SABRe: AFFORDANCES, REALIZATIONS AND PERSPECTIVES

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ABSTRACT

This paper focuses on the Sensor Augmented Bass clarinet Research (SABRe) in terms of musical practice, instrumentalist skills and compositional approaches. After a short overview of the concept of embodiment and instrument, the new possibilities of the SABRe instrument are exposed. Then, the first realized compositions present the strategies they deploy in view of the new control modalities and the exploration of affordances this augmented bass clarinet offers. Finally, some possible improvements and perspectives are outlined.

1. INTRODUCTION

The SABRe objective is to develop and evaluate a conventional bass clarinet augmented with various sensors. These sensors are divided into four different modalities, each providing different affordances[1] and demanding varying degrees of instrumental awareness. Technical details of the SABRe project have been described in a previous publication [11].

After a first project phase concerned with the construction and implementation of the instrument itself, the second phase now deals with an in-depth evaluation of the instrument and a number of musical realizations. These occur through collaborations with different clarinetists, as well as in several composer residencies, with the goal of obtaining a clearer picture of the musical usefulness and the technical improvements necessary to produce a robust musical instrument.

The project is carried out at the Institute for Computer Music and Sound Technology (ICST), part of the Music Department of the Zurich University of the Arts (ZHdK) with a long tradition in education of music practitioners: instrumentalists, composers, teachers, conductors. Thus, it remains self-evident that any technological innovation of the institute has to be firmly positioned within the field of the musical praxis.

Funded by the Swiss National Science Foundation (SNF) for a duration of two years, the SABRe project is now in a transition phase towards a small series production.

[1] In the Human-Computer Interaction (HCI) field, the concept of affordance refers to the action possibilities of an object that are perceivable by an actor. More about this topic in [4]

2. EMBODIMENT IN THE MUSICAL PRACTICE

According to the musicologist Jin Hyun Kim, embodiment necessitates a strong coupling between the player's body and his technical medium – which contains the music instrument and its control interface – in order to enter into both an auditory and tactile/kinesthetic feedback loop. This coupling happens on two levels: first with the resonating body of the instrument, whose vibrations are directly forwarded to the player's own body; second with the control interface, which physically connects the player to the controllable parts of the instrument [6].

This coupling leads – through the repetition of practicing – to an *habituation* of body techniques, which permit the development of a non-reflexive, pre-conscious and pre-noetic 'body schema' [3]: conscious reflection about physical activities and resonance feedbacks moves increasingly into the background and makes place for expressive musical shaping and the monitoring of playing at a higher level of instrumental awareness.

Embodiment is of great importance in the instrumental practice since it reflects a physical activity where both 'actants' [8] (player and instrument) are simultaneously agent and patient in an interactive process.[2] They are dynamically coupled with each other through a bodily-mediated action-perception loop, from which – each time newly – signification arises in a context-dependent interaction. Thus a musical instrument does not constitute a tool for expressing stable, pre-existing musical intentions according to the Cartesian mind-body dichotomy, but serves as a *"medium for sensory musical perception, which the musician experiences through the auditive and tactile/kinesthetic feedback during a performance."* ([6]:114)

3. INSTRUMENT

With the advent of electronics and digital music technologies, the line between tool and instrument has become blurred. In some cases the action of performing on an instrument has shifted from instrumental virtuosity based on physical training to intellectual control of a symbolic system with the aid of a technical interface.

[2] 'agent' and 'patient' refer to active and passive states in an interdependent relationship.

3.1. Traditional Instrument

Traditional instruments are built around basic physical modes of sound generation and have been refined and optimized for specific desired qualities in the instrumental sound. The playing modes on the instruments were developed in relation to the physical possibilities that the instrument and the player's body offer.

3.2. Digital Musical Instrument

Technological instruments dissociate the sound generating algorithms from the sound controlling gesture. The basic physical techniques of producing the sound have been replaced by signal processing algorithms and their metaphorical representation – usually through a real-world descriptive approximation. In today's new digital music instrument (DMI) designs, the traditional fusion of control interface, mapping structure and sound generation is split up. Many technical innovations have focused either on one of these three aspects, but only few provide an overview on the whole discipline. Some background work on new concepts related to new media art, as well as an overview of the implication of engineering would help to better understand this quickly evolving field.

3.3. Augmented Instrument

The augmented instrument sits at the junction between the traditional and digital musical instrument. Even though acoustic instruments have long been modified physically and amplified electrically, a radical hybridization of instruments has only been made possible with the advent of digital signal processing and new sensor technologies. The remarkable quality that these mixtures present lies in the juxtaposition of the physical sound production modes and control interfaces with the abstract and symbolic representations inherent to digital signal processing algorithms. Contrary to purely digital instruments, the augmented instruments usually maintain their traditional playing and sonic capabilities and superpose an additional layer of agency related to digital sound processes.

In order that this additional layer of agency do not simply serve the dualistic "*idea of enhanced human expressivity [. . .] realized by augmenting the control dimensions of a musical instrument by means of interactive computer systems that translate and manipulate input data to output data.*" [7], all the funny interfaces, innovative mapping strategies and complex sound generating algorithms that have been invented in the past decades must be confronted with the years of practicing of instrumentalists, and by that virtue expand the perspectives of both trained instrumental players/composers and new instrument developers.

4. SABRe

After about 250 years of development and practice, the bass clarinet offers a set of affordances and constraints which requires from the player the acquisition of extremely differentiated body techniques. These body techniques are continuously controlled by a dual acoustic and tactile/kinesthetic feedback loop, enabled by the physical coupling between the player and his instrument.

The control interface of a traditional bass clarinet consists on the one hand of the keys and on the other hand of the mouthpiece/reed setup. For a skilled clarinetist, a virtuosic level of motor control is achieved at the fingers, which are very independent of each other and work with a precision in the order of some milliseconds[3]. The entire diaphragm-larynx-tongue-lips system is also trained with much patience in order to achieve a high degree of synchronization, to be able to coordinate different muscles for stable sound production and to control attacks or subtle timbre changes.

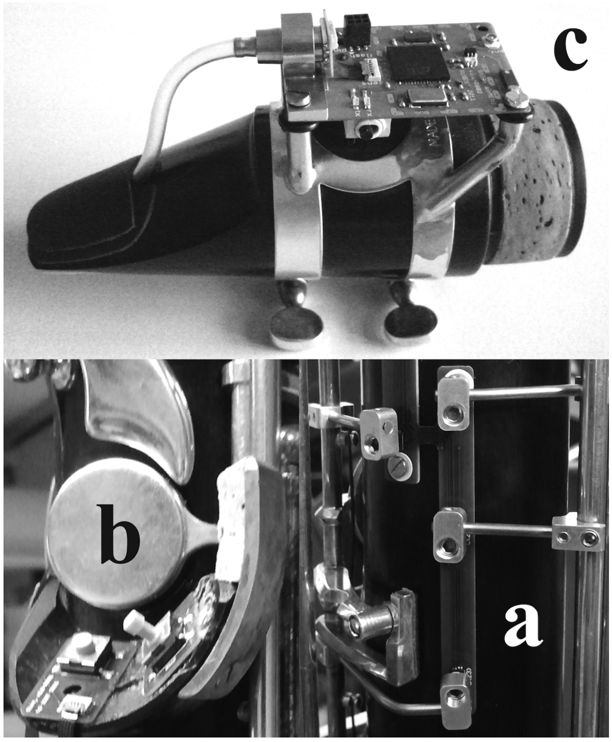

Figure 1. *Three of the four SABRe prototype sensors: magnet brackets clamped to the key axes and measuring key positions (a), thumb switches below the left thumb and octave keys (b) and air pressure sensor with autonomous communication device (without battery) (c).*

4.1. Affordances

In order to take advantage of the improvements of the traditional instrument which have been optimized over the years, SABRe makes a use of all the instrument's properties: neither the control interface nor the sound generating

[3]To the authors' knowledge, no experiment has been conducted to measure this accuracy, but that value is most likely similar to the time resolution of " *two tones of different pitch, the second beginning T seconds after the first* " mentioned by John R. Pierce in [9]:4 and corresponding to the case of two keys not being pressed simultaneously.

part have been altered. Furthermore, it is an assumed objective not to move too far from the existing playing techniques, so that they may serve as a foundation on which a new practice may be developed. In that manner, the entry threshold remains affordable for trained clarinetists and their years of experience can be leveraged for the acquisition of a new body knowledge.

4.1.1. Key Sensors

The *key sensors* (Figure 1(a)) provide real-time information about continuous key positions, about the pressing and releasing speed as well as additional meta-information like clarinet fingerings or MIDI note values.

The most direct use of these sensors is probably fingering retrieval, where the binary value (open/close) of each key can be captured in real time. This mode requires the lowest level of awareness from the player, since it makes use of fingering information which is already provided by conventional playing and where complex sequences can be written on a score and executed with a very high accuracy. This allows e.g. to control a DMI without having to learn new fingerings and to retrieve pitch information without microphone and pitch recognition system.

Key sensors also provide continuous position values, as well as pressing and releasing speed calculation, which offers control values in the time domain. It has to be pointed out, that these measurements take place in key displacement ranges of less than 10 millimeters and require yet undertrained skills: players mostly focus on the binary key positions. Even though this *de facto* limits the accuracy and reproducibility of the output values, it does offer data of a different quality, directly related to the traditional instrument 'selection gestures' [2].

4.1.2. Air Pressure

Control of *mouth air pressure* (Figure 1(c)) is a well trained skill of wind instrument players, primarily used to regulate sound intensity, but also for subtle timbre changes or sound control in different instrument registers. Since SABRe allows 'soundless playing' – by completely closing the reed at the mouthpiece aperture while providing mouth pressure – it decouples the air pressure parameter from the conventional direct acoustic feedback. This opens up the possibilities of using pressure as an accurately controllable expressive value.

Since the sound production is not impeded by the air-pressure sensor, digital sound processing can still be used in complement to pressure measurement, as well as for pitch recognition and does not interfere with the SABRe sensors in any way.

4.1.3. Thumb Switches

The *thumb switches* (Figure 1(b)) afford similar gestures than the clarinet keys, but are intended to be used in a different manner and offer other feedback qualities. First, while keys are often pressed over a relatively long time (from one to several note periods), the thumb switches are used as toggles to trigger events and are quickly pressed and released. Second, the switches differ from the clarinet keys in shape (about 5 mm diameter), displacement (less than 1 mm) and haptic feedback ("click" sensation).

Notwithstanding, the left hand thumb is less in demand on the clarinet than other fingers and the switches remain (at least partially) reachable while having the thumb or octave key pressed. With new coupling and habituation processes, this feature should afford a high level of virtuosity.

4.1.4. Inertial Sensor

In traditional music performances, musical gestures mainly serve direct sound production or transformation. Other movements – 'accompanist' or 'ancillary gestures' [2] – are often not conscious or serve different goals such as expressivity support.

Since the 1970s, a number of music works have been deliberately staged by the pioneers of experimental musical theater like a.o. Kagel [5], Stockhausen [12] or Aperghis [1], assigning a new role to the former 'accompanist gestures'. These gestures however work on a visual channel and are not meant to affect – in the worst case they act as an impediment to – sound production. The fact of capturing movements with the *inertial sensor* connects both the visual and acoustical channels by delivering information about position, orientation and acceleration of the instrument. This can be used as control parameters and at the same time serve staging necessities.

This new paradigm of transforming formerly 'accompanist' into 'instrumental' gestures could easily become the most challenging aspect of the SABRe affordances. Since many musicians are neither trained nor particularly comfortable with movement, this presents a field to be explored systematically in order to obtain experience, identify exploitable patterns and build a strong proficiency.

5. REALIZATIONS

The first phase of evaluation for the SABRe project is still ongoing and composers willing to experiment have started working with this new interface. The very first piece written for SABRe [10] makes use of three different features of the instrument: fingering patterns, instrument spatial attitude and rotational acceleration.

Fingering patterns serve synchronization purposes and trigger sound events through the use of key combinations, which do not correspond to any notes that would normally be played and which cannot occur accidentally.

The inertial sensor is utilized to guide a sound in a surround environment by 'drawing' i.e. pointing towards the desired displacement on the floor with the bottom of the clarinet. For this purpose the instrument's tilt and heading angles are calculated from the gravity vector values of the accelerometer. In addition quick rotations of the instrument around its vertical axis give rise to unambiguous values of the gyroscope, which are also used to trigger events, but this time in a more visually obvious manner.

For a different composition, which is currently being written, an alternate approach using MIDI notes extracted from the fingering patterns is chosen. These notes play a virtual instrument in parallel to the acoustic one and propose a complex counterpoint based on real-time sound transformations.

Finally, a proposition is made with the capture of synchronized audio and sensor data sequences. These sequences can be used on the one hand to analyze a player's performance in qualitative and quantitative terms (e.g. in order to analyze timing and tempo) or can be used for playback at a later time in a different setting such as the composer's studio.

6. PERSPECTIVES

SABRe extends the bass clarinet at its control interface, thus providing a tactile/kinesthetic feedback through the conventional instrument physical properties[4]. However, the augmented part of the instrument does not provide the same vibrational coupling through 'resonance' as does the base instrument. A feedback channel might be added in a future implementation through tactile actuators. This warrants further investigations which exceed the current scope of the project.

The new possibilities opened up by SABRe are by far not completely covered by the application examples and first musical realizations mentioned in the sections 4.1 and 5. The intention of the research project is to spread the word in the interested communities, make several copies of the instrument available to clarinetists and composers and to collect composition and performance experience. Thus, when a certain playing proficiency has emerged, it will be possible to evaluate the new instrument in the light of its embodiment potential.

7. CONCLUSION

By building upon a mature musical instrument and its optimized control interface, the SABRe project exploits a solid framework in order to extend the instrument control possibilities. The four data capture modalities provided give new affordances to the interface, while preserving those offered by the conventional instrument, thus allowing the player to take advantage of already acquired instrumental skills.

The collaboration with an interested community of musicians will serve as much for evaluation purposes as for the generation of new musical ideas. These will further open up the possibilities the instrument has to offer. Once this knowledge has successfully been acquired by several clarinetists, it will be more easily transmitted. With this ultimate step the SABRe project will have succeeded in extending a traditional music instrument. The long-term goal is to eventually establish a benchmark for augmented bass clarinets (and other woodwinds) and to bring forth a repertoire of new pieces of music for this instrument.

[4] With the exception of the thumb switches, which have their own tactile/kinesthetic properties.

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