Toward the Adoption of Design Concepts in Scoring for Digital Musical Instruments: a Case Study on Affordances and Constraints

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Abstract. This paper, we propose the idea that a score for a Digital Musical Instrument (DMIs) can be approached from a design perspective. In particular, we focus on the concepts of affordances and constraints. The paper describes the use of scores in a piece called XXV composed for Chimney, a DMI and Cello. Both the piece and the system are detailed with a focus on design concepts. In the conclusion we compare our approach to other literature that discuss the use of score with DMIs. Based on this, and the results obtained, we present recommendations regarding the use of score in DMIs. Future work is also outlined.

Keywords. Digital Musical Instruments (DMIs), Design, HCI, Music score

1 Introduction

In the last decades, technology has spread from workplaces to home, leisure, culture, everyday activities, and the arts. For this reason the Human-Computer Interaction (HCI) community has been gradually increasing the scope of its investigation from work environment to culture, art, and also music [1]. At the same time, the computer music community started borrowing tools from HCI [2]. Design concepts such as affordances and constraints gradually became standard within the debate about novel musical interfaces and Digital Musical Instruments (DMIs) [3]. The concepts of affordances and constraints became influential in the field of HCI moslty thanks to the contribution of Donald Norman. Norman introduced the concept of perceived affordances that describes the perceived properties of a given object [4]. He also introduced the concept of constraints and discriminated between physical, logical, and cultural constraints. Constraints can be seen as interaction boundaries. Physical constraints are closely related to affordances and are the actual physical limits. Logical constraints involve the use of reasoning to determine the alternatives, and they are valuable in guiding behavior. Cultural constraints are conventions shared among a specific cultural group [5].
In literature related to HCI and DMI, these concepts have been widely adopted to

study interactive properties of DMIs [6]. Moreover, given the importance of interactivity, composing strategies often involve the use of interaction design tools and concepts including affordances and constraints [3], [7]. Composing and designong the interactive properties of the DMI often became interconnected. For this reason, the distinction is often blurred between the designer, the composer and the performer [8] and a new musical actor was conceptualized: the composer-performer [9]. The composer-performer is usually also the designer of the instrument; he/she performs with and, in most of the cases, his/her music pieces are embedded in the instrument itself [10]. Finally, as the name suggests, the composer is the performer. As a consequence, there is no necessity of scores in these performances.
On the other hand, within the contemporary context, composers frequently combine acoustic instruments with electronic systems such as tape live electronics, and sampling. Various notations have been created for this purpose [10]. Nevertheless, perceptive and interactive properties of scores are not formally considered in this approach. As a consequence design concepts such as affordances and constraints are not studied.
In this paper, we present how the design concepts of affordances and constraints have been used for creating the score of a piece composed for cello and a DMI (Chimney). Norman described how constraints and affordances interconnect mouse and screen [5]. We propose a parallel between the visual element - the screen corresponds to the score - and the tangible element - the mouse corresponds to the cello.

2 Historical development of scores

In the western musical tradition, the concept of authorship is not only bound to the music itself, but rather to scores [11]. With the establishment of printing during the Renaissance published scores began being disseminated. Composers were no longer only the people who create new music but also people who wrote scores. In the 18th and 19th centuries, printed scores continued to gain importance [12]. The adoption of scores in western music is so linked to the music itself that, at least for classical musicians, score and piece are used as synonymous. During the last century, composers started to write not only music notes but also text that describes performative actions. The score of Aus Den Sieben Tagen by Stockhausen, for instance, consists of a number of phrases that describe how to perform [13]. Another significant example is John Cage, whose scores would often provide written indications that provide descriptions of actions [14]. Relevant is also Maderna's Serenata per un Satellite. In this piece the musical structure is undefined: the score only notates the musical material [15].
A recent development in the field of computer music research is the introduction of score following algorithms [16]. These tools aimed at creating performances where the timing of the electronic sounds follows of the instrumentalist. This approach provides the performer with some freedom in phrasing the music, althought the scores tend to be quite traditional. Magnusson proposed a novel approach within the live coding context, considering live coding as a new evolutionary and interactive branch of musical score [17]. His proposal, despite being fascinating from a DMI perspecti-

ve, does not include performances with traditional instruments. In 2017, Gurevich introduced the idea of DMIs in response to scores [18]. In this paper, we propose to use design the other way around: design scores in response to existing DMIs.

3 Case Study on Design Scores for DMI – XXV for Chimney

We now describe the use of scores in a piece called XXV with a specific DMI: Chimney. Chimney is a Digital Musical Instrument that fosters composing music without control over development in the time domain. XXV is scored for Cello and Chimney. Before presenting some discussion on the usage of the score, we provide a brief description of the system and a previous work. A more comprehensive description of technical details can be found in a paper by Morreale and Masu [19].

Chimney is composed of a canvas (a two-dimensional space), a database of sound files (objects), and an algorithmic walker (Fig. 1). The performer loads his sound files on the database before the performance. During the performance, he/she can select the sound objects and place them on the canvas. The algorithmic walker randomly roams throughout the canvas: as it encounters an object, the file associated to that specific object starts playing.

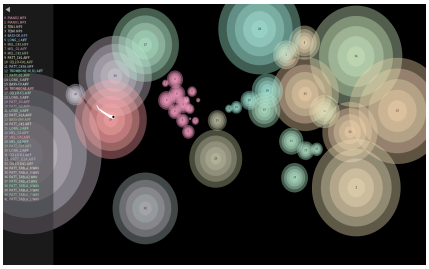

Fig. 1. Chimney.

Therefore, the musician part of the control is reduced to (i) selecting the musical objects that could be played during the execution, and (ii) placing them in the two-dimensional space. Under these conditions, the temporal structure of the piece cannot be organized. Thus, the music is no longer organized according to the phraseological temporal structure, and the musical objects become the focus of the composition. Chimney forces the composer to devise a specific compositional approach, finding a new balance between composition and improvisation. The paper by Morreale and Masu presents the shifting from a time-based to a sonic object composing approach describing in detail a composition named Alinearity [19]. Alinearity could be performed as a solo piece or in duo with a trumpeter. The piece did not have a score in either of the cases. In the duo version the trumpeter was instructed about how the musical patterns were composed. He was given some time for rehearsing the piece to become familiar with the software and the musical material, but he had no written notation to follow. After the performance, the trumpeter was interviewed. During the interview it emerged that he would have appreciated having had a score. Based on this observation we composed a new piece: **XXV** scored for Cello and Chimney. The pie-

ce was premiered at the Center for Digital Music of Queen Mary University of London in May 2017. The score of XXV is composed with the objective of favoring a non-linear development of the musical performance. To this end, the score consists of 35 patterns that can be played in any order. The musical patterns are scored on two A4 sheets of paper. As two A4 pages can be on a book stand at the same time, the performer can see the entire score simultaneously. The patterns are clustered in the pages according to musical similarities. Patterns that have similar musical elements (e.g. triplets) are in the same area of the page. The cellist can play the notated patterns in the order that he/she prefers, aiming at engaging in a dialogue with the computer. The cello player can also improvise new patterns elaborating the notated music material. In XXV, the musical objects loaded in Chimney's database are synthesized versions of the notated patterns.

4 Affordances and Constraints in the Score

The score of XXV has a double function: firstly, it encodes the musical patterns that the cellist can perform; secondly, it recalls the interactive behavior of Chimney. In other words, the score has both interactive and musical functions. Both are tied to the specific characteristic of performing with and alongside Chimney:
1) the temporal structure of the music can not be decided;
2) the music is bound to precomputed sonic elements.
As a consequence, its score cannot consist of a time-based sequence of musical events. Instead, it should be composed of a number of musical elements, or patterns, whose succession can be decided in real time. From a musical perspective, each succession of patterns must be valid. To this end, tonal cadences are to be avoided. In other words, the overlapping and any succession of the patterns should produce a result that is musically coherent with the rest of the piece. The rest of the harmonic choices, and the rhythmic and melodic features of the patterns, follows the personal musical aesthetic choices of the composer. The composing strategies and the aesthetic choices of the composer are beyond the scope of this manuscript.
We now analyze affordances and constraints of the score as an object. A score as a physical object – a sheet of paper with musical symbols imprinted – has specific affordances. A score affords reading. In a standard situation, reading a score starts from left to right, going linearly throughout the entire sheet of paper. In this specific case, given the peculiarity of Chimney, the piece requires (that is, should afford) a non-linear reading of the score. To achieve this, the score should facilitate gaze navigation throughout the pages. This implies (I) avoid turning pages; (II) facilitate the identification of the patterns by clustering similar patterns in the same portion of the page.
A score composed of patterns affords non-linear reading, and mirrors the non-linear behavior of the random walkers in Chimney. As described below, non-linear reading is not an aspect of the score that is exclusive to Chimney. We have seen, for instance, how this approach was used by Maderna in his Serenata. The peculiarity here is that this element of the score is deeply bound to Chimney, not derived by a composing idea or aesthetic. In the presented case, non-linear reading is an element that was designed to allow the cello player to perform alongside Chimney. Specifically, in the presented work, the notation was designed in response to the randomnes of the DMI.

The content of the patterns - the musical notes - can be seen as cultural constraints. The notes printed on the score limit the interactive possibilities of using the cello. There is neither physical nor logical constraint that forces the cellist to play those specific notes. The cellist is simply asked to perform according to certain harmonic, rhythmic and melodic limits. These are cultural constraints. In his paper about affordances and constraints, Norman states that it is wrong to claim that the design of a graphical object on a screen affords to click. He states that the user can click on the object, but also can click anywhere. The fact the graphical object provides a target is a cultural constraint (convention) rather than an affordance [5]. Similarly to a graphical object on a screen, the score suggests some specific behaviors (to perform the notated patterns). This is a cultural constraint, a convention that exists among western classical musicians, not an affordance.

5 Conclusion and future work

We will now summarize the use of the concepts of affordances and constraints in the present work. The overall structure of the score in XXV affords a way of reading similar to the behavior of the Digital Musical Instrument, Chimney. The content of the patterns is a cultural constraint that suggests a manner of using the cello. The content of the pattern also contains the personal aesthetic of the composer.

We mainly focused on the design concepts of affordances and constraints. In our analysis, we showed that the score should mirror at least some of the interactive feature of the DMI. In the presented case, the score was also considered as a physical object. The fact that we designed an object that could be read without turning a page is related to the physicality of the object rather than on any notation issue.

In this paper, we introduced the idea that a design perspective can be used to create scores for mixed initiatives with traditional instruments and DMIs. This approach does not affect the aesthetic choices of the composer; it only intends to facilitate the interactive aspects of the performance. This proposal aims to find a contact point between DMIs and traditional instruments. Systems for score following [16] adopt scoring focusing on the traditional instrumentalist. The electronic is relegated to a secondary role in the interaction that occurs during the live performance. On the other hand, the live coding approach developed by Magnusson [17] focuses only on the computer performer and does not include traditional instruments. The idea of creating DMIs in response to existing scores proposed by Gurevich [18] is closer to what we described in this paper, but he started from existing scores to designing new DMI. In his work, the focus is more on the existing repertoire.

We propose the reverse, creating scores mirroring the design feature of existing DMIs. Our proposal primarily aims at using DMIs in mixed initiatives with a classic instrument keeping the two on a balanced level of importance. Secondly, our approach could be used with the aim of creating repertoire and archives based on DMIs.

Future work will aim to investigate more deeply the topic proposed here. The discussed concepts of affordances and constraints can be adopted in other case studies, that could bring novel perspectives. Other HCI concepts such us Appropriation and Ambiguity could also play an important role in the design of scores. Investigating those

issue could include design workshop with composers and performers, specific evaluation studies, and comparative studies of different approaches.

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