Inside Beethoven!
A Musical Installation for a New Listening Perspective

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Figure 1: The Inside Beethoven musical room installation.

ABSTRACT

On the occasion of the 250th anniversary celebrations of Ludwig van Beethoven in 2020, we developed the musical room installation "Inside Beethoven! The Audience Goes on Stage". It is a stage with virtual musicians. Visitors are invited to enter, take the position of the musicians and listen to each of them at close range. The installation emulates the listening perspective of the musicians, thus, providing an uncommon experience to visitors who are mostly used to listen to music from recordings or from a concert audience's perspective. The musicians play Beethoven's septet op. 20 and its trio arrangement op. 38, two exclusive 14 channel music productions. Both versions are aligned and can be switched seamlessly. Digital music stands visualize the score. In this paper we trace the genesis and construction of the installation and point at some conceptual and technical challenges tackled.

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CCS CONCEPTS

• **Applied computing** → **Sound and music computing**; **Media arts**.

KEYWORDS

Beethoven, Music, Artistic Installation

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1 HAPPY BIRTHDAY, BEETHOVEN!

Interactive music exhibits can offer new perspectives and provide new ways to experience and appreciate music. For the year 2019–2020, which marks the 250th anniversary of Ludwig van Beethoven's birth, we created the interactive music exhibit "Inside Beethoven!", which lets visitors explore ensemble sound and instrumentation. Some interactive music exhibits provide sonic experiences with new aesthetics, by using sound synthesis and music generation often coupled with a tangible user interface. In "Brain Opera" [12] the users can experiment with various interactive music instruments. Other music installations provide new perspectives on traditional styles by composing with chance [10] or with remote collaboration [4], conducting a symphonic orchestra [3], or experiencing medieval music by using interfaces based on historic instruments [9].

"Inside Beethoven!" lets visitors explore the polyphonic sound of Western classical music. At first glance, the visitor sees a fairly "common" concert situation (fig. 1). The sound is similar to what is known from classical concerts. But when getting closer, entering the stage and stepping into the position of a virtual musician the visitor also steps into his/her listening perspective and experiences the ensemble performance from there. The instrument is heard louder, just like in real life (if the visitor dares to enter the stage during live performance). All other instruments are sounding from their respective positions. This is realized with a special loudspeaker setup. The exhibit exploits the acoustic effects of distance attenuation and directional hearing and, thereby, makes the polyphonic interplay of the musicians more transparent to the listener than listening from the distance or via stereo speakers/headphones can do. The virtual musicians play Beethoven's Septet op. 20 [2] and its trio arrangement op. 38 [1]. The timbre of these two instrumentations can be explored by switching back and forth seamlessly between the two versions with a button at the center of the stage.

Previous exhibits have also provided possibilities to interact with ensemble sound. In the interactive conducting exhibit "Personal Orchestra" [3], the user can emphasize different instrument groups by conducting towards them. The installation "bang!" [7] features a rock band on a virtual stage wherein the user is tracked in order to adapt video and sound mixing accordingly. A new perspective on instrumentation and timbre is also of pedagogical interest. The OrchPlay software [16] uses hand-crafted orchestral renditions and allows the user to mute individual instrument group, thus allowing users to explore how they establish a complex orchestral timbre.

The realization of "Inside Beethoven!" was an interdisciplinary effort. Musicologists have researched the two pieces and created a digital music edition. Eight musicians rehearsed and played the pieces. Tonmeisters did the music production. Computer scientists conceived the construction and technical implementations. A booth builder company was involved to built the exhibit and a graphic designer shaped its visual appearance. The following sections will provide an overview of this work.

2 SEVEN VERSUS THREE: THE MUSIC

When looking for an adequate "installation object" in Beethoven's oeuvre, we had to take into account that the size of our exhibit should be as compact as possible in order to facilitate transport conditions as well as allowing a presentation in smaller museums. Therefore, from the very beginning of our plans orchestral works had to be excluded. Instead we searched for a chamber music work that fulfills several preconditions:

(a) a manageable number of instruments,
(b) instruments with different playing techniques and timbre,
(c) a work which shows a great variety not only in the character of the individual movements but also in the structure of its musical sections, i.e. alternation between homophonic and imitative passages, frequent passing of melodic lines from one instrument to another, role changes between solistic and accompanying function, and
(d) a large bandwidth of different timbres through various instrumental combinations.

We identified Beethoven's Septet op. 20 (composed in 1798—1800) and his own arrangement for trio-formation op. 38 (finished in 1802, published in 1805) to fit ideally. The septet's sufficiently large, mixed wind/string instrumentation offers a wide timbral palette, especially since the colorful combination of these individual instruments and different pairings demonstrate ensemble playing in an extraordinarily varied way. According to Egon Voss, this is the true sense of Beethoven's remark that the instruments here were "tutti obligati", i.e. the opulent parallel voice leading does not create the feeling of main and subordinate parts, but rather musical figures in various timbres [17]. Beethoven effectively created a kind of chamber symphony with seven instruments just before he was working on his 1st symphony op. 21 which was premiered in his Vienna concert of April 2nd, 1800 together with the septet.

On the other hand the trio version allows the visitor to experience the change of roles of the identical instruments and their different sound embeddings as well as the tracing of the modification of motifs which move from the original septet version to the right or left hand of the piano. And it is most interesting to see/hear where Beethoven endeavoured to make this arrangement more "chamber music-like" by not only introducing new idiomatic but also new contrapuntal elements in the trio version. His "translation" [5] thus moves the work from the domain of serenade and divertimento, indicated e.g. by the structure of the movements, to the more ambitious field of chamber music [19].

Both works were already in the process of transcription into the machine-readable MEI format[1] as part of a digital music edition [6]. On this basis we created a special version of the septet score and at the same time a second version which combines septet and trio score into a synoptic presentation. This allows a direct comparison of the arrangement with Beethoven's original. Furthermore, the MEI encoding meets the prerequisites for a direct linking of the Verovio-rendering with the audio recordings.

The recordings took place in a concert hall. A common approach to recording classical music is the use of a "main microphone system" consisting of two omnidirectional microphones as a starting point [8]. These microphones are the focus and priority in achieving a good balance and overall presentation. To get the best final result it may require additional "support microphones" that are placed near the individual instruments. They allow for better sound separation and therefore more flexibility in the mixing. In case of

[1] https://beethovens-werkstatt.de/, last access July 2020.

the Beethoven recordings, we used special microphones that were clipped as close to the sound sources as possible to avoid the influence of the room acoustics and get signals that are as close as possible to the experience of the performing musicians.

3 SETTING THE STAGE

Both, construction-related and technical challenges, had to be mastered in the course of building "Inside Beethoven!". Although no big problems per se, a holistic view reveals various non-trivial details and interwoven considerations which are worth being exposed.

3.1 The Stage: Construction

"Inside Beethoven!" is a stylized concert stage that can be explored by the audience while the virtual music ensemble performs. From this premise follow two principle design decisions, (1) the arc-shaped positioning of the virtual musicians that is typical for chamber ensembles, and (2) the semi-open room layout that is closed behind the musicians and open towards the audience space. However, the installation was exhibited at several different locations, some with limited space. So it had to be portable and compact, yet large enough to provide space for a chamber septet.

The rear wall was curved in parallel to the arc of the digital music stands keeping enough distance. While the two outside walls are still plane, the combination with the curved inside wall increases stability and creates a cabinet in the corner for technical equipment. The cables between the walls and under the raised floor connect the loudspeaker system and digital music stands. A carpet beneath the floor spares vulnerable floors in the museums. A circumferential wedge bar bridges the 5cm-high step for wheelchair users.

On the curved rear wall the musicians are displayed life-sized behind their music stands (fig. 1). In addition to the seven players of the septet we needed to incorporate a piano player for the trio. Due to the size of the instrument and in order to capture its acoustical spaciousness we strech it over double bass and french horn. Above the musicians we use a color coding that recurs at the front panels of the music stands in a more artistic rendition of the instruments.

The music stands are solid desks with square displays. Hidden within behind a sound outlet grid are speakers. Acoustically advantageous, the speakers' sound reflects off the musicians' images on the wall, creating the impression when listening from the center that the sound originates from them. Such a spatial distribution of virtual sound sources could also be achieved with other, more expensive techniques, such as Ambisonics and wave field synthesis. We benefit from the fact that the musicians are stationary at their stands, thus representing static sound sources.

The acoustic concept of goes even further. So far, the sounds are placed in close proximity to the corresponding musicians so that listeners when approaching their position get a spacial impression that emulates how and from where musicians hear their companions in the ensemble. But the sound sources always sound the same up close and at a distance, whereas important to us when approaching a musician, was an additional effect, a "timbral emphasis on proximity". Therefore, when visitors step into the musician's position behind the music stand, they enter the sound cone of a directional speaker that is mounted above the musician. A carpet on the floor dampens reverberation and further sound propagation.

Figure 2: Visitors can read the musical score on the displays.

It is important to be aware of the fact that directional speakers in general are far from a flat frequency response which renders them quite disadvantageous for musical purposes. The rather nasal sound completely lacks frequencies below 100Hz. Slightly increased volume levels distort quickly. Consequently, the role of these speakers was merely to add a slight high frequency gain, a subtle timbral effect to give the impression of having the ear close to the musician. This is based on the acoustic fact that distance attenuation of higher frequency content is steeper than lower frequency content [13].

3.2 Behind the Scenes: Technical Development

All fourteen loudspeakers and 7 displays are driven by a PC and multi-channel audio interface. The latter comes with a fully-fledged mixer and DSP capabilities, such as multiband equalizers and compressors, necessary tools to adapt the music recordings to the specific requirements of the loudspeaker setup and the acoustic circumstances of the different exhibition venues. Software-wise we developed a custom media player, the "BTHVN Player" that provides synchronous 14-channel audio and playback, precise alignment of septet and trio and the possibility to cross-fade them at any time, and a volume control rotary encoder.

The MEI encoded score was converted to pixel images and composed to a single video file for each recording. Our first approach for displaying the score was a single "endless" staff that scrolled constantly. However, early tests showed that this could cause a feeling of dizziness. We therefore resorted to a page-based approach with quick page flip animations. All screens show the same score images but highlight the respective staff with the colors corresponding to the stage design (fig. 2).

When visitors trigger the switch in the center of the exhibit, BTHVN Player performs a 1 sec crossfade between septet and trio at the exact same musical position, thus, maintaining the musical flow while the timbre changes. A fully automated alignment computation of classical chamber music is still considerably error-prone today. Current state-of-the-art approaches use various forms of "Dynamic Time Warping" (DTW) [14]. In musical contexts it is commonly based on "chroma features" [15], "CENS features" [11]. In the case of our Beethoven recordings, the limitations of this approach became

obvious right at the very beginning: long, decaying chords are mapped only imprecisely to each other, slow musical sections tend to cause the alignment to diverge. Extremely large deviations in the basic tempo in some parts of the two recordings even caused the alignment to contain excessive offsets. After experimenting with various DTW-based methods, we resorted to a manual alignment to achieve the highest possible accuracy.

Septet/trio switch and volume knob were implemented using the Arduino-based SPINE circuit board and the SPINEprog software driver [18]. They communicate with the BTHVN Player via OSC. After the piece of music is finished, the BTHVN player waits a certain time before starting again. This time can be set individually according to the wishes of the local exhibitors.

The installation is accompanied by additional media. A wall chart gives a short introduction and a QR code that links to the accompanying website.[2] There, visitors can access the VideApp, a visual analytics tool that displays both works in a combined score, inks variations, deletions and additions with different colors, visualizes event density, harmony and voice contour. Furthermore, we compiled a media book that offers more in-depth information incl. a comprehensive photo gallery of the construction process, recording sessions and genesis of the designs. The media book comes with an Audio CD with both, the septet and trio.

4 THE AUDIENCE

Throughout 2020 and 2021 "Inside Beethoven!" visits six locations in Germany and Austria. It featured a huge and consistently positive reception in the press and was also featured in two professional journals, "neue musikzeitung" and "VDT Magazin". Especially the new approach to experiencing music was praised as innovative.

The feedback of visitors and exhibitors was more differentiated and informative, though. The visual design was praised. Also the media book was well received. Some visitors asked for more elaborate instructions on how to walk through the installation and what they should pay attention to. Some also needed more explanation of the septet/trio switch. We did get not so much feedback on the animated score. It was probably to be expected that notes would be displayed on the music stands. But of course these are accessible mostly to those who are able to read music. For the other part of the visitors it would have been more fruitful to enrich the score animation by videos showing of the musicians playing.

At the venues we experienced very different environmental noise levels. Some particularly loud instances rendered the directional speakers practically useless. In quieter environments the overall volume level was frequently perceived as too loud at realistic settings and had to be reduced. The possibility to set rest periods and the volume knob turned out to be the most important aspect for exhibitors, especially when employees work within earshot. Occasionally we were asked whether the installation could be extended with further pieces to provide more variety. This would also be an incentive to revisit the installation several times (as some visitors did) and spend more time with it.

Concerning the music recordings, even though of high quality the production process was still much like it is common for classical music productions with a focus on the CD medium. This means, instead of separating the instruments acoustically, the ensemble was recorded at once in a concert hall which results in a certain amount of crosstalk even on the close microphones. Crosstalk, however, reduces the clarity with which the sound sources can be located and differentiated. The recordings should also be as dry as possible. Any acoustics add to the venue's acoustics which adulterates the impression of presence of the virtual musicians. Hence, it is important for future music productions in a similar context to leave the conventions of classical music production behind.

[2] https://beethovens-werkstatt.de/inside-beethoven/, last access: July 2020.

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