cl TROMPA

TROMPA: Towards Richer Online Music Public-domain Archives

Deliverable 6.5

Working Prototype for Instrumental Players v1

Grant Agreement nr	770376
Project runtime	May 2018 – April 2021
Document Reference	TR-D6.5-Working Prototype for Instrumental Players v1
Work Package	WP6 - End User Pilots
Deliverable Type	Demonstrator
Dissemination Level	PU – Public
Document due date	30 April 2020
Date of submission	28 May 2020
Leader	MDW
Contact Person	Werner Goebl (goebl@mdw.ac.at)
Authors	David M. Weigl, Werner Goebl (MDW)
Reviewers	Cythia Liem (TUD)

Executive Summary

This deliverable is the 1st version of the demonstrator deliverable for the instrumental players pilot submitted on M24 of the project. This deliverable is submitted concurrently with the other WP6 pilot deliverables that are the main deliverables related to Milestone 3 – Working integrated prototypes ready v1.0. Although these deliverables are demonstrators rather than detailed reports, their main purpose of this document is to present the functionalities of the pilot and a link to its actual implementation.

Deliverable 6.5, the working prototype for instrumental players, is implemented in TROMPA's *Companion for Long-term Analyses of Rehearsal Attempts* (CLARA). This web application enables users to review and analyse rehearsal renditions (MIDI streams and associated audiovisual recordings) by reference to a musical score rendering, using the score as both a meaningful music representation and an index into a rehearsal timeline. The application is capable of visualising fine-grained performative aspects including tempo curves and MIDI velocities (corresponding to performance dynamics), both for individual performance renditions and across renditions, and it facilitates navigation to corresponding sections of different renditions, facilitating comparisons between rehearsal attempts.

Implementation of these features was informed by a user pilot study performed on initial mockups, as well as through feedback obtained at various dissemination events. Plans for additional formal user studies evaluating the current prototype and informing future development have had to be modified to accommodate restrictions imposed by the ongoing global COVID-19 pandemic, but will go ahead with a more pronounced online component in the coming months.

This document presents an overview of the currently implemented functionality alongside illustrations of the interface; outlines plans for future development up to the second release of this deliverable (to be informed through the above-mentioned user studies); and details current and foreseen future integration of this pilot with other TROMPA technologies, most notably T3.5 (music information alignment), T5.1 (data infrastructure), and T5.4 (music performance assessment mechanisms).

This prototype also functions as a first demonstration of the secondary, user-retained data layer of TROMPA's data infrastructure, implemented using *Personal Online Datastores* (PODs) proposed by the W3C Solid Project, a web-decentralisation initiative headed by Sir Tim Berners-Lee that provides users with fine-grained control over ownership and access to their data, supporting TROMPA in its mission of supporting FAIR and GDPR-compliant enrichment of public-domain music archives.

Version Log		
#	Date	Description
v0.1	13 May 2020	First draft including the description of the pilot.
v0.2	25 May 2020	2nd version including review comments
v1.0	28 May 2020	Final version - minor fixes

Table of Contents

1. Introduction

This deliverable is the 1st version of the demonstrator deliverable for the instrumental players pilot submitted on M24 of the project. This deliverable is submitted concurrently with the other WP6 pilot deliverables (D6.3, D6.4, D6.5 and D6.7) that are the main deliverables related to **Milestone 3 – Working integrated prototypes ready v1.0**. Although these deliverables are **demonstrators** rather than detailed reports, their main purpose of this document is to present the functionalities of the pilot and a link to its actual implementation.

The structure of the deliverables is shared amongst all deliverables D6.3 – D6.7 and contains three main sections. Section 2 presents the main functionalities of the pilot by providing screenshots, a URL where we can access the pilot software, a demo video of the pilot along with instructions on how to use the pilot. Section 3 is dedicated to the user evaluation of the pilot, reporting on initial target audience and recruitment strategies, and on adjustments made to compensate for the ongoing global COVID-19 pandemic. This section is strongly related to **Deliverable 2.2 – Complete Requirements** submitted on M18 and the upcoming deliverable **D6.8 – Mid Term Evaluation** to be submitted 3 months later (M27). Section 4 provides an outlook over future planned development over the final year of the project. Section 5 is related to the integration of WP3 technologies to the pilot as well as the integration of the pilot to WP5 components.

2. Main functionalities of the prototype

2.1. Access information

- **Pilot Prototype** source code is available online[1] https://github.com/trompamusic/clara. The public-facing version of the code is in the "clara200" branch.
- A live demonstrator is available[2] and is also accessible through the TROMPA subdomains[3][4].
- A video demonstration of the prototype is available online[5].

2.2. Requirements

The pilot needs the following requirements to be used:

- A web browser (PC or tablet) is required to use the pilot to view and analyse rehearsals
- A MIDI instrument connected to a computer with additional software provided by the multimodal music information alignment component (T3.5) is currently required to record new rehearsals for analysis. We aim to simplify this process by integrating the T3.5 software with the TROMPA Processing Library, moving the processing to the server and thus removing this requirement from the client.

2.3. Pilot Functionalities

The main functionalities of the application at current state of development are:
(Using the web client)

- Log in (authenticate) with a user's Solid POD
- Review rehearsal attempts stored within the user's POD (privately, requiring authentication to view)
- Display a rendered score view of the MEI encoding used during the rehearsal
- Display score-aligned tempo curves for each rehearsal attempt
- Display inserted or omitted notes
- Playback audiovisual recordings of each rehearsal attempt (if available), highlighting notes in the score and segments of the corresponding tempo curve in time with playback
- Visualise MIDI velocities (corresponding to dynamics) via the highlight colours of notes during playback
- Easily switch between rehearsal recordings by clicking on the different tempo curves (also switches playback and note highlighting), or by using a drop-down menu
- Easily navigate the rehearsal timeline by clicking on score elements, tempo curve segments, or by seeking along the audiovisual player's progress bar (in each case, updating note highlighting, tempo curve highlighting, and playback to the appropriate position)
- Navigate on a higher structural level (MEI sections) using a drop-down menu

[1] https://github.com/trompamusic/clara
[2] https://trompa.mdw.ac.at/
[3] https://clara.trompamusic.eu
[4] https://instrumentalplayers.trompamusic.eu
[5] https://drive.google.com/file/d/13CImIN2VwlEsZTG2L3bzK-vSWYo4TNyK

- ❖ Automatically turn the page of the score where playback progresses beyond that point (or where the user seeks playback beyond the page, using the tempo curves or progress bar)
- ❖ Log out (e.g. to log in with another user)

Using the additional functionalities provided by T3.5 processes

- Record new rehearsal attempts of a piece
- (Optionally) view real-time alignment performance feedback (notes highlight as performance progresses)

2.3.1. The interface

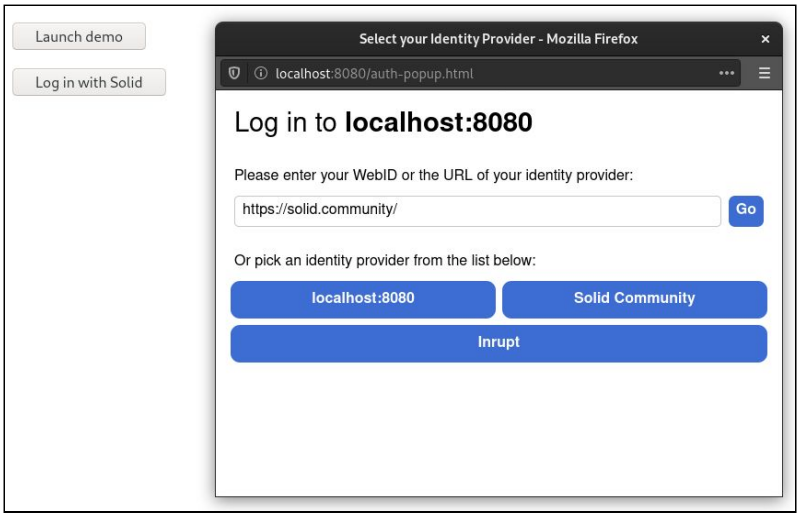

Figure 2.1. Initial page load and authentication.

On initial page load, the demonstrator currently presents two buttons: “Launch demo”, and “Log in with Solid” (Figure 2.1). Clicking on the first launches the CLARA application with data retrieved from a public demonstrator Solid POD[6]. Clicking on “Log in with Solid” instead allows users to authenticate with their own Solid POD using the pop-up authentication window pictured above. The styling of this pop-up is currently the Solid default, and will be adjusted to fit TROMPA’s look and feel in future development.

Figure 2.2. Graph traversal (loading screen).

[6] https://clara.solid.community/

On authentication, the user name (retrieved from the Solid POD) is displayed alongside loading messages (Figure 2.2). In the background, a process is now traversing a Linked Data graph of aligned music information, reshaping and caching this data for use in the client. The process currently takes around 15–20 seconds; we will aim to optimise this in further development.

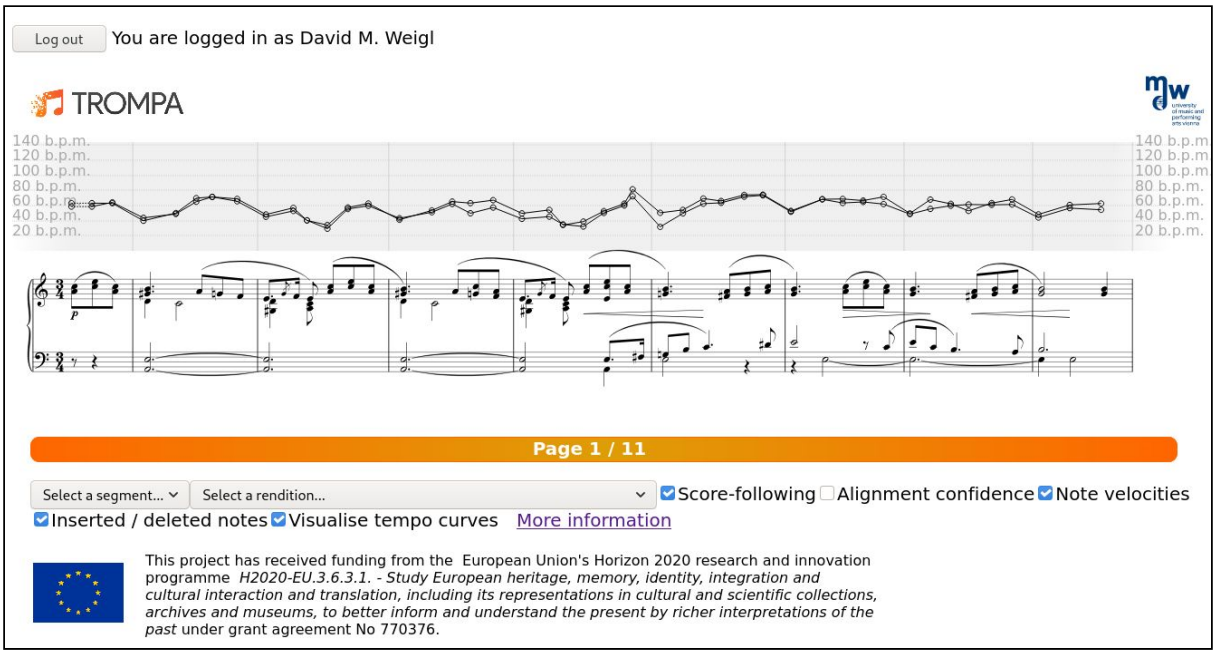

Figure 2.3. Main interface.

Once loading completes the main CLARA interface is rendered (Figure 2.3), displaying three major components (alongside a “Log out” button to return to the initial screen, project logos, and a funding acknowledgement). From top to bottom, these comprise: an analytical graph view displaying score-aligned tempo curves for all loaded rehearsal renditions (two in this example); a rendered score view; and a control panel, allowing users to select a score section (“Select a segment”) or a performance (“Select a rendition”) from drop-down menus, or to toggle interaction options including:

- “Score-following”: highlight notes and automatically turn pages in time with performance playback;
- “alignment confidence”: display metadata about the confidence of the alignment algorithm for each timeline point;
- “note velocities”: visualise performance MIDI velocities for each note;
- “inserted / deleted notes”: visualise detected performance errors; and,
- “visualise tempo curves”: display score as a single system with associated score-aligned tempo curve visualisation (turning this off removes the tempo curves, and displays the score split into multiple systems).

Figure 2.4. Interactive multimodal rehearsal review and analysis.

Users are able to navigate across score sections and performance timelines, enabling intuitive means of rehearsal review and analysis. Such interactions are illustrated in Figure 2.4; here, the user has selected a particular performed rendition, either from the drop-down menu, or by clicking a point along the corresponding timeline in the tempo visualisation. This triggers the media player to play the corresponding performance recording, jumping to the appropriate instant if one was selected through a timeline click.

Users can quickly and intuitively jump along the timeline, on a section-level through the drop-down menu, or on a note level by clicking onto the digital score, in either case cueing media playback to the appropriate instant; or, they can seek to a particular time in the recording playback, jumping the score and tempo visualisation elements to the corresponding place.

As playback progresses, both the tempo curve corresponding to the currently selected performance and the rendered notes in the digital score display change colour, indicating current playback position; the colouration of the notes gives a subtle indicator of performance dynamics, mapping MIDI velocity to a colour from light yellow (low velocity, pianissimo) to dark red (high velocity, fortissimo).

Together, the facilities to seek along a performance recording through interaction with visual representations of the musical score or the corresponding timeline, and the ability to quickly jump across performances (by clicking across timelines, or selecting from the drop-down menu) greatly facilitate targeted review and analyses of specific rehearsed sections, within and across performance renditions.

2.5 Connection to requirements

The following section replicates the technical success criteria for the instrumental players pilot from **D2.2 - Complete Requirements**[7], updating with the state of development as of M24.

Technical success criteria:

- Performers can record new renditions easily, with minimal intrusion into the ecological context of music rehearsal.

Current state: recording of new renditions is supported but currently requires users to manually run T3.5 alignment technologies. We plan to significantly simplify (dockerise) this task, and then to integrate it with T5.3 (Processing Library) over the next 3 months (see Gantt chart, section 4). This will allow us to successfully meet this criterion.

- Support for MIDI piano rehearsals — optionally, support for acoustic instruments at later stages of the project.

Current state: MIDI piano rehearsal support has been achieved. Support for rehearsal with other MIDI instruments and with acoustic instruments has been moved out of scope (future work).

- High-quality performance-to-score alignments generated on the fly by the TROMPA processing library, without requiring user interference.

Current state: high-quality alignments generated, but currently requiring user action – see above on Dockerisation and integration with T5.3

- Performers can easily select which renditions (their own and others' performances) should be available for comparison, and can easily compare and analyse different renditions within a rehearsal context.

Easy comparison and switching between performances (via interactive visualisations) is implemented. Sharing of renditions between performers, and management of which renditions to include in a comparison, to be implemented by M32 (see Gantt chart, section 4).

- Performers can author annotations through an intuitive interface. Annotations are stored using a data model sufficiently expressive to encapsulate the intended meaning of

[7] This deliverable is confidential to the consortium only

performative rehearsal annotations, and can be set to be private, shared with particular users, or publicly available.

Web Annotation data model chosen and schema implemented within both CE and MELD clients. Access control layer (private, shared, public) provided through Solid PODs – though currently not manageable in-app (part of the “rendition sharing” development task, to be ready by M32).

- ❖ Performers can undertake small fixes or improvements to the MEI score encoding, through integration with TROMPA MEI crowd-improvement tooling.

MEI scores can be pulled into the pilot application by reference to CE and to trompamusic-encodings GitHub organization. MEI crowd-improvement tool under ongoing development as part of T6.3.

3. User evaluations

3.1. Initial target audience & recruitment strategies

An initial pilot study involving mockups, reported in D6.1, alongside feedback obtained at a number of dissemination events (including the first International Workshop on Requirements, Use-Cases and User Studies for Digital Music Libraries and Archives, RUCUS 2019) have informed development of the prototype thus far. Per **Deliverable 6.2 - Planning for the Execution of Pilots in Real Life Settings** [8], we had planned to conduct further workshops on annotation requirements, acquire rehearsal data, and run further focus group studies around interaction with the pilot, incorporating instrumental performance students (all of whom study piano) and piano teachers at mdw as participants. These would have run face-to-face in small groups, using Clavinovas and the CEUS grand piano available at mdw as instruments.

3.3. Impact of COVID-19 crisis and adjusted target audience & recruitment strategies.

Due to the restrictions imposed by the global pandemic situation, the intended schedule of user studies has been delayed. In the medium-term future, in-person studies involving groups of users are unlikely to be feasible, though one-on-one sessions with a single researcher and a single participant sharing a room may be possible (pending continuation of the diminishing trend of COVID-19 outbreaks in Austria, and corresponding institutional and governmental decisions). We plan to move at least a portion of the intended testing to an online context in order to compensate, with precise decisions on physical tests pending development of the situation. Concretely we are planning for three distinct sessions:

- M26: Online presentation of the demonstrator and mockups for further development
- M27: Online or in-person (situation permitting) demonstration of recording own performances using D3.5 technologies
- M32: Online or in-person (situation permitting) demonstration of recording own performances transparently through the prototype application; organising, sharing, and publishing annotations and performances.

For each session, we will obtain feedback through structured interviews and questionnaire responses. Each session will involve participation of instrumental performance students and piano teachers at mdw. We will aim to involve at least 20 participants in each study; and, to retain participants as far as possible across these studies. The experimental procedures have been submitted to and approved by the mdw Ethics Review Board.

[8] https://trompamusic.eu/deliverables/TR-D6.2-Planning_for_the_Execution_of_Pilots_in_Real_Life_Settings.pdf

4. Future outlook

The following Gantt chart details anticipated development activity following the first release of this deliverable.

Task \ Month	26	27	28	29	30	31	32	33	34
Simplify (Dockerise) alignment & Solid publishing workflow									
CE integration: alignment workflow to TPL									
CE integration: multimodal component									
Integrate DSE (score selection + annotation) components									
CE integration: publishing renditions to CE									
Rendition sharing and collection management									
CE integration: music performance assessment component									
Bug fixing and optimisation									

5. Integration with other TROMPA WPs

This section summarizes the integration of the prototype with the components and technologies developed in other WPs, including WP3 (automatic description), WP4 (crowd-sourcing and human computation technologies) and WP5 (contributor environment and core components).

5.1. Relation with TROMPA WP3

WP3 tasks	Currently integrated	To be integrated in next version
T3.5 Multimodal music information alignment	Reading of aligned music information fully integrated. Writing (i.e., aligning new performances) currently requires running of prototype-external scripts	Integration of writing (aligning new performances) into the prototype client.
T3.2 Music description	Rhythmic descriptors (tempo curves)	Further descriptors; particularly relating to dynamics

5.2. Relation with TROMPA WP4

WP4 tasks	Currently integrated	To be integrated in next version
T4.2 Annotators	n/a	Allow T6.5 users to write and load performative annotations targeting both score elements and instants / intervals within (single or multiple) rehearsal renditions

5.3. Relation with TROMPA WP5

WP5 components	Currently integrated	To be integrated in next version
T5.1 Data infrastructure	Integration with user-retained data layer (Solid PODs)	Integration with the Contributor Environment (CE): Query (find scores to perform); Publish (rehearsals and/or annotations to CE)
T5.2 Digital score	Rendered (MEI) score display,	Score element selection for

edition	paging, interaction	annotation
T5.3 Multimodal integration of music data	n/a	Integration of T3.5 workflows in TROMPA Processing Library; integration of multimodal component UI for query of the CE
T5.4 Music performance assessment mechanisms	Computation of extent performed in a given rendition timeline; determination of inserted and omitted notes (performance errors)	Computation of aggregate measures (quality, difficulty) based on extent performed and error rates, for a given user and across users; visualisation of this information.
T5.5 Annotation tools	n/a	UI for annotation of score and rehearsal renditions, as well as for loading and writing of annotations (and annotation collections)

6. Conclusion

This document has presented the state of the TROMPA working prototype for instrumental players – CLARA, the *Companion for Long-term Analyses of Rehearsal Attempts* – as implemented at first release (M25). This release implements features identified as useful to our target audience of highly skilled (amateur and professional) pianists in initial pilot studies. All required technologies are in place – most interestingly, processes that enable the alignment of rehearsal recordings and music score encodings (MEI); a novel extension of the *Music Encoding and Linked Data* (MELD) framework to offer interactivity between structural and temporal Linked Data (corresponding to score descriptions and performance timelines) at a highly granular, note-based level; and, an integration with Solid PODs (*Personal Online Datastores*), allowing users to retain ownership of their data and control its access (private, shared with specified other users, public).

Though effectively feature-complete, many aspects of the rehearsal recording workflow currently require manual intervention through the running of scripts to record, align, and organise the data describing rehearsal renditions. These functionalities will gradually be automated and integrated into the web application in coming development, alongside facilities to integrate more closely with the TROMPA contributor environment, allowing scores to be retrieved by query to the CE, and renditions to be published to the CE pending user request. The user-facing interfaces driving this functionality will be subject to validation and improvement through oncoming user studies, the outcomes of which will be reported in the next version of this deliverable.