On Visualizing Music Storage Media for Modern Access to Historic Sources

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Figure 1: *Example of a piano roll (left) and paper disc (right). Both use early technology to carry music information.*

Abstract

Finding a balance between conserving historic objects and using them for research is one of the big issues in historic collections. Digitization holds the opportunity to offer a safe and non-destructible access to historic objects, making them available for research. With this poster, we want to give insight into our planned visualization system, using close and distant reading access for visual analysis approaches and allowing musicologists novel approaches to normally fragile and endangered media.

CCS Concepts

• Human-centered computing → Scientific visualization; Information visualization; Visual analytics; Visualization systems and tools; • Applied computing → Sound and music computing;

1. Introduction

Digital advantages are well known and often used to explain the need for digitization projects. Often encountered are reasons like "making data available", "making research shareable", and "easier replication of knowledge". In more unusual settings, like object-related research, advantages like "preservation" and "non-destructible access" are of even higher value [KKM*20]. The Music Instrument Museum of Leipzig University does hold a vast range of historic objects, related to music generation, transfer, and preservation. As usual for a museum, these objects are rarely designed to be preserved for years, decades, or even centuries. Especially organic materials are prone to damage and deterioration throughout the time. While modern conservation practices do enable most materials to be conserved, this does not help with already existing damages and mostly render the objects *useless* for research purposes, as they cannot easily be used or removed from their conservation environment. While digital processes do help in making these objects more available for modern research, this does only result in available data. Making use of this digital data is the next step of object-related research, in the musicological domain called Organology. To help organologists, we will deploy distant and close reading visualizations, giving views on the currently to be digitized data. Hence, making these objects not only accessible for researchers and museum visitors but also allow novel visual analysis approaches desired by today's musicologists.

2. Background

There are few scientific publications dealing with music storage media (MSM) digitization or even (visual) analysis. Examples like the work of Debrunner [Deb17] and Shi et al. [SSA*19] only focus

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on a single out of multiple dozens of formats of piano rolls. Even worse, for the metal and cardboard discs, no available publications are to be found [KFF*22] at the moment. In the last four years, two projects dealt with the digitization of MSMs in general.

2.1. TASTEN – Piano Rolls

The 3,200 piano rolls digitized in the project – which translates in German to *keys* – are of high value for musicologists [KFJ22]. (Mostly) produced at the beginning of the 20th century, they do offer unique insights into the playing techniques of famous pianists like Grieg, Reisenauer, and Richard Strauss. In a time where neither streaming services, nor sound recordings like CD or vinyl existed, the only other source of information about the question of *"How did well-known pianists play their famous works"* are oral and written reviews. While these are normally used in musicology, they do tend to be subjective and biased. A special recording system enabled pianists to produce so-called mother-rolls which transferred their finger movement in a hole code. During their play, a mechanism rolled up a sheet of paper of up to 50 meters and each key pressed by the pianist resulted in a hole being punched into the paper. To write down his musical ideas, a composer was obliged to use a standardized musical notation system (like the *Common Music Notation* or *CMN*), which might not capture all the nuances and musical expression he had in mind. This changed considerably with the new recording system: The intangible element of the historic interpretation, the performance itself, was — for the first time in history -– stored repeatable and encoded on the piano roll. For research purposes, piano rolls do not only offer an audible but also a visual representation of a performance. Questions about phrasing, agogics, ornaments, dynamics, velocity, and playing technique can be answered clearly by the study of the piano rolls. This even exceeds audio recordings' capability to protocol a pianist's interpretation, because today – over a hundred years after its creation – we are still able to recognize every last nuance of the finger movement.

2.2. DISCOS – cardboard and metal discs

The 500 discs under investigation in the DISCOS project – Latin for *disc* – follow a similar notation as the piano rolls. Each possible tone is located on a separate track and holes do represent moments of sound generation. They differ from piano rolls in terms of length and repertoire. While piano rolls have a length of up to 50 meters, they could store a whole piano sonata or symphony arranged for the piano, whereas cardboard or metal discs are only able to play music for about a minute and therefore do mostly reproduce popular tunes arranged for organettes, comb tongues, chimes, or bells. Further, the tone tracks on a disc are arranged circularly instead of linear, making them even harder to read for humans. Lastly, the discs were not produced by a musician playing on a recording instrument but punched into the material in a more craftsman-like fashion.

3. Digitization Pipeline

Resulting of the TASTEN project, we have 3,200 single scans of piano rolls available. These up to 5 GB .tiff files are joined by 500 pictures of discs. With this dataset, we developed a pipeline, consisting of preprocessing, edge-detection, clustering, and mapping. Thus, we were able to achieve the production of midi-files allowing the user to play the music carried on these objects [KFF*22].

4. Planned Visualization System

While the achieved midi-files do let us present the musical masterpieces contained on the objects – without damaging or risking either the carrying media nor the also historical playback instruments – we do want to make this data available more easily. For this we plan a visual analysis tool later to be included in our musicological research tool *musiXplora* (www.musiXplora.de) [KFJ20]. Next to a query and filtering functionality for the MSM, metadata (title, format, interpret, and more), as well as photographic images and the reconstructed sounds are made accessible. Together with the visualizations, this will result in publicly available data as well as support for (semi-)automatically analyzing musical features, like *"which chords are encoded through the holes"*, *"which rhythm pattern is used"*, or *"what is the key of the piece"*.

The tool in development is mainly planned for researchers and musical experts who are used to reading CMNs and might struggle with the different formats between CMNs and piano rolls/discs as well as between different formats inside one type of these media. Besides these multiple differences, both media types share their hardly human-readable notation. Hence, the first requirement of the visualization system is to achieve easy access to the encoded notation. This is to be achieved through format-independent visual annotations on the images. These include automatically determined and placed bar lines as well as either annotated tones or even the whole chords including their note length. For the more complex piano rolls, further encoded information like dynamics would be needed to be visually translated, as well. The second requirement dips deeper into the visualization department. To support users in tasks like *comparing different versions of the same musical piece*, *comparing composed CMN and recorded medium*, *analyzing techniques of specific interprets*, and more, the tool needs to give insight into the different musical features hidden in the media. These include basic features like tone(s), dynamics, and keys like in the first requirement, but also metadata like interprets, the title of the piece, production year, and technique, as well as more complex musical features like melody, repetition, or re-use. For this, the linked-view visualization will also include mundane visualizations of these low-level features as well as close-reading access to above-mentioned musiXplora (meta-)data.

5. Conclusion

For the collection of about 4,000 music storage media like piano rolls or metal and cardboard discs of the Music Instrument Museum of Leipzig University, a visualization system is needed to help domain experts in accessing and visually analyzing these historic and fragile objects. As part of the planning and evaluation process, a discussion of different visualization approaches, as well as the presentation of prototypes is to be conducted. Hence, the best way of helping in analyzing the music encoded in these – partly – destroyed media is to be developed. Deployment of curated visualization techniques will help in close reading analysis of for example low-level musical features like tones and rhythm, as well as distant reading analysis of for example comparisons between objects.

References

[Deb17] DEBRUNNER D.: *Von der Welte-Rolle zur parametrisierbaren Wiedergabe auf synthetischen Instrumenten und Midi-fähigen Selbstspielklavieren*. Hochschule der Künste HKB, 2017. 1

[KFF*22] KHULUSI R., FRICKE H., FUHRY D., PIONTKOWITZ V., FOCHT J.: On Digitizing Historic Music Storage Media For Computational Analysis . *Digital Humanities Conference 2022* (2022). 2

[KFJ20] KHULUSI R., FOCHT J., JÄNICKE S.: Visual analysis of linked musicological data with the musixplora. In *International Joint Conference on Computer Vision, Imaging and Computer Graphics* (2020), Springer, pp. 183–204. 2

[KFJ22] KHULUSI R., FOCHT J., JÄNICKE S.: Visual analysis of linked musicological data with the musixplora. In *Computer Vision, Imaging and Computer Graphics Theory and Applications - 15th International Joint Conference, VISIGRAPP 2020, Revised Selected Papers* (United States, 2022), Bouatouch K., de Sousa A., Chessa M., Paljic A., Kerren A., Hurter C., Farinella G., Radeva P., Braz J., (Eds.), Communications in Computer and Information Science, Springer Science+Business Media, pp. 183–204. Publisher Copyright: © 2022, Springer Nature Switzerland AG.; 15th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications, VISIGRAPP 2020 ; Conference date: 27-02-2020 Through 29-02-2020. doi:10.1007/978-3-030-94893-1_8. 2

[KKM*20] KHULUSI R., KUSNICK J., MEINECKE C., GILLMANN C., FOCHT J., JÄNICKE S.: A survey on visualizations for musical data. *Computer Graphics Forum* (2020). 1

[SSA*19] SHI Z., SAPP C., ARUL K., MCBRIDE J., SMITH III J. O.: Supra: Digitizing the stanford university piano roll archive. In *ISMIR* (2019), pp. 517–523. 1