

# Lohengrin TimeMachine: musicological multimedia made with MELD

Musicology is often presented in linear, textual form, even though its materials are complex and multimodal. Scholarship must necessarily simplify and dramatically reduce complexity in order to make an ordered prose argument that others can follow. More detailed interaction with the scholar's observations occur almost entirely through other resources.

We present the *Lohengrin TimeMachine*, a web application in which linear musicological scholarship (in the form of an essay and a video) is augmented by user-driven interactive, multiple-path exploration of related material that can be explored independently from the text. The material, which includes musical notation, audio, analytical content, and textual quotation is accessed through a touchscreen-optimised web application for guided and self-directed exploration. Underlying resources are published on the web using standard file formats (including MEI and TEI) and associated with machine-readable Linked Data, supporting the creation of additional interfaces or analyses.

The application is intended to be accessible to enthusiastic amateurs as well as scholars, and concerns Wagner's use of motives in his early opera, *Lohengrin*, arguing for a more sophisticated understanding than 'Leitmotif' guides often communicate. It is optimised for use with a tablet, without excluding other means of browsing. The musicological content was conceived, written and, for the video, presented by co-author Laurence Dreyfus, a Wagner specialist, with the companion realised through a multi-disciplinary collaboration.

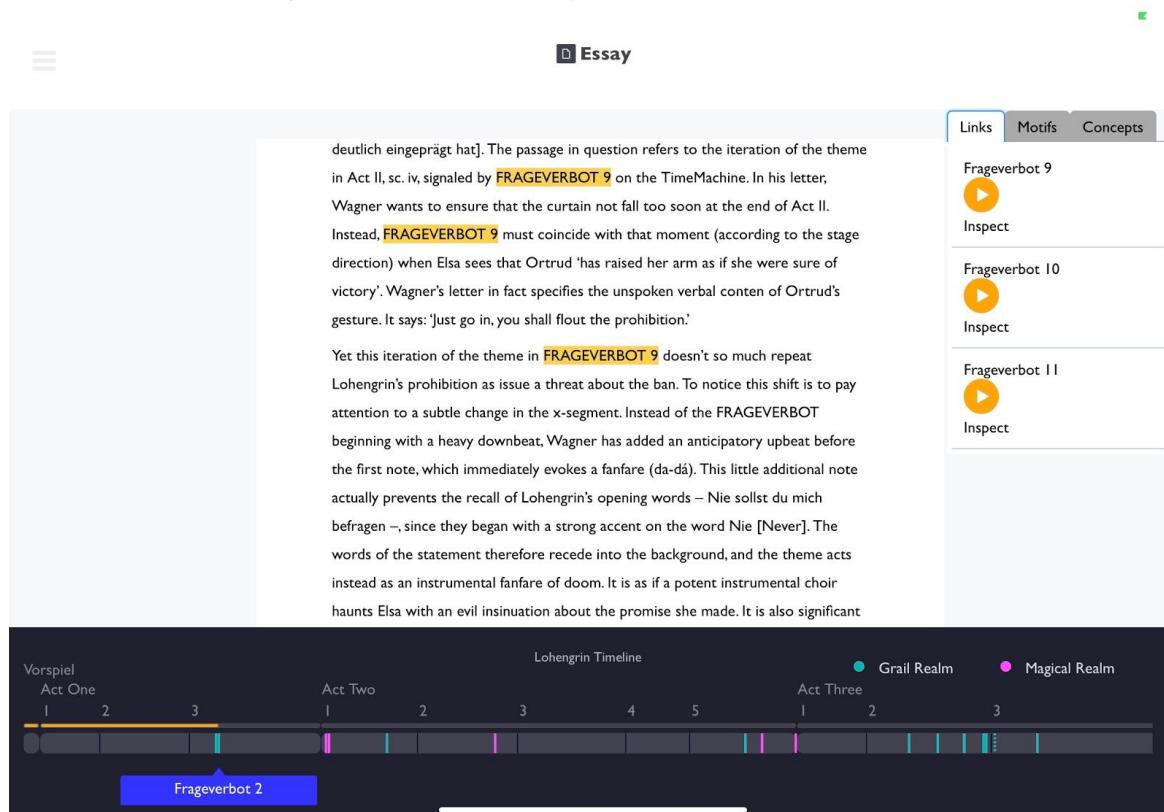


Figure 1. The Essay view, with the opera timeline (below) and links to other views (right).

The *Lohengrin TimeMachine* allows users to explore the compositional devices Wagner uses to vary his motives, browsing the whole opera for motive occurrences and their musical and textual contexts. Visualisations and recordings support the analysis, making it accessible to an audience that might otherwise struggle with a Wagnerian orchestral score. Exploration of this material can follow or be triggered by the musicological article and video, but can also be entirely reader-driven, with free browsing of the curated musical landscape.

## The application and its data

The application dynamically constructs views using data published openly using standard file formats and Linked Data frameworks (Lewis et al., 2018). Materials are retrieved live from a public web server. Music notation is published as MEI, and text, including the main article, as TEI. Relationships and more abstract information are made available using the Resource Description Framework, serialised as JSON-LD and TTL: annotations use the Web Annotation model (Barnes et al, 2017), while much of the musical information is represented using the Music Ontology.

The sum of all these forms an independent, repurposable, and open Research Object (Page et al, 2013). Interactive user views are generated directly and dynamically in the browser from this knowledge graph using novel visualisations, which enable the user to navigate all possible paths through the evidential multimodal materials.

The *TimeMachine* is built with a new version of the MELD (Music Encoding and Linked Data) framework (Weigl & Page, 2017). MELD traverses Linked Data graphs to select and filter relevant information, with reusable components for creating and retrieving annotations, and for displaying and interacting with musical, textual, graphical and audio-visual materials. MELD – and the *TimeMachine* – is written in Javascript<sup>1</sup>, and operates over resources and data structured using Web standards.

In the *Lohengrin TimeMachine*, we provide two different views for music notational content. Vocal scores are rendered from MEI using Verovio, with structural analysis (musical sections) dynamically overlaid (Figure 2, left pane). Activating these annotations triggers audio playback from the beginning of that section.

For full orchestral scores, a new, more abstract, notational visualisation of MEI is used, simplifying the complexity of a Wagnerian orchestral score. In our orchestration pane, each instrument playing at a particular time is shown as a coloured ribbon, with the instrument's section of the orchestra providing the colour (Figure 2, right pane). This highlights differences in orchestration that may be invisible in a vocal score. This visualisation is realised as SVG, generated by a React component within the *meld-clients-core* module.

---

<sup>1</sup> MELD server infrastructure for writing and querying annotations is in Python, but is not used here.

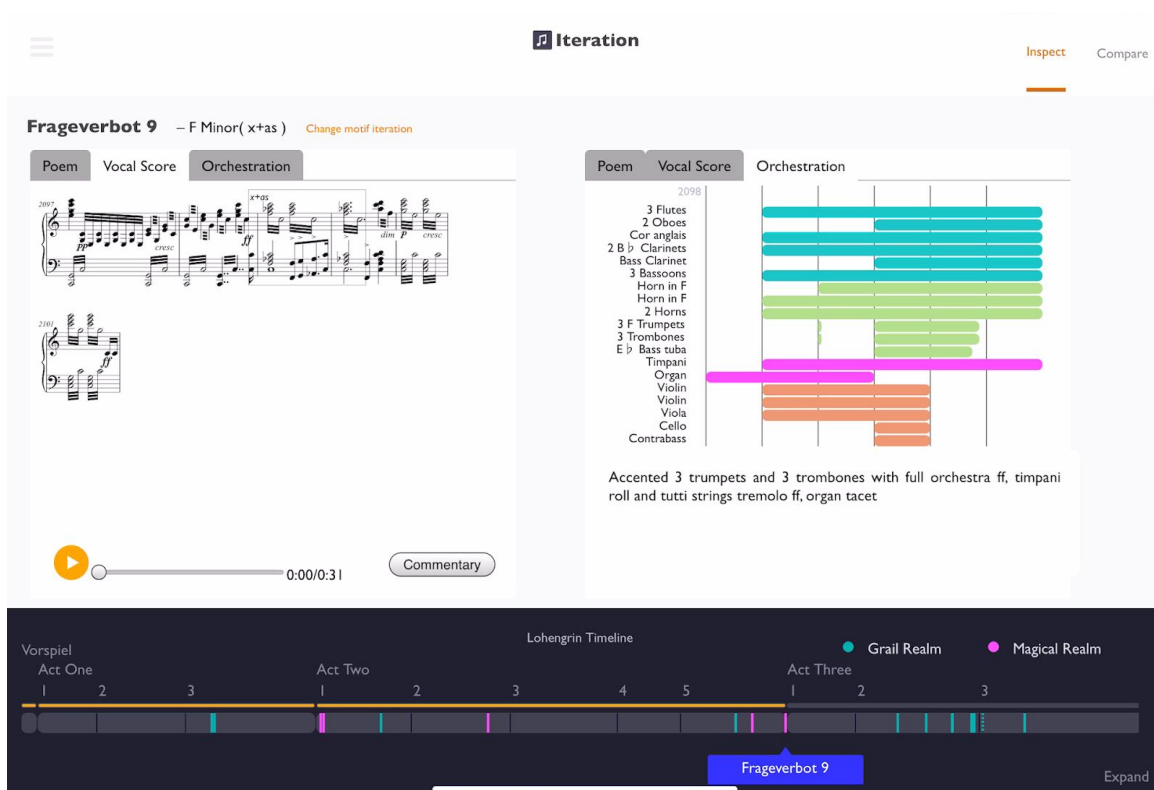


Figure 2. Iteration view, showing the vocal score (Verovio) and the orchestration summary view, as well as the vocal score, and audio and commentary links.

For an opera thousands of bars long, overviews are crucial. An ever-present timeline shows all occurrences of a motive, providing a visual summary and a base for navigation. In the Time Machine view (figure 3), users can also flick left or right through motive occurrences in a carousel-like rapid overview – as libretto, vocal score or orchestration summary. The view summarises the sequence within the opera, supporting quick comparisons, and also acting as an index to detail views.

The essay and video themselves are also integrated in the app, providing important narrative grounding, and a reader or viewer is presented with relevant links into various of the application's views as they watch (figure 4). TEI in the Essay view, and in commentary and historical texts is rendered to screen using CETEIcean<sup>2</sup>. This Javascript library, like Verovio, displays its source material, preserving structures and IDs where possible. Since the source material here is text, the result can be HTML with custom tags, styled using CSS.

<sup>2</sup> <https://github.com/TEIC/CETEIcean>

The screenshot shows the 'Time Machine' application interface. At the top, there is a navigation bar with three tabs: 'Vocal Score' (selected), 'Orchestration', and 'Poem'. The main content area displays musical notation for 'Frageverbot 2—A Minor (x-x-y)'. The notation includes vocal lines for Lohengrin and piano accompaniment. The lyrics are in German. A 'Commentary' box on the left provides additional context: 'Lohengrin sings complete FRAGEVERBOT a semitone higher; orchestration on repeat altered with woodwind anticipations which correspond to stage direction *noch bestimmter*, (more decisively)'. Below the commentary is a play button and a progress bar showing 0:00/0:38. At the bottom, a 'Lohengrin Timeline' is displayed, showing the progression through Act One, Act Two, and Act Three. The timeline is divided into segments, with 'Frageverbot 2' highlighted in Act Two. The timeline also indicates the 'Grail Realm' (blue) and 'Magical Realm' (pink).

Figure 3. The Time Machine view, set to browse by vocal score. Browsing is also possible using the Orchestration view and Libretto ('Poem', as Wagner called it).

## Discussion

The application is possible because of a combination of factors. With a musicological study that was conceived by its author for interactive exploration, and collaborating on design with that author, we can ensure that the visualisations we provide are relevant and add to the academic argument and to a user's understanding of the material.

On a technological level, the combination of web standards and formats – especially MEI – that are easily addressed using URLs supports building rich, specialised applications without the need for bespoke or closed data formats. Furthermore, open-source rendering libraries such as Verovio and CETEIcean, which preserve to a large extent the structure of their originating documents and propagate IDs through from the XML to the rendered result, provide essential support for semantic on the data level to be transformed into interactive exploration on the application level in a principled and re-usable way.

By relying on walking linked data graphs to discover information and resources, MELD has no requirement for its materials to be collocated on the same server or published by the same institution. There is no reason in principle why information and media could not be drawn from multiple external sources, such as Wikidata, Europeana or YouTube, nor anything to prevent others building MELD apps using the *Lohengrin TimeMachine's* resources.

The MELD framework has already been used for a variety of musically-rich interfaces. We believe that *The Lohengrin TimeMachine* can serve as a model for many more.

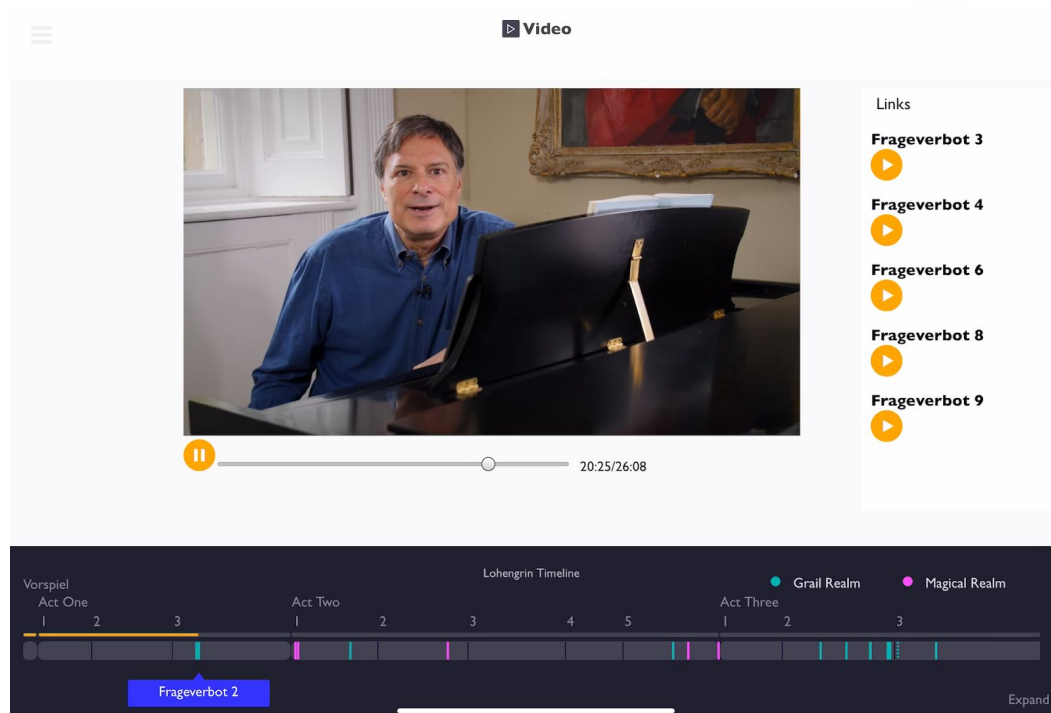


Figure 4. As in the Essay view, in the Video view, relevant links appear in the sidebar.

## Acknowledgements

The Lohengrin TimeMachine was developed by the AHRC-funded Unlocking Musicology project (AH/R004803/1) as a companion to the essay “Asking a Forbidden Question: A new view of musical themes in Wagner’s Lohengrin” by Prof. Laurence Dreyfus (University of Oxford Faculty of Music). Unlocking Musicology builds on research undertaken during the Transforming Musicology project (AH/L006820/1) with important contributions from Carolin Rindfleisch. The MELD framework was created, with David Weigl as lead developer, as part of the Fusing Audio and Semantic Technologies for Intelligent Music Production and Consumption project, funded by the UK Engineering and Physical Sciences Research Council (EP/L019981/1). We thank Will Elsom for his work on the Lohengrin Time Machine design specification, Steve Pierce and Oxford Filmshed Productions for the video tutorial, and Ralph Woodward for his music engravings.

## Bibliography

M.E. Barnes, N. Ledchumykanthan, K. Pham, and K. Stapelfeldt. Annotation-based enrichment of digital objects using open-source frameworks. *Code4Lib Journal*, (37), 2017.

D. Lewis, D.M. Weigl, J. Bullivant, K.R. Page. Publishing musicology using multimedia digital libraries: Creating interactive articles through a framework for Linked Data and MEI. in *Proc. DLFM 2018*, Paris, France 2018.

K.R. Page, B. Fields, D. De Roure, T. Crawford and J.S. Downie. Capturing the workflows of music information retrieval for repeatability and reuse. *Journal of Intelligent Information Systems*, (41/3), pp. 435–459, 2013.

D.M. Weigl and K.R. Page. A Framework for Distributed Semantic Annotation of Musical Score: “Take It To The Bridge!”. In *Proc. ISMIR 2017*, Suzhou, China, October 23–27, 2017, pp 221–228, 2017.