Preservation of an interactive computer-based art installation – a case study

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Abstract: In contemporary digital art computer technology plays an integral part not only in the creation of art pieces but also in their functioning as artworks. Such digital artworks have usually a performative or interactive character and therefore rely on an underlying working computer system. Since computer technology advances with such unrelenting pace, hardware and software modules eventually become obsolete. How to preserve digital art works in these circumstances from an art preservation standpoint is much debated. In this article we discuss issues in the preservation of digital art works using as a case study a 15 years old interactive art installation '15 seconds of fame'. The art installation could be maintained in a good working order first just by small changes, reacting mainly to new versions of operating systems. After more then ten years a complete rewrite of the code was necessary to move it to a new computing platform.

Keywords: digital art; born-digital; art installation; art preservation; software maintenance; case study; portraits; pop-art; work in progress; interaction.

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1 Introduction

As with any new technology, artists soon accepted computers as a new tool for artistic expression. Computer technology in its pioneer phase used as output devices mostly printers and plotters and therefore computers were initially used in fine art primarily to produce prints. First art prints made with computers date to the 60-ties (Dietrich, 1986; Zajec, 1978). The use of computers was at that time more complicated than it is today and artists had to employ the help of computer programmers. But this symbiotic relationship between artists and scientists or engineers perseveres in computer art even today, although the human-computer interface has evolved tremendously. Artists are usually not content to use merely some standard computer applications and solutions but are often trying to push the limits of existing technology (Miller, 1998a) which requires the help of computer scientists (Miller, 1998b; Trifonova et al., 2008; Solina and Dragan, 2014).

With the explosive development of computer technology computers became more powerful, smaller and equipped with various sensors and new output devices that integrated them with our physical environment on the one hand and connected them into world wide computer networks on the other hand. Thus art that uses computers evolved predominantly into interactive art (Trifonova et al., 2008; Edmonds, 2010). Various sensors, cameras in particular, were employed in the feedback loop that enables interactivity. Multimedia and the invention of the World Wide Web in particular gave the new tendencies in computer arts a tremendous boost. Interactivity in the context of contemporary art and technology typifies a relation or cooperation between the machine and the subject (Lieser, 2010). Installation art is often less object than event, existing often only for the duration of an exhibition (Real, 2001). Wilson (2002, 2010) wrote two comprehensive surveys of new media art, where art, science and technology intermix.

A substantial part of contemporary art moved away from the production of artefacts towards organising events or providing services. In the post-industrial society innovations, the use of new technologies, originality and individuality are gaining in importance. Art which is following these trends and using new technologies is simply different from the older art, it is post-objective (Benjamin, 1980; Strehovec, 1997). The meaning of authorship in modern art has also changed and appreciation of art has evolved from pure contemplation to a much more active relationship with a viewer or a participant (Groys, 2014). A patron of contemporary new media art expects contents that can be modified, added to or interacted with.

In the profusion of new artistic artefacts, the important question is not only about their contents, the way they are presented, how they appear, but also are they still ‘real’ artistic artefacts since they are often not created by artists? Engineers, programmers or scientists who are usually without any formal artistic education often produce such artefacts. The artist today is often a member of a collaborative team that produces such artefacts so that the role of the ‘artist’ as the creative agent is shifting to the entire team and is not concentrated in just a single individual as is the norm in traditional art (Edmonds, 2010). The described changes in the art scene were possible only because of the changes in other areas of the society and because the reality itself has undergone such drastic changes (Strehovec, 1997).

An artistic artefact is interactive when a physical action of the observer causes a change in the artistic artefact. Objects and installations that are interactive receive signals from the environment, they process the signals to finally transform the signals again into

a visual form which is then 'exhibited'. Signals or actions from the environment have an influence also on the evolution of the artefact. The artistic artefact is at the inception usually not in its final form since the artist does not want the artefact to be separated from the everyday life (as artistic artefacts in the past used to be) but to become a living artefact which can be manipulated with or played with, so that the observer becomes an actor. The artist creates the artefact with the intention that others develop it further (Strehovec, 2008). Artistic interactive works range from very simple interactions where an observer or selected visitor is asked to press a button to initiate an action between the installation and itself. Then he simply observes the changes of the installation. In the centre of an interactive installation can be a continuous process that a visitor can influence or interact with, for example, play with virtual water droplets falling on and running over a virtually enhanced stone sculpture (Solina and Meden, 2016). Sometimes the interaction requires some motor skills, ability and practice, which means that the installation engages all our senses (Strehovec, 2008) as for example in the art installation virtual skiing (Solina et al., 2008). Interactive art installations are therefore according to the technology employed and the modes of human computer interaction often closely related to computer games (Edmonds, 2010). The main distinction is the somewhat different intended pleasures derived from interacting with them.

The mental process that takes place when we observe an art artefact can already be considered as an interactive process in the sense that the mental process is a response to our observation. An analysis of such mental processes in case of new media art works is described by Bovcon (2013). Cornock and Edmonds (1973) defined four basic categories of interactive installations that characterise the relationship between artwork, artist, viewer and environment. These four categories are:

1 Static, where there is no direct interaction between the artwork and the observer, as when an observer is looking at a painting.

2 Dynamic-passive: the art piece can change in a predictable way to outside environmental influences and the observer is just a passive observer of these changes.

3 Dynamic-interactive: same as dynamic-passive with the added factor that observers can also assume an active role in influencing the changes of the art piece. This influence is achieved primarily using various computer-based sensors.

4 dynamic-interactive (varying): in this category an additional modifying agent takes the role of changing the initial configuration or behaviour of the art piece. The performance depends therefore not only on the current influencing signals but also on the previous signals that means the entire history of interactions. Machine learning and other artificial intelligence methods can steer the performance of such artwork (Shamma, 2009).

The installation '15 seconds of fame' is used in this article as a case study for discussion of the preservation of computer-based artwork. It employs a camera to detect the presence of observers and turns the images of their faces into pop-art portraits. According to the above classification it can be characterised as dynamic-interactive.

The aforementioned explosive development of computer technology is on the other hand the main reason why computer-based art pieces have in general o short life span. Software and in particular hardware solutions become dated quite rapidly and maintaining computer-based art pieces is not just a software maintenance problem but it must be considered in the context of art preservation. One can understand that the greater the complexity of interaction, the more demanding is the preservation of such an art pieces. Digital preservation is a pressing matter since large parts of our cultural and artistic heritage are endangered due to obsolescence.

There are still no generally accepted and clear guidelines how to approach the preservation of computer-based art (Serexhe, 2013). The problem is obviously multifaceted and requires a multidisciplinary approach. Art communicates simultaneously on sensory, emotional, mental and spiritual levels (Wands, 2007) and preservation must concentrate on those aspects which are at the hearth of the art piece. Preservation should focus both, on the tangible realities of an art piece and its cumulatively realised expression, function or message, which can be together referred to as intangible aspects of an art piece (McHugh et al., 2010). In this article we put forward the problem of preserving computer-based art pieces as a case study of the interactive installation '15 seconds of fame'. An earlier version of this article was presented at a conference (Solina et al., 2014).

The main lessons for successful preservation of an installation that we learned during the study are:

1 that the original equipment should be maintained as long as possible

2 all necessary changes due to software and hardware updates should preserve primarily the experience and feel of the art piece

3 in all stages ample documentation should be recorded and collected

4 repeat exhibitions or performances of the installation are the best strategy for its long-term preservation.

Changes of the original art piece are sometimes sensible, especially if the original concept does not change or is even amplified. Preservation of born-digital art pieces, especially if the artist remains involved, is therefore often considered as a work in progress.

The rest of the article continues as follows. Section 2 presents in more details the motivation for this article, in Section 3 current digital art conservation strategies and methods are introduced and discussed, in Section 4 software maintenance issues, which are at the hearth of digital art preservation, are outlined from a software engineering perspective. In Section 5 artistic considerations leading to the '15 seconds of fame' interactive installation and its functionality are briefly described as well as its history of exhibiting. Section 6 compares the original and the later versions of the installation from a hardware, software and functional standpoints and, finally, in Section 7 the preservation measures undertaken on the installation '15 seconds of fame' are discussed. Conclusions are in Section 8 where preservation guidelines that were learned on the basis of this case study are given.

2 Motivation

Due to the fast development of computer technology, computer-based art works need to be adapted to new hardware and new software platforms, so that their use and appreciation can be pursued also in the future (Serexhe, 2013). This necessary adaptation is a common issue in software engineering. In computer applications every new software version is expected to put to use the newest technical advances and to introduce new or better functionality. From art conservation position, however, as much as possible of the original should be preserved. Therefore, in preservation of born-digital art, these two principles clash.

Figure 1 An observer in front of the interactive art installation entitled '15 seconds of fame' (see online version for colours)

Notes: The installation consists of a flat computer monitor framed as a painting and a digital camera hidden in the picture frame (note the round hole above the monitor), which are both connected to a personal computer, generally hidden from the view. The camera takes a photo of the observers in front of the installation every 15 seconds. Custom written software detects faces on the captured photograph and randomly selected one of the faces. This face is then turned into a pop-art portrait, inspired by the artistic style of Andy Warhol, and displayed for 15 seconds on the monitor.

In this article, we discuss the issues of digital art conservation that we faced on the example of the '15 seconds of fame' interactive art installation which generates pop-art like portraits. The installation was originally created in 2002 (Solina, 2004; Solina et al., 2002) and is described in more detail in Section 5. In the original version of the

installation, a personal computer, a flat computer monitor and a separate digital camera was used (Figure 1). The installation was taking pictures of visitors and converting them pop-art portraits to be displayed on the monitor in 15 second intervals. Portraits produced by the installation could be ordered by e-mailing a unique portrait ID number (Figure 2) to the server, where the portraits were collected. In a newer version of the same installation, the personal computer and the camera were replaced first with a mobile phone offering a built-in camera and wireless connectivity for distribution of portraits. The mobile phone could be integrated into the picture frame of the computer monitor. The most recent version of the installation runs on a Raspberry Pi computer (https://en.wikipedia.org/wiki/Raspberry_Pi) connected to a miniature camera. Due to its tiny size it is even easier to integrate it into the picture frame. Instead of using a dedicated server and email communication for ordering of the portraits, a social network is used to distribute the portraits.

Figure 2 The original version of the installation '15 seconds of fame' showing a flat computer display, framed as a painting with a round opening on top for the lens of the digital camera (see online version for colours)

Notes: The photograph shows the picture frame that could be disassembled to enable easier transportation of the installation. left of the generated pop-art portrait on the display is a timer counting down the 15 seconds, to the right of the portrait is its id number, used for e-mail ordering of portraits from a dedicated web server.

However, is such expansion of functionality in accordance with art conservation principles? Social networks did not exist when the installation was initially conceived. But users nowadays expect that most user friendly computer applications can connect to social networks. The installation has to perform automatic detection of human faces in images. In the past 15 years, faster and more robust computer vision methods for face detection were developed. Is the use of newer and better methods of face detection acceptable from a conservation standpoint? Is a more robust, illumination independent face detection a substantial change of the original installation? How does the replacement

of the original hardware equipment influence the art installation? Does reimplementation of the software and use of new software libraries change the essence of an art installation? Since later in the life of the installation larger computer monitors were used, the picture frames also had to be changed accordingly. In the rest of the article we will try to address all these questions in the wider framework of digital art preservation.

3 Digital art preservation

3.1 Definition of the problem

Digital art preservation is distinct from digital heritage, which strives for conservation of art in general by means of digitalisation. Digital art conservation is about conservation of art that was already born in digital form. Although digital art was produced since very recently, from the 60-ties onward, and hence belongs to our times, it will soon be relegated to the past because of its ephemeral nature and highly transient technology (Serexhe, 2013).

Digital art is a fast moving discipline, performative in its nature, subjected to ongoing development because creators adapt their creations continually to new technical developments. Conservation of digital art therefore sounds as a conservative endeavour as it would try to stop the fast moving development in digital arts. But as any artwork, digital art bears witness to the era and society in which they were created. Each piece of art could only be created in such a time, in such a society, not earlier and not later. Therefore, also the preservation of digital cultural artefacts assures a continuity of our memory within time.

The first institutions that were faced with the task of ensuring long-term access to digital objects when original software and hardware are not available anymore were national libraries and archives. Preservation of born-digital art is, however, a whole new problem field because due to a large variety of different and inherently ephemeral material, such as software and hardware components (videotapes, CDs, DVDs, play-back equipment, displays, processors, sensors, operating systems, language compilers, etc.), individual digital art pieces must be approached on a case by case basis. Digital media, although effortless to copy and multiply, is much more vulnerable to catastrophic signal damage than analogue media (Real, 2001).

Paintings, sculpture, published texts on paper enjoy a reasonable grace period following their conception during which one can assume their survival practically without intervention (McHugh et al., 2010). During that time there is normally plenty of opportunity to determine the artistic significance of works. In contrast, preservation of digital art works such as installation art requires almost immediate action, much earlier than the significance of an art piece for a particular artist or in general can be established.

Although a basic substance of any artwork lies in the idea, such idea should be expressed, communicated, comprehended through being experienced by our senses. Documentation of an artwork can therefore in no way replace the work itself. A painting cannot be replaced by photography of the original. The same holds for digital art. Documentation of a digital piece of art can only help in remembering. One should strive to preserve also digitally encoded work in their historic form and their aesthetics, the behaviour of interactive installations, even under changing technological conditions.

This goal is very difficult to achieve since without constant maintenance of such works, the rapid technological advances makes them obsolete in a very short time period. Maintenance means ongoing replacement and renewal of their components, hardware and software elements, such as adapting to new operating systems, porting software to new hardware, transforming data to new formats, sometimes rewriting the entire code in a new programming language. This situation is very different from older art where conservation usually means preservation of the status quo.

In the article we are concerned mainly with computer-based installation art which embraces both tangible and intangible qualities.

3.2 What exactly needs to be preserved?

There can be several aspects of installation art that need to be preserved and what exactly needs to be preserved must be decided on a case by case analysis. For example, sometimes the computing equipment is hidden; sometimes the same equipment can have a sculptural and conceptual role, critical to the understanding of the art piece. Unlike classical works of fine art, installations include also dimensions of experience, movement, sound, time – making them similar more to performance arts such as dance, theatre and music (Real, 2001). In performance-based art, each performance of a piece can be different, especially theatrical and musical performances. In fine arts, however, there is a strong ethic of authenticity, originality and historical accuracy, original objects are sacrosanct, facsimiles are taboo. Installation art seems to be somewhere in the middle. Installation artist acts as a composer and curator as a conductor when an installation is exhibited. Unfortunately, unlike theatre and music, an installation is rarely based on a text or a music score that can serve as a starting point for any interpretation. All kinds of documentation are therefore critical in installation art. Installations can be recreated with different equipment as long the essential spirit and experience are preserved. An installation is in such a case not an object but primarily a performance that the artist designed as an experience.

To decide what needs to be preserved, one has to find out what are the essential elements of a piece or what is at the hearth of it (Real, 2001). First, one should make explicit those external or situational influences that must persist to realise or perform a work and preserve its original artistic intention (McHugh et al., 2010). Context is often beyond the control of the preservation environment and therefore context is a critical dimension that should be covered in documentation. Next are the object components of the work, they correspond to units of information that form a logical group. The final elements are processes that perform the interpretation of data objects and their realisation as information objects which can be seen or experienced by a visitor (Real, 2001).

Even when dealing with fine art objects, a change of the frame of a picture, despite its influence on perception, is generally not regarded as materially a part of the work of art. A similar situation prevails in architecture preservation and in preservation of technical heritage where new materials or replacement spare parts are legitimate to enable the use of functioning of tangible heritage. New media art also legitimately changes over time to reflect emerging requirements and opportunities and adaptation to different locations.

Reinterpretation means reformulating the piece according to an updated understanding of its conceptual aspects. The term variable media often used to characterise installation art actually embraces the idea that preservation of the installations must accept the possibility of change or variation over time. In fact,

installations that are measured and defined too narrowly, risk to become frozen, contrary to the spirit of evanescence, temporality and change inherent in the medium (Real, 2001). But any additions should be satisfactorily sanctioned by the author or other stakeholders, if not; it detracts authenticity (McHugh et al., 2010).

The artist's perspective at work's creation is crucial and artists are the best arbiters of that which has value within a piece. They often sanction preservation interventions and they can contribute more information about the piece than any other. Later, since leaving their custody and when artists are unavailable to participate in the preservation of their work, art historians and curators should take their place.

A serious problem in digital art preservation is lack of expertise. Professionals in museums and galleries that are in charge of conservation have usually an entirely different set of skills, mostly related to fine art techniques. Software professionals, on the other hand, are generally not familiar with art preservation issues. Specialised museums and collections of new media art are usually best equipped to face the problem, such as for example the Center for Art and Media Karlsruhe [Zentrum für Kunst und Medien (ZKM)].

3.3 Strategies for digital art conservation

Although meaningful solutions for digital art conservation can be proposed only for a limited time span and each art work should be approached on a case by case basis, two general strategies have evolved (Serexhe, 2013):

1 To preserve the work's original behaviour, as well as its aesthetics, the original components (computer, electronic interfaces, digital control units, monitors, sensors, etc.) or exactly identical equipment should be preserved as long as possible along with the original software in functioning condition. Namely, hardware such as display or projection equipment has an influence on the aesthetic dimension of a work, for example, a picture on a cathode ray terminal monitor looks different than on a modern, high-resolution raster screen. Faster and more robust processing and computer monitors of a higher resolution therefore do not necessary mean an improvement in the context of digital art preservation. This strategy of preserving original components, called also a museum or storage approach (Guttenbrunner et al., 2010) can be usually done only as long as the original equipment can be serviced.

2 As a parallel measure, the operating systems, programs, applications, sensors and any other components should be upgraded as necessary by the development in technology. This should be done, however, in such away that the content, behaviour and the aesthetics of the work do not change. However, artists who find themselves in this position, where in order to preserve their work, they have to migrate their system to new hardware, adapt to new operating systems, use better and faster sensors, etc., they often strive to improve at the same time not only the technical but sometimes also the aesthetic or functional aspect of their work. In such scenario, the work then becomes a permanent work in progress.

To realise the second strategy two predominant approaches are used, migration and emulation (Guttenbrunner et al., 2010; Becker et al., 2007).

- *Migration* secures the substitution of lost of obsolete original components with newer materials. This migration to a new technological platform should ensure consistency and authenticity and preserve all the essential features and the conceptual characteristics of the original object. An important part of this strategy is the migration of intrinsic media assets to more stable formats. For every new technology, digital data should migrate to the new format.
- *Emulation* means imitating the appearance of lost or obsolete original components. Emulation operates on environments for objects rather than on the objects themselves. Emulation mimics a certain hardware or software environment: a processor or an operating system. Emulation for digital preservation normally keeps the data in its original form and keeps the original software to handle the data. This strategy was successful for preservation of console video games (Guttenbrunner et al., 2010).

The above described strategies were succinctly summed up by International Council of Museums (ICOM) in four points:

1 conservation of the original materials

2 replacement with functionally equivalent elements

3 changes due to functionally similar components

4 recreation and reinterpretation.

3.4 Documentation of installation art pieces

Although documentation can not replace the work itself, extensive documentation of installation art works is essential precisely because of the difficulty of proper preservation of original components. The documentation process can be compared to the conception of musical scores for recreation, re-exhibition or reperformance at a later date (McHugh et al., 2010). It is necessary to document both the physical and experiential qualities of the work, the tangible and the intangible aspects (Real, 2001).

Plans, texts, drawings, software code, photographs, screen captures, video documentation and interviews with authors should all be included in a comprehensive documentation. Photography alone might accentuate some minor details which are actually irrelevant to the piece. That is why multiple documentation formats are needed, incorporating different points of view. It is important to know why the artist made certain choices of media, equipment and how they would do it in the future (Real, 2001). Extracting information that the artist might consider as self-evident and not worth mentioning is sometimes the most difficult. When dealing with fine art objects conservators are focused on what is wrong with them and how to fix them, but in installation art it is important to record what is right.

Aside of documentation, repeat performances of an installation offers the best guarantee for its long term survival since in this way the essential characteristics of the work should clearly emerge and all the necessary, albeit small changes are made in time, to keep the work exhibitable (Real, 2001).

3.5 Related work

Media art notation system (MANS) is a 'formal notation system for media art', developed by Richard Rinehart to document and preserve born-digital art and other forms of art by museums (Rinehart, 2007). Using the metaphor of the musical score, media art should be able to be reproduced by different media-equipment, based on the information acquired from a document like the variable media questionnaire (Lessiter et al., 2001).

Investigating the significant properties of electronic content over time (inSPECT) was an international project aimed to facilitate the preservation of digital objects. Significant properties are those aspects of a digital record that must be preserved over time in order for it to remain accessible and meaningful (McHugh et al., 2010). Preservation and long-term access through networked services (PLANETS) was a four-year digital preservation project co-funded by the European Commission under the Sixth Framework Programme. The project ran from 2006–2010 and built practical tools and services to help ensure long-term access to digital cultural and scientific assets (Becker et al., 2007; Guttenbrunner et al., 2010). The preservation of the collection of artworks held by the Ars Electronica using the PLANETS framework was studied by Becker et al. (2007).

A new vocabulary for supporting new media art preservation was introduced by McHugh et al. (2010). Valuable insight into the practice in the preservation and documentation of technology-based installation art is offered also by Real (2001). Other aspects important for the preservation of born-digital art are the cost of ownership and the scope of the activity. Preserving an entire collection of digital art is quite another endeavour than preserving a single art installation (Cowick, 2016).

4 Software and hardware maintenance

A substantial part of software that supports the functioning of modern society is so called legacy software that was originally developed for older computer systems but was later adapted to newer technology. Software maintenance costs represent almost two-thirds of the total software costs (Glass, 2001).

Any further development of a software system after its first release can be put under the cover of maintenance. Different types of maintenance exist: corrective to fix errors, perfective to implement new or revised requirements, adaptive to new technologies or platforms and preventive for internal reorganisation. Software engineering issues special to interactive installation art were analysed by Trifonova et al. (2008).

From a digital art preservation point of view, adaptive maintenance is the most crucial, since it is almost unavoidable over a longer period of time if the goal is to keep the art works performing. Even if the goal of the maintenance is to keep the system performing as it is, new operating systems and newer hardware or software modules can have a subtle influence on the appearance and behaviour of the system and hence influence the aesthetics of the art work. Although the appearance of hardware equipment used in general computer-based solutions is normally abstracted, the outer appearance of hardware equipment in art applications is sometimes part of the overall design. This was, however, not the case in the installation '15 seconds of fame' where the actual computer and camera hardware is hidden.

Exchanging individual components of an existing computer-based solution can be tricky since software and hardware equipment interfaces tend to evolve over time and

sometimes even cable connectors simply do not match any more. We experienced this type of problem when we tried to exchange in the '15 seconds of fame' installation just the computer monitor for a newer and larger one. However, due to evolving standards we could not connect the monitor with a digital interface to the old computer which had only an analogue interface for the display.

Another important feature of newer computer monitors is that their aspect ratio is changing towards wider screens. Until about 2003, most computer monitors had a 4:3 aspect ratio, but after 2010, virtually all computer monitors have a 16:9 aspect ratio [34]. Since we decided to use a square format for the generated portraits, as Andy Warhol often did for his celebrity portraits, this trend in aspect ratio was detrimental for our installation display. Fortunately, computer monitors with an aspect ratio of about 2:1 appeared recently which makes possible to display two square portraits side by side (Figure 9). On another level of maintenance is the dilemma if existing software methods and algorithms could be replaced with better, faster or more robust ones. This is quite a common question in fast moving technical areas such as computer vision. Errors or inconsistencies of existing methods might actually constitute an integral aesthetic feature of the original digital art work. Therefore before deciding on any maintenance work on a digital art piece, one should consider beside software and hardware engineering issues also preservation principles.

5 Interactive art installation '15 seconds of fame'

The installation '15 seconds of fame' was inspired by Andy Warhol's often quoted statement that "in the future everybody will be famous for 15 minutes" (Simpson, 1997) and his photography derived paintings of famous people (Warhol et al., 2003). Warhol used to take images of faces from mass media and transformed them into paintings and prints. Warhol portrayed in this way, celebrities from arts and politics and some of these images became true icons of the 20th century.

The visible part of '15 seconds of fame' consists of a computer monitor, framed like a painting. A digital camera is hidden behind the frame, so that only a round opening for the lens is visible in the passe-partout above the computer monitor (Figure 2). Pictures of gallery visitors standing in front of the installation are taken by the digital camera which is connected to a personal computer that processes the pictures and displays them on the monitor. Digital photos of the observers in front of the installation are taken every 15 seconds and analysed by the computer to detect faces. As most automatic object detection methods, automatic face detection was around the year 2000 still reasonably difficult to achieve, especially if sample variations are significant as is the case in detection of faces. Large sample variations that face detection must cope with arise due to a large variety of individual facial appearances, skin complexions, head orientations and changes of illumination (Viola and Jones, 2004). Initially, we used in the installation a colour-based approach for face detection that we developed specially for this purpose (Solina et al., 2003). The colour-based nature of that face detection made it very sensitive to illumination and different skin complexions. Since it was not always possible to exhibit the installation in daylight or under white-balanced studio illumination, we tried to improve our face detection results by applying colour-compensation methods (Kovač et al., 2003; Kreslin et al., 2014).

To produce his celebrity portraits, Warhol segmented the chosen face from the background, which he replaced with uniform colours, and often highlighted some facial features such as the mouth or the eyes, started the process with a negative of the photo, or overlaid the photo with geometric colour screens, etc. (Warhol et al., 2003). These techniques of transforming a photograph into a painting could be described with a set of formal construction rules using shape grammars (Kirsch and Kirsch, 1988; Gros and Solina, 1992). Using such rules in the installation would require automatic segmentation of the input face images into their constituent perceptual parts: face/background, eyes, mouth, hair, etc. These tasks were 15 years ago still fairly complex to be solved routinely and consistently in a few seconds on a large variety of input images. We decided therefore to try to achieve similar effects with much simpler means. The installation '15 seconds of fame' does not identify any facial features but just applies different filters to the input image.

The art installation '15 seconds of fame' was conceptualised already in 1996 and implemented in 2002 (Solina et al., 2002). The installation tries to make selected visitors observers of the installation somehow instantly famous by, first, making their portraits in a Warhol-like, pop-art fashion, out of their photographs captured by the installation and, second, to make them implicitly famous as their portraits appear as paintings on the walls of galleries and museums at least for a limited time frame. The prophesied 15 minutes would hardly make the installation interactive and, therefore, the 'fame' interval – the interval in which each generated portrait is displayed, was shortened to 15 seconds. A further twist in the installation's scenario is that faces used for the generation of the pop-art portraits are selected by chance among all detected faces of people in front of the installation at the moment when the picture was taken. This serendipitous selection of faces is meant to allude that fame in mass media tends to be not only short-lived but also quite random.

The next step in generating a '15-second' portrait was therefore to randomly select one face among all detected faces in the picture and to crop it from the original resolution photograph. This processing performs a similar function as a photographer using a telephoto lens to take a portrait of one of the visitors from that viewpoint. Since gallery visitors often stand in front of the installation for several 15-second intervals, we integrated a rule in the random selection process to prevent the selection of a face in approximately the same location in two subsequent 15-second intervals. To achieve Warhol-like pop-art effects a random combination of three well-known graphic filters – posterise, colour balance and hue-saturation – with an additional process of random colouring is applied. To drastically reduce the number of distinct colours, similar-looking pixels are joined into uniform regions. Random colouring selects a colour from the colour palette of the already-filtered image and replaced it with a randomly selected new colour. In this way, millions of different filtering effects can be achieved. Some portraits generated by the installation can be seen in Figure 3.

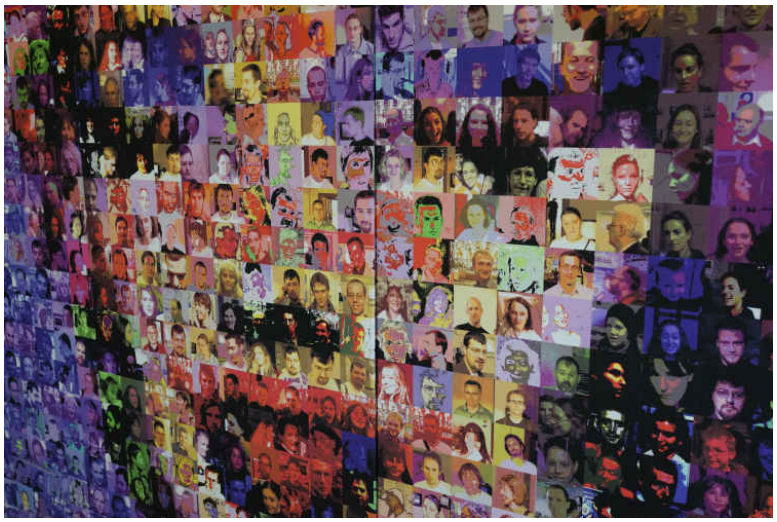
Figure 3 A selection of pop-art portraits generated by the installation '15 seconds of fame' during various public art exhibitions in Maribor, Slovenia (2002), in Ljubljana, Slovenia (2002, 2003, 2014), in Graz, Austria and in Klagenfurt, Austria (2004) (see online version for colours)

Already during the first exhibition we were overwhelmed with requests for the generated pop-art portraits. Although it was against our original intention to demonstrate with the installation the ephemeral character of the image-based celebrification process, we surrendered to the large demand. In fact, we even had selected pop-art portraits printed on canvas in a small 12 × 12 cm format as promotional gifts. High quality prints of selected '15 seconds of fame' portraits were also exhibited in Maribor in 2003 in the framework of the 9th International Festival of Computer Arts and at the solo show of the installation in the SVC gallery in Ljubljana in 2004 (Figure 4). After the first exhibition, we had to fulfil the requests for portraits manually by emailing them. Then we made a web server so that the displayed portraits could be ordered simply by sending email with the corresponding ID number in the subject line, which was from then on displayed along the portrait (Figure 2), to our server where all generated portraits were stored for a limited time period.

Figure 4 Two large format photomosaics after the famous Warhol's Marylin Monroe portrait were made as a tribute to Andy Warhol out of portraits generated by the installation '15 seconds of fame' for the solo exhibition in the SVC Gallery in Ljubljana in 2003 (see online version for colours)

Source: Solina (2005)

Figure 5 Detail of a Marylin Monroe photo mosaic made out of '15 seconds of fame' portraits (see online version for colours)



Note: Individual portraits printed on canvas are of size 5 × 5 cm, so that the individuals on the portraits can be recognised up close without difficulty.

From the portraits made by the installation, two large format photomosaics of Warhol's Marylin Monroe portrait (Figures 4 and 5) were made for a solo exhibition of the installation as a further testimonial to Andy Warhol (Solina, 2005).

5.1 Documentation

The installation was exhibited for the first time in 2002 at the 8th International Festival of Computer Arts in Maribor, Slovenia. Several exhibitions in art galleries followed, in Ljubljana, Graz and Klagenfurt. The installation was also used on many occasions for promotion of study programs at the Faculty of Computer and Science, at the Technical museum of Slovenia and at Science festivals. A solo show of the installation was held at the SVC gallery in Ljubljana in 2004 (Solina, 2005). The installation was also included in the 15 years retrospective exhibition of ArtNetLab in the ZDSLU gallery in Ljubljana in 2014 (Dannenberg et al., 2014).

The installation was carefully documented at all public exhibitions. Photographs and sometimes video (Bučar, 2002, 2016) were taken of the exhibited installation. The most representative of the generated pop-art portraits were also saved. In the archive are also press clippings and video excerpts from the national television which was reporting about the installation. Academic publications about face detection and illumination compensation that was developed for the installation (Solina et al., 2002; Juvan et al., 2002; Kovač et al., 2003; Solina et al., 2003; Kovač et al., 2003) as well as the original artistic concept (Solina, 2004) are available from the same web site. The entire archive is openly accessible on the internet (Home Page of '15 Seconds of Fame' Project, http://black.fri.unilj.si/15sec). The exhibition catalogue from the solo exhibition in the SVC gallery is also there (Solina, 2005).

6 Hardware and software of the '15 seconds of fame' installation

The installation '15 seconds of fame' was developed in 2002 on a PC computer and a detached digital camera. About ten years later porting of the installation software to a mobile phone platform became feasible since mobile platforms started to offer sufficient computing power in combination with an integrated camera and wireless connectivity. The latest implementation of the installation made in 2016 is based on a Raspberry Pi computer and a Raspberry Pi camera module. We discuss in this section implementation details of all versions of the installation and the challenges that we faced in preserving the installation in a working state.

6.1 PC-based implementation

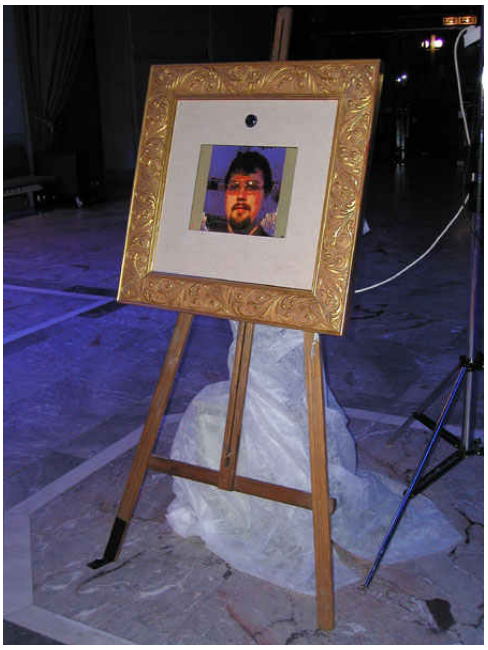
In the original, PC-based version of the installation two hardware configurations were used, which was motivated also by the need of easier transportation of the installation to different locations.

1 In the very first version, the monitor was a 17 inches Samsung, the massive wooden frame for the monitor was on purpose gilded and very ornate and could not be disassembled (Figure 6). The camera was an Olympus C3020 ZOOM, with a 32–96 mm lens, set to maximum wide angle (Olympus, http://www.dpreview.com/products/olympus/compacts/ oly_c3020z/specifications). Image resolution was 2,048 × 1,536, which enabled detection of faces even of observers which were far away from the camera. The selection of the camera was motivated by the fact that Olympus offered the purchase of a SDK library for computer control of the camera,

which was essential for our application, since we needed to trigger the camera from the computer and to transfer the captured images from the camera to the computer. Nowadays, most higher priced cameras have this functionality, many even a wireless transmission of images to a computer. Special SD cards even exist that beside the storage of images offer also wireless transmission.

2 For the second version of the installation a wooden frame that could be disassembled for easier transportation was built (Figures 1 and 2). The installation was accepted for presentation and exhibition in the framework of the ACM multimedia conference in New York in 2004 (Batagelj et al., 2004) and dissassembling the frame for transport was the only sensible solution at that time. The software was running on a PC laptop computer and the computer monitor was lent by colleagues from the Columbia University. Since the cost/size ratio of flat computer monitors was decreasing substantially in that time period, a larger 19 inches Samsung monitor was selected. A smaller camera Olympus C40 ZOOM with lens 35–98 mm and resolution of 2,272 × 1,704 was used (Olympus, http://www.dpreview.com/news/2001/09/03/olympusc40z). The selection of the camera was limited by the decision to use the same software module for the communication with the camera and the same SDK library.

Figure 6 The first version of the installation '15 seconds of fame' used a traditional looking massive gilded wooden frame for the computer monitor to imply that the computer generated portraits are also fine art (see online version for colours)



The module for face detection was written in C++. Initially, we developed a method of face detection based on skin colour (Solina et al., 2003). Adjoining blobs of skin colour were integrated and if the ensemble meets some preset geometric constraints, the blob was labelled as a face. Before applying face detection the input image was reduced to

160 × 120 pixels. The smallest face that could be detected was 11 ×1 2 pixels and the largest 96 × 106. This detection method was unfortunately very sensitive to changes in illumination although this problem was somewhat alleviated by using different methods of illumination compensation that we also developed (Kovač et al., 2003). Later the new Viola-Jones method of face detection (Viola and Jones, 2004) which is not colour dependent was used in the installation. As a module for the Viola-Jones method for face detection exists in the OpenCV library we simply used this implementation. The smallest face that could be detected was 24 × 24 pixels since the input image could be captured by the camera in higher resolution and the computer processor was more powerful.

The module for colour transformations which simulates the pop-art effects was also written in C++. The three colour filters or transformations `color_balance.c`, `hue_saturation.c`, and `gimplut.c` (posterize) emulate filters for colour balance, hue saturation and posterization from the open source program Gimp. Before the face image was subjected to colour transformations, it was enlarged to the uniform size of 400 × 400 pixels, the resolution used also for the final display of the generated portraits.

The main communication module between the hardware and other software modules was written in Pascal/Delphi. The whole application was running under Windows XP and later modified and tested to run under Win 7. The entire system had about 4,500 lines of code (Delphi, C++, C, C#).

6.2 Mobile phone implementation

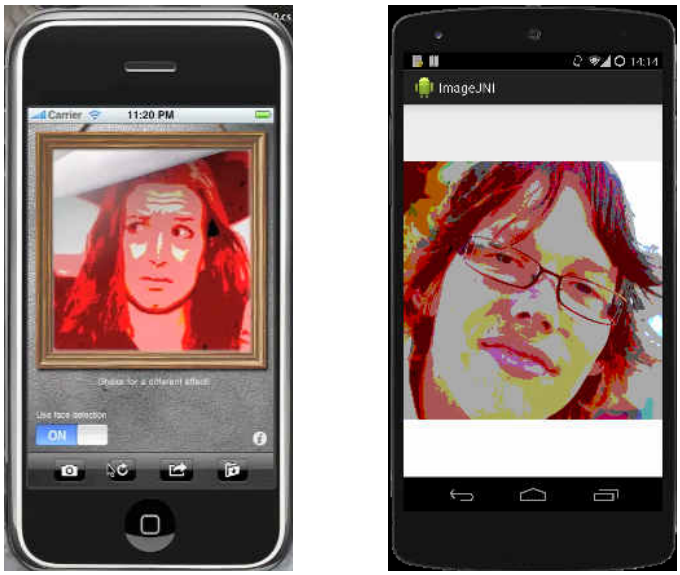
Smart mobile phones are currently computationally as powerful as personal computers ten years ago. Considering the functionality required for the installation we need a smart mobile phone with a built-in camera, the possibility to connect it to an external HD monitor, wireless connectivity to the internet using WiFi or 3G-4G for distribution of images, and a powerful processor. The installation ‘15 seconds of fame’ could therefore run on a smart mobile phone completely self-contained.

The first migration of the ‘15 seconds of fame; to a mobile platform was done in 2010 in the format of an iPhone app. This app was meant primarily as a demonstration that such migration is possible and a teaser for the actual interactive installation. A user of the application could take a photo, decide to use face detection on the photo or not, and apply to the obtained image a randomly selected pop-art effect.

The second migration to an Android platform in 2014 had the goal to replace the personal computer and the attached digital camera in the actual installation. The phone could be connected to a large monitor so that the outside appearance of the installation can remain identical to the original version.

At the same time, this mobile version could perform also autonomously only on the mobile phone. We used Android Studio and Java for application development. The size of the final portraits is 500 × 500 pixels. However, we ran into problems when we tried to connect the video output of the mobile phone to the existing computer monitor of the installation for which the wooden frame was built (Figure 2), since the video resolution of the phone was too large for the monitor. The mobile phone implementation was therefore actually never used in a public exhibition of the installation.

Figure 7 The installation '15 seconds of fame' was implemented as an app (a) on the iPhone mobile phone and (b) on the android mobile phone platform (see online version for colours)



(a) (b)

Figure 8 Raspberry Pi 2 model B computer with a camera module is used in the latest implementation of the installation '15 seconds of fame' (see online version for colours)

6.3 Raspberry Pi implementation

The Raspberry Pi platform (https://en.wikipedia.org/wiki/Raspberry_Pi) has developed into a very versatile and powerful computer used in a multitude of different applications. One of the advantages is also its low cost, a factor which should be considered if the installation would be at a later stage produced in several copies.

We tested two versions of the Raspberry Pi computer, Raspberry 2 model B and the latest Raspberry 3 model B, as well as two types of camera, a Logitech C525 with an USB interface and a Camera module officially supported by Raspberry Pi. We settled finally on Raspberry 2 model B which has enough computing power for the application and the Raspberry Pi Camera module due to its small size. The Camera module has a five megapixel fixed-focus lens. We use also an additional wide lens attachment that extends the horizontal camera angle to 122 degrees.

Raspbian Jessie, a version of Linux, is used as the operating system, while the phython programming language serves for programming so that functions for face detection in the OpenCV library can be used. Further software libraries used by the applications are Picamera, which offers a phython interface for the camera module, PyGame for the full size display and NumPy, used for pop-art effects.

6.4 Sharing of portraits on Facebook

We decided to use for the distribution and sharing of portraits, generated by the installation, the Facebook social network. We opened on Facebook a dedicated page for the installation: https://www.facebook.com/FRI15sec, entitled '15 seconds of fame – an art installation', where the generated portraits are published in real-time.

An application can automatically load images on a Facebook page, by obtaining an access token and page ID from that page. Our installation loads a new image on its Facebook page only if a new face is detected by the installation.

Figure 9 Monitors with about 2:1 aspect ratio enable the display of two square portraits side by side (see online version for colours)

6.5 A new computer monitor

We decided to replace finally also the computer monitor for the display of the generated pop-art portraits. The tiny Raspberry Pi camera and the Raspberry Pi 2 model B computer can now be fitted directly into the actual picture frame making a hole into the pass-partous around the computer monitor obsolete. Since computer monitors manufactured these days are much wider than they used to be (Wikipedia, https://en.wikipedia.org/w/index.php?title=Display_aspect_ratio&oldid=727507504), we

decided to display on this new monitor two square portraits of the same person next to each other but with different colour pop-art effects (Figure 9). Such close arrangement of multiple versions of the same artwork was often used also by Andy Warhol. We are using an ultra-wide monitor with a 21:9 aspect ratio and 34 inches diagonal (LG, http://www.lg.com/us/monitors/lg-34UM67-P-ultrawide-ledmonitor). A new wooden frame that can be disassembled was made to fit the new monitor.

7 Discussion

We have presented the genesis and further evolution of the computer-based interactive art installation '15 seconds of fame; during the last 15 years. Although at the beginning of this process we were not considering our modernising interventions as art preservation activities, we were incrementally making all the necessary changes to keep the installation in exhibitable state. Since the original authors were involved in these activities all interventions were weighted against the original intentions of the installation. The original interaction of the installation with the public was all the time preserved, that is the surprise of confronting its own generated pop-art portrait and the gradual process of understanding how the installation's inner logic generates the portraits.

If several observers are present in front of the installation, the fact that the person depicted in the portrait is chosen by pure chance was still difficult to grasp by most visitors. We observed quite often that people would step squarely in front of the installation, trying somehow to force the system to select them for the next 15-second period, demonstrating in this way a sometimes open and sometimes more subdued competition for 'media' attention, illustrating the theatricalisation and the need for self-presentation in all spheres of life (Frohne, 2002). In a way, the installation '15 seconds of fame' was a harbinger of the recent selfies craze.

Most people like to look at themselves, be it byway of photographs, paintings or mirrors, not just out of vanity, but as a way of seeking self-discovery and self-assertion. In our predominately image-mediated culture, seeing one's face in mass media is a sure sign of fame, whatever the true cause may be (Frohne, 2002). The installation '15 seconds of fame' described in this paper tries to make instant celebrities out of common people by reversing Warhol's process – producing their Warhol-like portraits and putting them on gallery walls to make the portraitees in this way famous albeit for just 15 seconds (Solina, 2004). In his film and video projects, Andy Warhol was in fact fascinated with the celebrification of 'nobodies' that marks the beginning of an era in which media attention has become the new mirror of the individual's self-perception.

The installation was from the beginning well documented (Home Page of '15 Seconds of Fame' Project, http://black.fri.unilj.si/15sec). After gradual migrations to new versions of PC operating systems and a new method of face detection to keep the installation in a stable working order, a major upgrade was done in 2014 first by moving the installation to a mobile platform and then in 2016 to the Raspberry Pi computer, rewriting the entire code in this process. This development reflects quite well Lehman's laws of software evolution (Lehman, 1980), requiring continuing adaptation of the code to evolving and changing software and hardware platforms until the system eventually comes to a point when it is more advantageous to replace it with new code on a new hardware platform.

The installation can therefore remain after this overhaul essentially the same in the way how visitors interact with it and also the outer appearance of the installation is in Andy Warhol's spirit. The installation is now also much more self-contained since all the necessary hardware is now just in the form of a framed computer monitor. Besides recreating the identical feel of the original installation using new hardware and software, a functional upgrade of the installation was made. We opted to 'improve' the installation by conforming it to the recent trends in information society, such as connectivity to social networks, which did not exist when the installation was created, to distribute and share portraits. We have demonstrated in practice that the best preservation strategy is to repeatedly exhibit the installation and how important is the involvement of the original authors in that process.

We were entertaining also other 'improvements' of the original installation in the sense of art work in progress. Since users of new media manifest a continuously shortening attention time span (Carr, 2011) which in the case of the installation '15 seconds of fame' was manifested by observers' sometimes loosing interest in the displayed portraits during the 15 seconds intervals. Therefore we considered to display instead of a static face image a very slow motion video of the face. For example the 15 second interval could be filled with extending the playback of a three second video recorded at normal speed. Another idea to attract attention, that we also considered, was to divide the portrait into 25 square shaped elements that make a 5 × 5 mosaic and show how the initially jumbled elements are progressively put into the right order. In this way the identity of the portraitee would be revealed with a time delay, heightening the expectation to recognise the 'chosen' person in the process. Such gamification interventions are quite common to engage users to enter a prolonged interaction with an application (Pavlin et al., 2015).

8 Conclusions

What have we learned in the case study which was analysed in the article? We learned that the art installation '15 seconds of fame' could be maintained in a good working order by small changes every few years, reacting mainly to new versions of operating systems and using a better face detection method. We have also learned that changing just individual hardware modules can be difficult to realise since the standards for interconnecting hardware components tend to change over time. After about ten years a complete rewrite of the code was necessary to move to a new hardware platform – a Raspberry Pi computer in this case. This switch to a miniature and cost effective platform was beneficial also from a space saving perspective since the entire necessary hardware is now hidden in the wooden frame of the computer monitor. The generated pop-art portraits are now published on a dedicated Facebook page so that portraits can be shared much easier. Although the installation runs now on different hardware and using rewritten software the interaction with the visitors remained basically the same. The case study presented in this article demonstrates that a more fluid view on preservation, looking beyond material artefacts, can be artistically fruitful. The key to successful preservation is also the involvement of the artist whenever possible, repeat re-creations, careful documentation, delegation of responsibility to trusted individuals or institutions (Real, 2001).

Guidelines and standards of care for born-digital are evolving although this is an emerging field with many unanswered questions (Real, 2001). Preservation of born-digital art is an interdisciplinary endeavour but the role of the artist is central since the artist understands and knows best what is at the heart of the art piece. One needs to look beyond the material and consider the processes and interactions which are the less-tangible qualities of the installation (Real, 2001). Digital art preservation is confronting ever more challenging cases. While in the past, most digital art works were in a sense self-contained, off the grid, they are now more often dependent on some internet services, such as in the case of the Atlas 2012 project (Bovcon et al., 2013). Preserving such distributed digital art works which use cloud-based services, over which one does not have any direct control, can be exceedingly difficult.

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