e-Installation: Synesthetic Documentation of Media Art via Telepresence Technologies

Jesús Muñoz Morcillo, Florian Faion, Antonio Zea, Uwe D. Hanebeck, and Caroline Y. Robertson-von Trotha

Abstract In this article, a new method for the conservation and dissemination of media art through "synesthetic documentation" is presented. A "synesthetic documentation" is the description and reproduction of complex multisensory information that a work of media art produces. This new method is called "e-Installation" in analogy to the idea of the "e-Book" as the electronic version of a real book. An e-Installation is a virtualized media artwork that reproduces all synesthesia, interaction and meaning levels of the artwork. Advanced 3D modeling and telepresence technologies with a very high level of immersion allow the virtual re-enactment of works of media art that are no longer performable or rarely exhibited. The virtual re-enactment of a media artwork can be designed with a scalable level of complexity depending on whether it addresses professionals such as curators, art restorers, and art theorists, or the general public. An e-Installation is independent of the artwork's physical location and can be accessed via head-mounted display or similar data goggles, computer browser, or even mobile devices. In combination with informational and preventive conservation measures, the e-Installation offers an intermediate and long-term solution to archive, disseminate, and pass down the milestones of media art history as a synesthetic documentation when the original work can no longer be repaired or exhibited in its full function.

Keywords Media art conservation • Telepresence • Virtual reality

A preprint of this chapter was published on August the 6th 2014 on arXiv.org (http://arxiv-web3.library.cornell.edu/abs/1408.1362)

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M. Boştenaru Dan, C. Crăciun (eds.), *Space and Time Visualisation*,
DOI 10.1007/978-3-319-24942-1_11

Research Aims

The main aim of this research is to design a novel synesthetic documentation method for media artwork at risk under the perspective of "informational preservation" (Muñoz-Viñas 2011). For this purpose, advanced 3D modeling and telepresence technologies have been used, which allow a realistic immersive experience. This chapter is a first step to improve conventional media art documentation not only for re-enactment purposes but also allowing permanent access to the virtualized artwork. In this way, the multimodal limitations of traditional audiovisual documentation methods such as video or photography are overcome. The goals within the involved research fields (media art conservation, advanced 3D modeling, and telepresence) include the enhancement of media art documentation on a synesthetic (i.e. multisensory) level and the development of improved techniques for immersive representation and interaction. In addition, the transversal effects of this work have influence on relevant research questions including the change of the authenticity concept in art conservation theory and the use of telepresence as an art creation tool.

Introduction

Media art has existed since the early 1960s. However, compared to traditional genres such as painting or sculpture, the lifespan of a piece of media art is very short: the technology it needs to operate is also the cause of its caducity. Moreover, museums are faced every day with the inexorable decline of technology-based artwork. Works of media art not only require constant maintenance but also take up much more exhibition space than museums can provide. As a result, they are often dismantled for maintenance and repair, or remain in the museum depot for long periods of time. When this happens, these pieces of art are no longer accessible to curators, art theorists, and the interested public. In this case, a detailed documentation that mostly consists of construction plans, interviews with the artists, and audiovisual material such as video or photography is the only way to ensure that these works of art can be examined. However, this kind of documentation cannot entirely reproduce the synesthetic experience level that media artwork such as video, sound art, kinetic sculptures, or media art installations requires to produce meanings. Curators and art theorists can only speculate on the full aesthetic impact of an artwork on this basis, unless that artwork is reinstalled.

In the near future, art restorers will not be able to repair media artwork in accordance with satisfying authenticity criteria. Technical decay ageing or damage can originate a deviation from the original appearance of a work of media art, which may have importance for the meaning of the work (see e.g. Hummelen and Sillé 2005). The reason for this is above all the obsolescence of technical components that are no longer being produced, such as CRT TVs and RGB projectors, CCF lamps, or old data storage forms such as punched tapes or even old EPROMs. Given this scenario of a cultural heritage that is jeopardized and difficult to access, there is an urgent need for a new kind of documentation that allows, as much as possible, for a realistic representation of all the synesthesia levels implied in media artwork. Such documentation is necessary to protect and preserve the meanings and processes that might otherwise be lost along with the material work itself. Advanced 3D modeling and telepresence technologies can make a significant contribution in this regard.

As an anthropological category in the history of ideas, telepresence is a concept that can be traced all the way back to ancient times: the dream of an artificial life, an artistic tradition of virtual reality (e.g., life-size and immersive depictions), and the religious search for a disembodied conception of the human mind are the anthropological constants that converge in the idea of telepresence (Grau 2000). According to that, the human mind is naturally predisposed toward immersive experience without simultaneously being incredulous of such experiences. Nevertheless, the definition of telepresence used in computer science research follows a less epistemological and much more technical notion as formulated by Sheridan (1989), who, assuming the human predisposition for telepresent experience, describes it as “the extension of a person’s sensing and manipulation capability to a remote location.” This “remote location” can also be a virtual world. According to both definitions, a carefully designed telepresence system would allow realistic access to and interactions with virtualized works of media art, in particular with those that are temporarily not available to the public, or those whose continuity cannot be guaranteed through current curatorial and conservation practices. The development of this new documentation method and its dissemination requires an interdisciplinary cooperation between experts in modern art preservation and documentation, experts in 3D modeling, telepresence technologies, and long-term archiving, as well as art communicators.

State of the Art

Since the end of the 1990s, there have been several international projects on the conservation and restoration of media art that bring the importance of documentation into focus as the first step to conserve and archive this new heritage. Several well-known projects and conferences about preservation and conservation of media art are “Modern Art: Who Cares?” (“Modern Art: Who Cares?” was an interdisciplinary research project and an international symposium on the conservation of modern and contemporary art in 1995), “Seeing Double” (“Seeing double. Emulation in Theory and Practice” was a project on art emulation in 2004), “Inside Installations” (“Inside Installations: Preservation and Presentation of Installation Art” 2004), the activities of the DOCAM Research Alliance (“DOCAM – Documentation and Conservation of the Media Arts Heritage” 2005-2010), as well as newer projects on the conservation of artwork created with computer technologies, including “Digital Art Conservation” (“Digital Art Conservation” was a European research project for the conservation of digital arts in 2010).

All these projects have one very important feature in common: they all regard media art documentation as an integral part of conservation strategies. From this point of view, it can be affirmed that documentation is also an indispensable part of the media art conservation process itself.

Institutions such as the Daniel Langlois Foundation and the INCCA Network have already performed pioneering work identifying conservation issues, observing artistic and curatorial practices, and proposing conservation strategies for the preservation of compromised art forms such as media art installations, video sculptures, Net art, and game artwork. The value of documentation for modern art conservation is also a commonplace in art restoration (Gomes 2011). Good documentation requires well-founded knowledge about the piece of art in question focusing on conceptual and technological details and information about the intention of the artist and his or her expectations. In the year 2000, the art restorer Jon Ippolito published the “Variable Media Questionnaire” for ephemeral media art (Depocas et al. 2003). From today’s perspective, it was the first attempt to involve media artists in conservation issues following a standard questionnaire similar to Erich-Ganzert Castrillo’s detailed questionnaires and technical interviews with German painters (Castrillo 1995). Information about intention, future expectations of the artist, the optimal framework for exhibition, details about used technologies, and advice about how to preserve the artwork and what kind of replacements can be taken into account, help curators and art restorers in their decision-making processes, to respect crucial authenticity criteria during conservation practice and reinstallation. Sometimes it is no longer possible to exhibit a media artwork in its original medium. In this case, it can be migrated or emulated. Ippolito distinguishes both strategies: “To migrate an artwork is not to imitate its appearance with a different medium, but to upgrade its medium to a contemporary standard, accepting any resulting changes in the look and feel of the work. To emulate an artwork, by contrast, is not to store digital files on disk or physical artifacts in a warehouse, but to create a facsimile of them in a totally different medium” (Depocas et al. 2003, p. 51).

Making media art accessible to the public sometimes implies the need to vary some parameters of an artwork while still respecting the authenticity of its meaning. Migration and emulation are two documentation-based methods that allow the transmission of meaning at the expense of the original medium. In such cases, there is also often the need for a “reinterpretation” (Depocas et al. 2003, p. 52), that is, an adaptation of the art concept to the new medium. Both strategies can be included in the “informal preservation” model (Muñoz-Viñas 2011), that is, the preservation of meanings through documentation and migration, in opposition to the “preventive preservation” that tries to conserve all original parts of the artwork as long as possible with direct and environmental preservation measures. The “informational preservation” serves also as a frame for conservation strategies and as a starting point for the idea of virtualizing media artwork in order to create an e-Installation as a kind of “migrated” artwork.

In addition to the inclusion of the artist in the conservation process, there are also descriptive methods that allow a personal perspective on the art experience such as art depictions and video documentations. In combination with the technical and background information provided by the artist, it is possible to get a good idea of the whole artwork, although less intellectual effort would be needed and the findings would be more accurate with an intuitive experience of the artwork as is. Moreover, most video documentations with a conservation background tend to show a time-lapse recording of the set-up and dismantling of media art installations (Brake-Baldock et al. 2007), whereas the available video documentations for the public do not even cover the full time length of media artwork.

We have to differentiate between the conservation and visualization of digital-born and virtual art, and digitization as a conservation mechanism. Single projects including "Aire ville Spatiale" (see http://aire-ville-spatiale.org/) and the "Immaterial ArtStock Museum" (Herbert 2014) represent first attempts to collect and preserve digital-born 3D art in a digital space such as Second Life, OpenSimulator, or realXtend. On the other hand, digitization has become a way to preserve and make accessible the content from old video art tapes (Blase 2005) or to reconstruct archaeological finding places and reproduce historic buildings, pottery, or sculpture (Salgado et al. 2005; see 3D-COFORM; Koutsoudis et al. 2014; Sfikas et al. 2013).

As for art visualization, the common opinion is that immersive virtual reality technologies (VR) offer very effective means to communicate cultural content, and are also effective for educational and presentation purposes (Scali et al. 2000; Jones and Christal 2002). In the case of archaeology, the potential of 3D and augmented reality (AR) technologies for conservation issues have already been identified in the past (see 3D-COFORM). These kinds of technologies, such as VR, AR, and Web3D, have, over the last 10 years, mostly been used by science and archaeological museums that are interested in making their content attractive to the public (Styliani et al. 2009; Carrozzino and Bergamasco 2010). However, the so-called "virtual museums" are at best "content museums," that is, websites with enhanced information in the form of pictures or videos. Genuine immersive platforms remain an exception.

Immersive hardware applications for cultural experience such as the CINECA Virtual Theatre or the ReaCTOR of the Foundation of the Hellenic World also dedicate large exhibit spaces for their settings (Carrozzino and Bergamasco 2010). The ARCO platform (Augmented Representation of Cultural Objects) (St. Sylaiou et al. 2010) uses interfaces to exploit multimodal visualization, but most of the VR devices being used in museums are desktop devices. Moreover, external devices including CAVEs (Cave Automatic Virtual Environment) or panoramic powerwalls are being used in modern museums to visualize new art forms or to complement the real museum's activities, but they are not being used as media art archives or for conservation or documentation purposes.

Nevertheless, there are already some VR systems that can interact with art in museums on the basis of commercial hardware such as "The Museum of Pure Form" (consisting of a CAVE and an exoskeleton with a haptic interface) or "The Virtual Museum of Sculpture" (panoramic powerwall). The disadvantages of these systems are that exoskeletons are heavy hardware and cannot easily be controlled by untrained operators, and that panoramic walls are very large and thus need large exhibit spaces. Because the use of head-mounted displays is not possible in combination with these systems, the participants cannot move about freely. Moreover, most of these projects (including exotic theater experiments with holographic illusions such as “The Virtual Exploration of Turandot Stage” [Carrozzino and Bergamasco 2010]) offer a noninteractive stereoscopic installation with movement and proprioceptive limitations for the participants.

For most media artwork—which is either at risk or rarely seen—there are documentation and conservation strategies in practice that do not consider the virtualization of the whole artwork as is but prefer a step-by-step preservation in order to keep the media artwork operating for as long as possible.

The virtualization of material parts integrating all digital software components and audiovisual signals, as well as all kinetic and interaction patterns, in a consistently playable, dynamic, and interactive 3D model would enable a new documentation method that allows telepresent accessibility to rarely exhibited or destroyed artwork to save the synesthetic level of experience and its structure of meanings. The benefits of synesthetic documentation for the conservation of the meaning and experience level of a media artwork were brought up by Muñoz Morcillo in 2011 in an essay on the documentation of changing media art (2011):

> In this case study [“Dancing on Tables” by Stephan von Huene], one sees that the documentation of the change of a media artwork implies both a technical as well as a perception-related documentation. The interactive nature of “Dancing on Tables” can mainly be found in the descriptions, no photo can document this fact. [. . .] Accessing this work would be virtually possible today if we had, e.g., an interactive 360° view of the installation and the ability to integrate its functions into a multimedia application [. . .].

Our research continues and materializes this idea of the perception-related documentation, that is, synesthetic documentation in the form of photogrammetrically comprehended, 3D-modeled and programmed artwork, and a suitable telepresence-based visualization of the virtualized media artwork using, for example, head-mounted displays (HMD), body tracking systems, haptic interfaces, and “motion compression” algorithms, that are being developed (Packi et al. 2010a; Faion et al. 2012; Pérez Arias and Hanebeck 2009; Rößler and Hanebeck 2006) at the Laboratory for Sensor Actuator Systems (ISAS) at the Karlsruhe Institute of Technology (KIT).

e-Installation: Telepresence as a Media Art Documentation Method

Multimodal devices and telepresence systems already allow a lifelike experience of virtual scenarios in a new kind of immersive virtual reality that implies genuine telepresence research topics such as the plenoptic (Adelson 1991), plenacoustic

(Ajdler et al. 2006), and plenhaptic (Hayward 2011) functions. The fusion of these technologies with body tracking and motion compression algorithms allows a very high immersive level of virtual presence, with which established VR systems such as CAVEs and Panoramic Walls cannot compete. The high immersion in combination with realistic 3D documented media artwork is the reason why our research addresses telepresence technologies and also prefers this terminology instead of the widespread VR notion of "a simulation of physical presence." Indeed, in an e-Installation there is no simulation but rather a realistic interaction with a "living document" that re-enacts all features of the real artifact. Moreover, the chance to interact with and observe other remote visitors is a quality indispensable for perceiving the "blind spot" of one's own perception. In this way, the visitor can become a second-order observer of the art system, as in real life.

The e-Installation as telepresence-based documentation builds a new category of media art documentation and conservation. As a new method, it will take time to determine accurately what kind of media art can and should be documented with it. For this purpose, many experiments with different works of art will be necessary. Even more difficult is the standardization of measures and steps that have to be performed to re-enact a work of media art, because every artwork has its own very specific features and representation claims. For now, we can say that works of media art with kinetic and audiovisual elements as well as wide-ranging art installations such as land art are especially suited for conversion into virtual 3D art environments that can be visited with a convenient telepresence system. In particular, kinetic and sound artwork by artists such as Jean Tingely, Alexander Calder, Nam June Paik, Rebecca Horn, Jeffrey Shaw, and Stephan von Huene, but also temporary modern art installations such as Christo's wrapped buildings, Ólafur Elíasson's artificial waterfalls, or even Per Barclay's liquid installations come into consideration for e-Installation.

For every media artwork that has to be synesthetically documented, it is necessary to carry out a detailed investigation of its meaning, the artist's intention, its technical features, its construction plans, and so on. This investigation has to be performed following systematic data collection methods according to modern art conservation practices (e.g.,"Modern Art: Who Cares?" was an interdisciplinary research project and an international symposium on the conservation of modern and contemporary art 1995; "Seeing Double. Emulation in Theory and Practice" was a project on art emulation 2004; "Inside Installations: Preservation and Presentation of Installation Art" 2004; "DOCAM" – Documentation and Conservation of the Media Arts Heritage" 2005-2010; "Digital Art Conservation" was a European research project for the conservation of digital arts 2010; Depocas et al. 2003; Real 2001). The selection criteria depend on several aspects, which have to be determined by art experts and computer scientists. For the present research, we defined the following key aspects: (a) the artwork's relevance in terms of art history; (b) the artwork's level of vulnerability and accessibility; (c) access to a documentation of the artwork with detailed information about, for example, the artist's intention and the materials used, as well as the artwork's technological basis and its construction plans; (d) the technical viability of the documentation method; and (e) the conceptual and material suitability for the telepresence-based documentation method.

As in the conservation and restoration of modern and contemporary art, a "decision-making model" (see, e.g., Hummelen and Sillé 2005, pp. 164–172) is needed to deduce the conservation options, that is, the "virtualization and re-enactment options" in the case of an e-Installation. The "virtualization and re-enactment options" can be very different depending on the object and the artist's intention. Some artists attach a lot of significance to apparently trivial things whereas other aspects of an artwork are of much less importance to them. Knowing these details helps avoid mistakes and misunderstandings. The transmutation of the material conditions of an artwork through its virtualization can also change its meaning, so the relation of the physical conditions of an artwork to its meaning must be investigated before a virtualization treatment is proposed. If there is no connection between the material conditions of an artwork and its meaning, then it is possible to reproduce the basic structure of the artwork without laborious photogrammetric methods or the use of sensor data for textures. On the other hand, if the material conditions of an artwork are essential for its meaning, then it is necessary to reproduce it with high accuracy using textures, photogrammetric techniques, and so on.

The Telepresence System and the Case Studies "Versailles Fountain" by Nam June Paik and "10,000 Moving Cities – Same But Different" by Marc Lee

In order to explain how the virtualization and the visualization in a telepresence system work, two case studies were carried out. For the present research, we used the proprioceptive extended-range telepresence system (Packi et al. 2010b; Fig. 1) of the Intelligent Sensor-Actuator Laboratory (ISAS) at the Karlsruhe Institute of Technology (KIT).

The telepresence system at ISAS offers a broad and very adequate experimental ground for testing and developing realistic art scenarios. It consists of several basic components: (1) a server PC that runs the telepresence framework and streams audiovisual data to the user; (2) a visualization system worn by the user that visualizes the streamed data; and (3) a tracking system that allows the user to navigate and interact within the telepresence system. Here are more details about the three basic components:

1. *The server PC:*

The server PC is in charge of rendering the 3D scene from the user's point of view and streaming the resulting audio and visual data to the client. A programming interface for Python and C++ is provided to control the system's logic.

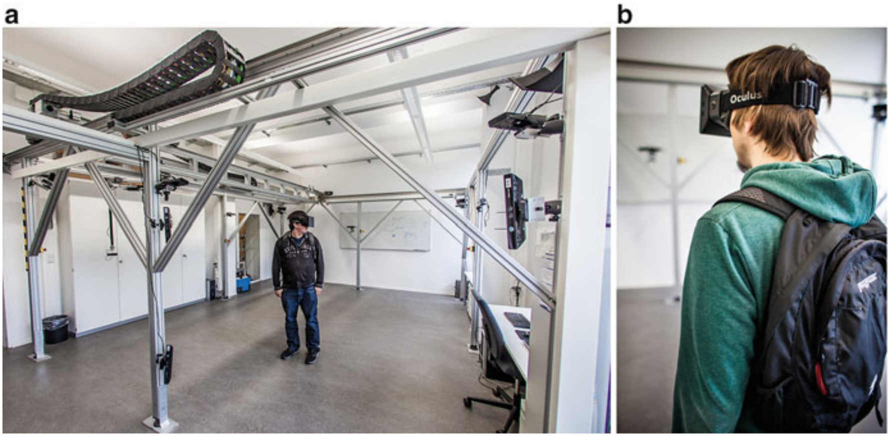

Fig. 1 (**a**) Telepresence system at ISAS (**b**) Visualization system: HMD and portable PC

2. *The client PC:*

The client PC, stored in a backpack carried by the user, displays the data streamed from the server PC. For visualization, the system uses an Oculus Rift Head-Mounted-Display (HMD) and surround-sound headphones.

3. *The tracking system*:

The tracking system consists of a room with an area of 5×5 m^2, which is being observed by a network of eight Microsoft Kinect Devices. The captured data are used to estimate the user's head pose, that is, position and orientation, which determines the user's point of view for rendering.

In order to allow the experience of extended-range environments, a technique called "motion compression" (Rößler and Hanebeck 2006) predicts the desired walking path and adjusts the visual input of the HMD to guide the user on a slightly transformed path that fits into the telepresence system. As an example, if the predicted path is a straight line in the virtual environment, the algorithm would lead the user on a circular path. Figure 1 shows a prototype of the telepresence system used at the ISAS Holodeck laboratory. A specialized form of this system that minimizes invasiveness is being planned for use in museums and galleries, in which a user can experience the telepresence environment simply by putting on a mobile phone-based HMD. In the following, we discuss how e-Installations can be created and re-enacted in telepresence.

"Versailles Fountain" (1993) by Nam June Paik, depicted in Fig. 2a, is a two-channel video sculpture that can be visited at the ZKM | Center for Art and Media Karlsruhe. The lavish fountains of Versailles are used here as a metaphor for the entertainment system of our time. It consists of 30 neon and 38 CRT monitors in various sizes. The TV monitors are switched in two different circuits producing a

Fig. 2 (**a**) Video sculpture "Versailles Fountain" at the ZKM (**b**) Intermediate 3D model, manually created in Blender. (**c**) Virtualized version, as shown in the telepresence system

barely perceptible half-second time delay between UHF (ultrahigh frequency) and composite video connections.

The following criteria were taken into account in selecting this specific artwork as a case study:

1. Endangered artwork: The sculpture consists of old neon lamps and CRT televisions, and is not always accessible to the public due to preservation work being done on it.
2. Relevance: This is considered an important work by Nam June Paik, acclaimed as one of the "fathers of video art."
3. Accessibility: There is little audiovisual information (mostly just photos) about this artwork, and the work is not always available to art experts and the interested public. A temporary absence of this artwork due to maintenance or lending the artwork to other exhibitions could be bridged with the performance of its digitized version.
4. Indirect conservation: The availability of the artwork as a digital surrogate could increase the lifespan of the original.

Concerning "10,000 Moving Cities – Same but Different" (2012) by Marc Lee, depicted in Fig. 3a, the artist's intention to virtualize the artwork fully was the starting point for the case study. Furthermore, net art is a jeopardized form of cultural heritage because of its dependence on the World Wide Web, which brought about additional challenges for the case study, such as the creation of an encapsulated offline version.

For the identification of authenticity criteria and a decision-making model in Marc Lee's "10,000 Moving Cities – Same but Different," a questionnaire by Fabienne Blanc about a similar work (Blanc 2013) was enhanced for a detailed interview with the artist that focused on conservation issues and exhibit requirements, among other things.

With reference to "Versailles Fountain," the research on the art piece was complemented by the specific knowledge of the relevant curator and technical personnel at the ZKM Museum. Once information relating to art history, material conditions, technical documentation, and the artist's intention were carefully examined and contrasted, a treatment model for 3D modeling and telepresence re-enactment was designed with a focus on computational complexity reduction, while still respecting the requirements and authenticity criteria for digital re-enactment.

According to the experiences with "Versailles Fountain" (VF) and "10,000 Moving Cities – Same but Different" (MC), the technical process of generating an e-Installation can be structured into five essential parts:

1. Creating a basic geometric 3D model
2. Modeling details using captured information such as photographs and depth images
3. Incorporating existing digital content
4. Implementing the program logic

1. *Basic model*

Some parts of the artwork, such as the cubes (MC) and the body (VF) of the original installations, can be modeled as simple, basic geometric objects with the 3D modeling software Blender (http://www.blender.org/). For the "Versailles

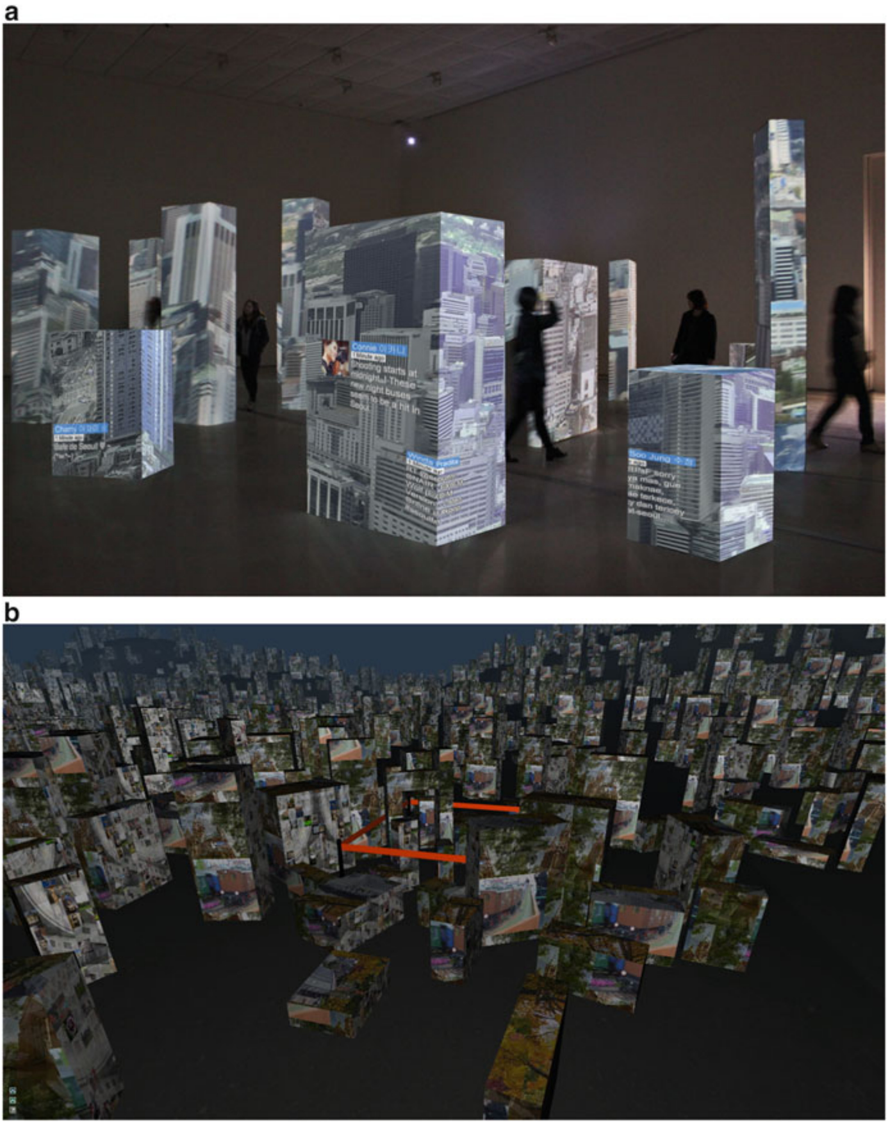

Fig. 3 (**a**) Net artwork "10,000 Moving Cities – Same but Different" at Seoul (**b**) Virtualized version in the telepresence system

Fountain," the complete body of the artwork was found to be simple enough to apply this type of modeling. In Fig. 2b, an illustration of the 3D model is given.

2. *Captured Data*

More detailed components, such as complex geometry and textures, were reconstructed using real data captured from the installation with a consumer digital

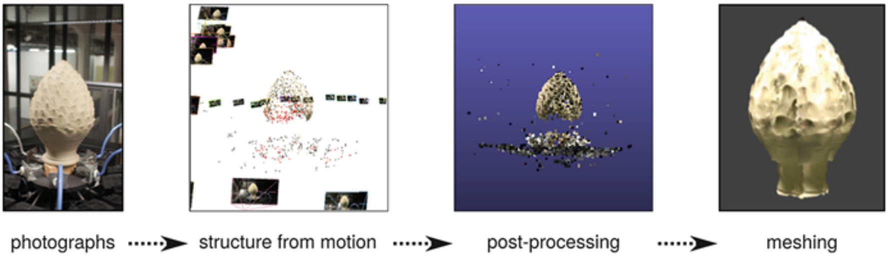

Fig. 4 3D reconstruction using Structure From Motion

camera. In particular, we applied Structure From Motion (Changchang 2011; Changchang et al. 2011) to reconstruct the 3D geometry of the pinecone on top of the VF artwork (see Fig. 4). For postprocessing and meshing, Meshlab (http://meshlab.sourceforge.net/) was used. This software tool was developed in the context of the 3D-COFORM project (see http://www.3dcoform.eu).

In addition to the Structure From Motion technique, a panoramic image of the surroundings was created in order to embed the VF into its exhibition environment at the ZKM.

3. *Digital Content*

Existing digital content, that is, video files (VF) and code (MC), was adapted and incorporated. In VF, two video files, stored on the hard disk of a PC, are played in a loop on the television sets. MC contains five browser applications written in PHP and HTML, which generate audiovisual collages of current Internet content that are then projected onto the cubes. Another application, which also requires a connection to the Internet, implements a menu with content taken from Google Maps.

4. *Program Logic*

We implemented the program logic for both e-Installations in Python. For the VF, the logic simply required displaying the video files in the form of video textures on the virtual televisions in the “Fountain”. In the case of MC, implementing the logic was much more complex, as it required (1) displaying current browser windows as a video texture, and (2) allowing for interaction with the menu. This included implementing the menu for the selection of cities, as well as implementing virtual speakers and virtual projectors that project video textures onto the cubes. This has been challenging from a technical perspective, as all the digital content of MC is loaded online from the Internet, that is, from Google Maps, Twitter, YouTube, and other sites. Figure 5b shows the menu, as implemented in the telepresence system. For an intuitive interaction with the menu, the user equipment was extended by a handheld mouse (McClelland 2014). Figure 5a shows a user operating the device.

Once an e-Installation is created according to the scheme described above, it can be experienced using the telepresence system at the ISAS lab. As mentioned at the beginning of this section, in the telepresence system the user is equipped with a a

b

Fig. 5 (**a**) User carrying the equipment for experiencing “10,000 Moving Cities” (McClelland 2014) (**b**) User interface of “10,000 Moving Cities” as seen by the telepresence user (McClelland 2014)

head-mounted display as well as headphones and can freely explore the e-Installation by walking and looking around. A server PC runs the application and synthesizes the multisensory impressions of the e-Installation according to the current user location and perspective. These impressions are then transmitted to the client PC and rendered to the user.

The synesthetic documentation of "Versailles Fountain" allows unrestricted access to a very realistic model of the sculpture and its meaning level for everyone everywhere. In this scenario, the virtualization and telepresence visualization of a static video sculpture with embedded original video signals was tested.

"10,000 Moving Cities" provided a different scenario with realtime data from the Internet and interaction with a search interface. The cooperation with the Swiss Net artist Marc Lee has shown that an e-Installation also offers a very attractive alternative for exhibiting immersive Net art beyond the conservation of synesthetic documentation.

Using the experience gained in creating e-Installations for these two works, we conclude this section by describing a general methodology for digitalizing works of media art. First, a detailed description of the artwork and its meaning has to be made. This information includes all technical data, art theoretical and conservation-related information available that is needed for a meticulous migration of the artwork respecting its originality and authenticity. Second, a base 3D model is created out of the physical geometry of the artwork. This task can be made easier by creating and reusing generic templates of common objects such as televisions, boxes, or video projectors, whenever this shortcut does not modify the meaning of the artwork. Third, the base model is enhanced with detailed reconstructions of specific aspects relevant to the work. For this, off-the-shelf reconstruction programs (such as the aforementioned Structure From Motion), which take photographs and depth images as input, can be used. Of course, the decision of which parts are deemed relevant needs to be taken with input from the artists and art experts that supervise the authenticity criteria. Fourth, digital, time-varying media content is digitalized and encoded. In particular, this includes video and audio data. Finally, the logic needs to be reproduced in the virtual model. This consists, for example, of modeling the dynamic mechanisms of how individual parts move and interact with the public, and re-enacting this behavior within the digital replica.

Challenges of Digital "Re-Enactment" Beyond Technical Issues: Curatorial Decisions and the e-Installation Paradox

During the digital re-enactment of a work of media art and its transfer into a telepresence system, some curatorial decisions must be taken. Curatorial input led to the implementation of specific environments as well as to relevant decisions concerning detail modeling.

Environment

In both cases, an environment was re-created in order to preserve contextual information: the real exhibition place in the case of VF, and an imaginary landscape conceived by the artist in the case of MC. This re-creation helps document the intention of the curator and the artist, respectively.

Modeling Detail

Ideally, the entire composition of the sculpture, including hardware, circuit, and wiring diagrams, has to be captured. The following questions regarding the level of modeling detail have therefore been addressed:

1. What level of detail has to be achieved in the modeling of hardware components?
2. Should unintended side effects such as a half-second time delay between the UHF and the composite video signals of VF be emulated?

After discussions with the curator and the ZKM technicians, it was clear that the position of the knobs of VF has no effect on the images. This means that the modeling of the rotation of the knobs can be omitted without the sculpture losing authenticity at the level of meaning. In the case of the half-second time delay between the monitors in VF, this was not originally intended by Nam June Paik and is only perceptible on closer inspection, so there was no need to emulate this.

The e-Installation Paradox

The creation of such a complex digital artifact, that is, an e-Installation, is an interesting paradox for the conservation of media art: the synesthetic documentation becomes an artwork itself, and needs, for its part, a preventive preservation framework in order to keep functioning when the software context and the hardware configuration change. In particular, the virtualization of physical components of digital-born artwork, as in Net art or game art, does not guarantee a long-term solution for the conservation of meanings and processes. For this purpose, continuous maintenance with regular updates and adaptation of all involved software components is required. Therefore, e-Installations are also a subject of study for long-term archiving experts.

Conclusions

In this chapter, a new synesthetic documentation method for the virtual re-enactment of media artwork was presented and tested. This new method, which is called e-Installation, can be integrated into modern art conservation practices as a form of extended documentation within the framework of an informational preservation strategy. In addition, it offers scalable access not only for curators, artists, conservators, and art theorists, but also for art communicators and the general public. An e-Installation also provides 3D modeling and telepresence experts a large field of research on human perception thresholds, which influence the complexity and resolution of the virtual re-enactment.

We have seen that a realistic and useful e-Installation implies a deep knowledge about the artwork and its authenticity criteria. This is only possible if systematic modern art documentation and conservation planning methods such as the "variable media questionnaire" and the "decision-making model" (section "e-Installation: Telepresence as a Media Art Documentation Method") are first taken into account. In this way, mistakes can certainly be avoided during the virtual re-enactment.

Two scenarios have so far been tested: the video sculpture "Versailles Fountain" by Nam June Paik and the Net art installation "10,000 Moving Cities – Same but Different" by Marc Lee. In both cases, five steps were followed for the technical implementation: (1) documentation of the artwork, (2) creation of 3D objects in Blender, (3) use of sensor data, (4) integration of existing digital content, and (5) the implementation of the art program logic. The resulting application runs on a server PC that synthesizes the sensory impressions of the artwork according to the current user location and perspective in a telepresence system.

The synesthetic documentation of works of media art at risk is still in its infancy. New scenarios are required to achieve new goals and define systematic decision-making models. As an example, kinetic art and land art are particularly suitable for the improvement of realistic proxemics, multiple-visitors interaction, and second-order observation. These art scenarios require further development of telepresence techniques such as haptics and motion compression.

The present research has also shown that an e-Installation can transcend current conservation thinking by creating an entirely new media artwork in collaboration with an artist. Finally, the use of an e-Installation within and beyond a conservation context has implications for the authenticity concept, which requires further study.

Acknowledgments We would like to acknowledge the support of ZKM director Peter Weibel, curator Bernhard Serexhe, and technician Mirco Frass for facilitating access to Nam June Paik's video sculpture and for sharing their knowledge. We would also like to thank the students Jennifer McClelland, Pascal Becker, and Xuefei Zheng for their work on the re-enactment of "Versailles Fountain", as well as the Swiss Net artist Marc Lee and the students Jennifer McClelland, Filip Szeliga, Michael Schröder, and Jan Philipp Gerlach for their cooperation in implementing "10,000 Moving Cities – Same but Different". For helpful advice, we also thank Jens Görisch and Antonia Pérez Arias.

References

3D-COFORM, http://www.3dcoform.eu
Adelson EH (1991) The plenoptic function and the elements of early vision. Comput Model Vis 1, pp 3–20
Aire Ville Spatiale, http://aire-ville-spatiale.org/
Ajdler T, Sbaiz L, Vetterli M (2006) The plenacoustic function and its sampling. IEEE Trans Signal Process 54(10), pp 3790–3804
Blanc F (2013) TV-Bot: interview mit Marc Lee. In: Serexhe B (ed) Digital art conservation. Theorie und Praxis, AMBRA|5 & ZKM, Karlsruhe, pp 426–429
Blase Chr. (2005) Vom magnetischen “Altbild” zum digitalem “Neubild”. Über die Rettung alter Videobänder im Karlsruher ZKM-Labor für antiquierte Videosysteme. In: AKMB-news, 11 (2), p 44
Blender, http://www.blender.org/
Brake-Baldock K te, Kallinen S, Wijers G (2007) Video documentation of installations, Netherlands Institute for Cultural Heritage, see http://www.inside-installations.org/project/detail.php?r_id=357
Carrozzino M, Bergamasco M (2010) Beyond virtual museums: experiencing immersive virtual reality in real museums. J Cult Herit 11, pp 452–458
Castrillo EG (1995) Archiv für Techniken und Arbeitsmaterialien zeitgenössischer Künstler. Enke, Stuttgart
Changchang Wu (2011) VisualSFM: a visual structure from motion system. http://ccwu.me/vsfm/
Changchang Wu, Agarwal S, Curless B, Seitz SM (2011) Multicore bundle adjustment. CVPR, Providence
Depocas A, Ippolito J, Jones C (2003) Permanence through change: the variable media approach. Guggenheim Museum, New York, pp 47–53
“Digital Art Conservation”, http://www.digitalartconservation.org/
“DOCAM”, http://www.docam.ca/
Faion F, Friedberger S, Zea A, Hanebeck UD (2012) Intelligent sensor-scheduling for multi-kinect-tracking. In: Proceedings of the 2012 IEEE/RSJ, IROS, October, Vilamoura, Algarve, Portugal
Gomes S (2011) Documentation of contemporary art: a case study of private collection, e-conservation, No. 20, p 82–91. See http://www.e-conservationline.com/content/view/1013
Grau O (2000) History of telepresence: automata, illusion, and rejecting the body. In: Goldberg K (ed) The robot in the garden. Telerobotics and telepistemology in the age of the Internet, pp 227–243
Hayward V (2011) Is there a “plenhaptic” function? Philos Trans R Soc Lond Ser B Biol Sci 366 (1581), pp 3115–3122
Herbert A Immaterial Art Stock Project – digital preservation in a 3D virtual museum, Proceedings of VRIC 2014, April 9–11, Laval, France. See also http://ener.ensad.fr/projet-immaterial-art-stock/
Hummelen I, Sillé D (eds) (2005) Modern art: who cares? An interdisciplinary research project and an international symposium on the conservation of modern and contemporary art, Archetype, London, pp 164–172
“Inside Installations: preservation and presentation of installation art”, http://www.inside-installations.org/home/index.php
Jones J, Christal M (2002) The future of virtual museums: on-line, immersive, 3D environments. Created Realities Group, University of Texas, Austin
Koutsoudis A, Vidmar B, Ioannakis G, Arnautoglou F, Pavlidis G, Chamzas C (2014) Multi-image 3D reconstruction data evaluation. J Cult Herit 15(1), pp 73–79
McClelland J (2014) Development of a human-computer-interface for the e-Installation of Marc Lee’s “10,000 Moving Cities – Same but Different”. Diploma Thesis, Karlsruhe Institute of Technology (KIT)

MeshLab, http://meshlab.sourceforge.net/

Muñoz Morcillo J (2011) Überlieferung von Medienkunst und digitale Nachlassverwaltung. In: Roberson-von Trotha CY, Hauser R (eds) Neues Erbe. Aspekte, Perspektiven und Konsequenzen der digitalen Überlieferung. KIT Scientific Publishing, Karlsruhe, p 127

Muñoz-Viñas S (2011) Contemporary theory of conservation. Elsevier, Oxford, pp 21–23

Packi F, Pérez Arias A, Beutler F, Hanebeck UD (2010) A wearable system for the wireless experience of extended range telepresence. In: Proceedings of the 2010 IEEE/RSJ, IROS, October, Taipei, Taiwan

Pérez Arias A, Hanebeck UD (2009) A novel haptic interface for extended range telepresence: control and evaluation. In: Proceedings of the 6th International Conference on Informatics in Control, Automation and Robotics (ICINCO 2009), July, Milan, Italy, pp 222–227

Real WA (2001) Toward guidelines for practice in the preservation and documentation of technology-based installation art. JAIC 40(3), pp 211–231

Rößler P, Hanebeck UD (2006) Simultaneous motion compression for multi-user extended range telepresence. In: Proceedings of the 2006 IEEE/RSJ, IROS, October, Beijing, China, pp 5189–5194

Salgado SL, O'Connor N, Tsapatori M, Soler JA (2005) The ORION Project. A European Union Thematic Network, MARQ, Arqueología y Museos, pp 103–112

Scali G, Segbert M, Morganti B (2000) Multimedia applications for innovation in cultural heritage: 25 European trial projects and their accompanying measure TRIS. In: Proceedings of 68th IFLA Council and General Conference, August, pp 18–24

"Seeing double. Emulation in Theory and Practice", http://www.variablemedia.net/e/seeingdouble/

Sfikas K, Pratikakis I, Koutsoudis A, Savelonas M, Theoharis T (2013) Partial matching of 3D cultural heritage objects using panoramic views, multimedia tools and applications. In: Proceedings of ICIAP International Workshops, Naples, Italy, 9–13 Sept., pp 169–178

Sheridan TB (1989) Telerobotics. Automatica 25(4), pp 487–507

St. Sylaiou K, Mania A, Karoulis MW (2010) Exploring the relationship between presence and enjoyment in a virtual museum. Int J Hum Comp Stud 68, pp 243–253

Styliani S, Fotis L, Kostas K, Petros P (2009) Virtual museums, a survey and some issues for consideration. J Cult Herit 10(4), pp 520–528