SONIFICATION OF JAPANESE CALLIGRAPHY BY GESTURAL CONTROL OF SOUND SYNTHESIS

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ABSTRACT

It is detailed the strategies implemented for a sound representation of Japanese calligraphy (kanji) using a Leap Motion and a Wacom Intuos tablet as gesture capture tools for the control of sound synthesis. Two modes of sonification will be explored, one described as metaphorical, the other as objective. Kanji are characters that the Japanese have assimilated from Chinese culture. Being logograms, each of them has a meaning, in the manner of the cuneiform characters preceding the Phoenician and Greek alphabets. Kanji are figurative in scope, though generally abstract for an uninitiated eye. Ten characters have been selected for their symbolic potential with associated sounds in their semantic field.

Keywords
Leap Motion, Wacom Intuos, Kanji, granular synthesis, gestural control, sonification, logograms, Japanese calligraphy.

1.CONTEXT

The idea of generating sound by simple gestures of the hand has something magical and exciting. As proof, Lev Termen's Theremin is still manufactured and marketed in a array of versions modernized by Moog [1]. Many contemporary artists have made gesture a central element in their sound creation work [2] [3] [4]. As a composer and performer, my interest is to develop an instrument that can be used in performance situations over the long term and that uses affordable and reliable gesture capture interfaces. In addition, it seems to me that the gestural control of sound synthesis has the potential to create devices allowing an innate control of the sound production, and that the computer allows to limit to no materialism nor any timbre or articulation. Obviously, mapping strategy is the essential element of the success of such systems but an arbitrarily chosen mapping can be intuitive? Ryan, [5] emphasizes the importance of the relationship between the effort provided and the resulting sound and demonstrates the need to have a model (whether musical or not) to define mapping strategies that are understandable by the audience and interesting to explore for the musician. Fels et al. [6] introduced the concept of transparency in mapping strategies. It corresponds to a criterion making it possible to qualify the physio-psychological distance that the public and the instrumentalist maintain with the mapping. This distance - this opacity - would tend to diminish when we use metaphors to define a meaning and massively accepted mapping. Japanese and Chinese calligraphy result from an ancestral quest for balance and harmony between strokes. The execution of the calligraphy does not tolerate any hesitation in the line. The gesture must be confident, assured and fluid. It seemed to me that starting from these harmonious sequences of gestures would be an effective basis for looking for natural mapping. Writing is a technique that goes back more than

5,000 years [7], the human uses his hands and tools to draw for at least 40,000 years. Although unfortunately, writing or drawing can not be practiced by all human beings on the planet, the fact remains that these techniques - these means of expression - are almost universal.

2.TECHNOLOGICAL PRECEDENTS

2.1 Data Gloves

The gesture capture tools used in contemporary creation follow technological developments. The Microsoft Kinect released in 2009 was widely used. This one, however, aims to detect large gestures and does not offer the possibility of capturing subtle gestures as the hand excels at producing. A long tradition of developing and using data gloves seeks to make the movements of the hands and fingers musically expressive without the need to resort to the practice of a traditional musical instrument. Thus the VPL Datagloves [8] project developed by Thomas Zimmerman in 1982 at a prohibitive price of $ 9000 will inspire many projects including The Lady's gloves initially created by Laetitia Sonami in 1991 [9] and of which Bert Bongers will realize a version in 1994, the VAMP [10], by Elena Jessop, developed at MIT media lab and presented at NIME 2009 or The Gloves [11] developed by Dr. Thomas Mitchell and her team, Bristol University, for singer Imogen Heap in 2011. Only these projects remain isolated attempts, and although technologically and artistically successful and meaningful, the tools they use can not allow the emergence of a literature and a repertoire that inevitably involves a large number of practitioners and amateurs.

2.2 WACOM Intuos

Graphics tablets such as those marketed by Wacom are tools of a flawless finish intended primarily for graphic designers with a high level of requirement in terms of gesture capture. Some models are relatively affordable, easy to implement in various environments such as Max, Processing or Super Collider and offer a resolution capable of transcribing the most subtle lines (cheap models already offer a resolution of 2540 lines per inch and a transcription pressure by 10-bit words). The fact of being limited to a flat surface can greatly reduce their dramatic impact however, the artists generally resort to the projection of images generated by these gestures to transmit their expressivity to the public [12] or simply project a video capture of the manipulation of the tablet. The ensemble Cantor Digitalis [13] has repeatedly demonstrated the musicality of an orchestra of graphic tablets. The Intuos model used here captures the position of the pen on the tablet and the pressure of the tip on it. Although some Wacom tablets are sensitive to the tilt of the stylus, this is not the case of the Intuos model used. R. Dudas, then J. M. Couturier and C. Gondre created an external object for the interfacing of Wacom tablets in Max's environment [14].

2.3 Leap Motion

The Leap Motion, marketed mid-2013, is a USB device that creates an invisible area in which to interact. Equipped with infrared cameras, its optimal field of vision is up to 60 centimeters above the device, with an angle of 150 ° wide and 120 ° deep [15]. Shape recognition algorithms seek to detect the forearms, palms and fingers of the user. The Leap Motion can detect a very large number of gestures which makes it versatile. Its SDK is regularly updated to increase its detection performance and increase its reliability (a new API provided in May 2014, for example, provided the ability to detect the skeleton, and thus to detect the fingers continuously when folding them). Although there are many alternative proposals to capture this typology of gestures, [16] [17] [18], Leap Motion remains to this day the means presenting the best report reliability / price / versatility for the detection of subtle gestures of the hands and fingers while having the advantage of being non-intrusive, very compact and used by a broad and active community of transdisciplinary developers.

The device has a dedicated application sales platform on which several are intended for sound creation. Among them, GECO [19], created by Geert Bevin ignores the individual detection of the fingers and puts the emphasis on the expressive control (effects, filters...) more than on the articulation (release of notes). These applications are primarily intended for a wide audience and in fact are effective and simple to handle but may also be limited in their potential for expansion and adaptability by not being designed to be architectures open to other environments.

To interface the Leap Motion in Max, there are, to my knowledge, three external objects, aka.leapmotion by Masayuki Akamatsu [20] and MRleap, by Martin Ritter [21] as well as an object made by the ISMM team of IRCAM [22]. The latter is based on a newer version of the SDK and offers superior ergonomy. The operation of the MRleap object has been treated in detail by its author [23]. It analyzes the flow of data sent by the Leap Motion by frame window according to a pyramidal architecture (top-down), which would validate the data during their "respective life cycles" by seeking first to isolate the objects to be analyzed, then to make comparisons of the displacement of the analyzed objects between the frames. Each frame is identified by a number and reports status information on the number of hands recognized, the position of the hands, and so on. By comparing values between frames, the object reports information about translation, rotation, and scale. In the substructure of a frame, the object will interpret the information for the hands then for each finger thus respecting this pyramidal approach. Finally, the external object MRleap is able to recognize gestures of scanning a hand in front of the camera, circular movements and mimicking typing on the keyboard or on a screen.

3.METHODOLOGY

3.1 Japanese calligraphy

One of the most important aspects of calligraphy is the pressure exerted by the bristles on the paper. Indeed, a fundamental apprenticeship in calligraphy consists in sensitizing oneself to feel the pressure exerted on the hairs via the kinesthetic channel informing us about the resistance encountered as well as via the tactile channel, sensitive to the friction of the hairs on the surface. Thus, the master calligraphers develop an extreme sensitivity to these haptic sensations [24] allowing them to develop their art and to distinguish themselves from each other. [25]. In order to take this aspect into account, I envisage a future version of this research-creation which will employ a controller developed by the Californian company "Sensel" whose commercialization has started since the winter of 2017. It is a tablet tactile technology that will allow it to be sensitive to any tool, including a brush. This will allow to be more faithful to the experience of the calligraphy and to exploit more the haptic feedback.

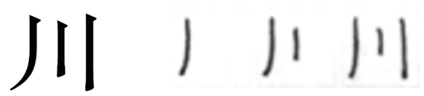
Other essential features of the art of calligraphy are:

- The angle of attack of the lines. Indeed, the ends of the lines generally form angles of 45 ° relative to the frame of the sheet. This is done by adjusting the yaw of the wrist (the z-axis) and the pitch (y-axis) to properly position the bristles of the brush.
- The order of execution of the strokes. The kanji are classified according to the number of lines it contains, these can cumulate from 1 to 23 strokes. These strokes generally run from top to bottom and from left to right. The passage from one stroke to the next can be done almost continuously, (without raising the brush of the sheet) or require to interrupt the contact between the brush and the sheet. This implies a progressive movement in the plane of the sheet : translations.
- The direction of the strokes. On the plane of the sheet, the lines are horizontal, vertical or oblique, and may have different angles. It is therefore translations that may require rotations.
- Curvature of the strokes. In Japanese calligraphy, there are four styles of writing: archaic, classical, semi-cursive and cursive. The same character may be difficult to recognize for a novice eye according to whether it has been written in one or the other of these styles. I use the classic style. This style, however, limits wrist rotations and curvature of strokes.
- The speed of execution. Indeed, confidence in the gesture and the ability to be fully in the moment are important factors in calligraphy. These parameters have a direct impact on velocity. Also, one can occasionally pause, to control how the paper will absorb the ink or not. This is measured by velocity.
- Hair pressure has a direct impact on line thickness and other parameters that are difficult to discriminate (such as line consistency, ink absorption factor, etc.).

To conduct this research-creation work, I chose ten kanji presenting different levels of difficulty. These are still relatively simple to draw and are taught by Japanese children in the first and second year of school (gakushuu).

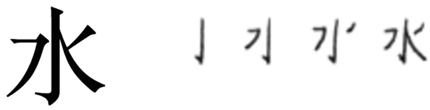
Here they are in ascending order of the number of lines:

- Gawa, kawa / River / 3 strokes



- Yama / Mountain / 3 strokes

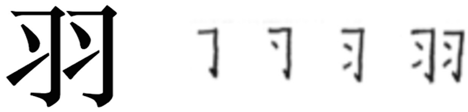
- Mizu / Water / 4 strokes



- Hi / Fire / 4 strokes

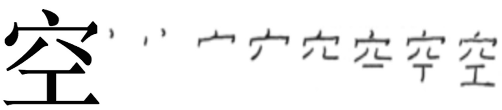
- Ki / Tree, wood / 4 strokes

- Ha, hane / Wing / 6 strokes

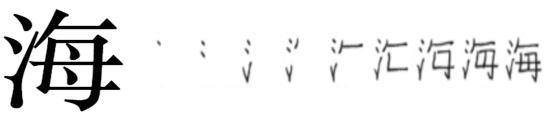


- Mushi / Insect, Larva / 6 strokes

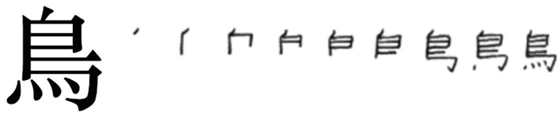
- Sora / Sky, air / 8 strokes



- Umi / Sea / 9 strokes



- Tori / Bird / 11 strokes



[26]

Finally, the practice of calligraphy is an activity a priori uni manual (although we can consider the role of the non-dominant hand, which is to maintain the sheet in place or discuss about the fact that his whole body, must be connected to Qi and posture in its entirety participates in the realization of the work), however, the use of calligraphy techniques for sound synthesis can quite induce the performance of auxiliary tasks. Beaudouin et al. [27], demonstrated that the use of bi-manuality allowed increased efficiency in manipulations in WIMP and post-WIMP paradigm environments (Windows, icons, menus & pointers). While the dominant hand is busy writing, the other hand may be required for selection, sequencing, mixing, and so on.

3.2 Audio synthesis

Sound generation is based on granular synthesis for metaphorical representation and additive synthesis for objective sonification. I consider granular synthesis very suitable for the project for several reasons. First of all, the fact of using concrete sound sources as raw material is quite logical because it is a question of metaphorically representing symbolic, figurative or abstract characters. Also, I have regularly been able to observe that granular synthesis makes it easy to obtain organic results, evoking natural phenomena or animal activity [28] [29]. Finally, as detailed in the mapping section, certain parameters, such as grain index, grain size or density, call for obvious and intuitive mapping strategies. Additive synthesis is more conducive to objective representation. Indeed, while granular synthesis allows the use of a set of concrete and complex sources, the relative simplicity of the sounds produced by the additive synthesis implementation I chose allow a sonification favoring the comparison of the characters between them.

For reasons of efficiency and adaptability, I worked within the Ableton Live environment. This environment has the advantage of being able to embed Max-made patching with Max4Live while having many functional and practical tools in addition to the power and flexibility inherent in using a professional digital audio workstation.

As a granulator, I use a Max4Live patch developed by Robert Henke "Granulator II" [30]. This granulator is simple but robust and low in resources. It has the advantage of being easily modular because it is incorporated into the environment of Ableton Live, which makes it possible, for example, to quickly adjust the number of granulators required or to make complex routing, very efficiently with the treatment chains., while offering facilities for mixing. The sounds used are chosen according to the semantic field of each kanji and come from personal sound banks. Since these are metaphorical and subjective sound representations, only aesthetic choices guided the sound result. I wrote audio montages of between 10 seconds and 1 minute, with one or two montages per character. For example, for Tori, which means "bird", I use songs of raven, flamingo, goose, duck, owl, etc., which I mix in a discursive montage.

The additive synthesis model that I decided to use is based on the first 12 partials of the harmonic series to which I added 12 arbitrarily selected partials. The system consists of an aggregate of three Operator Synthesizers of the Ableton Live Suite version, each supporting 8 partials. Dynamic frequency shifters were added and distributed on the different oscillators with the will to obtain glissandi on the X and Y axes. The pitch decreasing from top to bottom and increasing from left to right.

3.3 Mapping strategies

3.3.1 Setup

Ableton Live supports MIDI assignments and its fairly rigid system can easily be augmented by the addition of Max4Live tools such as Multimap [31] which allows assigning a degree of freedom to several parameters of the synthesis model. (one to many) and adjust the dimensions between the source and the destination. Multimap does not offer by default the ability to make expressions between the source and the destination in the manner of what Libmapper [32] proposes, however, since it is an editable Max4Live patch, it is easy to increase its possibilities in this direction.

The use of intermediate layers for mapping [33], [34] has obvious advantages of flexibility and adaptability, allowing the modification of connections without breaking all the connections, thus favoring the experimentation of various mapping. Libmapper is used for the middle layer of assignments. Thus, Leap Motion and Wacom communicate their values as sources for Libmapper, and a Max patch contains map.in objects that are assigned to as many Multimap instances in Ableton Live. Each Multimap is named according to a key parameter of the granulators (such as index or grain size) and is connected to Max via MIDI CC messages. This not only makes it possible to quickly test different routing between controllers and synthesis parameters by interfacing Libmapper without having to modify the connections in Ableton Live (which is much more rigid than Libmapper) but also, Multimap allows to send these MIDI CC messages to as many synthesizers as necessary since it suffices to multiply the number of destinations within the Multimap patch.

Experiments have been made using a Leap Motion and a WACOM graphics tablet and the strategies employed are relatively similar, the Z axis of Leap Motion being entrusted to the pressure for the graphics tablet. I focus more on the WACOM tablet, the Leap Motion with weaknesses that I detail in section 4.

3.3.2 Mapping for the metaphorical modality.

The mapping adopted for this modality is essentially one-to-one. The 3 continuous degrees of freedom offered by the tablet are exploited to which were added 2 additional dimensions, calculating in Max, the instantaneous velocity at a frequency of 200 Hz, representing windows of 5 ms.

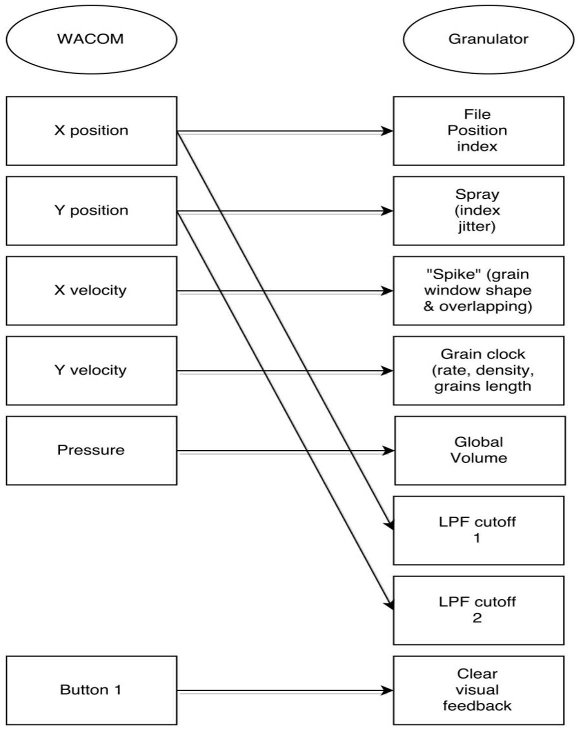


Figure 1: *Schematic diagram of metaphorical mapping*

3.3.3 Mapping for the objective modality

The so-called objective sonication of kanji was carried out via the use of additive synthesis, as described in section 3.2. The relative simplicity of the sound produced makes it possible to better appreciate the differences between the various characters and thus to appreciate their sonification by comparison. Since the frequency shifters used are dynamically modulated to create glissandi on the horizontal and vertical lines, one can more easily perceive the translation and the rotations using the metaphorical modality.

However, in order to complicate the synthesis model and make the sound a little richer, ring modulation is subtly used on the first part of the series and the product of this modulation is slightly added to the direct sound to create low frequency beats. A bandpass filter emulating the behavior of ladder-type MOOG filters has also been added along with a slight reverb with fast decay (<800 ms) and mixed with the direct signal, for the sole purpose of softening the sonication of the extremities of kanji. Finally, LFO's have been used to modulate the pitch of the oscillators. The speed and the intensity of modulation increases when one is static and decreases during displacements, evoking metaphorically the absorption of the ink by the paper when the brush is immobile.

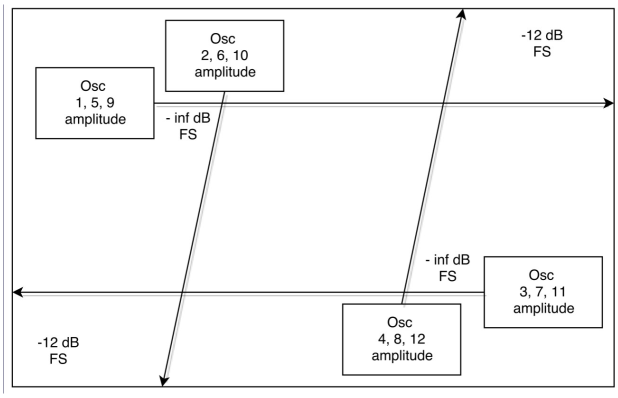


Figure 2: *Distribution of the control of the amplitude of the 12 oscillations along the two dimensions x and y.*

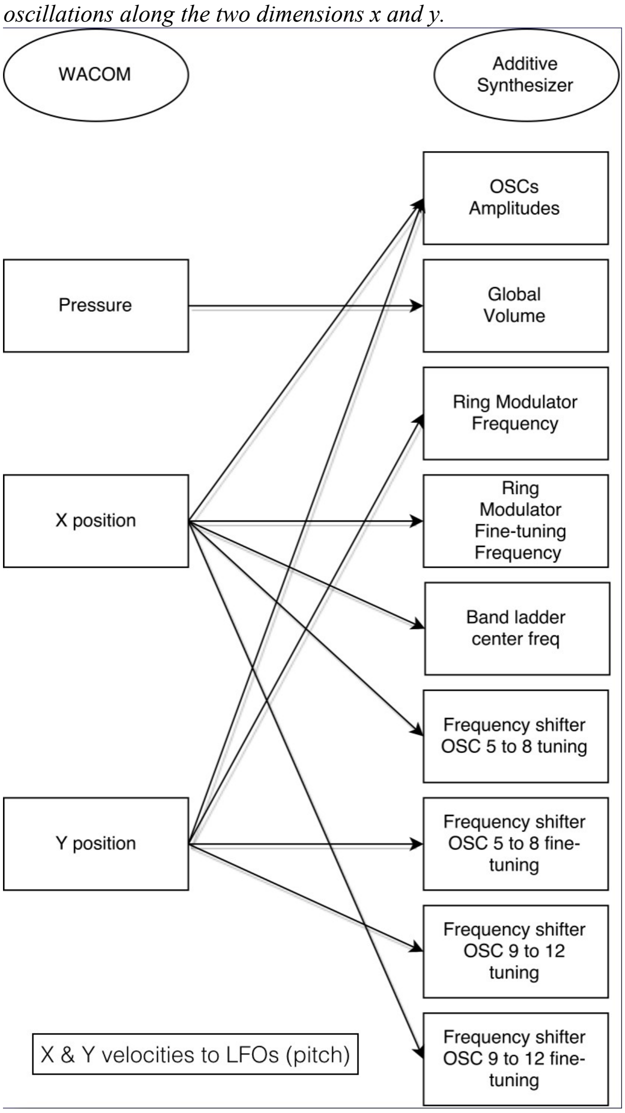


Figure 3: *Schematic diagram of objective mapping*

4.DISCUSSION

4.1 Leap Motion

While projecting his hands into a virtual universe, by its contactless nature, is what makes the Leap Motion particularly attractive, as it stands, it is also in my opinion its greatest weakness. Indeed. for now, we are not allowed to touch this world, to feel it. The absence of feedback by the haptic channel, which Rovan and Hayward [35] say is a key element in the relationship between a musician and his instrument (and of course, a calligrapher with his brush) disconnects us from the controlled interface. This physiological distancing seemed to me particularly puzzling. In addition, since the device is not completely reliable (a validity indicator - confidence - allows to ignore the erroneous information but it happens regularly that the recognition algorithm simply no longer distinguishes anything, virtually creating phases of empty), I do not think that the Leap Motion can, alone, be a viable device for use on stage, except of course, that its possible (and very probable) failures are taken into account when writing the work and its staging.

However, when the capture of the gesture operates faithfully and transparently, the device proves to be a driver of faithful and intuitive expression.

Kanji sonication via the Leap Motion has something attractive. Appart from the absence of haptic sensations that are lacking, the sensation of evolving in a spectro-morphologically complex sound material, within a 3-dimensional space is particularly playful. Also, the reproduction of gestures learned during the practice of calligraphy, and associated with this sound event - which is the main interest of this research - is quite satisfactory. Indeed, as expected, the natural layout of these characters, coupled with a thoughtful mapping, based on a universal metaphor, and by means of a controller offering as many degrees of freedom (position in x, y and z, velocity on 3 axes, roll, pitch, yaw and more if we add the individual finger recognition) is rich in possibility while being natural because based on a typology of gestures related to writing.

As part of a performance, as mentioned, the Leap Motion does not seem sufficiently reliable and robust in its role of recognition of the gesture to be used alone. But coupled with other devices that will fill its gaps (using for example more reliable controllers for event triggering and programming patches anticipating its potential failures) it is a wise choice for its qualities described in point 2.3.

4.2 Wacom Intuos

The sonication of kanji is more natural using a graphics tablet and it makes sense because it is writing and the use of a graphics tablet is based on the paradigm of drawing on a surface with a stylus.

What we gain in analogy and naturalness, however, we lose in number of degrees of freedom. For the tablet used (entry level, Wacom offers higher models with more degrees of freedom), we have the position on 2 axes, the velocity on 2 axes, the pressure on two axes (2 distinct ends of the stylus) as well as 2 switches.

Still for comparison with the Leap Motion, the graphics tablet has the advantage of being reliable in its capture, to offer a rudimentary haptic feedback - no complex and dynamic vibrotactile sensations - but greater than just moving your hand in the air without resistance, and to propose a better visual return of the interaction zone.

The Kanji sonification is here again particularly playful. For the same reason that linking the writing - and all the long learned and practiced gestures that this implies - to the generation of sound material is culturally meaningful and easily understandable, both by the practitioner and by his observers.

4.3 Sonification

The driving force of this research-creation is the sonification of kanji, and hence an appreciation of their differences, their qualities, their singularities, on the basis of sound parameters and assignments of common parameters.

In perception, this appreciation differs greatly according to the proposed modality. In the case of the metaphorical modality, each kanji unfolds its individuality since it is associated with unique sound elements. However, since the mapping is systematic, we can still appreciate the similarities between them. These similarities come in the form of duration, the number of elements in the sound sequence, the perception of the energy deployed, the velocity of the gesture, etc.

For the calligrapher, this gesture-sound relationship is obviously accentuated by proprioception. For the public, it is another thing, it is necessary to stage this gesture so that its sonification is transparent. Several solutions are possible: video capture and retransmission in order to direct attention to the signifying element or to generate a visualization of the gesture making it possible to reinforce sonification.

For pure creative purposes, it can generate sound material based on elements of language, opening the voice to all kinds of semantic and rhetorical associations rich in potential.

5. FUTURE DEVELOPMENTS

The use of the Sensel Morph tablet for a future evolution of this research-creation project will allow to include a haptic feedback of the manipulation of the interface. The perception of the touch of the bristles on the surface as well as the kinesthetic information of the movement and the resistance of the bristles will certainly increase the expressive potential of the interaction with the device. Also, the use of varied sizes of brushes will allow to experiment different tactile sensations and to increase the dramaturgical character of the device. Finally, I wish to add to the Digital Musical Instrument the capacity of visual synthesis, thus strengthening the relation with the initial gesture and the possibility for the public to have a better understanding of the gesture-sound relation and thus, to increase the transparency [6] mapping.

6. CONCLUSION

The sound production based on the capture of the gesture by the WACOM tablet is particularly pleasant and natural. Certainly since this is an almost universal writing technique. This device is particularly expressive in that it allows transparent mapping and transmits the information faithfully [36]. Also, the inherent ability of the graphics tablet to allow full navigation [37] among its degrees of freedom further enhances this expressive potential and enables the development of complex yet intuitive sound creation environments. Furthermore, the device can also allow separability of its dimensions by the use of programming if this proved necessary. Finally, the analogy with the spaces of timbres described by Wessel [38] is obvious and it is certain that its use in spectral music and related tools [39] is to be encouraged. The three-dimensionality of the volume of recognition allowed by the Leap Motion is attractive, but the lack of reliability of the device dramatically reduces its expressive potential and the absence of haptic feedback - although minimal with the tablet - does not favor it more.

Sonification of characters - here kanji but others are to consider - offer many benefits as described in 4.3.

The metaphor of writing for the generation of sound material has something universal enough to allow natural mapping for the practitioner and transparent for the public.

7. ACKNOWLEDGMENT

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