Penguin: Design of a Screen Score Interactive System

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Abstract. In this paper, we present Penguin, a system for live scoring, and Studio I, a piece composed for the system and an accordion. The system is shaped in two modules, one that generates a musical stream in real-time and the other that manages a live scoring process. Penguin is designed to be used in interactive performances alongside traditional instruments. Studio I is a piece for Penguin and accordion. The interaction design of the system and the piece were fine-tuned involving the instrumentalist. We provide a general description of Penguin and present the design process that led to the development of the interactive performance. The design process led two main contributions. Firstly, we identify and frame a new performer role that mixes performing and conducting elements. Secondly, we discuss how the design process of the system affected the ownership of the aesthetic of music.

Keywords: HCI, Design, Scores, Screen Scores, Music Performance.

Introduction

The emergence of Digital Musical Instruments (DMIs) and interactive musical systems in general, has blurred the distinctions between composers, designers and performers. Developing the instrument has become part of compositional processes. Schnell and Battier proposed the concept of composed instrument to describe those musical tools that incorporate the musical aesthetics in the technology itself (2002). These authors presented a number of interactive metaphors for composed instruments: playing, conducting, and playing together.

Screen score systems (Hope and Vickery 2011) can be considered as a particular typology of composed instruments, where an instrumentalist engages with the screen of a digital system by reading it. In this case, the composer and the performer are different actors. The instrumentalist is the actual end-user, involved in the interaction with the system. Still, the composer/developer uses the technology to express his/her compositions. Screen score systems have been used for musical pieces that provide the performer with some degree of freedom to improvise on the plotted score. Nevertheless, the authorship of the composer over the piece remains clear, since the composer encodes the aesthetic of the piece in the technology. Additionally, in western music tradition scores are responsible for determining the authorship of composers (Van Orden 2013).

In this paper, we present Penguin, a screen score composed instrument, and the piece Studio I for Penguin and accordion. The composer of the piece is also the first author of this paper. The final interaction design of the system and the piece were developed with the involvement of the end-user (the accordionist). This process consisted of a recursive iteration of rehearsal and evaluation, with consequent modification of the system and of the piece. We describe the interactive and musical modifications that occurred in the process, and how these modifications re-framed the role of the performer due to the combination of performing and conducting elements. We also discuss how the process affected the aesthetic of the composition embedded in the instrument.

Related Work

Score, DMIs, and Screen

Scores are one of the fundamental elements in western musical practice, particularly in the classical tradition. Important relations between score and computer music were investigated with score-following algorithms (Orio, Lemouton, and Schwarz 2003). These tools aim at facilitating performances with classical instruments and electronics, synchronizing the timing of the electronic component with the instrumentalist. These tools are generally successful in the improvement of the expressiveness of the performances, but did not introduce any fundamental change to the relation between instrumentalist and traditional paper scores.

A novel conceptualization of scores is presented by Magnusson in the context of live coding (2011). He describes live coding as a new evolutionary and interactive branch of musical scores: the code is musical notation that is interpreted by a machine. More related to our study is the literature concerning screen score systems designed to be read by traditional instrumentalists. For instance, Kim-Boyle presents systems designed to control open-forms (flexible musical pieces) by the usage of the real-time generation of score (2006). The author describes how he adopted real-time generated score within the context of his composing practice for classical instruments. Relevant is also the Bach library for the visual programming environment for audio Max/MSP, designed for real-time computer-aided composition, generating scores according to algorithmically defined musical structures (Agostini and Ghisi 2013). A wide reflection about screen scores was provided by Hope and Vickery (2011), who classified four main screen scores categories: scrolling scores, permutative scores, transformative scores and generative scores. According to this taxonomy, Penguin is a generative and transformative score system.

Involvement of End-Users in the Development of Music Technology

User-Centered Design (UCD) is "a term to describe design processes in which end-users influence how a design takes shape" (Abras, Maloney-Krichmar, and Preece 2004). In the context of music and HCI, UCD approaches have revealed to be successful in designing tools where the compositional element is not prominent. For instance, Wilkie et al. explored the usage of conceptual metaphors to involve non-musicians in participatory processes (2013). UCD has also been successfully applied to the design and development of music pedagogical tools (Core et al. 2017) or to explore audio-visual systems (Correia and Tanaka 2014). These related studies showed the benefits of adopting this approach to increase the user experience. However, applying UCD to composed instruments is a complex task, as the development of such systems is part of a compositional process. Indeed, with a participatory approach, the technology may no longer be designed and developed only according to the aesthetic needs of the composer. Our involvement of the end-user in the design of Penguin and the Studio I piece were informed by UCD.

Penguin

Penguin is a digital music system composed of two main modules: a module that manages a score in real-time – the Screen Score Module; and a module that generates a stream of synthesized audio – the Audio Module. The system is designed to be used in mixed performances with one instrument engaging in a musical dialogue with it. The system is implemented in SuperCollider, a platform for audio synthesis and algorithmic composition, and relies on LilyPond, a music engraving and file formatting program, for the generation of the score.

Penguin organizes the overall musical structure as a succession of "sections". Each section is characterized by a specific chord/harmony and a set of possible rhythms. The sequence of the harmonies, the typology of rhythms, and the length of each section are predefined and stored in the system before the performance. The system generates the actual rhythms in real-time, according to the given descriptions. During the performance, Penguin automatically generates the score and plots it on a screen, while generating the audio stream (figure 1). The system also manages the sequencing of the sections. The instrumentalist is required to improvise on the given harmonies and the given rhythms, engaging in a musical dialogue with Penguin. During the participatory process emerged that the performer needed some control over the system leading the implementation of a controller.
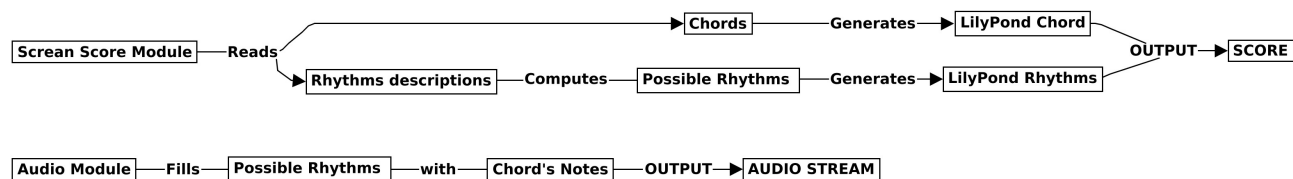
Figure 1. Overall structure of Penguin

Screen Score Module

The Screen Score Module uses almost standard musical notation (pentagram and notes), but harmony and rhythm are managed independently and plotted in different areas of the screen. The harmony is notated in the top part of the screen, and the rhythms are notated in the bottom part. Penguin generates the score relying on LilyPond, in three successive steps. In step one, it generates a .ly file that contains both the harmony and the rhythms. In step two, the .ly file is compiled, and in step three the resulting pdf is opened and plotted on the screen. Steps two and three are automatized using the unixCmd method provided by SuperCollider, which executes a Unix command using a standard shell. The harmony is notated on a two-pentagram staff. Penguin automatically translates the chords stored as MIDI values into LilyPond notation. The generation of the possible rhythms requires creating the patterns. Each pattern fits in one or two 4/4 bars. The system reads the allowed values (quarters, eighths, triplets etc.) and creates four patterns that randomly combine the different rhythmic figures. In this process, the allowed values can also be slightly modified to complete the 4/4 bar. For example, if the system combines a four-sixteenths pattern with 2 quarter notes, the 2-quarter is transformed into a 3-quarter note. Figure 2 shows a sample of the score.
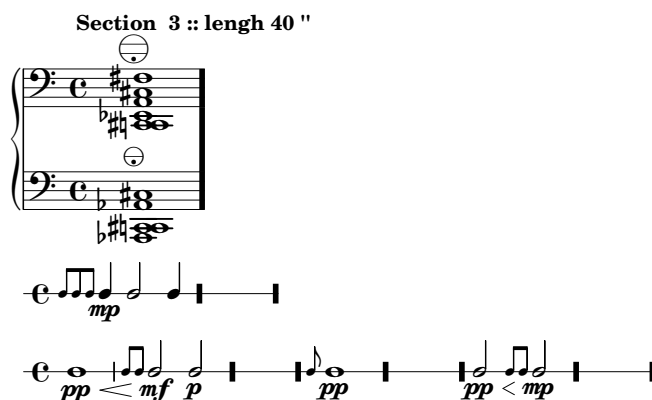

Figure 2. Sample of the generated score, with harmony in the upper part, and rhythms in the lower

Audio Module

The sound module generates a polyphonic stream of four lines combining the harmony with the patterns. For each line it recursively selects one of the possible patterns and fills the notes based on the chord. The system reiterates this operation up to the end of the section, then applies the same principle to the material of the new section.

Interaction Between Penguin and the Performer

The system is designed to be used alongside a classical instrument. The instrumentalist is the actual end-user involved in the musical performance. He/she has the freedom to interpret the notated harmony and patterns by improvising on this given material. The role of the instrumentalist in the musical performance was not completely defined before the final process. Consequently, the interaction between the system and the performer was undefined. As we detail in the next section, the role of the instrumentalist changed. Initially the instrumentalist was a soloist, who interacted with the technology only musically by reading the score in the screen. It emerged that the instrumentalist needed actual control over the system. Therefore, the performer was provided with a tool to manipulate the volume of Penguin.

Design with the Instrumentalist: Methods, and Results

The creation of the piece Studio I for accordion and Penguin relied on a recursive process with the end-user (the accordionist), having as an objective a public performance. In this process, the relation between the performer and the system was re-framed, and the system was fine-tuned according to the needs of the performer – leading to the change of the overall interactive musical metaphor. This process was structured in several steps, using observation and interviews: 1) rehearsal with the first prototype of Penguin, where observation was conducted, followed by unstructured interview with the performer; 2) prototyping of a study score for personal study; 3) final rehearsal for a public concert, and the concert itself, each followed by an unstructured interview.

Rehearsal Stage

The objective of the first rehearsal was to test the musical interaction between the performer and Penguin. Initially, the accordionist was informed about the functioning of Penguin and her role. The piece was then rehearsed twice. The session concluded with an unstructured interview regarding strengths and weaknesses of the design of the system.

From the rehearsal observation, it emerged that the more the performer became confident with the harmonies, the more she was able to dialogue efficiently with the musical output of Penguin. This observation was also confirmed in the subsequent interview. In particular, she expressed the need to further study the piece, in order to find the right balance between her spontaneous creativity and the global form of the piece. To achieve this result, she explicitly required to have a printable version of the score with all the chords and some indication about the overall musical form. Overall the performer declared that performing alongside Penguin was stimulating, but also demanding.

Prototyping of a Study Score

According to the request of the performer, we created a printable study score. This score was composed of 13 pages (one for each section of Studio I) with an introduction that described how the rhythmic density evolves in the sequence of sections and how sections succeeded one another. In each page, the harmony and a sample of the possible rhythms were notated. After some private study, the performer required to have a more compact version of the score, with all the chords on one page, to have a better overview of the overall structure. We generated one pattern for each section as an example of its rhythmical structure.
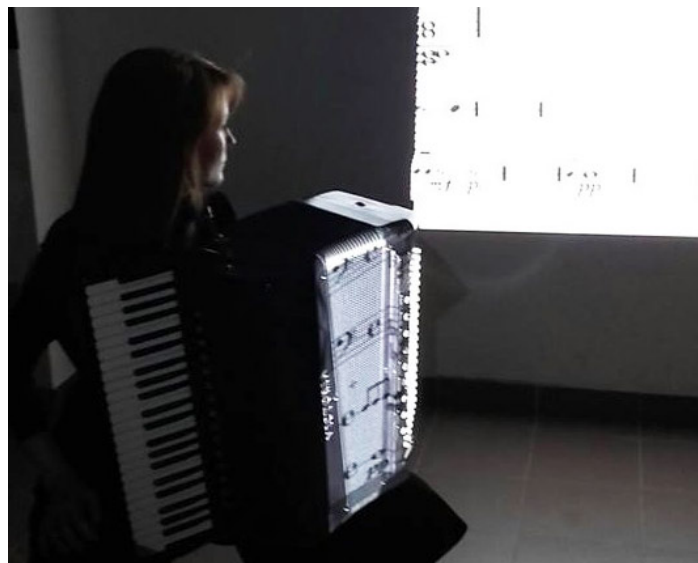

Figure 3. The performer during the final rehearsal

Final Rehearsal and Concert

In the interview following the final rehearsal (figure 3), the accordionist expressed the need for manipulating the volume during the performance. We then set up a physical controller with a knob that allowed her to modify the volume of Penguin. Thanks to this modification, she could perform more expressively and dynamically. With this setting, the performer not only dialogues with the system, but also plays the role of the conductor, controlling the overall dynamic.

In the final interview, following the public performance, the instrumentalist declared that she enjoyed the performance, both from a musical and from an interaction perspective. In spite of that, she expressed a difficulty in considering this a piece for accordion, performable by any musician, and that she felt that the piece was bound to her performance. The accordionist declared that she felt comfortable to perform the piece and that she liked the musical result. However, she did not think that another accordionist could feel the same confidence or achieve the same musical quality.

Discussion

We believe there are two main contributions from our study. Firstly, we identified and framed a new performing metaphor, that merges playing together and conducting elements. Secondly, we developed some reflections concerning the involvement of end-users/performers in the development of a composed instrument.

Performing Metaphor and Role of the Performer

The design process led two main modification to increase the expressiveness of the interaction with Penguin: 1) creation of a printable score for private study, and 2) control of the volume. Despite the fact that these modifications did not change the basic design of the score generation, they changed the overall performing metaphor. The need of a paper score can find a justification in the regular practice of classical musicians. Classical musicians are trained to study repertoire. In this process, musicians learn to articulate the phrasing of specific moments according to the global form of the piece. Given the fact the Studio I was initially proposed as a piece and not as an improvisation, it appears clear the instrumentalist wanted a similar understanding of the entire form of the piece.

Although control of the volume can be seen as a slightly different modification of the system, it changed the overall musical metaphor. As declared by Schnell and Battier (2002), composed instruments can have different interactive metaphors: playing, playing together, or conducting. Providing the instrumentalists with the possibility to manipulate the volume of Penguin shifts from the interactive metaphor of playing together to the metaphor of conducting and playing together at the same time. The accordionist switches from being a soloist to becoming a soloist and a conductor. The overall musical metaphor changed: from the a "Concerto" in the Romantic period, where the soloist is only a soloist and does not conduct the orchestra – playing together metaphor; to the idea of a "Concerto" in Baroque time, where the soloist is also the maestro concertante (Taruskin 2006). For this role, we propose the name Soloist Concertante.

End-User and the Aesthetic of the Composed Instrument

In the introduction section we exposed how, within the context of DMIs, the compositional processes involves the development of interactive technology and the definition of interactive paradigms (Schnell and Battier 2002). Designing and developing a composed instrument is part of the compositional process. When the composer and the designer are same person, the authorship of the composer over the musical pieces is not affected. With Studio I, despite the fact the composer and the designer were the same actor, the composer is not the sole responsible for the interactive choices. The overall idea of the piece and the interaction, along with the harmonic and rhythmic choices, maintained the original shape, but other elements changed. The design process gradually shifted the musical scenario from the composition of a piece to the creation of a sonic art performance. The authorship is shared between the composer and the performer, and the final performance is bound to the idiosyncrasies of the performer. To redo the performance with a different performer, the same process will be required. Consequently, we argue that Penguin is a co-created composed instrument and that Studio I is a co-designed interactive performance, which relies on those specific actors to be performed.

Conclusion

The main contribution of this work is the involvement of an end-user in a design process of a screen score system, affecting the aesthetic of a musical piece. We rely on the concept of composed instrument by Schnell and Battier (2002) to describe those musical tools that incorporate aesthetics of the related pieces. During the design process we adapted the interaction design to the emerging requirements. These modifications improved the user experience, but reduced the composer's control over the aesthetics of the piece. The outcome is therefore twofold: firstly, it identified a new musical role and interaction metaphor; secondly, it highlighted issues on to the involvement of end-users in the design of systems embedding a musical aesthetic. The main limitations of this study relate to only analyzing one case. Future work will involve more performers to more broadly investigate the relation between design process and control of the aesthetic.

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