HANDSKETCH: BI-MANUAL CONTROL OF VOICE QUALITY DIMENSIONS AND LONG TERM PRACTICE ISSUES

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ABSTRACT

In this paper, we describe the development of a new musical instrument, called the `HandSketch`. This new instrument is developed in respect with the Convergent Luthery Model [10]. It means that this instrument has to be practicable right from the beginning of the prototyping, in order to allow the progressive embodiment of the object. This specificity leads us to focus our control paradigm on the writing.

KEYWORDS

Computer music, tablet, voice synthesis

1. INTRODUCTION

The `HandSketch` is a digital instrument made for the bi-manual control of voice quality dimensions: pitch, instensity, glottal flow parameters [6]. It is made of purshasable devices: a pen tablet and force sensing resistors (FSRs). More precisely it is built around a Wacom™ graphic tablet [31], played vertically along the upper part of the body. The `HandSketch` uses a particular polar transformation of the control space in order to fit the requirements of ther prefered hand. A sensing strategy inspired by woodwind and string instruments is adapted to FSRs for the use of the non-prefered hand. It is important to highlight that the instrument evolved in nine consecutive versions – being now called `HS1.8` – and thus reached a more stable shape and behavior. The most recent playing situation is illustrated in Figure 1.

Figure 1: Typical playing position when performing the HandSketch in 2009: sitting down, arms and hands surounding the controller. This setup also have the particularity of using a headset microphone, as a way of inputing realtime voice.

In this paper we first propose a discussion on the pen-based control of music (Section 2). In the same Section we continue by addressing a serie of issues related to the improvement of pen-based gestures. In Section 3 we describe choices that have been made concerning the non-prefered hand. Finally a significant part of this chapter is devoted, in Section 4, to discussing the long-term practice of this instrument and its influence on expressivity.

We also want to notice that the `HandSketch` project does not attempt to "prove" any superiority or relevance, compared to the wide instrument making community. As it has been shown in [10], the assessment of a musical instrument remains an open proble. We can argue that a systematic approach is used in order to define our control strategies, but we can not totally pretend that this instrument does not rely on any idiosyncratic idea. The relevance of this instrument is rather justified by its ability to achieve Analysis-by-Interaction [10].

2. PEN-BASED MUSICAL CONTROL

Graphic tablets, which are initially developed and sold to meet the needs of image professionals (designers, architects, editors, etc.), can today be considered as a common device in computer music. They have actually been used since the 70's, for example in the Xenakis' UPIC system [22]. More recently the compositional and scientific work of Wright [34], Momeni [23] or Kessous [1] are considered as significant.

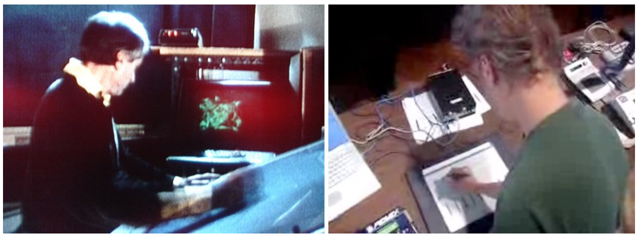

Figure 2: Two video archives. On the left, I. Xenakis playing on the control surface of the UPIC system (1987). On the right, M. Wright doing timeline-scrubbing with a realtime sinusoidal model (2006) on a Wacom™ tablet.

Today we can observe an unanimous use of Wacom™ products. Indeed most of the models provide a large number of parameters, with high precision and low latency, structured around our intuitive writing abilities. For instance a professional model sends values for the x axis, in a range of 0 to 65535 (16bits), with a samplerate of about 100Hz. These properties make tablets really good candidates to fit the Hunt and Kirk's *real-time multi-parametric control system* criteria [13, 33]. It is also intersting to highlight that these performances are far beyond what MIDI can propose. The availability of many softwares which bridge the Wacom™ parameters, through OSC or with a direct plugin, such as Max/MSP, also contributes to the wide dissemination of the controller.

In this Section, we present our work in the mapping of pen-based gestures with attributes of the vocal expressivity: pitch, loudness and voice quality. First we describe the early tablet-based prototype, called RealtimeCALM (in 2.1). Then we give some motivations in the use of pen-based gestures for the precise control of pitch (cf. 2.2). Finally we propose some improvements in the ergonomy of the tablet playing (cf. 2.3).

2.1. First prototyping with RealtimeCALM

In the early years of this thesis, there has been quite a lot of emulation in the design of a controller which aimed at manipulating the voice quality dimensions of the RealtimeCALM synthesizer [9]. In this early work we proposed and demonstrated two instruments, one of which already used the tablet – an A6 Wacom™ Graphire™ – as the main device for achieving expressive vocal sounds. That insight happened after an extensive use of the glove as a speech synthesis controller – following what Fels did with GloveTalk [12] and GRASSP [25] – as way of moving to the production of singing.

In our first prototype, the horizontal axis of the tablet x is mapped to the fundamental frequency. Concrete performative situations – typically improvisation – show that 2 or 3 octaves can be managed on a A5/A6 tablet, after some musical training. Vertical axis of the tablet y controls the voice quality, with the use of the "presfort" dimension that has been described in [10]. Finally the pressure on the tablet p controls the loudness of the sound, through the modification of E, the amplitude of the GFD negative peak, as illustrated in Figure 3.

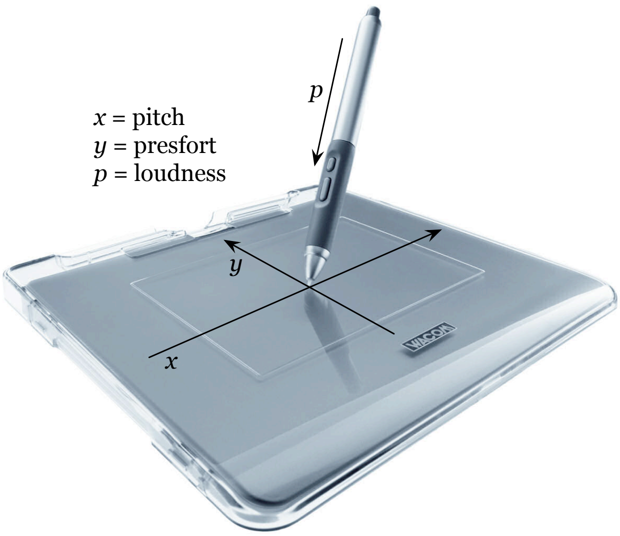

Figure 3: Mapping used in the RealtimeCALM system: x controls the fundamental frequency, y is mapped to the "presfort" axis, and p controls the loudness.

2.2. Pen-based gestures and fundamental frequency

Prosody and melody play a strategic role in expressive speech and singing production, respectively. We therefore significantly focus the design of our new controller on the accurate and realtime control of pitched sounds. Surprisingly, there is not much literature on pen-based continuous *pitch* and *intensity* gestures, as opposed of course to that of continuous pitch acoustical instruments, like the violin [36], but to that of some electrical devices, like the theremin [27].

The HandSketch can be seen as a new digital case of fretless playing, known to be difficult but powerful. One of the most advanced formalization concerns the helicoidal representation of notes in the Voicer [15], involving the well known Shepard circularity in perception of fundamental frequency [28]. Let also mention the Kyma [19] initiative, which developed a great framework for Wacom™ control of sound synthesis, but without formally considering (*pitch*, *intensity*) issues. In this work, we aim at formalizing the pen-based interaction, essentially by the solving of ergonomic problems.

2.3. Solving ergonomic issues

In this Section, we introduce a particular framework for expressive pen-based (*pitch*, *intensity*) musical gestures. This structure is much more based on ergonomic issues and on their impact on sound synthesis, than on psychoacoustic representations. Our approach considers that natural pen movements are mainly forearm- and wrist-centered soft curves (cf. Figure 4), easier to perform than lines [9] or complete circles [16]. Then come finger movements which have a refinement purpose.

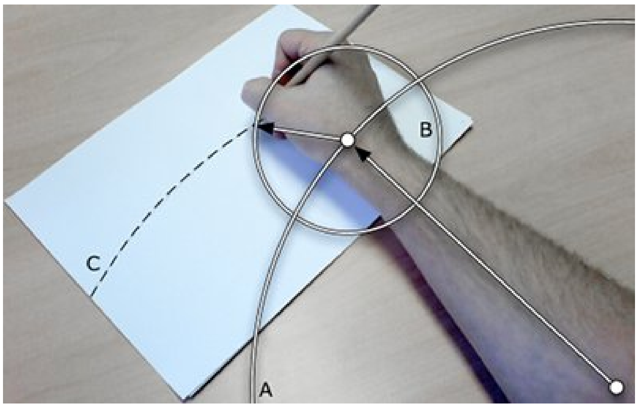

Figure 4: Pen drawing soft natural curve (C) on a surface. It can be seen as a mechanical combination of forearm- (A) and wrist-centered (B) movements.

Therefore we define a strategy in which pitch information results from a transformation of (x, y) cartesian coordinates into polar coordinates, but where the the center of the circle position (x_C, y_C) is tweakable, in order to fit forearm and wrist circular movements. Typically this center will clearly be out of the drawing surface, close to tablet border, where the forearm is supported. This concept is part of the playing diagram that is visible on Figures 5 and 6. The conversion is presented in equations 1 and 2.

$$R = \sqrt{(x - x_C)^2 + (y - y_C)^2} \quad (1)$$

$$\theta = arctan(\frac{y - y_C}{x - x_C}) \quad (2)$$

with R and θ respectively the radius and the angle of the (x, y) point, measured in polar coordinates, with the center localized in (x_C, y_C), instead of (0, 0). In Figure 4, we show the decomposition of the circular movement, from wrist and arm submovements. The resulting curve is C, here supposed also circular. (x_C, y_C) is considered as the center of this circle C, achieved for a particular value of R.

2.3.1. Mapping of the angle

As pitch control is now related to θ, angular information will be normalized and modified in order to lay out a range of notes in which every semitone (in tempered scale) corresponds to the same angle. Then an arbitrary parameter to set is the number of octaves that are mapped on the whole angle variation (typically between 2 and 4). The conversion is obtained with equations 3 and 4.

$$f_0 = f_{0_R} \times 2^{\frac{i}{12}} \tag{3}$$

$$i = N \times 12 \times \frac{\theta - \theta_B}{\theta_E - \theta_B} \tag{4}$$

where N is the number of octaves we want on the playing surface, θ_B is the leftmost angle visible on the playing surface, θ_E is the rightmost angle visible on the playing surface and f_{0_R} is the reference frequency corresponding to the θ_B position. A typical pitch modification on this diagram is illustrated in Figure 5.

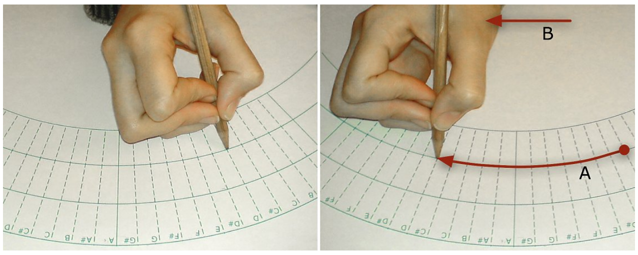

Figure 5: Two snapshots (left: before, right: after) in the demonstration of a forearm/wrist movement (B) achieving a simple pitch modification (A).

2.3.2. Mapping of the pressure

Concerning intensity mapping, we decided to keep the same approach as in the `RealtimeCALM` control model [9], in which sound intensity and stylus pressure were linked. It appears to be relevant, because based on the drawing metaphor, "making sounds" is related to "using pen", and pen is indeed used when pressed on the playing surface. A logarithmic distorsion function can also be added, depending on the sensivity that we want to simulate, while touching the tablet. This add-on is directly inspired by non-linear mappings typically available for MIDI keyboard velocity.

2.3.3. Mapping of the radius: interest in finger-based gestures

Some timbre features have to be controlled coherently with ($pitch$, $intensity$) gestures. A typical situation is singing synthesis control. Indeed voice quality inflections often appear synchronously with pitch and intensity modifications, and combined control of these parameters effectively contributes to the expressivity of the resulting sound [8].

Linking radius R with voice quality dimensions leads to curves which are more complex than in Figure 5, where R dynamically changes. Nevertheless underlying forearm and wrist movements remain the same as in Figure 5, and refined training just consists in integration of finger flexions. A typical mixed modification on the playing diagram is illustrated in Figure 6. We can see the wrist movement B, combined with the finger flexions C, resulting in the mixed gesture A.

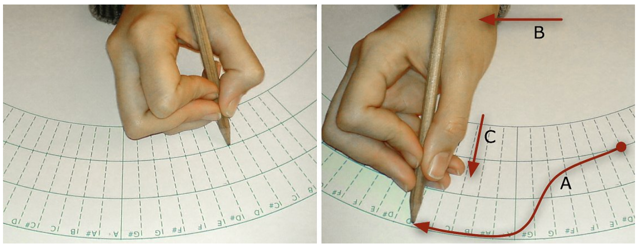

Figure 6: Two snapshots (left: before, right: after) in the demonstration of mixed θ and R modification (A) involving both forearm/wrist (B) and fingers (C).

Another interesting aspect of our layout concerns vibrato synthesis. Indeed we know that oscillations do not concern only pitch, but also energy and several spectral parameters [30]. In addition it appears that pen-based vibrato can easily be achieved by little circular movements around a fixed point. In such a gesture, f_0, R and p are all involved in the achievement of the vibrato, which offers good opportunities to develop flexible multi-dimensional mappings around vibrato effects. These issues are extensively discussed in [10], as a application of Analysis-by-Interaction.

3. NON-PREFERED HAND ISSUES

The mapping strategies developed in Section 2 proposed some ergonomic improvements, compared to existing tablet-based controls, mainly in pitch and intensity manipulation. Performing on the diagram illustrated in Figures 5 and 6 makes it possible to learn simple techniques, such as legato or vibrato, in order to reach an interesting level of expressivity for interpretation and improvisation.

However, ore advanced $pitch$ and $intensity$ structures, like arpeggios, trills, or appoggiaturas are not possible. Moreover even with the large number of parameters transmitted by the stylus, only slow timbre variations can be achieved. We observe that pen-based gestures have a inherent lack in controlling articultions of all kinds.

In this Section, we present a controller for the non-prefered hand, attached to the tablet (cf. Section 3.1). Then, in Section 3.2, we describe three main challenges that we propose to focus on, resulting in three kinds of gestures that are achieved with this non-prefered hand controller: fretboard, aggregative and articulative controls.

3.1. The A+B strategy

Considering the preceding constraints, the use of multiple pressure-sensing surfaces appears to be powerful. In this category, we can find several all-in-one controllers, such as Tactex MTC Express Pad™, Lemur™, or Z-tiles™. We decided to develop an original "on-tablet" shape based on 8 independant FSRs from Infusion Systems™, for technical reasons: portability, unicity, price, latency, and flexibility.

In this configuration, FSRs are separated into 2 groups, A and B. A sensors are aligned to define A thumb positions. In our setup, $A = 3$. B sensors are aligned to achieve four fingers playing techniques. Having one sensor more than the number of available fingers gives particularly creative possibilities, thus we choose a value of $B = 5$. This $5 + 3$ strategy proved to be particulary efficient when playing the instrument. We also want to highlight that this configuration evolved with the instrument, with setups going from $4+4$ to $8+0$.

A major ergonomic issue of this configuration was to find a comfortable layout. As this problem could not be solved effectively with an horizontal tablet, it has been decided to flip the device vertically, in a position close to accordion playing, as it can be seen in Figure 1. Thus the group of 5 FSRs are placed on the front side, and the group of 3 FSRs on the rear side of the device. It results in the grabbing of the tablet border.

With a longer practice, we can notice that such a movement does not affect the writing abilities required by the prefered hand. Moreover it extends the practice in new directions, as we explain in Section 4.1. Figure 7 illustrates the front and rear position of the FSR sensors and the way the non-prefered hand interacts with them.

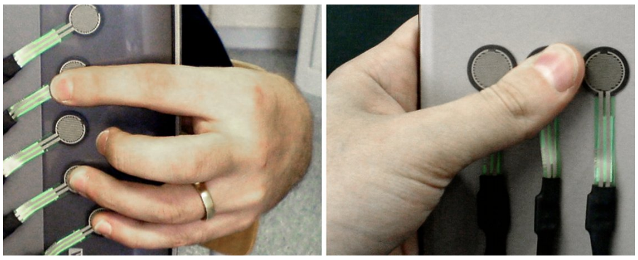

Figure 7: Demonstration of front and rear views of a 5+3 playing configuration for the non-prefered hand controller, with a typical hand position.

3.2. Non-prefered hand gestures

The $A+B$ strategy is used in order to configure three separate behaviors for the non-prefered hand: fretboard, aggregative and articulative controls. This Section gives an overview of these three mappings. The $5+3$ configuration is adapted to the choosing of one of these mappings. Indeed the thumb position (rear panel of the `HandSketch`) is used in order to select one of those, by pressing on one of the three FSRs.

3.2.1. Fretboard control

This technique is developed in order to allow direct (pitch, intensity) modifications based on multi-finger playing techniques. It means that a current pitch f_0 is built from the pen-based reference with equations 3 and 4, then a deviation depending on adopted four fingers position is applied. In the context of singing performance, it can be used to achieve fingering sequences inspired by fretboard playing. A note pointed on the tablet corresponds to a reference fret on the virtual fretboard. Then pitch can be increased (3 semitones) or lowered (1 semitone), as illustrated in Figure 8.

Another interesting application is the realtime mimicking of speech intonation. Indeed we know that the f_0 curve in speech can be seen as the combination of a slow ascending/descending slope, plus dynamic inflections synchronized with the syllables [18]. Using the pen for slow slopes and the FSRs for quick inflections is actually really efficient.

3.2.2. Aggregative control

This technique is implemented in order to perform large pen movements, with a structural control on harmonic contents. Thus various finger configurations correspond to pitch and intensity non-linear mappings in a way arpeggios, defined scales or other note articulations can be achieved. Practically the pitch contour is flattened around stable values and the intensity is modulated to sound louder around chosen notes. The amount of this control space distorsion is linked to average FSRs pressure values. This kind of modifications are directly inspired by Steiner's work on the Mapping Library [29].

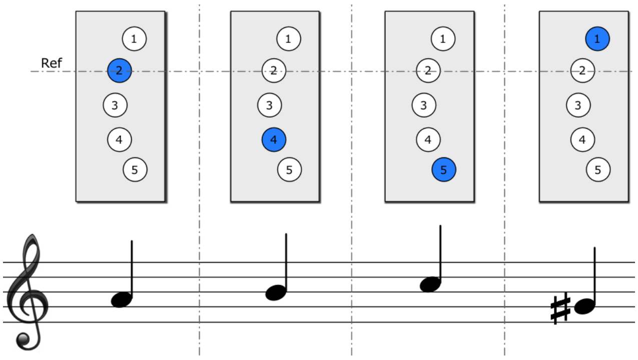

Figure 8: Illustration of a non-prefered hand "string-like" playing technique, with captor 2 as the reference fret, corresponding to a *A4* pointed on the tablet.

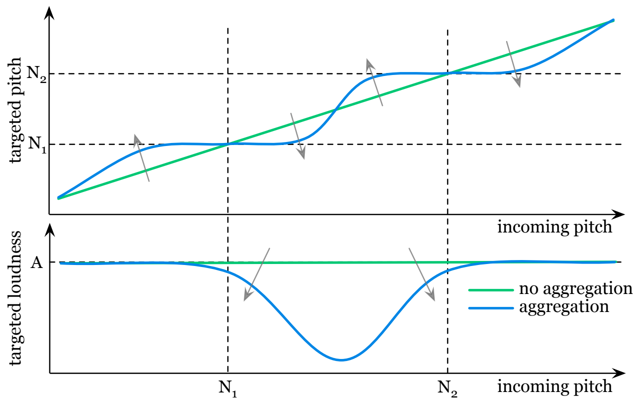

Figure 9: Example of aggregative control distorting pitch and intensity curves. Without aggregation pitch and intensity are as incoming from the tablet (green curves). When aggregation is required, pitch is flattened around given notes N_i, and intensity A is reduced between them (blue curves).

In Figure 9 we observe how the aggregative control modifies pitch and intensity curves. Without any aggregation, pitch and intensity are not modified (green curves). Indeed targeted pitch equals incoming pitch (straight line) and intensity stays at the incoming value A. When aggregation is activated (blue curves), the pitch is flattened around given notes N_i and the intensity decreases between them, in order to attenuate the transition.

3.2.3. Articulative control

Movements on the FSR network reveal to be really dynamic. We have obtained that 10 gestures by second can be reached. Considering that each position on the network can be mapped to a symbolic value, it makes this configuration particularly close to the needed rate for generating phonemes in realtime (i.e. about 10 phoneme/second).

Through GloveTalk and GRASSP, Fels has shown that the achievement of fully hand-controlled speech synthesis (phonemes + prosody) is still an open problem [12], and the adding of voice quality modification even increases the complexity. In this thesis, we highlight that browsing a database from syllable to syllable is really intuitive with the FSR network [7]. But there is probably a really exciting research topic, related to the generalization of the $A + B$ strategy for generating phonetic streams.

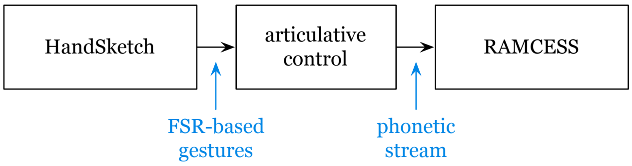

Figure 10: FSR-based gestures coming from the HandSketch, mapped to the Ramcess synthesizer in order to produce a phonetic stream in realtime.

In Figure 10 we can see how the FSR-based gestures would lead to the generation of a phonetic stream, that would be used as an input for the Ramcess synthesizer. The mapping for the articulative control could be based on associating some finger positions with a given phoneme, exactly like it is done in the GRASSP framework [12].

4. LONG-TERM PRACTICE OF THE INSTRUMENT

When discussing about the making of new digital instruments, the issues of expertise and feedback, in the practice of these instruments, come recurrently. Poepel [24] or Dobrian [11] already addressed this problem in recent papers. Indeed they focuse on the relevance of virtuosity as a need for expressive interaction with sonic contents. More pragmatically they evoke the need for a larger contribution of skilled performers in the assessement of musical innovations.

It seems that existing frameworks – albeit very useful during conception – only give a part of the answer to this issue. We can highlight e.g. the digital instrument model [2], ergonomic assessments derived from HCI [32], or Cook's recommandations in the development of new controllers [5]. Obviously the amount of new controllers presented each year increases. But if we think about their lifetime and incorporation in the contemporary performer/audience dialogue, we do not have such a clear picture.

In this Section we do not expose improvements achieved on the existing HandSketch, but rather a comment on the fundamental reasons that pushed this instrument to reach its current shape, and a discussion about associated practices. The idea that the HandSketch is a novel instrument is reconsidered and the behavior of the graphic tablet itself as an expressive controller is generalized.

This reconsideration of the HandSketch aims at integrating our approach in the historical picture started by Zbyszynski [37]. He proposed the digital tablet as a major instrument of the contemporary music, and gathered the most significant players, in order to build a set of techniques that can be shared within the community.

In this Section, we discuss the way the vertical playing position evolved along these three years, from a rather static behavior to the position illsutrated in Figure 1. This discussion targets the size and the orientation of the tablet (cf. Section 4.1). It gives interesting keys to understand how this position influences the overall attitude of the performer on stage. We also explain how the position justifies and even modifies the behavior of both the preferred and non-preferred hands (cf. Section 4.2).

4.1. Size and orientation

The first motivation for the current size and orientation of the tablet was the opportunity to develop new kind of gestures based on the writing skills [6]. Indeed most of existing practices associated with the graphic tablet were more or less close to a browsing strategy: taking advantage of the bi-dimensional control surface in order to move into a given sound space. With the use of a large tablet along the natural trajectory of the arm, more dynamic, expressive and "embodied" gestures could be achieved. The fact that the audience could see the control surface has also been highlighted as a interesting performing aspect.

However the decision of flipping and enlarging the sensing area was more or less intuitive. Without having a clear access to underlying reasons, it was difficult to think about transferring the instrumental interest of the HandSketch on other instruments. The use of existing interaction models or assessement strategies provided some answers:

- in the scope of usual HCI assessement, considering ergonomic aspects of the position: precision in moving, speed to reach a given point, etc;
- but also highlighting that using two hands with highly differentiated purposes gives better performances, as it is suggested by Kabbash [14].

In order to get further answers we had to involve time in practicing the instrument and discussing with many people about it. The HandSketch participated to more than 30 events (concerts, demonstrations, workshops, etc) and has probably been tried (with different levels of involvment) by about 100 people. It gives us today the possibility to highlight two mechanisms, considered as really important in order to consolidate the approach of playing vertical tablet:

- the fact that the gravity field and centers of gravity of the body play an important role in the way the performer and the instrument are connected;
- the way an object (i.e. its position, shape and size) influences the attitude of a performer and thus the expressive contents of his/her playing.

4.1.1. Gravity-related performing issues

Research in applied physiology shows that the shape and the position of the human body is strongly related to the alignment of forces applied on different segments, such as shoulders or knees [35]. This can be seen as an intrinsic strategy for positioning ourselves in the gravity field. It defines how balance and tension are underlying our overall attitudes. Explicit use of the gravity can be found in advanced practices of several instruments, e.g. in the idea of moving *passively* the fingers during the bowing gesture [17]. The body/object relation and the effect of gravity are also an important issue in other activities such as martial arts, and more precisely with the *Bokken* [20].

But it is interesting to notice how this topic is missing in the digital instrument making literature. Few contributors discuss the influence of gravity (and its impact on body/object interaction) in their practice of the instrument [26]. However this is probably one of the most important aspects of the vertical tablet playing in its way of highlighting the body expression, and the tilting of the tablet from horizontal to vertical playing highlights the importance of gravity.

In the *normal* use of the tablet (i.e. in horizontal position, in front of the performer), the pressure is achieved in the same direction as gravity, with the arm rather far from the center of gravity of the body. Consequently the body is static and comfortable, as the performer achieves browsing movements. Risk and effort, two aspects crucially involved in the interest of a live performance, appear not to be accessible for the audience.

At the beginning of the HandSketch, the tablet was placed fully vertically on the knees while sitting down on a chair. Then the overall position progressively moved from the formal sitting on a chair to a different attitude: sitting on the ground (cf. Figure 1). There are three significant differences between the former and the current positions.

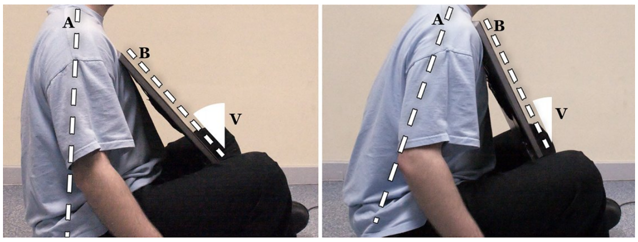

Figure 11: Tilt (B) of angle V due to spine movements (A).

1. Verticality is broken. As the device is supported by the lateral part of the knees on one side, and by the upper part of the chest on the other side, it makes an angle V of 30-40 degrees with the vertical direction, as illustrated in Figure 11.
2. The angle of the tablet V is correlated with the movement of the spine. Therefore this angle can vary, as illustrated in Figure 11. This aspect is really important because the behavior of the spine is correlated with the emotional state [3].
3. A given position on the sensing area becomes a *suspended* situation – pressing on a tilted surface is unstable – and requires concentration (cf. Figure 12). Playing that way for a long period reveals that this unstable connection between the body (through the behavior of the spine) and the located pressure on the surface helps the audience for understanding the risk and the difficulty of the performance.

4.1.2. Keeping the concept, changing the size

Evoking the concept of category in the context of digital instrument making is difficult. All electronic or digital instruments are often classified in one big cluster: that of "not acoustic" instruments. Decomposing a given instrumental concept (e.g. bowed strings) and developing different practices mainly due to the size (e.g. violin, cello, double-bass) is not obvious in the digital world. Except for the digital keyboard, and its number of keys leading to various sizes, sizing rarely happens for digital instruments [21].

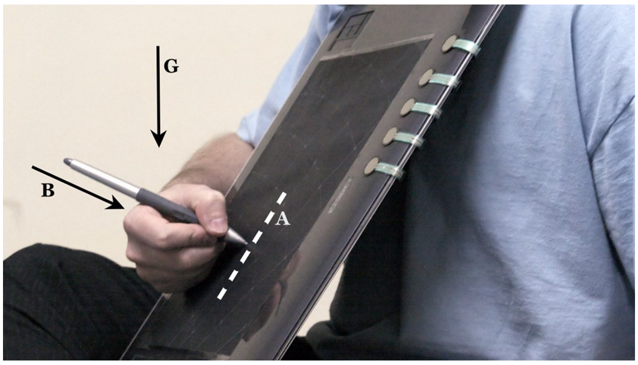

Figure 12: Gravity (G) and pressure (B) on the tilted area (A).

Playing the graphic tablet gives the opportunity of accessing various sizes (from A6 to A3) with the same resolution and features. The wacom object for Max/MSP can send (x, y) coordinates as a relative position between 0 and 1 for all the supported tablets. Therefore the size of the controller can be changed easily without disturbing sound synthesis. It creates a comfortable context to test the influence of size.

Figure 13: Position when the A6 tablet is played.

As it could be expected the relative size of the tablet – compared to the size of the body – plays an important role in the attitude proposed by the performer. Smaller tablets (A5 and A6) can be played on one knee (cf. Figure 13). The performer is more comfortable and invites the audience to focus on what is happening around that location. With bigger devices the way of playing is much more imposed by the shape of the controller, and the connection with the spine is stronger. The performer and the tablet become like a unique system, and expressing results from the body behavior.

4.2. Generalizing the aim of each hand

In Sections 2 and 3, the hands are described from their functional point of view. Considering Cadoz's typology [4] it means that the preferred hand makes a modulation gesture through the pen scrubbing the tablet, and the non-preferred hand performs selection gestures on the FSR network. However we explain in Section 4.1 that the preferred hand plays a much more important role in the achievement of expressivity. Indeed the contact point between the pen and tablet is a complex combination between the tilt of the surface and how the position of the arm is influenced by gravity.

Therefore the preferred hand can be seen as the tensing factor of the performing behavior. If the performer relaxes this hand, the contact point slips out of the sensing area and the relation stops. In our mapping, the sound would stops as well.

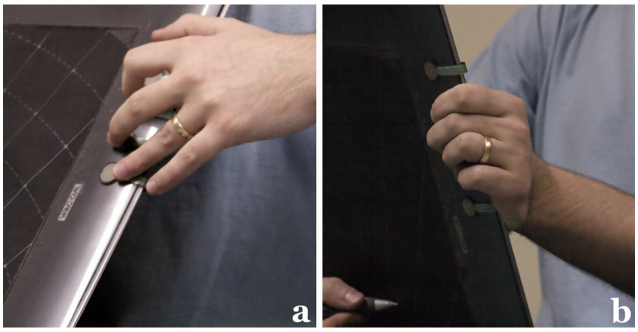

Figure 14: Different attitudes with the non-preferred hand.

The practice of the tablet reveals that the non-preferred hand also has a kind of hidden purpose. Indeed we explain in Section 4.1 that the tablet is linked with spine movements, creating a strong correlation with the behavior of the upper part of the body. In this context the non-preferred hand is intuitively used in order to develop the body movements in other directions e.g. tilting the tablet further than vertical.

Finally the exact configuration of sensors for the non-preferred hand is not so crucial as soon as there is a continuum in the grabbing attitude, from the full acceptance to the total rejection, respectively illustrated in Figures 14a and 14b.

5. CONCLUSIONS

In this paper, we described the development of a new digital instrument, based on a graphic tablet and attached FSR sensors: the `HandSketch`. The prototyping of this instrument results from the Analysis-by-Interaction methodology that has been explained in [10]. Here we present several important aspects of this work:

5.1. Innovative mapping for pen-based gestures

The main aspect of the `HandSketch` is the use of pen-based gestures for the combined control of various aspects of voice production. In this paper, we have first introduced how the tablet, a 3-axes controller, could be mapped to some voice production parameters: pitch, loudness and voice quality dimensions. Solutions to some ergonomic problems have also been proposed, leading to an adapted circular representation of pitch, and the use of radial finger-based movements for voice quality modifications.

5.2. Embedded FSR network and vertical playing

The role of the non-prefered hand has also been discussed and a controller, embedded on the tablet, has been proposed. This non-prefered hand controller is based on a FSR network. The unusual configuration of FSR sensors (five sensors on the front panel and three sensors on the rear panel) has modified the playing position from horizontal to vertical. Three mappings have been proposed for this FSR network, based on various purposes for the non-prefered hand: fretboard, aggregative and articulative controls.

5.3. Long term practice of the instrument

The development of the `HandSketch` takes the benefit of three years of playing, and eight successive prototypes. This continuous combination of prototyping and practice gave the opportunity to discuss in details the underlying aspects of this tablet-based musical performance. In this discussion, new properties have been highlighted in the playing, such as the impact of size and orientation of the tablet on the overall performing behavior. These new properties are important in order to plan further development of the `HandSketch` and extend the interest of tablet playing to new instruments.

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