*”; includes exploration of environments, meaningful tasks to complete, dialogue—between players or with a non-player character (NPC), and quizzes;
- Meaning—incorporates culture and history (i.e., intangible heritage [23]) and story (interactive narrative);
- Player character—role-play (in a historical environment), 3D avatar (visual equivalent of the player in the virtual world), and its personalization;
- Others elements—inclusion of NPC as virtual (inter)active inhabitants and multi-player mode;
- Cultural and historical/visual and behavioral/environmental/auditory/olfactory accuracy and realism.

For presence of these 17 key elements, four famous 3D role-playing and action adventure games were analyzed, namely ‘The Elder Scrolls V: Skyrim’ (Bethesda Game Studios, 2011), ‘Mass Effect’ (BioWare and Demiurge Studios, 2008), ‘Assassin’s Creed II’ (Ubisoft Montreal, 2009), and ‘Red Dead Redemption’ (Rockstar San Die-

go, 2010). Most of the elements were found in these games except quizzes and cultural and historical/olfactory accuracy and realism.

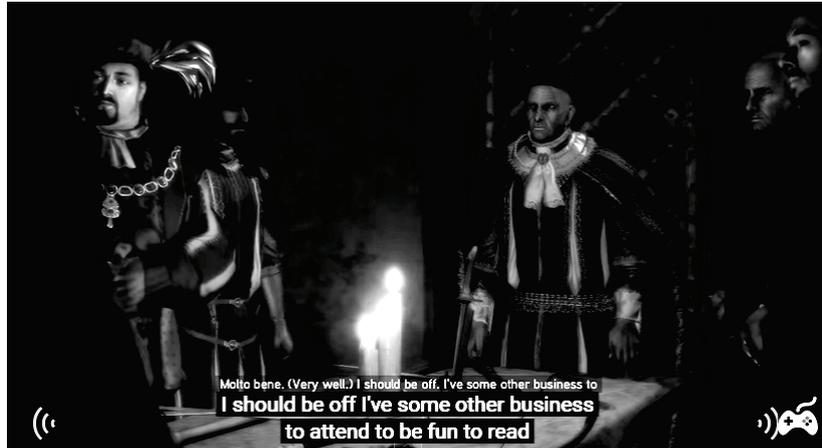


Fig. 2. Screenshot with recreated historical characters of Assassin's Creed 2 gameplay.



Fig. 3. Screenshot of Assassin's Creed 2 gameplay.

Two of the games, though meant for fun, very much resemble applied games for cultural heritage. 'Assassin's Creed II' is a 3D action adventure game presenting the Renaissance epoch in Italy during the 15th century with great cultural, visual and behavioral accuracy and realism. The game recreates famous historical characters such as Niccolò Machiavelli, Pope Alexander VI, the Pazzi family, and Leonardo da Vinci, although not all the characters are historically accurate (fig. 2). Nevertheless, the spirit of the epoch is transmitted very realistically together with virtual recreations of locations and buildings of the real world. Another entertainment game focused on cultural heritage and analyzed in [29] is 'Red Dead Redemption' (Rockstar San Die-

go, 2010)—a 3D action adventure game representing the American–Mexican border at the beginning of the 20th century (fig. 3). Having excellent narrative and roleplay, this multiplayer depicts a *"period of great change between this savage, horrendous world with delusions of nobility evolving into modern society"* [30]. The game allows emergent game play by using the Free Roam option, which switches to no-narrative mode offering various activities like free roaming, looking for treasures, hunting animals, taming wild horses, and many others.

3.2 Serious Video Games for Cultural Heritage

Although having traditionally much smaller budgets compared with games for fun, serious (or applied) heritage games advanced a lot during last years using real-time interactive simulation of realistic virtual heritage scenarios, virtual and augmented reality [6, 20], and artificial intelligence [24]. As a tool for learning cultural heritage, SGs possess incredible potential thanks to offering free choice of learning place, flexible time-management, choice of learning time and speed, autonomous learning in the game context, self-controlled learning, problem-solving, systemic-thinking and willingness for cooperation [31]. SGs for cultural heritage fall in several main categories:

- A. interactive virtual museums—use gaming technology for both entertaining and educating visitors [32] usually by incorporating some exploration and reassembling tasks and quizzes. Examples of museum games are ‘Virtual Egyptian Temple’, ‘Olympic Pottery Puzzle’, ‘Walk through Ancient Olympia’ [23] and ‘ThIATRO’ [33];
- B. prototypes and demonstrators—games based on 3D virtual reconstruction 3D and geo-referenced modeling of ancient historical sites like the ‘Pompei: The Legend of Vesuvius’ edutainment game [34] (fig. 4a) and ‘Roma Nova’ SG [35] based on the Rome Reborn model [36], which provide not only realistic archaeological exploration with historical accuracy but also political, religious and artistic walkthrough with crowd restoration of ancient characters with procedurally generated NPC;



Fig. 4. Gameplay of ‘Pompei: The Legend of Vesuvius’ (a) and brain-control field trial of ‘Roma Nova’ [35] (b).

- C. games for acquisition of cultural knowledge and intangible heritage—include intercultural skills and language training games with high-fidelity 3D simulation of cultural settings. Examples of such games are ‘Croquelandia’, ‘Adaptive Thinking and Leadership System’ (ATL), ‘Second China’, the Tactical Language and Culture Training System (TLCTS), BiLAT, and the ‘Virtual Environment Cultural Training for Operational Readiness’ (VECTOR) [37];
- D. social tagging and knowledge acquisition games—SG for encouraging players to submit accurate information about cultural artifacts embedded into the games for further knowledge verification and mining. ‘One-Up’ is a multi-round mobile crowdsourcing metadata tagging game [38] fostering players to propose high-quality metadata and rewarding them based on metadata specificity and accuracy. ‘Waisda?’ [39] is a video labeling game used to annotate TV heritage by integrating tags with professional annotations.

Besides these four groups, there exist SG using cultural heritage-specific technologies such as augmented reality, which can be applied to each of the groups. Another example is game adaptation according to the cognitive and emotional state of the player. The brain-controlled modification of the prototype game ‘Roma Nova’ [35] uses an Emotiv Epoc headset for detection of cognitive and facial changes and applying them for gameplay adaptation (fig. 4b).

4 Video Games as Cultural Heritage

Being interactive media with ever growing impact, video games themselves are part of the human movable cultural heritage. They are artifacts representing development level of visual art and information technology typical for the time of their creation. Games about James Bond (007), Batman, or other famous personages are played by people of all ages and reflect many aspects of society and history [40]. However, due to hardware obsolescence and data degradation most of the first video games might be lost forever in a similar way to lost films produced in the beginning of last century. In fact, this has already happened to the arcade games. Not only will this be a significant loss for their players who feel nostalgia and keep nice remembrances of past gaming time, but even more importantly, out-of-date games preserve a snapshot of the technological and socio-economic achievements of their epoch and provide evidence of the progress in game industry evolution.

Preserving game software together with its artistic or cultural content should include various aspects of video games and virtual worlds such as narrative, artistic objects, game mechanics and, eventually, documentations, gameplay videos, historical facts and game environment. Emerging NGOs like the Video Game Heritage Institute¹⁴ try to preserve these old video games by maintaining archives of game copies with all the hardware necessary to play them and, as well, game libraries with original hardware and software equipment needed to play each game. There are many video

¹⁴ <http://vghi.org/>

game museums (online archives^{15,16}, onsite¹⁷, or both^{18,19}) showing the story of most prominent video games and their cultural impact. Other museums host video game exhibitions, such as Museo Games (hosted at the French Conservatoire national des arts et métiers) and Game Story (at the Paris Grand Palais) [41], or provide temporary hosting for traveling video game exhibitions [42].

Preservation of video games and other types of digital games is part of the overall preservation of digital content worldwide. In 2004, the Game Preservation Special Interest Group (GPSIG) was founded and since then consolidates effort of organizations and individuals for preservation of video games [43]. GPSIG works closely with museums and digital archives for organizing conferences and other events and developing game studies and specialized research projects such as the Preserving Virtual Worlds (PVW) project [44] aiming at developing methods for preservation of digital games and interactive virtual environments. The PVW project analyzed popular video games such as ‘Doom’ and ‘Warcraft III’ and 3D virtual networked client-server component-based environments like ‘Second Life’ in terms of hardware and software obsolescence, scarcity, third party dependencies, lack of code documentation, authenticity, IPR and context. The authors [44] analyzed the dependence of the restoration of electronic game equipment on the type of artifact, including acquiring old hardware, emulations and virtualizations, migrations and reenactments. As a foundation for developing standards for metadata and content representation appropriate for long-term archival storage, the Reference Model for an Open Archival Information System (OAIS) has been accepted. The OAIS Archival Information Package Data Model was proposed for metadata and packaging descriptions. Another similar project concerning game metadata and citations in institutional collections is the ‘Game Metadata and Citation’ project²⁰. Future emerging open standards for virtual worlds and video games will facilitate such efforts for digital preservation of video game cultural heritage.

5 Discussion

Video games made an enormous progress since their infancy until modern times. They entered successfully various content domains including that of cultural and historical heritage. However, dynamic in evolution and market volumes of commercial entertainment games still supersede greatly that of serious, or applied, games. First of all, their average budgets differ dozens of times. For example, the total cost of developing and marketing expenses of Skyrim was about 85 million USD [29] while most of the serious games have funding of from dozens up to hundreds thousands of USD. Nevertheless, both games for fun and applied games for cultural heritage meet many

¹⁵ <http://www.vgmuseum.com/>

¹⁶ <http://www.archive.org/details/gamevideos>

¹⁷ <http://www.vghmuseum.org/>

¹⁸ <http://www.nationalmediamuseum.org.uk/collection/NewMedia>

¹⁹ <http://www.computerspielemuseum.de/>

²⁰ <https://gamecip.soe.ucsc.edu/node/26>

similar technological, artistic and socio-economic challenges which are to be resolved in near future.

Among the main technological challenges are new and accessible game engines, novel technologies for augmented and mixed reality [6, 20, 36], advanced techniques and tools for graphic rendering such as realistic control of transparency, reflection and refraction, annotated entities and artificial intelligence for planning and controlling crowd simulation [23], NPC behavior and content generation [19]. Techniques for adaptation of individual gameplay according to responses of the player's autonomous [18, 31] or central nervous system [35] become more and more popular, especially for applied gaming. Open software platforms for easy creation and flexible customization of video games appear very promising for teaching students in any subject including cultural heritage such as that of ADAPTIVES [45], which is based on 3D mazes and embedded mini-games for assessment or fostering visual skills and creativity.

Artistic problems in game evolutions are mainly connected with novel methods for efficient creation of game content. Design of applied games for cultural heritage relies highly on use of instruments specialized in automatic content production. Software tools like Make3D²¹ and Blender 3D²² convert two-dimensional still images into 3D models automatically or semi-automatically, providing view access to the scene's depth. By using a VRML viewer, Flash or Adobe Shockwave, users can 'fly' or 'walk' through the 3-D scene, or watch a rendered 3-D movie.

Socio-economic issues involve the readiness of society for acceptance of games for cultural heritage. Many teachers cannot accept the challenges of digital game-based learning at all [10]. On the other hand, while entertainment games concerning cultural issues are very famous (section 3.1), SGs do not yet enjoy high popularity. Unlike the recreational game market, the market model of SG does not rely on the demand/supply ratio but rather on direct funding by organizations having interest in applied gaming. Therefore, SGs are mostly created on request having as first priority the didactical value but not playability of the game [20] and putting learnability issues before playability.

6 Conclusions

This paper discussed video games in two senses: first, as a modern and highly interactive media with high social penetration offering excellent opportunities for presentation and popularization of cultural heritage and, second, as a part of the digital cultural heritage requiring special efforts for preservation together with their technological platforms and gaming environments. Two general groups of video games for cultural heritage were presented—entertainment games and applied (serious) games. There were discussed most important technological, artistic and socio-economic challenges concerning their future development and penetration.

The market space of both entertainment and applied video games entertainment games and applied will continue to grow in next years, together with that of gamifica-

²¹ <http://make3d.cs.cornell.edu/>

²² https://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pro

tion applications. The same is valid for the impact of video games thanks to their synergy of story, art and technological achievements including affective and adaptive gameplay. Commercial entertainment games will include more cultural issues regarding both tangible and intangible heritage mainly in implicit ways, whereupon some of them will stay open for modifications with means of adapting and evolving the original game, which creates opportunities for adding didactical and cultural elements to them similar to SGs. Applied games for cultural heritage with non-linear and interactive storytelling will be used more and more for immersive cultural presentation, teaching, assessment and training.

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