Longevity in NIME research: a case study using time-based media art preservation models

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ABSTRACT

This paper presents the reactivation of *Soundrise*, an interactive multimedia application for deaf children, as a case study to demonstrate the application of time-based media art preservation and reactivation strategies in NIMEs. Drawing upon the *Multilevel Dynamic Preservation* (MDP) model and the *Digital Preservation Object* (DPO), structured frameworks designed to comprehensively document time-based media art across different levels of information and iterative processes, this article introduces a novel decision-making process for reactivating NIMEs, outlined in five steps: *Collection*, *Assessment*, *(Re)Design*, *Implementation*, and *Archiving*. Through an exploration of the *Soundrise* reactivation, the article elaborates on each step of the proposed reactivation process, illustrating the application of the DPO and MDP model to ensure the preservation of the application. From the analysis of the previous iterations of the application, we also provide design reflections on obsolescence and longevity. By aligning our work with recent NIME literature on documentation and reuse, we aim to offer insights on how to preserve, reuse, maintain and document research.

Author Keywords

NIME, longevity, preservation, reactivation, reusing, interactive multimedia application

NIME'24, 4–6 September, Utrecht, The Netherlands.

CCS Concepts

•**Applied computing** → **Sound and music computing;** Performing arts; •**Information systems** → *Music retrieval;*

1. INTRODUCTION

The issue of long-term adoption of digital musical instruments in NIME has been frequently discussed [42, 45, 13], and the need for more research that investigates long-term engagement with music technology has been highlighted. The same issue has been explored in the context of time-based media art for a longer time compared to NIME. Therefore, in this paper, we studied the possibilities of using preservation frameworks coming from this field. In particular, we focus on the *Multilevel Dynamic Preservation* (MDP) model and the *Digital Preservation Object* (DPO) developed through several publications [5, 21, 19, 20].

In the paper, we will present a case study demonstrating the practical application of these frameworks outside the context of time-based media art, but within the research field. The case study presents the reactivation of *Soundrise* - an interactive multimedia application for deaf children. For this case study, we develop a five-step reactivation process that relies on the the MDP model and the DPO. This process focuses first on evaluating what has been done in the previous iteration of the artifact and then redesigning it to account for long-term engagement.

We will illustrate the sequential application of the reactivation process and time-based media art frameworks in the reactivation of the Soundrise application. Based on the results and examination of previous iterations of the application, we will offer design reflections on obsolescence and longevity, based on recent NIME literature.

2. BACKGROUND

2.1 Longevity of NIMEs

The issue of the longevous adoption of digital musical instruments has been raised several times in NIME. For instance, the music produced with DMIs is often limited [35] and tends to fail to survive beyond their initial presentation [40]. Marques-Borbon and Avila, while discussing longevity, posit the issue of instruments being maintained only "anecdotally or as paper citations" [41]. Morreale and McPherson systematically analyzed the work presented at NIME [45], illustrating that only a small percentage of devices presented at the conference have been used in many performances. Green criticized the tendency to develop technical systems instead of developing musicality research [28], which tended to unbalance the contribution toward the new interface (NI) and diminish the effort toward new musical expressions (ME).

In a recent literature review [42], Masu and colleagues identified some positive approaches to addressing longevity that have already been implemented by the NIME community (despite remaining a minority) focusing on the entire proceedings thus addressing both instruments and interactive systems in general. Considering the proceedings of three years, from 2020 to 2022, they found four commonly used strategies to sustain NIMEs, determined as:

- *Reuse old NIMEs* as is, without modification (examples include [33, 60, 22, 24, 29]);
- *Update old NIMEs by* modifying one or more parts to improve the tools or consider them from a new perspective of use (examples include [12, 55, 17, 39, 57]);
- *Integrate old NIMEs* with new technologies (examples include [9, 37, 49, 31, 56]);
- *Consider long-term engagement* while introducing new technologies (examples include [18, 16, 30, 50, 8]);

2.2 Documentation at NIME

Documentation plays a crucial role in ensuring longevity and replicability [36]. For instance, Calegario and colleagues also emphasize the importance of documentation and express concerns about the lack of supporting material in research papers. They argue that most papers lack documentation items and files beyond the paper's content. Overall the author highlights the significance of documentation in supporting replicability: "instruments become available for users in different locations and cultures and future generations, enabling more performers, composers, and audiences to experience artefacts or systems" [11]. In a recent paper, Bin proposed five strategies that can support the documentation of NIME work in order to promote an articulate critical discourse in the community [2]. In the paper, she proposes that documentation should be: *Collaborative*, *Ongoing*, *Flexible*, *Open*, and *Complete*.

2.3 Time-based media art documentation frameworks

Problems of documentation and longevity are common in the context of time-based media art. Artists, curators, practitioners, and researchers have tackled the aforementioned issues of longevity and proposed theoretical preservation frameworks by developing original documentation models [15, 52, 61, 53, 5, 32, 48, 7] studying and proposing practical reactivation projects [15, 61, 46, 53, 43, 47].

In this context, art preservation can only occur if there is the necessary information to reactivate the artwork, which is only possible if each reactivation produces the necessary information. The term reactivation originates from the concept of *activation* and *implementation* in Goodman's essays [26, 27], and refers to the actions required to make a work of art work in front of a spectators. The "re" in front of activation highlights the field of time-based media art, in which artworks are viewed as a *dynamic system* [38]. The artwork, its degradation, obsolescence, and preservation do not take place continuously, but rather through different and separate manifestations. Each manifestation requires a new activation of the artwork, which will sooner or later be deactivated. Thus, activation must be repeated (re) to make the artwork work again. Hence the concept of dynamic preservation that emerges as a process in the loop between documentation and reactivation [21].

Overall, there is a consensus that a documentation model that allows for recreation should concentrate on more than just technology but especially on experiences.

As proposed by the Variable Media Network, the documentation of the work should be medium-independent, so that it can be translated once the current medium is obsolete [15]. Annet Dekker proposed to document the process and the experience of the work keeping the memory alive and accepting a possible loss related to the original medium [14]. Many original models have developed from experience preservation, such as the DOCAM documentation model [52], Inside Installation's 2IDM model [61], and Joanna Phillips' documentation model [48]. The latter proposes a documentation section called "The Identity Report" which specifies "the intended experience of the piece, outlines its variability parameters, and provides guidance for future preservation"[48].

Focusing on experience, a reactivation process can flexibly approach technology, reusing pieces of the original technology if explicitly required, and leaving space for improvements and upgrades through technology migration [59, 62].

The *Multilevel Dynamic Preservation* (MDP) model [6, 5, 21, 20] extends the previously mentioned models by proposing a documentation structure defined on different levels of information and through different iterations of the artwork, thus considering preservation and reactivation as a dynamic continuum. As this is the main model we refer to in the work presented in this paper, we provide here a slightly longer description.

Any activation of the artwork - including migrations, updates, and changes in technology, performances, and in technical and artistic instructions - is considered an iteration. By creating a track of these iterations the model suggests preserving the artwork as a process of change. The model suggests archiving each iteration of the artwork as a *Digital Preservation Object* (DPO). A DPO includes all the items that represent that specific manifestation which can be of three different item typologies: *bit* are analog and digital items (hardware and software, installation and performative objects, fixed-media files like video or audio used in the manifestation, etc.); *data* are all that useful information about the realization of the artwork (score, technical notes, high-level description of algorithm, instructions, etc.); *experience* are any document that bears witness to some aspect of the artwork (photos, audio-video documentation, interviews, experimentation, test, etc.). Furthermore, the MDP model includes the *multiple belongingness* property, allowing *bit* and *data* to belong in different DPOs. If some (or even all) parts of the original or previous manifestation are reused, those will also be registered as elements of the new DPO (while *experience* items are designed to gather information about the ongoing exhibition and therefore must belong to a unique DPO) [21]. Figure 1 shows a graphical representation of the model.

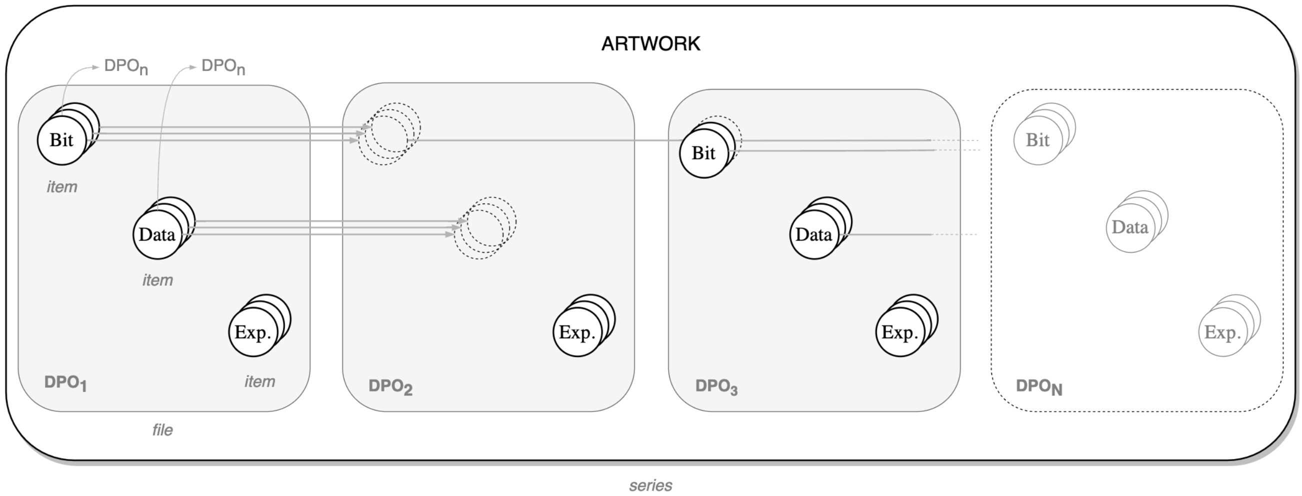

Figure 1: Graphical representation of the *Multilevel Dynamic Preservation* (MDP) model including the *Digital Preservation Objects* (DPOs) with their relations as presented in [20].

Although this model is designed in the context of time-based media art preservation, it can also serve to promote maintenance and support longevity in other areas, e.g., research projects and multimedia applications. In this paper, we adopt the model in the reactivation of an interactive sound application designed to help deaf people. This particular application was chosen as a case study because of its simplicity, basic technological interactions, and its ability to highlight the rich complexity of NIME preservation - NIME intended here with it's broader conception of research on interactive music and multimedia systems [34].

2.4 Original Soundrise

Soundrise is an educational game originally developed by Centro di Sonologia Computazionale (CSC) in 2012 that aims to support children in discovering their voices. It is designed to complement a speech therapy treatment and to offer an autonomous learning instrument, mainly targeting deaf children. The system aimed at allowing them to explore and acquire a deep understanding of their vocal capabilities and monitor their progress through the graphical feedback generated.

Technically, Soundrise is an interactive application that uses real-time analysis of vocal features providing visual feedback, thus helping children understand their voice through a visual representation. The child's voice is represented by a sun. The sun moves and changes on the screen according to the sound expressed by the child's voice: it can rise and fall vertically according to the pitch; it can grow bigger or smaller depending on the sound intensity; it changes its color, based on the vocal timbre detected. The recognition of the last property is related to the identification of the five vowels of the Italian language: each of the possible five timbre (as many as the vowels) corresponds to a different color of the sun.
In 2012, the application was developed through two master thesis projects at the CSC, carried out by Stefano Giusto [25] and Marco Randon [51]. In Stefano Giusto's thesis, the application was developed using the real-time graphical programming environment Pure Data and the external library *timbreID* [4] for audio features analysis (Figure 2 shows the application running in a 2012 computer). In Marco Randon's thesis, the application was modified to enhance its portability across different platforms. This new version of the application was developed in C++ language, using the *libpd* library for communication with Pd. The scope was to improve the graphical interface and adapt the application to touchscreen devices.
In 2023, the project was resumed in a bachelor's thesis by Gabriele Turetta [58], who resumed the application, improving the graphical interface, and porting it to a web environment with Javascript and *three.js*. This thesis project did not include the development of the audio feature extraction. The theses developed in 2012 presented relevant evaluations of the application acquired through two usability tests. The tests were designed to evaluate the interface and detect eventual obstacles against the application performance. According to the goal of the application, it was necessary to verify the correct correspondence of the graphical feedback with the extracted vocal features.
Both evaluations yielded positive results, especially confirming the effectiveness of the graphical interface's simple design. Some vulnerabilities arose in the representation of the vowel extraction.

3. REACTIVATION PROCESS

In 2023, CSC promoted new thesis projects to reactivate and update the *Soundrise* application and stimulate further research on sound technologies for people with special hearing needs. The projects yielded significant insights into the preservation of research activities and products.
In particular, we devised five steps to optimize the impact of a reactivation, that accounts for dynamic preservation, and future reuses. As a practical result, the reactivation of the *Soundrise* were not only aimed at producing a cross-platform and better usable application but most importantly at creating a long-term and preservable research product.

3.1 Five steps to reactivate media and research projects

In our reactivation, based on existing reactivation strategies and the MDP model [21] presented above (Section 2.3), we

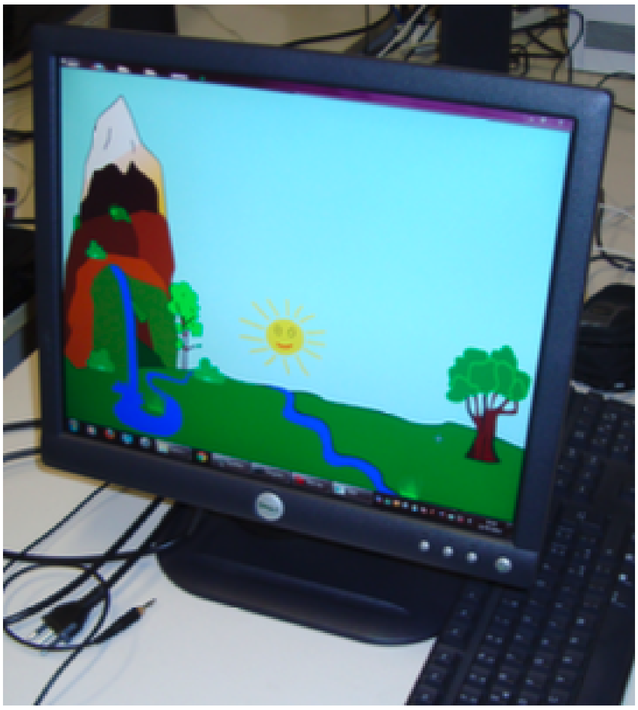

Figure 2: The original *Soundrise* running in an 2012 computer.

devised the reactivation of *Soundrise* in five steps that aim both at 1) a coherent reactivation, and 2) facilitate future reactivations by promoting the system longevity. The overall process is represented in Figure 3.

1. **Collection** of the project's constituent elements at every stage of processing (in this case, from 2012 to the present) to gather as much information as possible and get a clear overview of the dynamics.
   Outcome: a database of one or more DPOs.

2. **Assessment** of critical issues and vulnerability inherent in previous versions and prototypes; MDP functions as an analytical tool to examine the various iterations and detect improvements and difficulties between each reactivation.
   Outcome: a selection of DPO items usable/unusable.

3. **(Re)Design**ing the new reactivation requires a good understanding of the previous ones. It aims not only to solve problems and improve the overall outcome but also to think about maintenance and long-term reactivation. A low-level (Re)Design phase should be structured as Filipe Calegario's design process [10].
   Outcome: A new project that combines DPO items with reflections on longevity.

4. **Implementation** means activating the design, performing a performance, experiencing an installation, and deploying the application in the case of *Soundrise*. Using Goodman's words, implementation means "making the work work" [26].
   Outcome: a new working system.

5. **Archiving** step covers an important part of the reactivation process. The previous steps produce new documentation (assets, prototypes, notes, instructions, audiovisual recordings, etc) that should be archived following the MDP model structure thus allowing future reactivations.
   Outcome: A (hopefully) more sustainable DPO.

3.2 Five steps in the case study

Below we outline how we implemented the five steps in the reactivation of *Soundrise*.

Collection

The first step was to collect the items of the DPOs that can be analyzed and considered during the reactivation of the application.
For the *Soundrise* project, we were able to collect three DPOs - three versions of the application - that are individually linked to two master's theses (related to a first version in PD and a second in C++) and one bachelor's thesis (related to a web version that was not fully completed).
The thesis is a comprehensive document from which we can extract *experience* and *data* items. They include information on the design and evaluations (*experience*), commented descriptions of DSP algorithms, and mappings for audio-to-graphical interaction (*data*).
As an attachment to the thesis, stored in CSC servers, we had access to the applications and source codes developed in Pure Data, C++, and JS, representing the *bit* item. We organized these materials according to the MDP model (the three first DPO in the Figure 6) to represent the evolution of *Soundrise* over the different versions.

Assessment

All the collected elements were reviewed to identify issues, vulnerabilities, and strengths of the previous version.

Bit assessment. The previous DPOs present some specific issues concerning *bit*'s long-term maintenance and use. The PD implementation - **1st DPO** - requires users to install the PD software and familiarize themselves with audio settings which might not be ideal for all scenarios, especially targeting children. Furthermore, as mobile computing devices are becoming increasingly ubiquitous (especially the younger generation who often have access to personal mobiles but not always to a personal computer) PD introduces another barrier as it is not easily compatible with mobiles. The implementation in C++ - **2nd DPO** - requires a constant update of all the libraries, updating the code to fit the new OS requirements, and specific compiled versions for the different OS. Additionally, this interface, although it had the added feature of being suitable for touch-sensitive screens, was developed in OpenGL (Open Graphics Library). At present, OpenGL is increasingly being replaced by higher-performance systems and is no longer used: it cannot be said to be deprecated, as it is still supported by most platforms (except for Apple machines), it is simply no longer developed, and therefore is not updated in new technologies. This aspect represents a big limitation if the goal is to preserve an application over time. Javascript - **3rd DPO** - would solve the problem mentioned above, but the implementation choices rendered this specific implementation not ideal for future improvements: the code implemented only the graphical part - relying on external software (Blender) and framework (*three.js*) - without including the audio analysis and the user interface.

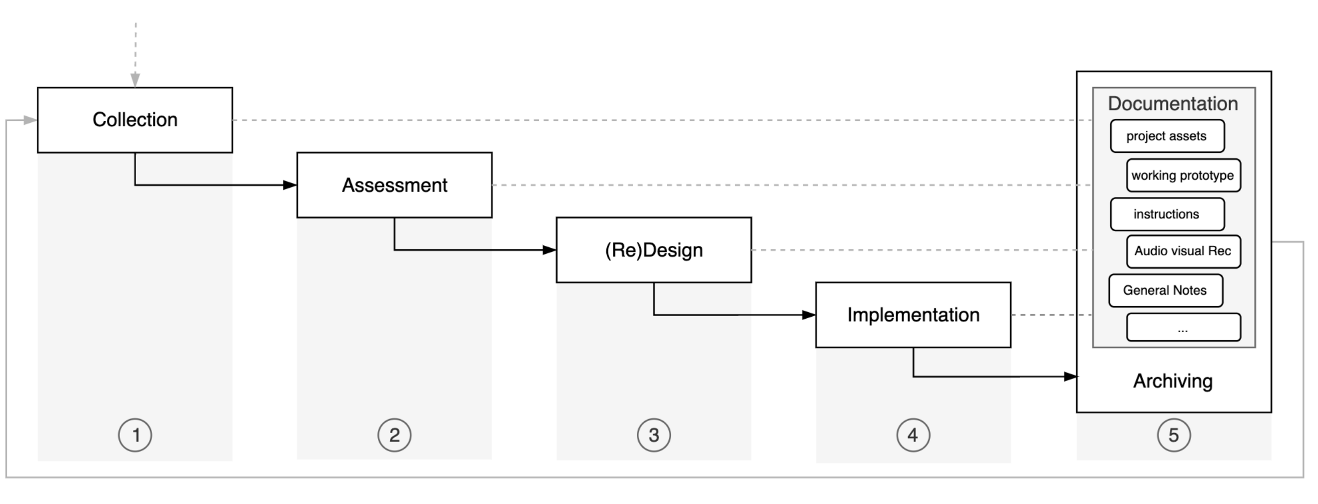

Figure 3: Graphical representation of the reactivation process composed of five steps: *Collection*, *Assessment*, *(Re)Design*, *Implementation*, and *Archiving*

Data assessment. In the case of *Soundrise*, we identified two types of *data*, one related to low-level processes and one related to the application design.
The low-level *data* include the description of the various Digital Signal Processing (DSP) algorithms and are deeply related to component assessments since they are often elaborated on the base of the technologies used. The DSP algorithms implemented in *Soundrise* were originally determined by native and external objects in PD. The DSP algorithm for pitch extraction based on the FFT depends on the `fiddle~` object, while the vowel detection based on melcepstrum coefficients originally relied on the PD's *timbreID* external library. The second DPO implements a porting of these algorithms using *libpd*, and the third version de facto implements only the interfaces, with no changes in the DSP.
The high-level *data* is represented by the design layer of the application which include the choices made about the processes' mapping. The link between the audio features and graphical representation in Figure 4 depends on the developers' design and the mapping between vowels and colors is based on existing literature in assistive technology and hearing impairments [54].

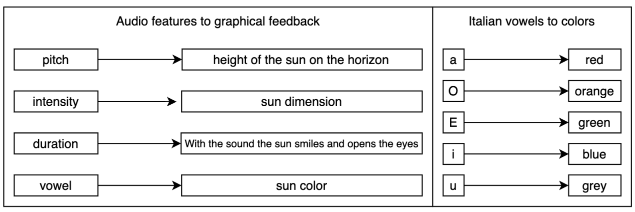

Figure 4: Audio features to graphical feedback mapping in *Soundrise*. An example of *data* item.

Experience assessment. The theses and a demonstration video are the only documents we can assess as *experience*. From this material, we assess that the graphic design of the application was particularly simple. The first two theses also provide the application evaluation through two usability tests, which allow for highlighting straights and vulnerabilities. Results showed that children fully understood the movement of the sun and the control of the graphic feedback through the features of one's voice except for some vulnerabilities in timbre. This allows us to conclude that the minimal graphic design of the application facilitates children to visualize the graphical feedback, while the vowel detection presents some vulnerabilities.

(Re)Design

Based on the assessment, we defined a set of design possibilities (based on [1], now on we will refer to these possibilities as design space) focusing on the longevity and sustainability of the application. The design space was limited to web-based technology, considering the future stability, improvements, and updating of the application.
Web applications offer accessibility across any device with a web browser, thereby obviating the requisite for distinct iterations tailored to diverse platforms, providing intrinsic scalability and seamless integration with supplementary web services. Additionally, the development of web applications can be on web-sourced libraries, which prevent obsolescence and promote longevity compared to proprietary solutions [3].
We also tailored the development environment towards longevity, future improvements, and updates, and thus we analyzed trends in usability and popularity of tools for web development. We selected ReactJS[1] as the development environment's front-end framework since it reports the greatest popularity as shown by the *2022 State of JS*[2] and the Stack Overflow Trends service[3].

Concerning the DSP algorithms, we decided to diverge from PD's objects but rather rely on the audio development possibilities of the browser, utilizing the Web Audio API[4] - a high-level JavaScript API that enables sound processing within a Web application. We decided to use Web Audio as it remained fairly stable over the past 10 years. The new development environment requires the migration of certain DSP algorithms. The estimation of audio intensity was im-

[1] `https://react.dev/`
[2] *State of JS* is a survey created to identify upcoming trends in the web development ecosystem `https://2022.stateofjs.com/en-US/`
[3] `https://trends.stackoverflow.co/?tags=reactjs,vue.js,jquery,angular`
[4] `https://developer.mozilla.org/en-US/docs/Web/API/Web_Audio_API`

plemented using an RMS algorithm (as in the old versions), while the extraction of voice pitch was implemented with an auto-correlation algorithm, replacing the FFT-based pitch extraction implemented in `[fiddle~]` object in PD.
We considered three paths for implementing the vowel extraction DSP 1) porting the PD and *timbreID* system in Web Audio API, 2) using and adapting *APEWORM*, an already existing real-time vowel detection in the browser[5], and 3) creating a new system suitable for the application. Applying the first route would have increased the complexity of the application and thus its maintenance since the PD's algorithm relies on an audio dataset with which the input signal is compared. The *APEWORM*'s algorithm is no longer updated (last updated in 2017 as displayed in the GitHub repository) and appears to be incompatible in many browsers (it currently works only on Firefox). Considering the incompatibility and complexity of these previous two paths, we developed a new system suitable for the application. From the maintenance perspective, we decide not to use external libraries and develop an algorithm with only Web Audio API's objects. The algorithm is based on *Linear Predictive Coding* (LPC) analysis and formant extraction which are compared against predefined ranges associated with distinct vowel sounds.
Concerning interface development, the use of Blender and *Three.js*[6] was considered. However, to simplify future updates and maintenance, based on the first two DPO evaluations (for which the simplicity of the design allows for a better understanding of the voice's graphical feedback), we decided to avoid using external software and libraries. The interface is completely implemented using ReactJS components and CSS animation.

Implementation

After studying all development paths within the defined design space and producing several prototypes, we finally achieved an efficient and functioning front-end application that relies almost exclusively upon ReactJS (a screenshot of the application in Figure 5). In the implementation phase, we also focused on the distribution of the web application. We used the web hosting service provided by Firebase[7] for the application deployment. To promote future improvements and developments of both the application and the related research, we licensed the web application with the open-source license GNU General Public License v3.0 (GPLv3.0).

Archiving

All the documentation produced in the previous steps of the reactivation process has been archived according to the MDP model. We added a fourth DPO, a new iteration of the *Soundrise* application (Figure 6)
The MDP model can easily adapt to relational and non-relational databases, web repositories, and local storage.
In this specific case, we implemented the model through a GitHub repository. The repository platform also allows the model to be extended. Version control software (VCS) such as GitHub keeps track of the project's history by providing new layer of controlled dynamicity at the level of archiving and individual DPO source codes. But it also allows the project to be simply shared, promoting openness and collaboration.
The important point to highlight here, is that we do not only include the code (which is the component in the DPO), but we complemented it with links to all the *data* (descriptions of the algorithms) and *experience* (the thesis in se, with all the information on the design and on the previous evaluation) items as part of the repository.

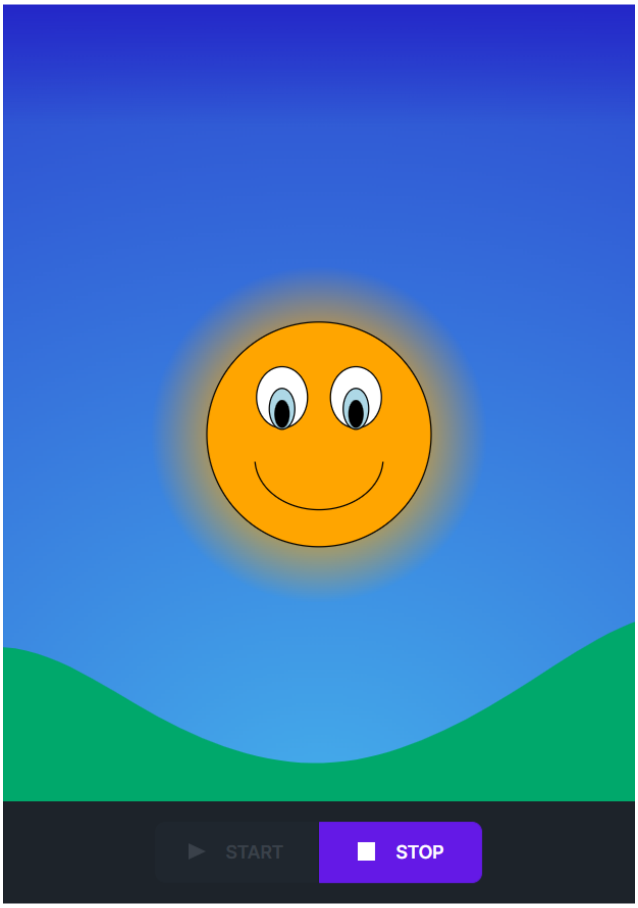

Figure 5: The basic graphical interface of the reactivated *Soundrise*.

4. DISCUSSION

Soundrise is a simple interactive music technology that highlights key and complex aspects of preservation and longevity in NIME research. The challenges of obsolescence, technology migration and adaptation, interactivity, documentation, and archiving are shared by educational applications and NIMEs. The case study illustrated the reactivation process, including migration to a Web-based application, adaptation of DSP algorithms, preservation of original interactivity, and collection of documentation to ensure longevity, maintenance, and facilitate future improvements.
The idea of reactivating this application for deaf children is not only to revive its functionality and potential but also to explore it further and avoid spending time and energy to start a new project from scratch. While the reactivation of the application can be considered in itself a contribution, in the scope of this paper we present it as a case study to show 1) how the *Multilevel Dynamic Preservation* (MDP) model and the *Digital Preservation Object* (DPO) [21, 20] can serve to reactivate and preserve a research prod-

[5] GitHub Repository `https://github.com/BYU-ODH/apeworm` (last access 8-2-2024) - developed from *VowelWorm*[23]
[6] `https://threejs.org/`
[7] `https://firebase.google.com/`

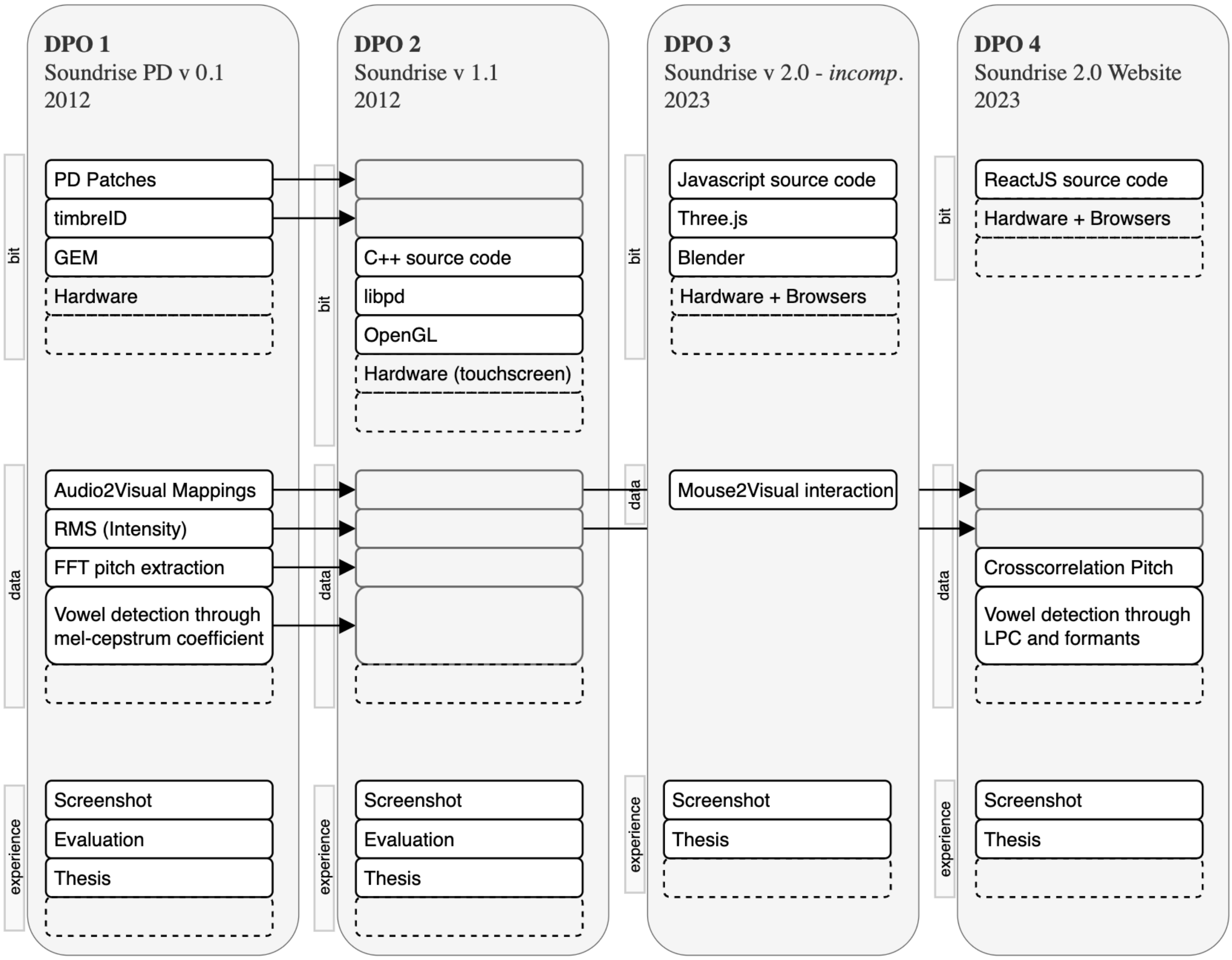

Figure 6: The four iterations of *Soundrise* archived according to the *Multilevel Dynamic Preservation* (MDP) model. Each iteration is collected as *Digital Preservation Object* (DPO)

uct 2) outline the five steps to reactivate media and research projects within the context of a real project.
We now discuss our work in light of recent literature on documentation, reusing, and NIME.

4.1 Documenting NIMEs

As we saw in the background section [11][2], to effectively preserve technological products and thus increase the lifespan of an artifact, a documentation model and a determined practice of reuse and updating are needed. This article aims to present a reactivation process that accounts for documentation as a pivotal aspect. Recently Bin proposed five characteristics to effectively document NIME research [2]:

- **Collaborative** - accurate documentation relies on the collective input.
- **Ongoing** record serve as a baseline to assess continuous developments.
- **Flexible** - circumstances changes and documentation needs to be open and adapt.
- **Openness** - documentation should be accessible and allow for open contributions.
- **Complete** - documentation should be checked to ensure it represents complete contributions.

Our reactivation model complements this proposal, by showing a way to effectively implement some of these points in practice.
Ongoing. The MDP model is structured to allow for maintenance and continuous development, recording the dynamic life of a product through DPOs and their relations. Indeed, the *Assessment* and the *Archiving* that characterize our five steps, respectively at the beginning and the end of a reactivation, frame the entire reactivation as a step in ongoing documentation.
Flexible. The model allows for recording all the changes (migrations, updates, and improvements) in the product and preserving all its past forms. The DPO provides a researcher with a flexible model where each media artwork or research product can be analyzed from a different perspective.
Complete. Again, including an assessment step in a reactivation helps to validate the completeness of a work, and improve it if necessary. While archiving the work of the proposed case study, we did not only include the code (*bit* according to the DPO model), but also included links to evaluation derived from previous research which impact the aesthetics and functionality (*experience* according to the DPO model), and the descriptions of the algorithm (*data* according to the DPO model), to easy future porting if needed.
The multilevel structure allows for keeping and organizing

all the documentation on different information levels (vertical structure) and in a timeline (horizontal structure). Collaborative and Openness are not directly addressed in the work we present in this paper since they should concern archiving, storing, and sharing platforms. We still account for these points by relying on an open repository[8], which could arguably foster future collaborations on the project.

4.2 Reactivation and Longevity

This paper aligns with the recent literature on the longevity of NIME research [40, 45, 41, 42] by proposing a strategy to actively reactivate and preserve research outcomes and musical instruments.

Masu and colleagues identified four approaches for a longevity NIME practice based on the analysis of NIME papers on updating and reusing [42]. This work offers a way to systematize such efforts by showing how a model originally developed for media art (the MDP and the DPO [21, 20]) can be fruitfully used in the context of NIME research. In particular, we outline how it can support three of the categories presented in [42]: *reuse*, *update*, and *long-term engagement*.

The process we presented in this paper facilitates the **reuse** (using the terminology by [42]); indeed, by offering a detailed action plan to recreate digital (music) technology it can facilitate the reuse, even if some specific technical implementations are different.

Our work also shows a thorough process to ease **updates** (using the terminology by [42]) of interactive music technology. Some recent papers [12, 55, 17, 39, 57]) presented updates of interactive music systems, and sometimes they actually account for issues of obsolescence and maintenance. In our work, we move forward on this path by connecting it to literature from media preservation (which has dealt with longevity issues for a longer time compared to NIME) [52, 61, 32, 48, 7, 5]. Indeed, the assessment phase in our reactivation process is implemented specifically to address maintenance by retrospectively analyzing the previous evolutions. Additionally, the *(Re)Design* phase takes into account future updates.

Our work also aligns with research based on **long-term engagements** (using the terminology by [42]). Indeed, the DPO [21, 20] provided us with a model that intrinsically accounts for the evolution of a system over time. By relying on this property, in the collection and assessment phases of our reactivation process we first analyzed and compared the different versions, highlighting criticisms. This is in itself a design contribution that allows for developing new knowledge from a critical analysis of design decisions that occurred in different iterations over more than a decade.

4.3 Reactivation and Replicability

In his essay on open source DMIs, Calegario stresses the importance of documentation as a resource for replicability of a DMI [11], that consequently facilitate its diffusion and the accessibility of the knowledge inscribed in the instrument itself. Reactivation also helps to support the longevity of such a knowledge, but, also implies a re-making process the copes with obsolescence [21]. As such, it requires a design phase of some parts that is usually not necessary when replicating a piece of interactive technology. In this paper, we formalize this redesign within a structured process of five steps. In both replication and reactivation, documentation plays a central role, and for this reason, we suggest using the insights proposed in this work in combination with the points highlighted by Bin [2].

The idea of reactivation comes from media art and usually aims at displaying of a piece of art in front of an audience [26, 27]. In this paper, we push this idea step forward, not focusing on the solely artwork, but on interactive systems in general, where there is no audience rather active agents interacting with the systems, and in this sense applying it to NIME research, as a filed that focuses in interactive music systems. We hope that our model, in combination with replicability principles [10] and documentation [2] can further support the longevity and sustainability of knowledge inscribed in NIMEs.

[8] `https://github.com/CSCPadova/soundrise-prj`

5. CONCLUSION

In this paper, we described the reactivation of *Soundrise*, an interactive multimedia application for deaf children. We present this work as a case study to outline how media reactivation strategies - the *Multilevel Dynamic Preservation* (MDP) model and the *Digital Preservation Object* (DPO) - can be applied to NIMEs. Furthermore, we developed an original reactivation process composed of five steps: *Collection*, *Assessment*, *(Re)Design*, *Implementation*, and *Archiving*. Based on the analysis of the previous iterations of the application, we also offer a number of design reflections concerning obsolescence and longevity. By discussing our work in light of recent NIME literature on documentation and reuse, we hope that our contribution can help other researchers to preserve, reuse, or maintain research outcomes.

6. ETHICAL STANDARDS

This paper complies with the ethical standard of the NIME conference [44] and does not present a conflict of interest. The project propose an original strategy for NIMEs reactivation and a case study in which no human or animal participants were involved.

In addition, this paper directly addresses the preservation and longevity of NIMEs, addressing pertinent issues essential to improving understanding of existing digital tools, promoting self-awareness of what has been done within the NIME community, and supporting the adoption of sustainable practices through innovative strategies.

7. ADDITIONAL AUTHORS

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