Elementary Gestalts for Gesture Sonification

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ABSTRACT
In this paper, we investigate the relationships between gesture and sound by means of an elementary gesture sonification. This work takes inspiration from Bauhaus' ideals and Paul Klee's investigation into forms and pictorial representation. In line with these ideas, the main aim of this work is to reduce gesture to a combination of a small number of elementary components (gestalts) used to control a corresponding small set of sounds. By means of a demonstrative tool, we introduce here a line of research that is at its initial stage. The envisaged goal of future developments is a novel system that could be a composing/improvising tool as well as an interface for interactive dance and performance.

Keywords
Bauhaus, Klee, gesture analysis, sonification.

1. INTRODUCTION
This work takes inspiration from the "musically-oriented" thinking of Bauhaus particularly evident, for example, in the activity of Paul Klee. Andrew Kagan in his essay on Klee says**:** "of all those concerned with the question of musical-pictorial interrelationships, no one devoted more time and energy to it, and no one arrived at more compelling answers, solutions, an insights than Paul Klee" [1]. Klee was a violinist and for a period he played with the Bern municipal orchestra and other Swiss musical organizations as a semi-professional musician [1]. We like to imagine that Klee's practice with the violin was a source of inspiration for his pictorial formalism and that the lines and curves that populate his paintings were somehow related to the practice of leading the bow on the violin strings.

Following Klee's teachings, we start from a dot, what he calls the mobility agent. By moving, the dot generates lines. This concept is well illustrated by Klee in the first example of his "Pedagogical Sketchbook" [2], a book intended as the basis for the course in Design Theory at Bauhaus. The dot is conceived as the atomic element that generates lines and planes. In a similar way we think of gesture as generated by sequences of dots forming structures that become complex at different levels. The approach is essentially abstract. Even if aiming at an interactive performative environment, no reference to physical metaphor or models (as for example in [3] or [4]) is pursued.

This paper wants to be the starting point for work that looks promising and will be further developed in the future. As discussed later, we envisage an extension of the principles discussed here to visual domain and we look at the definition of elementary gestalts, intended as unitary perceptual/expressive structures, activated by gestures as a possible way for defining effective (indirect) mapping between visual forms and sounds.

Here we present an initial demonstrative tool, realized with Max/MSP/Jitter that implements a sonification of gestures generated by hand movements. Elementary sounds are defined and employed for the sonification of two main categories of gestures: straight movements and circular movements.

The following section will give an overview of the aesthetics and ideals of Bauhaus, and in particular of Paul Klee, in relation to our work. Section 3 develops the issue of Elementary Gestalts for Gesture Sonification (EGGS). Section 4 illustrates the first prototype of a system based on EGGS. In Section 5 we discuss possible future developments and applications, and draw our conclusions.

2. KLEE, BAUHAUS AND TENETS OF DESIGN AND ARTISTIC PRODUCTION
In 1921, Klee joined the Bauhaus School of Art and Architecture where he taught until 1931, together with other important artists as the Russian painter Wassily Kandinsky, the German architect and designer Whalter Gropius, the German painter Joseph Albers, the Hungarian painter and photographer László Moholy Nagy, and others.

Basically, Bauhaus teaching encouraged the idea that there is a universal, non-figurative, visual language, and parallels were often made with the 'universal' language of music [5]. In particular, Klee's interest in musical aspects of painting is related to rhythm. In his essay [1], Kagan says: "It was the faceted shadings of Cubism which gave Paul Klee his first solid basis for musical-pictorial thinking. In Cubist patterns of alternating light and dark facets, he perceived a link to the foundation of music – rhythm..../...Throughout his career, Klee continued to work with and refine his concepts of pictorial rhythm". On the other side: "Klee himself, particularly during the early years of his career, was extremely circumspect about drawing analogies between the arts" and "Klee's effective application of musical models to his art only came through a very long and slow process of evolution". Also, Klee "believed in Goethe's assertion that color and sound do

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not admit of being directly compared./.. but both are referable to a universal formula." These concepts seem perfectly in line with nowadays psychological and technological research on cross-modality [6]. What we pursue in our present and future research is the exploration of cross-modality features (i.e. of Goethe's universal formula) by investigating an abstract version of the triangle gesture-sound-image.

In his Pedagogical Sketchbook, Klee points out a didactical path for his students in the Bauhaus, but at the same time, he presents the general principles of his artistic research. In the first part of the book, Klee introduces the transformation of the static dot into linear dynamics. In the colorful words of Sybil Moholy Nagy's preface to the Sketchbook, the line, being a sequence of dots, "walks, circumscribes, creates passive-blank and active filled planes" (see Figures 1, 2 and 3).

Figure 1: Dot generating an active line. Circular movement. Drawings by Paul Klee [1].

Figure 2: Dot generating an active line. Circular movement. Drawings by Paul Klee [1].

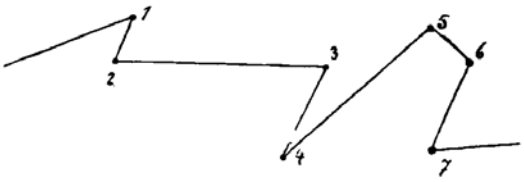

Figure 3: Dot generating an active line. Straight movement. Drawings by Paul Klee [1].

This abstract approach to visual representation is somehow equivalent to what we want to do in the auditory domain: free the sound from the task of expression and symbolization and give it an autonomous life in relationship with the linearity (or circularity) of gesture. Klee considered music as a mature model of what he wanted to achieve in the visual domain: he viewed "...the ultimate greatness of Mozart, Bach and Beethoven..." as a path to "...an equally monumental, universal visual art of the future..." [1]. The ultimate goal was "...to discover what universally applicable aesthetic properties could be isolated from the accomplishments of the titans of music and then to translate those discoveries... into practical, concrete, effective visual terms" [1].

What we are trying to do here, is a sort of reverse process, from gesture to sound by looking at Klee's lesson on dots and lines to define a new way of designing sound through gesture.

3. TOWARDS A SONIFICATION OF GESTURE THROUGH ELEMENTARY SOUNDS

At this stage of our research, the aim is to create a virtual instrument, producing "abstract" sounds via gesture analysis and recognition, where gesture is understood as an abstract entity. The objective is to look for original relationships between gesture and sound through the recombination of elementary categories. In our conception, we assume that there is no necessary relationship between gesture and sound. On the contrary, the goal is to show how it is possible to build new effective and meaningful relationships between gesture and sound, by defining abstract relationships and appropriate mappings. The main idea is to define a number of elementary components of gesture trajectories and to associate to each of them a specific category of sounds. In this section we discuss the principles adopted and the preliminary results obtained.

3.1 Elementary Gesture

Our mobility agent, the equivalent of Klee's dot, is a colored hand. Its movement produces lines and curves in (a 2D) space that are controlling sound generation. Klee starts from a point on a paper as an atomic element to generate lines and, at a higher level, planes. In a similar way, we start from a position (the hand) in the space in order to generate gestures and then sounds.

Indeed, sound/music production in general originates from gesture. Research on gesture analysis and interpretation is a vast topic [7]. A gesture is directly related to movement and it is charged with meanings that are related to dynamics, effort, inertia, as attributes of movement. In our work, all of this is bypassed by an abstract geometrical approach to gesture analysis.

At this stage of the work, we decided to reduce the set of gesture components to linear segments and curvilinear segments. By means of these two simple and very generic categories, we decompose gestures into a sequence of straight lines and curves. Accordingly, the sonification of gesture will be a sequence of sounds corresponding to the two categories. This is the basic geometrical principle that controls the selection of a sound family. Beyond this abstract (pictorial-like) part, a number of secondary parameters are considered in order to make a sound response more perceptually coherent with gesture evolution. This is discussed in the following subsection.

3.2 Elementary Sounds

As already said, we need to define two main categories of sound corresponding to straight gestures (movements) and circular gestures (movements). Presently, we decided to employ sounds generated by a simple additive synthesis: two harmonics form the "linear-sound" and eight inharmonic partials generate the "curvilinear-sound". Indeed, the curvilinear-sound produces a fast and continuous glissando, more precisely an infinite glissando in the Shepard's fashion (see [8] and [9] p.1069). The choice of an infinite glissando was taken to apply to the sound the concept of

rotation. In this category a further distinction is done between clockwise and counter-clockwise rotation.

An important aspect that is added to the abstract approach is related to movement attributes other than trajectory: absolute position and velocity. Even if no acceleration and effort-like features are considered, these attributes draw us back from an abstract world to a physical one. This is necessary to avoid the risk of monotony. Absolute position is mapped to pitch (higher position = higher pitch) and stero spatialization, and velocity is mapped to sound volume.

4. EGGS, A SYSTEM FOR ELEMENTARY SONIFICATION

The first EGGS realization has been implemented in Max/MSP/Jitter. As already discussed, we focused basically on two types of movements, straight and circular (see Figures 4, 5 and 6). In the future, we intend to use this elementary "bricks" to define compound gestures and a wider set of (sub-)categories as circles, ellipses, ovals, spirals, to be mapped to proper sounds, derived form the basic ones. Also, our analysis is presently limited to a bi-dimensional case. However, even by means of such an elementary mapping, the result "sounds" surprisingly rich and effective and the system revealed unexpected potentialities in terms of the exploration of sound-movement relationship.

Table 1. Relation between movement and sound

Type of gesture	Sound production
still	Silence
CW	ascending Shepard + simple glissando, depending on height
CCW	descending Shepard + simple glissando, depending on height
straight	simple glissando, depending on height

MnM [10] is a package included in the FTM [11], an external library for Max/MSP, and in it is provided a Gesture-Follower (see [12] and [13]). Unfortunately it was not suitable for our purposes. In fact, this tool is intended for recognizing a large collection of specific objects, while we need to recognize only some more abstract characteristics. Here the purpose is to identify a common characteristic of infinite objects. MnM needs to learn many single object family in order to recognize similar ones. Our aim is to find a common algorithm, a model that is valid for all cases of a general category, for instance, of the curvilinear movements (e.g. circles and spirals belong to the same category).

In EGGS, visual data concerning gesture are processed by a color tracking routine that returns five values. The first one, ranging from 0 to 3, discriminate between stillness, circular counter clock wise (CCW) movement, straight movement, and circular clock wise (CW) movement (see Table 1).

The second value is the scalar velocity of the gesture. The third one is the angle, in radians, of the velocity vector, calculated from the origin. The fourth value is the total angle, in radians, calculated from the starting of the session; this value is useful in order to have a continuously varying angle, avoiding the gap between the end of a circle and the beginning of the next one.

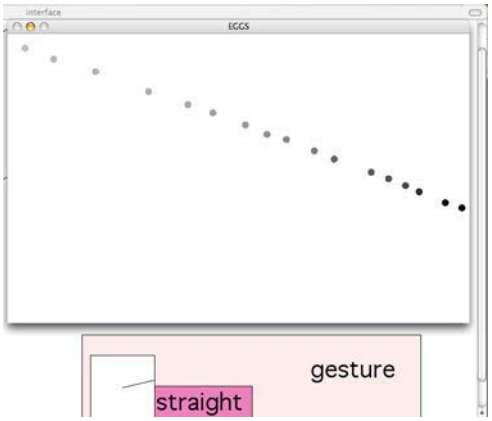

Figure 4: Trajectory detection and classification: a straight movement.

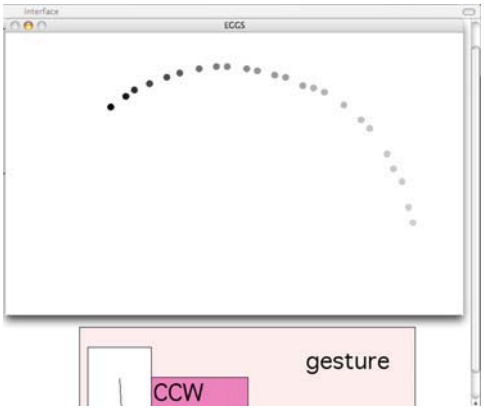

Figure 5: Trajectory detection and classification: a CCW curvilinear movement.

From a technical point of view, the discrimination between straight and circular movements is obtained by measuring the angle variations of the segments generated by three subsequent couples of points, i.e. the centripetal acceleration of the motion. A variation near to zero is classified as a straight trajectory, otherwise the curvilinear category is chosen.

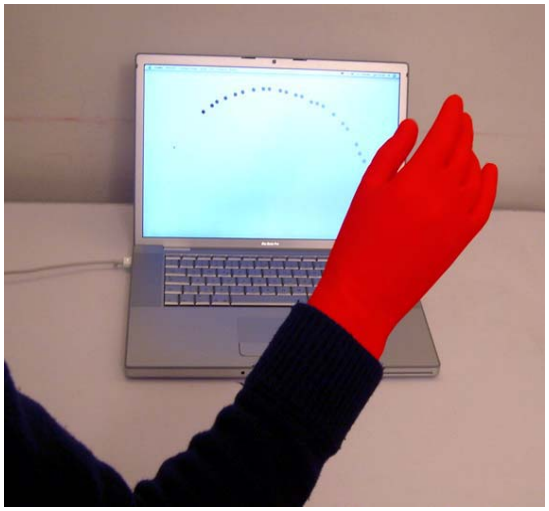

Figure 6: EGGS in action: detection of a curvilinear movement.

5. PERFORMATIVE POTENTIALITIES AND FUTURE DEVELOPMENTS

EGGS provides a basic performance system. Many possibilities of articulation and combination of the elementary mapping are conceivable. We have tested a simple realization of an accumulation process, where stillness is the starting signal of the looping of a sonification. A fast alternation of movements and still instants create polyphonic situations, in which every loop automatically fade out in time.

Also, as in any musical practice, the learnability issue is fundamental. Exercise is important in order to understand the possibilities of the instrument and obtain relevant results. However, not many technical skills are needed as any simple gesture produces a meaningful sonification.

Furthermore, following once more Klee's and Bauhaus' teaching and the "Punkt, Linie, Flaeche" (point, line, planes) paradigm, we are working on an extension of the system in order to define plane sonification. From a sonic point of view, this will correspond to sound textures. More in general, our future plans are to investigate the idea of using gesture as a control of both sound and image generation. We can imagine three directions in creating correspondence between sounds and images: mapping sound to image, mapping image to sound, and concurrent generation of sound and image. With EGGS, the ultimate objective would be to search for novel relations between sound and image by means of recombining abstract categories controlled by gesture. The intention is to investigate if the definition of abstract (gestural) categories and the definition of effective (and independent) mappings for both sound generation and image generation will reveal unexpected relations between images and sounds or video and sounds. A system like this could be adopted for artistic-oriented investigation of cross-modal and multimodal domains spanning sonic and visual media.

The system is conceived envisaging some possibilities for application in performing arts and interactive dance. EGGS may become a complete system through which a dancer, becoming an audio-video composer, would be an ideal (virtuoso) player of an instrument able to reveal novel correlations between audio and video.

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