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Emulation in the context of digital art and cultural heritage preservation

Requirements, Approaches and yet so much more to do

Abstract: The article focuses on current approaches and potentials for emulation technologies within the cultural sector. In order to mark the field, practical examples are given. They convey some of the interests of "computer culture enthusiasts", who engage themselves within cultural production and preservation. In order to sustain their heritage, they have started applying emulation technologies long before traditional institutions. Furthermore, institutionalized interests of cultural memory institutions are explained. Opposed to the enthusiasts' examples, they focus on the process of value creation within the cultural sector. Opposed to the formerly given examples, this approach is normally centered on (single) "objects" and their specifity, originality, authenticity etc. Coming to a conclusion we ask how far these two seemingly opposing lines might become reconciled. The theory of digital memory seems to be adapted for this alliance and broadens an outlook on future research activities.

Keywords: digital preservation, emulation, digital heritage, longevity, significant properties, non-enumerable properties

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1 Introduction

With the occurrence of home computers in the late 1980s, and even before,[1] artists started using digital technologies, computers or network based media for their ways of cultural or artistic production, communication and articulation.[2] Thus computer and digital technologies are not only found in the domain of industry and business application, science or within the service sector, but have become an integral element of daily cultural production.[3] Moreover, technology and culture as areas of interest are overlapping.[4]

Beyond a smaller group of specific, preliminarily planned media productions, most of the artworks or digital heritage goods happen to have developed – somehow. They were implemented one way or the other, are little or not at all documented, seldom follow predefined ways or existing rules, but instead often merge technologies which are not meant to fit properly to each other. They are cross-brand, cross-software, cross-technology and often even cross-style. This causes many problems. To simplify this highly interesting, very complex, diverse and nevertheless often extraordinarily sophisticated approach towards digital technologies in culture, one could state that most of the digital artworks or cultural productions in digital media are just different.

They are different in terms of being unexpected and surprising, often playful, cheerful and therefore at the limits of the applied technology. They use everything the technology offers like specific graphics or sound cards for effect generation, vintage sound systems or solitary data resources, effects counting on bandwidth and so on. This does not at all support their compatibility or interoperability, their portability and sustained preservation. They do not cover current archival regulations or fit into pre-defined sustainable file formats. Out-of-the-box solutions, which might be offered by current document-management-systems, are easily swamped. Thus, digital artworks can (very often) hardly be managed by fully automatized archiving routines. Beyond technical or documentarian aspects, one of the major challenges is the obligation to render decisions.

1 Moles (1971); Moles/André (1971); Franke (1971); Franke (Ed.) (1976); Blobel (Ed.) (1987); Nake (1993); Nake/Kersting (2006); Klütsch (2007), Herzogenrath (Ed.) (2008).

2 Claus (Ed.) (2006); Baumgärtel (2001 a); Baumgärtel (2001 b); Lieser/Baumgärtel (2010).

3 Coy (1997).

4 In this text, cultural phenomena in the field of computer games (Lange, Ed., 2002; Lange, 2006; Guttenbrunner, 2008; Bergmeyer, 2011), demo scene (Botz, 2011), 3D simulations and other forms of complex digital objects are excluded, even in their environment wide emulation communities have made.

In addition, digital works of art and cultural property do no longer occur "only" as "single object" or within the environmental framework of traditional memory institutions (e.g. museums, but also libraries and archives), but have located themselves in the public space of the network: on community platforms, subcultural blogs and even mainstream commercial sites or services such as Flickr, YouTube, Facebook, Google+ and many more.[5] Some artworks are conceptually based on services such as Skype or other, often temporary web applications or cloud solutions, so that they can hardly exist without these services' functions.

At the same time, these artworks, as lately emphasized by research projects such as Planets[6], Keep[7] and additions ones,[8] perfectly highlight gaps within valid preservation routines or emulation and virtualization products. In certain cases, as the following examples will explain, the internal structure and intention of cultural or digital heritage goods underline the importance of emulation as preservation strategy. Nevertheless, as far as the current state of emulation research and application is provided at different parts of this Journal`s issue, we can basically focus on the question: "how far can emulation technologies make sense in relation to both cultural commitments as well as in preservation actions?" We want to explain which topics are usually treated within the conservation framework of cultural goods before implementing technological solutions. In this field of analysis and negotiation, categories like "authenticity", "originality" or "integrity" are related with attributes like "importance" and "relevance". These token follow well known pattern of value generation. One of the core questions among this process is: "what are the significant properties of this object?" Even though the term "object" hardly covers the requirements or facticity of the following observed digital phenomena, we keep the term in order to be able to speak.

Even though the following considerations do not cover the whole field of emulation practice within the cultural field, because it is too extensive, we want to offer two quite opposed approaches. In order to open the field, two quite different approaches are presented: First a more engaged or activist approach towards emulation is observed, based on phenomena which have occurred within the cultural field. The term of "non-enumerable properties" is explained in order to highlight specific approaches developed within digital communities which have started to take care of "their own" memory.[9] As time passes, their stored data objects generate their own cultural value.

Following, the "institutionalized process" is shortly referred to, locating emulation within the identification and documentation process of preservation routines. This strategy is less erratic and focusses on "single objects" – representing a collections perspective.[10] This process ranges from the acquisition phase and initial documentation, via in depth analysis, so called "preventive" conservation actions up to restoration actions. At each step "longevity" is faced.[11] In order to identify the significant properties of the object, the model of a so-called "object logic" is introduced, which characterizes at least four main areas of importance. Finally we explain how far the concept of the "object logic" can be extended to net-based phenomena, which offer "non-enumerable properties" as described earlier. This last-mentioned aspect opens the view to phenomena of user action and tradition of "knowledge", as it is discussed in the context of "digital memory" of our own culture.

2 Community Driven Approaches

In order to illustrate the kind of digital objects the projects ***olduse.net***, ***MAME/MESS*** and ***Geocities*** are introduced briefly:

olduse.net is an archive of ten years of Usenet posts, containing the first messages from the Usenet's very beginning on June 5th 1981.[12] All activity that happened during the next 10 years is being replayed in real time, 30 years later. ***olduse.net*** is accessible via the classic NNTP or a web interface, which emulates a vintage terminal session with an original newsreader. This project was started by Joey Hess on June 5th 2011.

5 Aigner/et al. (2011).

6 The official website has been closed. For reports see: http://www.openplanetsfoundation.org/ (last accessed: 1. 7. 2012).

7 http://www.keep-project.eu/ (last accessed: 1. 7. 2012).

8 Important information portals are e.g.: http://www.digitalpreservationeurope.eu/; http://www.dcc.ac.uk/; http://cool.conservation-us.org/ (all links were last accessed: 1. 7. 2012).

9 This part and especially the terminology have been developed by Dragan Espenschied who participates actively in the web-cultural sector in both terms: as analyst and creator as well as artist.

10 Schreibman, et al. (2004); Altshuler (2005); Schwander (Ed) (2010).

11 Besser (2000); Jackson (2009).

12 http://olduse.net/ (last accessed: 1. 7. 2012).

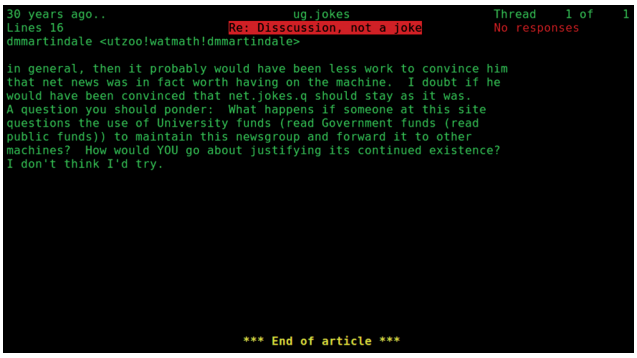

Figure 1: olduse.net Javascript terminal and news reader emulator. Created by Joey Hess in 2011, screenshot taken in 2012.

MAME is a community project by video game enthusiasts that aims to provide software emulation for every arcade video game hardware in history.[13] It was started 1997 by Nicola Salmoria and has produced an impressive kit of software components, focused on reproducing in detail every behavior and subtlety of the original machines. ***MESS*** is a spin-off project with the goal of providing a similar framework for home computer hardware and game consoles.[14]

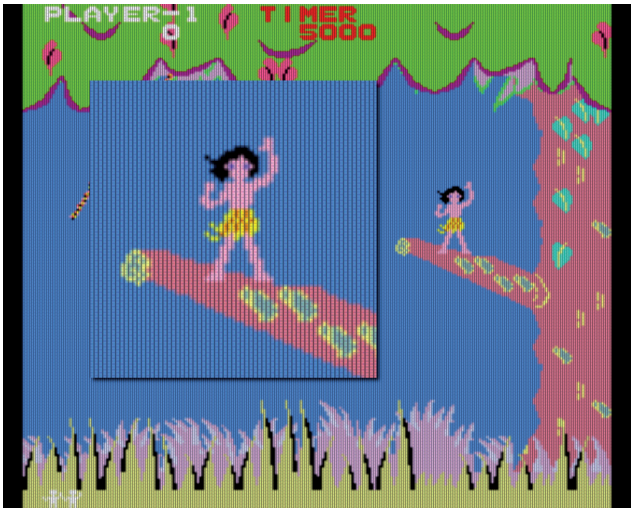

Figure 2: MAME aperture mask simulation overlay, with enlarged detail. Created by MAME team member "Sexybiggetje" in 2010, screenshot taken in 2012.

Geocities was a free web hosting service. It was initiated by the company Beverly Hills Internet in July 1995. Yahoo! acquired the service in 1999 and shut it down on October 26th 2009. A group of computer culture enthusiasts, calling themselves Archive Team, conducted a distributed mass-download of as many ***Geocities*** URLs as they could find out about and released this data one year later as a bit-torrent download containing 36.2 million files.[15]

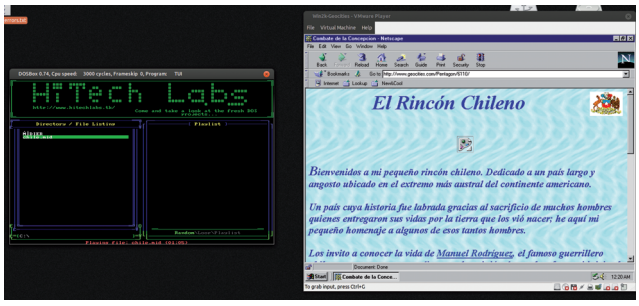

Figure 3: Re-creation of the visuals and audio part of a historic Geocities home page. VMWarre emulation of Windows 2000 with Netscape 4.03 and DOSBOX emulation of MIDIER sound player. Combined both re-create together an authentic appearance. Restoration created by Dragan Espenschied in 2012. Screenshot taken in 2012.

These examples show vividly that the outer boarders of these phenomena lose their ways and are therefore hard to observe as "objects".

2.1 Emulation and Encapsulation for Non-Enumerable Objects

Long before the conservation of digital objects appeared on the radar of traditional institutions, online communities have taken care of their own digital heritage. Such communities usually unite around a topic or practice its members are enthusiastic about, without direct financial or professional interests being involved. They might be producing cultural artifacts in peer production processes that they deem to be worth conserving or trying to conserve objects or phenomena which might be created by third parties, or have an interest in archiving as an activity itself.[16] Their approaches have been shaped by practical and technical concerns rather than established practices and traditions existing in library and archiving sciences and in many cases operate in a legal gray area. Especially copyright laws are frequently ignored. Yet,

13 http://mamedev.org/ (last accessed: 1. 7. 2012).
14 http://mess.org/ (last accessed: 1. 7. 2012).
15 http://thepiratebay.se/torrent/5923737/Geocities_-_The_Torrent (last accessed: 1. 7. 2012).
16 Reddeker (2006); Dekker (Ed.) (2011); Dekker (Ed.) (2012).

these communities have been tremendously successful in conserving aspects of digital culture that academia is still struggling to define.

In all the cases mentioned before – **olduse.net**, ***MAME/MESS*** and ***Geocities*** – there is no selection made on what objects under the main umbrella of the project should be treated to a conservation effort. Specifically, no set of Usenet postings, no arcade games and no personal home pages are discriminated or privileged. Instead, the goal is to cover all available objects and practically do "as much as possible." Functional and influential internet communities have long understood the necessity of clear, wide open goals with a low barrier to contribution, skipping long and paralyzing discussions, subordinating small differences to the great cause and putting into practice the Internet Engineering Taskforce's motto "rough consensus and running code".[17]

If, for example, a loosely tied group is forming in online communication channels with the goal to preserve a certain kind of digital cultural phenomenon, artifact or technical system from deletion, a selection of what objects should be prioritized or excluded during this effort is useless for the following reasons:

- The democratization of media has enabled so many authors and created so many audiences that no known conscious selection process is able to scale. It takes less effort to conserve all data than to pick "the most relevant." In the end, if everything is saved, everybody will get what they thought is the most relevant part anyway and the community will be able to operate on the set goal. Sticking to a selection process when it comes to digital mass culture is delusional. Ignoring digital mass culture simply contradicts the concept of digital heritage.
- By not considering discrete aspects of digital objects and instead attempting to create **dumb deep copies**, **non-enumerable properties** of the objects are the most likely to survive. Non-enumerable properties can be any combination of
  - properties which are located outside the digital object and are only revealed in the interaction with other objects,
  - properties not known to be relevant at the time of conservation – "common sense" facts like input devices, software versions, technical deficiencies, bugs – that are difficult to describe when operating from within a certain cultural setting
  - **ambiguous data**[18] that does not have a defined semantic meaning but semantics externalized in users' bodies and therefore is likely not indexable and easily overlooked, or
  - the multitude of practices of creating, manipulating and handling digital objects that are key to their future interpretation and understanding. Even supposedly simple objects like word processing files can appear in many different contexts. There is for most cases no single right way to "display" a piece of data.[19]

Making as few decisions as possible during the conservation process ensures that the future decision space for an artifact is kept open as wide as possible and minimizes the risks of inscribing an interpretation by the removal of properties.[20] At the same time, a minimum of decision-making to be done makes mass-conservation economically possible, especially since efforts undertaken by a community are usually concerned with a technically homogeneous set of artifacts.

Using software emulation is a feasible strategy for capturing most of an artifact of the above properties "by accident", though for the purposes of digital conservation, software has to be evaluated critically. For example, virtualization products currently available are focused on providing a shell for legacy business applications and do not necessarily put effort into reproducing effects that contribute to subtle and poetic effects of digital objects. For instance, in the leading virtualization solution VMware the emulation of historic sound hardware is underdeveloped to the point of being almost useless; the virtual machine's processor clock speed, in fact the speed of any component, cannot be changed. This is rooted in the cultural assumption that a computer has to work efficiently, doing everything "as good as it can", eliminating hassle and waiting time. However, for the authentic reproduction of many digital objects, properties currently considered inconveniences are important. – However, if "everything" was

17 http://www.ietf.org/tao.html (last accessed: 1. 7. 2012).

18 Examples for ambiguous data are desktop icon positions, nameless color flags on files saved in forks or metadata, UI preference configuration settings, empty or erroneous files. (Espenschied, 2012).

19 See for instance Cochrane (2012).

20 The dominance of the PDF-A format might serve as an example of over-interpretation by reduction: The PDF format assumes that documents are paginated formatted to fit to the dimensions of a carrier medium (paper) and being produced for printing. Digital text and word-processing files do not necessarily need to be handled like this and even might contain extra information, like editing revisions.

saved without discrimination, progress in emulation and virtualization software can lead to better reproduction results in the future. Such cases might require conservation decisions for taking actions to **enrich** – not reduce – the archived object's emulation to enable a more faithful reproduction.

The ***MAME*** team has exceeded this approach because as video game fans they understand that game designers, developers and artists needed to work with bugs, glitches and shortcomings of their media. What seems, from a current perspective, like a deficiency today, for example very low resolution graphics and rough aperture masks on CRT screens, was considered bleeding edge technology when the games were created and informed much of the visual style and possible interactions logic. ***MAME*** project members have worked to create aperture mask simulations "overlays" as a component of their complete emulation system for today's high resolution screens, making emulated graphics look dramatically more authentic on today's high resolution screens than with an emulation purely based on a representation of data in the historic screen buffer on a contemporary LCD screen. Once created, the modular architecture of ***MAME*** made this enhancement available to all emulated game titles,[21] and was subsequently included into the unrelated emulator DOSBox as "scalers."

This might be considered a quite interpretive part of the ***MAME*** project, but underlines that data does not narrate well by itself and the conservation of as many properties as possible in software is a worthwhile undertaking in addition to dumb deep copies.

Less technically complex but just as consequent is ***olduse.net's*** take on conserving historic Usenet postings by replaying every recorded event with a 30 year time delay. Experiencing just a handful of post trickling in every day, without any spam message interrupting, is just as fascinating as reading the actual contents. Reading is enhanced with an in-browser Javascript based terminal emulator running a text-based classic newsreader software. Navigating through conversation threads with keyboard commands and spiking through a 80×24 character screen peephole is a notably different experience from later newsreaders using a GUI and even more so from how online discussions are happening today. The artificial clumsiness enhances understanding of how and why each post exists in the way it does. Considering the heterogeneity of software and systems used to interact with the Usenet even shortly after its formation, a very convincing superset of properties has been chosen for emulation.

The Archive Team's ***Geocities*** rescue operation is not considered much with emulation of computer systems in the artifact it produced – the huge mass of historic amateur home pages –, but illustrates a divided, almost paradoxical approach. The public facing part of Geocities available via HTTP was everything the Archive Team could get, as the owning company Yahoo! did not cooperate in saving the data or even acknowledge it as valuable.

Figure 4: Excerpt from collection of Under Construction signs found in Geocities. Created by Jason Scott (Archive Team) in 2009. Screenshot taken in 2012.

An emulation environment to recreate an authentic Geocities surfing experience can be puzzled together from the information contained in the distributed data; without it, the data by itself is hardly making any sense. This deficiency in context was conquered by the Archive Team by delivering a captivating narrative on what the millions of home pages on Geocities actually meant and might mean today. The story about Yahoo! not respecting their users and Geocities being one of the most culturally underestimated outlets of expression stirred up quite some public awareness (most notable through Jason Scott's speech at the Personal Digital Archiving Conference 2011)[22] causing many people who had experienced Geocities first hand to speak up and inscribe notes of their perspective into the social media of today. The heritage of Geocities was saved, one part in a chaotic mess of files, another part in

21 Documentary screenshots of examples can be found at http://www.mameworld.info/ubbthreads/showthreaded.php?Cat=&Number=92158&page=0&view=expanded&sb=5&o=&fpart=1&vc=1 (last accessed: 1. 7. 2012).

22 http://youtu.be/lHh0_1yzopc?t=4m50s (last accessed: 1. 7. 2012).

parallel by users telling their stories in detached distributed locations.

This is close to be called an encapsulation of non-enumerable properties by inspiring inscription of personal stories in current media – a virtual machine for keeping narratives alive.

3 Institutionalized Conservation Approach

From an institutionalized point of view instead, single objects form the focus of operations. Well known principles like "originality", "integrity", "authenticity" and "significance", which are ethically pretended as core paradigms in art conservation, still pretend preservation actions.[23] At the same time many conservators have the feeling that longevity and current software applications or web-based platforms seem still equally false friends as durability and new generation consumer devices.[24] Even though technology watch reports tend to estimate permanence and technology assessment tries to cover parameters of risk and dynamics, they hardly face the artistic types of objects and the expected period time of at least 50^{+} years ahead. No reliable ways of telling how long current or future hard- and software devices, software-based tools, technology (including preservation tools) will last. Thus, it seems likely that preservation actions will require permanent support. The most current step from technological real live to encapsulated (emulated) preserved or sustained live needs to be proceeded in the best and possibly comprising way possible.

3.1 Approaching the object

In the long run, sustainable preservation strategies or even policies in the institutionalized cultural sector require an understanding of information technology. Preserving "only" the information of an object, in terms of the "content", is not often not sufficient. The objects are very often integrated into a specific software environment, which adds semantic values to the pure "content". The object need to be (technically as well as semantically) contextualized, because they are understood as specific articulations forms of digital culture. Beyond the former (original) appearance, which we have mentioned earlier as "originality", has to be ensured.

The other way round, one can say that, within the arts context, the invisible, digital parts of an object often obtain high importance. They generate not only certain audiovisual or haptic effects, but are furthermore embedded within a larger artistic concept. This means that the "effect" of an artistic software (application) cannot be observed split from the production process. Thus the original coding should be preserved within its historic environment and should so far contain and communicate a "feeling" of the context. The historic context, by means of certain technical development status (of a society/technical community), cultural climate and preferences (e.g. popularity of a specific tool), programming stile etc., should at least be adequately documented and sustained as good as possible.

In addition to the ontological status of the object, its proper functionality and appearance, the context needs to be sustained. Authentic historic context and information are often related to a specific technological environment. This "time specifity" can be encapsulated within a specific emulation environment. Emulation can be an important preservation instrument due to the fact that it results from the identification of the specific properties of both, the object itself as well as the technological implementation. This offers a specific context, which can hardly be migrated.[25] As figure 5 shows, four main areas of interest can be differed: technical core aspects, aspects of appearance, conceptual aspects and the historical differentiated context.

Technical core aspects includes the core data of the object (files and assets), the internal structure of the object as well as its implementation in relation to the system environment (OS). Here we differ between so called "core aspects" e.g. files and source code, which contain all elements which belong to the original coding/application, and "supporting elements". Supporting elements are normally soft- or hardware elements like the original platform or the system environment, which are relevant in order to precede the work but have not necessarily been built up by the artist/community. Their functionality is relevant but their facticity might be changed

23 Rothenberg (2000); Rowney (2004); Laurenson (2006); Richmond/Bracker (2009); Gagnier (2010).

24 Cullen/Hirtle (Ed.) (2000); Stovel (2007); Hermens (2009); INTACH (2009); Cruz (2011).

25 There are examples for format migration, but one needs to carefully differ between migrated objects desiderates in terms of documentation, implementation of a new version of the object (which should have a different indication and date) or a preservation action, which sustains the given version of the object. Otherwise there is the danger of producing replicas or losing value.

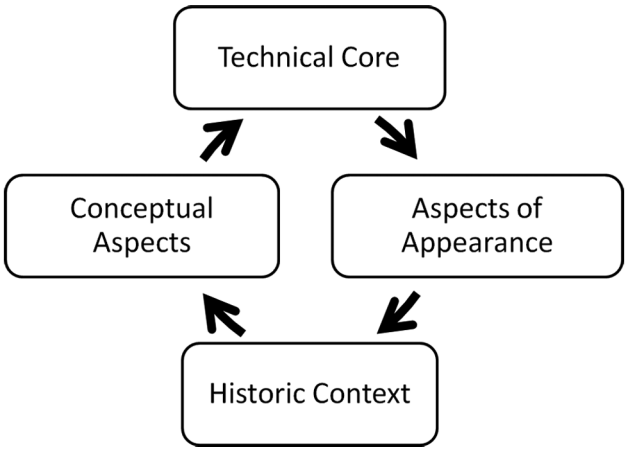

Figure 5: Object Logic. Dimensions specifying cultural significance. Concept created by Jürgen Enge and Tabea Lurk in 2010. Version 2012 b.

in future. Whereas the "core components" should not be modified but kept as such due to authenticity questions, "supporting components" can easier be adjusted/updated more easily from an ethical point of view. They have by definition not been implemented "touched" by the artist him- or herself. The decrease in relevance within the technical layer is important to enable stabilization actions. Nevertheless here the biggest and often irreparable mistakes can happen. Emulation instead reduces the risk due to the fact that it offers platforms which equal the original development environment.

Aspects of appearance face instead the functionality of the object from the user's perspective. This means that its handling and aspects such as the "look and feel", the installation of the object within a special or material based environment or aspects that have been described earlier in relation to ***olduse.net's*** command line handling are important in this context.

Conceptual or intentional aspects relate to the basic idea, the implementation mode (why was for instance a specific programming language used) as well as personal estimation/classification of the artist (does the artist/programmer tend to use at the bleeding-edge or firmly vintage soft-/hardware). These aspects seem important in a context where "originality" is (still) related to the idea of any kind whatsoever author/artist.

Finally the historic context shall preserve an idea of the kind of technology, which was available at the time of development, which communication tools were broadly used and additional socio-cultural context information, which is often related to a specific community/society.

These layers follow the classical categories of written documentation in conservation but enhance them by weighting their relevance and documenting relations. In addition, these aspects cannot be observed apart from each other: how could a source/core layer be built without any concept? This is why we tent to visualize this so-called concept of "object logic" as circular matrix.

4 Conciliating Discrepancies

The two approaches described in paragraph 2 and 3 work at first glance irreconcilably: on the one hand, there is the idea to encapsulate "everything" once and to store and later start the evaluation and identification of "meaning". On the other hand, especially within the institutionalized cultural sector, one is convinced that one must first understand the singular object and carefully identify each part capture before developing a proper conservation strategy in respect to the (singular) object. But are these two approaches really different?

We can learn from the "computer culture enthusiasts" approach that little is gained from isolated entries of individual posts etc. On web-based platforms it rather makes sense to take the entire platform into account. On this medium the digital society rages out its cultural actions and thus the platform itself acts as object. From a theoretical point of view to keep "everything" means to keep broad supplies of dated and directed links, dialogue-structures, internal references of different types and even linkage to related platforms, websites etc. in sight.

In order to figure out how far the concept of "object logic" can be applied to huge and little structured/hybrid digital objects such as web or community based platforms, we need to consider the whole communication environment (web-platform) as "the object" to be preserved. This causes the following considerations:

– Core Level: For web-based platforms, the functionality which is provided for the user belongs to the core components. It has to be sustained in addition to the filed data of the entries (cf. olduse.net, MAME/MESS and Geocities). Taking the fictional example of a platform like Facebook, which seems quite common today, not only the user profile would be of interest but also the display logic which tells the user, what his/her "friends" are doing in this very moment of visit. This functionality belongs to the core, because following actions are triggered by these mechanisms. It needs to be preserved in order to understand the internal dynamics of the web-platform. Furthermore, the search engine and additional features belong to the core. However, items that are relevant "only" in

terms of functionality, but are interchangeable as a tool, can be identified (only) as system-relevant. Staying with the fictional example of Facebook among those elements are cf. the storage system and the database. The storage system of those services is nevertheless often out-sourced on distributed cloud systems. Furthermore, it often contains a (equally removable) network component, which spreads the filed data to distributed storage servers. Also the database system is often relevant only in terms of operation and display but could be exchanged if similar functionality would be guaranteed.

- Appearance Level: Preserving huge parts of a web-based platform or the community platform as a whole by emulation, aims to provide an "artificial biotope", in which the objects former look and feel can be sustained. As long as the sustained parts stay representative, even selected "snippets" might secure the former appearance.
- Historic Context and Conceptual Level: Previously, many reasons were given to provide the benefits of the approach of enthusiasts in terms of historical completeness and the conceptual such as cultural diversity of retained content. The provision of context is often very difficult for individual works of art or single objects, as mainly focused by institutionalized preservation strategies. Their objects are often decontextualized from their (historical) meaning due to their age or additional aspects which have be changed since their original production. This means that the historic or semantic context needs to be mediated by written sources (descriptions, traditions) and further needs to be translated in the current time again and again. Opposed to the single object approach, the conservation of whole platforms seems to cause less context-driven problems due to its likeliness. It seems likely that the context can be identified independently of accompanying (semantic) descriptions. Instead the (encapsulated) object (platform) forms the context itself by the structure of its entries.

One could also say that it is a lot easier to develop a context out of a group of entries and a huge set of sustained information than to adequately provide the context for a single object. In addition, history has told us that aspects, which are deemed to be for granted today and thus shape our culture, are in general rarely dedicated, because everyone knows them.

To summarize these preliminary considerations one can state that the different steps of the "object logic" can be applied to whole platforms, as long as they are observed as object.

4.1 Conclusion

The brief outline makes clear that in addition to the institutionalized, object-centric approach community-based solutions exist which take into account the knowledge of context-bound knowledge and structures of action and behavior. The applied concept of emulation of the "computer culture enthusiasts" can be valuable also in a more classic conservation and restoration context of cultural transmission and tradition, because it receives the data, in terms of related or linked files, in their immediate context. But at the same time it pays special attention to the original system components. Even if the question of the selection is excluded, which seems very important e.g. in an archival environment, the approach meets the basic requirements of secure cultural "authenticity" and "integrity".

From a theoretical perspective, the applied sustaining operation, which treats both (data) objects and programs or applications equally, reminds of the *topos* of the von Neumann computer architectures which still characterizes computer technology and our concrete calculators. In 1945, scarce 25 years prior to the development of NASAs well-known OAIS model, the mathematician John von Neumann (1903–1957) developed the concept of common storage of data and instructions (programs/algorithms) in his *First Draft of a Report on the EDVAC*, which serves as a synonym for computer technologies ever since.[26]

We discuss the combined approach, which reflects in addition to the "pure" data (files, content, assets) also the structure and contexts of (digital) actions, under the term of "digital memory". The digital memory reaches beyond simple storage and deals with the tradition of digital and cultural heritage. In this context emulation occupies a central position. It enables a negotiation-based concept of memory that relates memorable knowledge processes from the existing data structures and their usage contexts and makes it technologically deducible.

We consider "digital memory" a place where the objects, actions, and their relationship to each other as data is permanently stored – sustainable and according to ontologically and ethically best possible conditions. (Data) Objects and their action-based context, which is mapped in their technological structure, are required at a later date to restore the "original knowledge". In this con-

26 von Neumann (1945).

text, emulation creates a virtual layer to the observed phenomena and enables a continuation in an "artificial biotope".

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