Towards a Graphical User Interface for Quantitative Analysis in Digital Musicology

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ABSTRACT

We introduce the first prototype of a web application for digital musicology: *BeyondTheNotes* (working title). The goal of the tool is to support the in-depth analysis of individual pieces of music as well as the large scale analysis and comparison of summative features of multiple pieces of music. In contrast to existing tools, BeyondTheNotes is ready to use without installation, enables the upload and analysis of own material and offers different visualizations of musical metrics like chords, pitches, durations and key. We design the tool according to the *User Centered Design Approach* to improve the usability and address the specific needs of musicologists. We describe the results of the requirement analysis and discuss future steps.

CCS CONCEPTS

• **Human-centered computing** → **Visualization application domains**; • **Applied computing** → **Sound and music computing**; • **Information systems** → *Information retrieval*; • **Social and professional topics** → User characteristics;

KEYWORDS

Digital Musicology, Statistical Musicology, User Centered Design, Visualization, Distant Hearing

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1 INTRODUCTION

Traditionally, musicologists examine individual pieces of music, or sometimes groups of the same, via qualitative methods that are established in the humanities. However, there has been a growing interest in quantitative and digital approaches in the humanities in recent years. One very prominent line of research emphasizing this development is found in the field of *Digital Humanities* and literary studies: *Distant Reading* (a term framed by [18]) describes the concept to analyze and visualize a large number of texts, predominantly with computational and quantitative methods. It is used to gain new insights and answer research questions that could otherwise not be answered e.g. about differences between entire genres or authors. The term is framed in contrast to *Close Reading*, the traditional in-depth analysis of individual texts oftentimes executed via rather qualitatively driven methods.

In regards to musicology, quantitative methods have been used for some time and are referred to as statistical musicology [19], computational musicology [6] or in analogy to the Distant Reading concept *Distant Audition* [1]. Sometimes this concept is also referred to as *Distant Hearing* [2]. Research approaches include the quantification and visualization of pitches, intervals, durations [15, 19] or of chords and keys [1] in large numbers of musical pieces. Note that the terms close and distant audition or hearing are not yet established and highly disputable since one does not really hear anything when examining the results of statistical analyses of symbolically represented music. However, in the following sections we will use the term Distant Hearing to refer to the concept of large scale quantitative analysis of musical metrics and Close Hearing for the in depth analysis of a single piece.

In a similar line of quantitative research, there are multiple commercial tools in the field of Music Information Retrieval. Some of them are designed to retrieve musical pieces via textual or audio queries [4]. There are few tools in the context of Digital Humanities addressing the needs of humanists [4, 5]. Some tools have been implemented to search for music on different abstraction levels of melodic similarity [3, 12]. While the aforementioned resources occasionally encompass functionality for Close and Distant Hearing analysis, the main focus is on the retrieval component.

Whereas there are tools for musicologists to analyze individual pieces of music, they suffer from some limitations. *Music21*, a python library [11] and *Humdrum*, a set of command line tools [14] are less accessible tools for occasional users or humanists since they require specialized knowledge or programming skills. There are some attempts to build tools that offer easier to use Graphical User Interfaces (GUIs) [6, 16, 20]. However, those tools often require rather complex installations of various components. Furthermore, while some offer rudimentary analyses of multiple musical pieces, the main functionalities are focused on the analysis of individual pieces. One more accessible tool which enables quantitative analyses is the *DLM VIS* site, a web based tool by [1]: Users can compare various features of multiple musical pieces e.g. via tempo and pitch histograms on a limited corpus of audio files.

Nevertheless, since there is still a lack of ready-to-use tools for musicologists, to support both Close and Distant Hearing based on sheet music, we started the development of *BeyondTheNotes* (which is the current working title of this software), a web based tool for the analysis of individual pieces as well as for the summative analysis of multiple pieces. While we certainly build upon ideas of the DLM VIS site [1], we also offer additional functionality and visualization methods e.g. the analysis of score data and the upload of own material. Furthermore, we also integrate methods of the *User Centered Design Process* [21] and usability engineering to design a more user friendly tool. We integrate the feedback of musicologists in early stages of development to design a tool that fits the specific needs of this user group.

2 DEVELOPMENT

Requirements Analysis

First, we gathered requirements via various methods: We conducted a focus group with two advanced students of musicology and also interviews with two practicing musicologists from the University of Munich. Our interest concerning these interviews and focus groups were (1) how musicologists perform research and (2) in what way they imagine a digital tool to support their research. We want to briefly describe some aspects that influenced the development:

Considering the methodological approach, qualitative analysis was prevalent and there is no fixed procedure for such analysis. The musicologists reported that they are primarily interested in the following aspects: leading notes, key, non-scale and non-chordal tones, intervals, the ambitus (pitch range), harmonies, rhythmic motifs and other sorts of reoccurring themes. One feature all the participants expect from a digital tool is the possibility to analyze own material. Most of the time analysis is done on just one piece or a rather small selection. Musicologists finalize their analysis by writing a text, for which they imagine that a tool could help by creating various types of graphs. In the context of Distant Hearing, musical metrics are oftentimes analyzed per composer or genre and frequency analysis of metrics are considered helpful. The musicologists we interviewed also expect a tool to offer the functionality to download the graphs and scores but also the raw data as JSON.

Technical Background

Since we want to develop an accessible tool that can be used without any further installation we decided to develop a web tool that can be used in any modern web browser. We use the *Django* framework as a back-end. For functionality concerning musical analysis we utilize the *music21* package.

3 FUNCTIONALITY

General functionality

As a predefined corpus we use the *music21 corpus* [9] that offers material of different eras and genres. However, users can additionally upload their own files in various file formats like ABC, MEI, Midi, MusicXML and multiple others. On the starting page users can either choose "Individual Analysis" for the analysis of just one piece only or "Distant Hearing" for the analysis and comparison of multiple pieces. An online demo of the prototype can be found here: https://beyondthenotes.herokuapp.com

Individual analysis

After searching for a specific file in the predefined corpus or uploading a file, users can choose various analysis types. Users can display the chords (in roman numerals or with the corresponding chord names), analyze the ambitus or the key. For the analysis of the chords, music21's chordify [8] function was used. Chordify reduces a score with various parts to a succession of chords (figure 1).

For the generation of the key possibilities, a variation of Carol Krumhansl's and Mark A. Schmuckler's algorithm was used [10]. It compares the distribution of pitches in the piece to sample distributions of pitches for different keys and returns the best matches. The key analysis can then be integrated into the chord analysis. Since the key analysis returns only correlation coefficients, the musicologist can choose which one of the four most probable keys they deem to be the most likely actual one. If chords are displayed as

Figure 1: Individual chord analysis

roman numerals, they are then adjusted to the new key. For the analysis of the ambitus, music21's ambitus function was used [7]. The highest and the lowest pitch of the ambitus are rendered in a staff at the top of the page.

Distant Hearing

In this section, the user first has to define the groups of music pieces that will be compared to each other. The users can define the groups in any way they want e.g. by genre. They can search for pieces and assign them to different groups. The user then has to select the pieces for analysis by checking the boxes on the side. There are five visualization sections with multiple graph types. All graphs are interactive and offer further information when hovering over key areas.

The chords section consists of three different bar charts: The count of roman numeral chords, of the chord roots (figure 2) and of the chord quality. The pitches section also has three bar charts: One for the count of the pitch names the pitch octave and the count of the pitch name with octave. The durations section offers six different bar charts: The count of the duration of notes and rests by their name, of the duration of the notes and rests by their values, of notes and rests together by their value, and one graph which shows the sound to silence ratio. The key section includes two different types of visualization. Two bar charts, which show the count of the key name and of the key mode, and a line graph for each group which shows the four most probable keys for each music piece (figure 3).

The ambitus has two different types of visualization. One is a horizontal bar chart. It shows the pitches on the x-axis. The bars reach from the lowest pitch to the highest pitch (figure 4). The second one is a boxplot, which shows the distribution of the ambitus over all the music pieces per group (figure 5). The user has the possibility to download the analyzed data in JSON to perform further analyses on the data set.

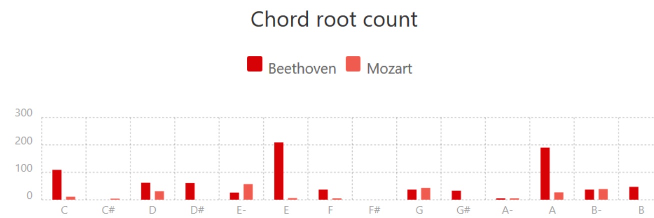

Figure 2: Chord bar charts

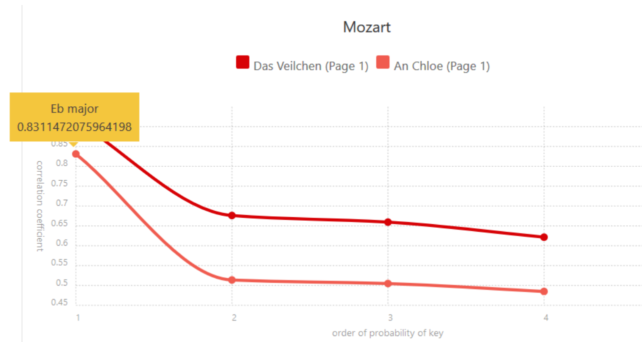

Figure 3: Key line charts

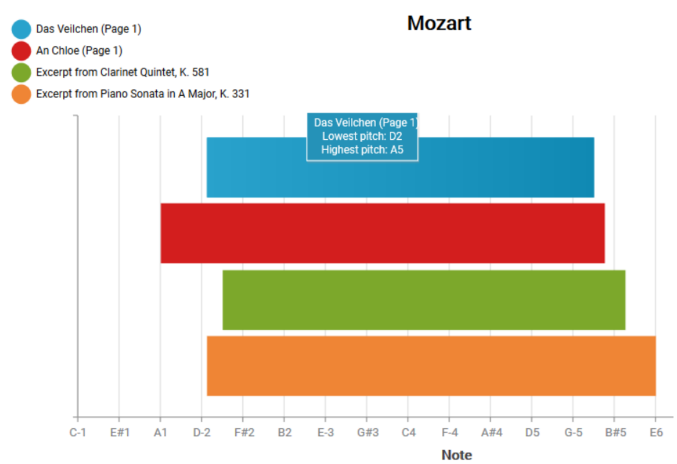

Figure 4: Ambitus range chart

4 DISCUSSION

The presented application is currently in early stages of development and we just recently began evaluations. We are working close with musicologists to explore first use cases on how the computational and quantitative approach of our tool can lead to new insights for musicology that would not be possible by solely traditional qualitative work. Therefore, we examine the research area of variation works. Variation is the melodic, harmonic, rhythmic or dynamic modification of a composition [17, p. 157]. One example of

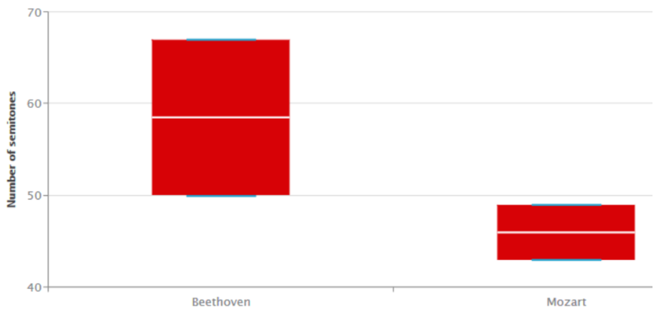

Figure 5: Boxplots of ambitus semitones for Beethoven and Mozart in our corpus

variation works are the ones based on *La Folia*, a Spanish 16th century theme, which was used as a base for variations by numerous composers throughout history [13]. By continuing the development of the tool and creating a fitting corpus we will be able to analyze whether the variations on this theme differ more by composer, by time, origin or by country.

Currently, BeyondTheNotes can be best used for exploring the general computational support for musicology research. Initial hurdles to explore are very low, due to the fact, that no installation or downloading procedures are necessary at all. This makes it an ideal tool for novices and students interested in the possibilities of digital musicology and the concept of "Distant Hearing" as well as a good addition for investigating new research opportunities.

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