A USABILITY STUDY OF EMULATION

Testing the usability of emulators using games

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Abstract – In this paper, we study the usability of a range of emulators using video games as an example digital material. We investigate four different emulators using four different games from a period spanning 1963 to 2011. Four students who each played all of the four games assisted us in the study. From their responses we identified a number of usability challenges. Finally, we discuss possible solutions to the usability challenges founded.

Keywords – Usability, Emulation, Access, Rendering, Interactivity

Conference Topics – Exploring the New Horizons; Enhancing the Collaboration.

I. INTRODUCTION

Most of the digital cultural heritage in existence is no more than a few decades old, but we are already in a situation where it can be extremely difficult to access older digital documents and applications. Internationally, scholars and technicians work on the development of preservation strategies to ensure future access to old digital material. One of the two main strategies considered is emulation. Emulation can ensure a high degree of authenticity, but this may also create challenges for the usability of the systems: When emulation imitates an old computer system, there is an implied claim that the user can understand and interact with the original system being emulated. Here we start to investigate to what extent this claim holds true.

Thus, the goal of our study is to examine the extent to which the fidelity of emulation systems cause accessibility issues when accessing older digital material.

A. Background

Various research projects have focused on emulation as a means to access older digital material.

EU-funded research projects such as PLANETS (Preservation and Long-term Access through Networked Services) [1] and KEEP (Keeping Emulation Environments Portable) [2], [3] have examined various technical issues of using emulation to preserve digital objects, especially complex objects like video games.

The Library of Congress-funded Preserving Virtual Worlds [4] project focused on the practical issues of video game preservation in general, for

17th International Conference on Digital Preservation

iPRES 2021, Beijing,China.

DOI: 10.1145/nnnnnnn.nnnnnnn

example studying the quality of the authenticity of a number of emulators.

These and other research investigations have contributed valuable knowledge about using emulation in digital preservation.

A project working with existing emulators in a framework is EaaS (bwFLA [5]). The main focus of the project is to offer emulation as a service (EaaS) [6] making it possible to access emulators and emulated digital objects though web interfaces.

Building on the EaaS framework the Emulation-as-a-Service Infrastructure (EaaSI) [7] project is developing an infrastructure to expand and scale the capabilities of EaaS. A part of EaaSI is the UVI [8] which attempts to dynamically generate view-paths based on analysis of the digital objects. This can be seen as a more advanced way of implementing the KEEP project's vision to match a digital object (using its file format) to a relevant emulator.

The emulators used within the digital preservation community are often developed outside the community. Most emulators come from an active community of video game enthusiasts. The focus on emulation quality of function and authenticity is therefore mainly on games more than other digital objects. However, a few preservation centric emulators have been proposed, the Emulation Virtual Machine (EVM) [9] (p. 8), the Universal Virtual Computer (UVC) [10], and Dioscuri [11].

A good emulation system ensures a high degree of authenticity in the execution of older computer applications, but exactly this fact can provide a number of challenges in terms of accessing the desired material: The strategy requires that the user is capable of understanding the original material and interacting with the original equipment being emulated. For example, will a user who has only encountered contemporary GUI interfaces be able to interact with command-line interfaces (CLI) [12] as the one provided by the DOS operation system?

Previous research projects have touched upon the usability side of emulation [13], [14]. However, our research does not only focus on the general usability, but also investigate whether a high degree of authenticity creates challenges for the usability.

II. EXPERIMENTAL SETUP

To investigate the implied claim that the user can understand and interact with the original system being emulated, we decided to conduct a usability study. We decided to make it a study of four games, using four emulators, and testing with four users.

We chose to conduct a study that was both small-scale and explorative, i.e. fairly wide in scope: We wanted to investigate whether the emulation approach actually caused any issues in a wider perspective, rather than doing a narrow study that could have made the data easier to quantify.

A. The four video games

To get an overview of any challenges of using emulators, a number of video games was selected, the diversity of which ensures that the use scenarios contain technical and expressive diversity as well as representativeness in Danish video games. It is relevant to separate video games as a case for this evaluation of emulation of digital materials, as video games represent an independent form of expression that is highly relevant for documentation and analysis of contemporary cultural production. The selected video games spanned the period of 1963 to 2011.

Name	Year	Platform	Publisher
Nimbi	1963	GIER (old Danish computer)	Piet Hein
Kaptajn Kaper i Kattegat	1985	PC DOS	Peter Ole Frederiksen
Sword of Sodan	1988	Amiga	Discovery [15]
Words United	2011	Android	Mingoville A/S [16]

Table 1: Overview of game titles used in the study

B. The four emulators

To each video game, there is an associated platform/environment and to that, we have chosen

an associated emulator. The associations between platform and emulator can be seen in Table 2.

Platform	Emulator
GIER (Old Danish computer)	GIER-Simulator [17]
PC DOS	DOSBox [18]
Amiga	WinUAE [19]
Android	Android Studio [20]

Table 2: Overview of emulators used in the study

C. *Emulation frameworks*

We considered using an overarching emulation framework and investigated two possible solutions that could be used to support our study: The KEEP Project emulation framework, and the EaaS-framework. Both of these, however, lacked immediate support for all of the systems we worked with.

Therefore, we chose not to use an emulation framework, and ended up installing the selected emulators directly on Windows. An advantage of choosing this course of action is that our study gives us a baseline of the usability of emulation without framework support.

After the formal ending of our study, we also investigated the possibilities of using Internet Archives "Emularity" framework. The Emularity framework offered support for two of the four emulators we used in our study. However, adding the other two emulators to this framework would have been a major task.

III. THE USABILITY STUDY

A. *The users*

In an attempt to best "approximate" the future user, we decided to work with students as our test users. The students were all in their early twenties, and they all came from "non-technical" fields. Given their relatively young age, it was our expectation that most of the games and emulated environments would be new to them, which also proved to be the case.

B. *Usability-experiment method*

To investigate the possible usability issues that the users could experience playing video games using emulators, we decided to use think-aloud [21] as our main method of investigation. The think-aloud method is a well-known usability-testing method, which gives great insight into the user's challenges in interacting with systems, in this case software (emulators and games).

C. *Logging*

1. *INTERACTION RECORDING*

All user interactions with the computer was logged using screen capture software. We recorded the user interaction together with the vision and sound from the program (emulator). Additionally we used a microphone to capture the users' verbal comments during the experiment. Having the user's interaction and speak linked in the same video made it easier to register and analyze the user's usability issues.

2. *AUDIO RECORDING*

To supplement the screen capture recordings we used a standard sound-recording device, that made it possible for us to also record the start, end, and between emulator shifts so we would not lose any of the user's speak (thoughts) while the interaction recordings were stopped.

D. *Questionnaire*

Each user answered a questionnaire concerning their (perceived) skill level regarding video games and computer skills in general. We also asked how often they play video games. All the users choose the same level for their skills in video games as the level for their computer skills in general. We also asked them how often they play video games (daily, weekly, monthly, or never). Their answers was one daily, one weekly, and two monthly

E. *Task list*

The users were give a set of tasks for each game/emulator combination in the test. The tasks were centered around basic operations within each environment, i.e. "start the emulator", "start the game [title] in the emulator", "play through stage 1 of the game", etc. For some of the games we provided

the users with a 1990's style joystick and asked them to use that when playing the game.

IV. USABILITY OBSERVATIONS

In general, our users had a hard time completing the tasks if left completely on their own (i.e. receiving no support or guidance from us). They all encountered similar issues as they went through the test.

A. Navigating an unfamiliar OS

It became obvious that the lack of a graphical user interface in some of the systems/emulated machines was a major hurdle. Among the issues encountered in the CLI based system (DOS) were the following:

For older systems like DOS, there is no easy way to get a visual overview of the "machine's" content or to search for content.

Users would look for ways of navigating or interacting with the OS using the mouse. They would click on text and program titles to make them run, not write a path on the command line and hitting Enter. In particular, this issue was seen when the users tried to navigate various interfaces with color-coded text that was interpreted as being "clickable".

Users would expect "normal (i.e. contemporary) OS features" like copy and paste between programs. This does not necessarily work within the emulator or between the emulator and the outside environment.

Certain concepts like "mounting a disk [disk image]" or typing commands to start a game were a completely unknown phenomenon for the users. The Amiga 500 boot screen (which is an image of a hand holding a 3.5" floppy disk) initially baffled them. None of them knew how to progress, until they were told that they could "insert a disk" using the settings within WinUAE (this is an example of a combined OS + Emulator issue, since the emulator actually fakes inserting a 3.5" floppy by using standard contemporary OS functionality such as choosing a file, using drop down-menus, etc.).

B. Input devices and peripherals

The old input device (joystick) was unknown to the modern user. Several of them had trouble finding the correct orientation (i.e. "which direction is forward?") and expected the two "fire" buttons to be mapped to different control elements within the game, in a similar way to the now-familiar ABXY layout on most modern game pads.

Once the users had started using the joystick, several of them expected all further interaction with the emulated machine to happen through this device.

C. Errors and messages

Error feedback (audio) both from the emulator/operating system and from within the games was hard to understand, as it is very different from modern computer feedback.

Situations occurred where it was very difficult to know where the fault was, and the user would think that it was e.g. an input device that had failed.

In order to maximize the authenticity of the experience, we had adjusted the emulators to run at the original machines' speed. Our users were not used to computers being slow and not responding immediately and they would sometimes think that an error had occurred or they had done something wrong. One user wished for a speed-up button. It is a challenge for the modern users that it can be difficult to determine whether things are just slow or they are failing.

CLI navigation proved to be a challenge, illustrated by the fact that one user had to ask for help to find out where the backslash (\) key was located on the keyboard.

The modern user is used to graphical games and therefore gets confused if the game contains larger "text surfaces".

D. Regarding the mobile device emulator

Generally, our users had an easier time understanding what was going on in the emulated mobile device. However, certain differences between the emulator and an actual smartphone still posed a number of issues. The most common one was that the mobile screen needed to be flipped to a horizontal position but the emulator had no intuitive way of doing that. Furthermore, there were no buttons, which the users expected, only a "secret" keyboard short cut.

V. CONCLUSION

Our observations indicate that a high degree of authenticity can create challenges for the usability of video games even though they are commonly considered some of the most user-friendly software. The observations therefore give some support to our initial hypothesis that, when emulation imitates an old computer system, there is an implied claim that the user can understand and interact with the original system being emulated.

Some of the usability challenges the users experienced could probably be resolved by using emulation frameworks to set up emulators and games in such a way that they are more directly ready for play, such as Internet Archive's "Emularity" or EaaS preconfigurations. In fact, several of the emulators do have these options, but the lack of familiarity with emulators (and the emulated devices) meant that our users didn't even think about the possibility of changing the settings. One user managed to open a DOS game by dragging the executable file to the DOSBox icon in the host OS. However, we find that an approach that uses tightly optimized settings tweaked by curators will be more costly in time for the game curators and therefore not an opportunity for all.

Our observations also indicate that not all usability problems can be solved by using emulation frameworks and pre set-up of games. Therefore, other approaches need to be considered. One such approach could be providing access to original OS user manuals and other original guides, or to make new emulator guides (written or as video recordings). Another option could be creating a "contemporary overlay" for the emulators, which behave in a more user-friendly way for the modern user and maybe even inject more modern behavior in the games/programs they emulate.

REFERENCES

[1] A. Farquhar and H. Hockx-Yu, "Planets: Integrated Services for Digital Preservation," *International Journal of Digital Curation*, vol. 2, no. 2, pp. 88–99, Dec. 2007, doi: 10.2218/ijdc.v2i2.31.

[2] "KEEP - Keeping Emulation Environments Portable." http://www.keep-project.eu/ezpub2/index.php (accessed Apr. 03, 2014).

[3] D. Pinchbeck, D. Anderson, J. Delve, G. Alemu, A. Ciuffreda, and A. Lange, "Emulation as a strategy for the preservation of games: the KEEP project," in *DiGRA 2009 - Breaking New Ground: Innovation in Games, Play, Practice and Theory*, Brunel University, London, 2009, pp. 1–5. Accessed: Apr. 02, 2014. [Online]. Available: http://eprints.port.ac.uk/2714/

[4] J. P. McDonough *et al.*, "Preserving Virtual Worlds Final Report," Aug. 2010. [Online]. Available: http://hdl.handle.net/2142/17097

[5] "bwFLA: Emulation as a Service." http://bw-fla.uni-freiburg.de/ (accessed Apr. 03, 2014).

[6] D. von Suchodoletz, K. Rechert, and I. Valizada, "Towards Emulation-as-a-Service: Cloud Services for Versatile Digital Object Access," *International Journal of Digital Curation*, vol. 8, no. 1, pp. 131–142, Jun. 2013, doi: 10.2218/ijdc.v8i1.250.

[7] "About EaaSI," *Saving Software Together*. https://www.softwarepreservationnetwork.org/eaasi/ (accessed Mar. 02, 2020).

[8] E. Cochrane, K. Rechert, S. Anderson, J. Meyerson, and E. Gates, "Towards a Universal Virtual Interactor (UVI) for Digital Objects," in *Proceedings of the 16th International Conference on Digital Preservation iPRES 2019*, 2019, pp. 191–200.

[9] J. Rothenberg, "An experiment in using emulation to preserve digital publications," Koninklijke Bibliotheek, The Hague, The Netherlands, 2000. [Online]. Available: http://www.kb.nl/sites/default/files/docs/NEDLIBemulation.pdf

[10] R. A. Lorie, "Long-Term Archiving of Digital Information," IBM Almaden Research Center, San Jose, Almaden, 2000. [Online]. Available: http://domino.watson.ibm.com/library/CyberDig.nsf/papers/BE2A2B188544DF2C8525690D00517082/$File/RJ10185.pdf

[11] J. van der Hoeven, "Dioscuri: emulator for digital preservation," *D-Lib Magazine*, vol. 13, no. 11/12, 2007, [Online]. Available: http://www.dlib.org/dlib/november07/11inbrief.html

[12] "Command-line interface," *Wikipedia*. Apr. 20, 2021. Accessed: Apr. 26, 2021. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Command-line_interface&oldid=1018991025

[13] J. Kim, "Researcher Access to Born-Digital Collections: an Exploratory Study," *Journal of Contemporary Archival Studies*, vol. 5, no. 1, May 2018, [Online]. Available: https://elischolar.library.yale.edu/jcas/vol5/iss1/7

[14] M. Hedstrom, C. Lee, J. Olson, and C. Lampe, "'The Old Version Flickers More': Digital Preservation from the User's Perspective," *The American Archivist*, vol. 69, no. 1, pp. 159–187, Jan. 2006, doi: 10.17723/aarc.69.1.1765364485n41800.

[15] "Sodan.dk." http://www.sodan.dk/oldbits/oldbits.html (accessed Jan. 15, 2020).

[16] "Mingoville.com - engelsk for børn!" http://www.mingoville.com/ (accessed Jan. 15, 2020).

[17] "GIER/Simulator - DDHFwiki." https://datamuseum.dk/wiki/GIER/Simulator (accessed Jan. 15, 2020).

[18] "DOSBox, an x86 emulator with DOS." https://www.dosbox.com/ (accessed Jan. 15, 2020).

[19] "WinUAE Amiga emulator." http://www.winuae.net/ (accessed Jan. 15, 2020).

[20] "Download Android Studio and SDK tools," *Android Developers*. https://developer.android.com/studio (accessed Jan. 15, 2020).

[21] T. Boren and J. Ramey, "Thinking aloud: reconciling theory and practice," *IEEE Transactions on Professional Communication*, vol. 43, no. 3, pp. 261–278, Sep. 2000, doi: 10.1109/47.867942.