Andre Marquetti

GameTrak

Contents

GameTrak

Introduction 3

I. Survey of Electronic Instruments 5

How does the joystick works 5

Figure 1 6

Joystick in electronic music instrument and electronic music 6

II. X Y Cartesian Plane and Z, Parameterization in Music and Sound 7

Introduction 8
Deterministic Algorithm 10

Figure 2 13

Randomness 17

Figure 3 17

Gaming 18

III. The interface models 19

Brief introduction 20
Conductor 24
Violin Model 25
Saxophone Model 27
Trombone Model 28
Piano Keyboard Model 28
Conclusion 31

IV. Bibliography 32

Introduction

Gametrak (2000), a 3-dimensional controller, was originally designed to simulate a virtual golf experience. *Gametrak* enabled the possibility of maneuvering a pair of coupled joysticks in three-dimensional space. An ordinary joystick x/y experience was enhanced from the added nylon tethers. 2 joysticks and 2 sets of tethers were mounted on a single efficient interface unit. The total number of possible parameters controls were six (i.e. 2 x x/y/z). Each parameter controlled sounds and images. The force pull back tension of the tethers increased with the outward motion. The added feedback provided the player a feeling of immersion in the play.

Gametrak embodies 3 categories of controllers as described in Mulder (1989.) *Gametrak* is mainly a touch controller but has some element of expanded range controller. This controller type is similar to the touch controller but "contact is only in a limited form…the performer can always 'escape' the control surface and make movements without consequences" (Mulder 1989, p.11). Finally, Gametrak is a very important class of controllers that are referred to, "the Hands, allow the hands move almost freely in space-finger motions are restricted to button press" (Mulder 1989, p.11). While *Gametrak* is not the Hands, it can be attached to the hands of playing musician to enhance performance of her instrument. The Hands and hands controller has an extensive history in the design of new musical instruments.

Since falling off market, *Gametrak* has experienced an upsurge interest as a prototype for new digital instruments (Burleson, Freed, Hansen, Jensen, McCutchen, Mesker, Skriver, 2009). These authors argued that the benefit of the Gametrak is its “flexibility” and “platform technologies for a wide variety of musical instruments and interactions” (SMC 2009). Their conference paper concluded: “the *Gametrak* is a convenient platform to learn about mapping strategies and can facilitate rapid “sketching” of user interfaces that may ultimately use untethered or inertial sensing” (Ibid.). I have identified and divided three major areas to introduce some designs within their appropriate context:

1.Hands Theremin model

2.Immersive controllers

3.Augmented instruments

The objective in the following paper is to explore some of fruitful interactions of *Gametrak* with performers and music composition. My approach will introduce fundamentals of electronic instruments while integrating *Gametrak* as a key element. A benefit of *Gametrak* is its internal design that includes both analog, like kinetics gestures of the hands, and digital computer counterpart.

Survey of Electronic Instruments

How does the joystick works

The basic idea of a joystick is to translate the x/y movement of a plastic stick into electronic information a computer can process. Joystick controller parameters function like sliders on a synthesizer (i.e. 2 sliders) whose levels are combined to control sound. The central position of the joystick corresponds to zero in the x/y Cartesian plane. Movement from left, right, upwards or downwards, changes value -1.0 to 1.0 horizontally and vertically, such that w = f (x, y) {(-1, -1), (-1, 0), (0, 0), (0, 1)}. The value -1.0 to 1.0 is normalized in any range suited for a particular function. The joystick is designed to control parameters in two dimensions over a continuous stream of values. It is not a good controller to effectuate steps e.g. a scale as a fast, jerking movement lacks precision. A better alternative to compensate for the "lack of precision" is to map specific regions or points triggered within the proximity of the joystick.

Data translation of *Gametrak* has no clear center (0, 0) x/y. The *x/y* mechanism has no pull force to bring the wand back to center. On the other hand, the *z* mechanism has a strong pull force to return the tethers to a state of rest. *Gametrak* is not calibrated with a continuous float 0.0 to 1.0 but integers 0 to 4000. The center is around (2000, 2000). Float values 0 to 1 is more desirable for sound synthesis parameters. To truncate the range it must be divided by 4000 (Fig 1).

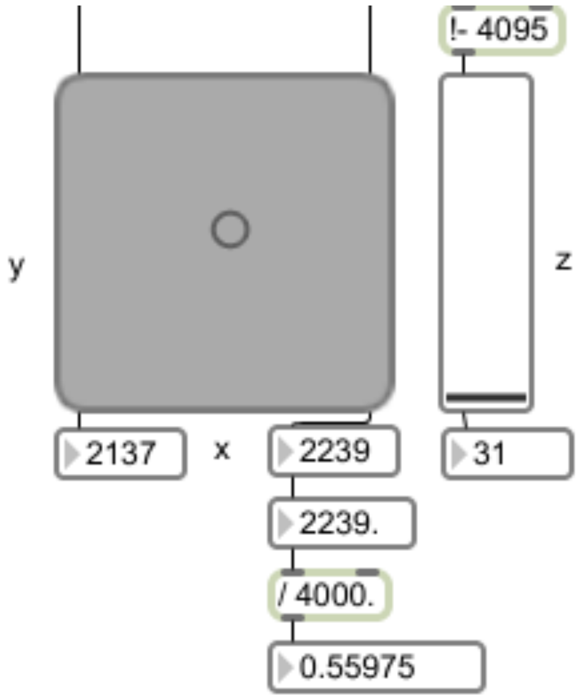

Figure 1

Joystick in electronic music instrument and electronic music

"As a bass player I wanted to bend pitch, I wanted to get some emotion into the thing, some loudness, some softness, and so on. We discovered that if we altered the voltage that went to the filter we could make the sound softer and louder, piano forte like, and also if we varied the voltage going to the oscillator a little bit we could get this pitch bending . . . I was hearing this stuff and couldn't get in between the cracks of the piano, so to speak." To further "get in between the cracks," Malcolm went out and got himself a model airplane joystick. He "fixed it up" so that in one direction it controlled pitch, and in the other direction it controlled the filter. This controller finally gave Bob and Malcolm the feeling that they were able to create "musical lines." (Pinch and Trocco 2002, p.179)

The introduction of analog synthesizers enabled a common voltage control knob to run a variety of modules (i.e. circuits). These modules affected, the parameters of sound in real-time. The typical voltage of a wave oscillator changes over a continuous range with a manually controlled knob. The infrasonic region (from 1Hz to below 20Hz) is useful as a controller for frequency and amplitude modulation. The audible frequency is above 20 to 10KHz audio attenuation (for reference, a 7 octaves keyboard encompasses frequencies 27.5 to 4186.01Hz). The circuits (i.e. discrete modules) of the synthesizer oscillators, filters, and amplifiers allow sharing of inputs and outputs. Break-points in the network are designed to allow a current to flow from any module to another changing the synthesis. The synthesizer keyboard, originally designed to emulate a piano or harpsichord playing, made the electronic interface look like an instrument familiar to most musicians. The joystick on the other hand, was introduced to enhance real-time playing nuances not readily available from an electronic keyboard. The *Gametrak* can do much more than just expression with its 2 joystick x 2 tethers interface. One set could be used strictly for expression and the other for synthesis parameters. Joysticks or *Gametrak* function as expressive real-time controllers. The joystick was conceived to add a human feel to the electronic, like a violin's vibrato. Its particularity is the correlation of movement with space and time. A two-joystick *Gametrak* unit can have two forms of "interaction" with two "forms" of rhythm or feel simultaneously.

The joystick interface was preferred to pan sound in space over loudspeakers (stereo, quadraphonic or octophonic). The configuration of loudspeakers reflected geometrical models of the square, rectangular, circle or eclipse.[1] Performance strategies were devised to explore the ambient nature of these shapes. The space movement of sound represented a unique electronic attribute. It simulated gestures based on the visceral characteristics of sound. The composer conceived sounds spatially with gestures suited to the music. Gestures could be further reinforced by sounds rendered from the additional instrumental source. A performer could of course play electronic instruments, such as synthesizer or mixer, and performance may be completely electronic "acousmatic."

The keyboard mapping was more reliable than joystick. Just like *Gametrak*, an additional feature of the early analog joystick was that it extended "control still further by suspending the bearing itself in a flexible mounting, permitting a third voltage output to be generated by movements in the vertical plane."[2] Three-dimensional mapping of parameters joystick controls require skills.

X Y Cartesian plane and Z, Parameterization in Music and Sound

Introduction

The *Theremin* (1928) proposed a multi-dimensional x/y/z spatial mapping of sound with physical attributes. *Theremin* spatiality involved handling the instrument with hands and arms kinematically, extending or contracting gestures within the proximity of two

---

[1] Noteworthy compositions for loudspeakers spatialization are Varèse *Poème électronique* (1958) 425 loudspeakers in Le Corbusier "Philips" pavilion, Stockhausen's *Sirius* (1977) 8 loudspeakers surrounding the audience, *Spiral* (1970) "50 loudspeaker groups in seven rings at different latitudes around the interior walls" of a sphere (http://en.wikipedia.org/wiki/Expo_%2770) and Emmanuel Nunes *Lichtung I* (1991). The panning above diffused mostly recorded sounds or real-time performance. *Sirius* was an all-analog *Synthi 100* synthesizer piece. The instrument joysticks were utilized in the live production of sounds and panning with faders.

[2] Manning 1985, p.123.

antennae, “giving a performance a unique theatricality” (Holmes 2002, p. 20). The *Theremin*’s sound was a monophonic sweep of sine wave frequencies with volume (amplitude) modulation.

The *Theremin* produced enough audio sidebands to make it an expressive instrument. Its ethereal sound and unusual interface inspired a new generation of performers. Most notably are Clara Rockmore (1932) and Lucie Begelow Rosen (1930) who championed the instrument by playing the most virtuosic melodic lines with the same expressivity of a violin, harp or clarinet. To achieve a desired melodic line, a performer had to probe pitches in a delicate manner while synchronizing her movement with the volume antennae. The system suggested a new means of performance extending physical movements. The possibility of immersing the body in an electro-magnetic field led to an electronic control environment named the *Terpsitone,* designed to spatialize dance movements with the *Theremin*. Although the *Theremin* emulated familiar instrument, it nevertheless remained the most authentic instrument of the electronic era. Its most influential feature was the introduction of the “hand” as a new mean of controlling expressivity.

Similar instruments adapted to the “hand’s” more flexible motion, followed in the analog and digital realm. Some examples of these instruments included Moog *Theremin* modified antennae (Roads 1996, p.654), Waisviz *Hands* (1984) shaped pair of metal plates (Homes 2002, p.23), Sonami *Lady Glove* (1991) (Collins 2006, p.193) Marty explains “Sonami uses her own glove and her movements are integral to the performing;

her has/had involves improvisatory realization, in which prerecorded sounds and her live speech and voice are subjected to synthesis."[3] Like Sonami, mapping the *Gametrak* could involve narrow ranges to activate sound samples or midi data. Other examples of the dataglove include Tod Machover *Electronic Gloves* (1990) (Taruskin 2005, p.508). *Gloves* are a type of immersive controller.[4] Machover's *Bug-Mudra* (1990), the music played by two guitars and one percussionist, is modified during the concert by the movements and gestures of the conductor's *dataglove*. This is among the early examples of digital hypermedia compositions.

Deterministic Algorithm

Deterministic Algorithm in informal terms, behaves predictably. Given a particular input, it will always produce the same output, and the underlying machine will always pass through the same sequence of states.

(http://en.wikipedia.org/wiki/Deterministic_algorithm)

Music is a complex art form to suggest remotely a foreseeable deterministic algorithm. On the surface, music is indeterministic within certain deterministic constrains that are dictated from a composition. Pitches and rhythms perhaps can be very precisely notated. However, two performers rendering the same piece will sound different. The gestural semantics of performers is a wide open-ended subject. Music notation is inexact and dynamic inflections are relative. Graphic notation with some constrains leaves all

---

[3] Marty (1988), in Dean 2003, p. 39.
[4] Miranda and Wanderley 2006, p.43.

parameters open to be determined. Parameters in a composition are interdependent. Timbres can best be described according to the composer's words. Music is spatial; McDermott (1972) argues "this spatial factor is a complex matter but has an embryonic form in the notion that pitch change is somehow spatial change." More importantly, McDermott relates to this notion of the pitch space to the interval space, register, density, and other factors which "are all spatial relations, frequently allied with temporal ordering…but spatial all the same." McDermott is critical in his deliberate attempt to formulate pitch space suggesting that "musical space is patent nonsense to some people…space is a safe, secure, well-ordered, and self-evident domain which will not suffer an association with impalpable sounds moving in time. Perhaps acoustics relates to space but not our concept of music."

The *Theremin* was introduced as a pioneering electronic instrument to study axial plane. In the context of "space," the *Theremin* is a model of deterministic algorithm. Only pitch *x* and amplitude *y* mapped the performer kinematics gestures *x/y/z*. The one dimensionality of the *Theremin* demonstrates flexibility for sound sculpting and wide ranging music expression. The *Theremin* parameters do not take into account the sound acoustic of a space (i.e. sine wave interact with the room.) Movements of the performer take hold in a continuous field. Can a performer with *Theremin* generate perfect octaves intervals? McDermott research's is based on the psychoacoustics of Helmholtzt.

McDermott formulates the following:

What happens in one octave within the context of the theory of the articulation of musical space is not in any way identical with something occurring in another octave, even a like *thing, e.g., the same motif. In other words the pitch-shape of a composition, the counterpoint of registral articulation, is too important a factor in the formation of the total event for the conceptual identity of the work abbreviated in one octave, one chord, twelve notes, or one. Octave equivalence is no longer operative. (McDermott, 1972)*

Acoustics with electro sources increase the level of audio information in space. McDermott's space is a space that "tolerates a multiplicity of uses of the concept so long as, in so doing, we provide ourselves with a fruitful heuristic device." McDermott proposes that time can be conceptually broken down in discrete units of space. A gesture has continuity (i.e. x/y) and relationships that can be followed, mapped according different scales. *Gametrack* interaction may be considered a two-type gestures system, where one form of feedback is responding to kinetic motion of the controller and the other is the actual instrument sound feedback (e.g. a violin.) Both gestures feedback network require the same consideration in order to establish a tight relationship of *Gametrak* and performer, which is the main objective of this paper: to develop non-traditional instrument fruitful designs.

In the music of Edgard Varèse (1983-1965) for example, Erickson (1975) explained on the individuality of timbres: "Pitches comprising the chord are difficult to hear out…he himself used such terms such as *sound-mass*, *interaction*, *projection* in a highly personal way, without going into technical detail in any of his published writings" (p.21). Erickson states: "I do not believe it possible to continue the fiction that pitch and timbre are independent separable dimensions" (Ibid.). Digital synthesizers, on the other hand, were designed to provide plentiful deterministic algorithms. The fine control of digital instrument of pitch for example, downgraded the analog sound representation of spatial perception (i.e. the Theremin.)

Gametrak has been studied as a Theremin application for calibration, mapping and scaling "simulating distance from a upright antenna, and the other hand, controlling volume based on z-axis extension, simulation distance from the Theremin's loop antenna" (see Fig 2).[5]

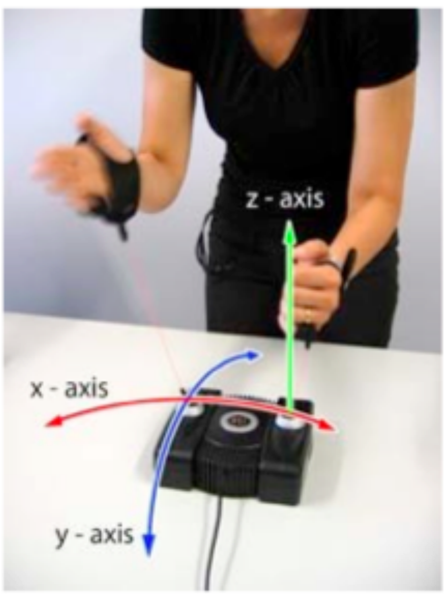

Figure 2: Tethered Theremin control axes

The benefit of the Theremin, Mulder (1989) explains: "Gestures are effective only within the range of the sensing field, while control surface does not exploit the full dexterity of

[5] SMC 2009, *Gametrak* Conference Paper.

the hands, because the gestural expression is reduced to only two variables" (p.13). A drawback of *Gametrak* is that it has to many parameters to map to. *Gametrak* is greatly enhanced if it is simplified.

Randomness

Gametrack has too many controls and every parameter can be mapped independently or combined, that is *X1-Y1-Z1* with *X2 -Y2 -Z2*. The most raw mapping (i.e. random) is a chain of permutations from one to six. Mapping functions are now introduced to explore music space with *Gametrak*.

This is a preliminary stage hoping to establish a more coherent logic and fertile dialogue between interface, digital systems and human performer. Boersen's thesis (2008) seeks to understand the nature of gestures from a violinist. Boersen conceives a simple feedback loop of performer skills and machine musician as a "chain function" of input/output and output/input. The following is his "chain function" but simplified:

For *B* the skilled performer function is *Xa* input machine musician, returns *Yb*. On the other side, *A* machine musician function is *Yb* input skilled performer, returns *Xa*. The internal process is the function *I*, *B* to *A to B* (p.62). Boersen explains his approach: "My own works often encompass tools such as metaphors and analogies represented by algorithms subsequently implemented into the computer environment. These algorithms simply represent a different aspect of our knowledge of the behavior of musical expression" (Boersen 2008, pp. 43-44).

A conclusion from his systems is that the performer and machine are open to adaptation and learning from what each can do. The simulation of computer feedback from performer may be discontinuous, while the response computer feedback to performer is continuous. This formulaic approach “machine musician” of Boersen is an interesting area of investigation “stochastic processes” in neural networks application of the *Gametrak*. This could be useful in the area of calibration when a simple one to one mapping is not possible. Below I will complement my conclusions in having to train the *Gametrak* with some kind of “neural net,” with two major points from Roads (1996):

1. Nonlinearity is essential for endowing the network with “decision-making power.” That is, quantitative changes in the input can produce qualitative changes in the output, rather than simply moving in direct proportion to the input.

2.The feedback (from output layer to the input layer) gives the network a memory of its past output. Traning forces the network to construct an abstract melody space in which each melody is represented by a point in the space. (pp. 904-05)

Boersen divides the “internal/external” processing cycle of “machine musician” in three stages: listening, generative, and actualization. At the output end of the processing’s line, Boersen is interested in electronic synthesis between performer and sounds. Miranda and Wanderley (2006) classify the feedback between the digital synthesis as secondary, and the gestural controller as primary (p. 3). For *Gametrak* , to be an effective instrument, the performer's axial movement must be the main parameter for consideration, not the sounds produced. The sounds are only consequential to fulfill or complement the needs and desire of musical expressivity. Boersen's preliminary modeling begins with Garnett and Goudeseune's research (1999): "We consider the family of sounds produced by a musical instrument as lying in a Euclidean space. The axes of this perceptual Euclidean space are given by parameters such as pitch, loudness, and various psychoacoustic measures of spectral content. A similar space is given by the control parameters of the instrument which may be both more numerous and more difficult to deal with abstractly" (Boersen 2008, 49). Although there are various gestural controllers that incorporate different physiological parts of instrument playing, Boersen is in concordance with the early analysis of *Theremin* and hand's paradigm. Better stated, it is this dissociation of the hands that is particular to an electronic controlled instrument in contrast to the traditional mode of instrumental playing.

Boersen considers each of the required movements to generate a tone in the violin as "divergent dimensionalities that would accurately depict the space the hand occupies" (Boersen 2008, p.50). The spatial model of Boersen's analysis is divided into three branches: *physical stance*, *manifold*, and *singularity*. For *physical stance*, Boersen has in mind the handling of the violin with player's left hand. Spatial dimensionality of left hand is informed from the haptic feedback network, between the player's movement on fingerboard and bowing intensity. Both exert the same intensity level on the player's interpretation of a melody. This is a simplified spatial model. Many more factors would have to be accounted for the player's feedback. The *manifold* is "the potential ability to zoom into the excess of dimensions that make up this space of the corporal hand – a multidimensional manifold of dimensions, unfolding and enfolding space in focusing on specific skills" (Boersen 2008, p.50). All expressivity is in the *manifold*. Boersen shows an axial coordinates figure of his *manifold* with disorderly random vector lines emanating from each point of pressure exerted from the left hand on the violin neck, fingerboard. Finally, *singularity* represents the dexterity of performer or suppression stage, "it is in this context that the performer can evidently equally well represent her hand by means of a convergence of the multi-dimensional manifold into a singularity" (Boersen 2008, p.51). Boersen suggests that the same proto-model can be simulated. It is the composer's creative choice to dictate in how to best model the system described. In *Figure 3* are isolated gestures that, performers are inclined to make with their instruments. They are not necessarily gestures adapted to the natural playing of the instrument. It is advantageous to exaggerate the gestures with *Gametrak* in order to optimize the too wide range with the narrow response of the tethers pulling.

Figure 3:

Gaming

The proliferation of joysticks in electronic games needs no further examination. Many games are played in multi-dimensional spaces triggering an extensive library of audio effects. In a game, the player's objective is to battle an opponent or solve some threatening obstacle (e.g. a maze). If the game is well designed the experience will be rewarding for the player and listeners. Listeners are extrinsically woven with controller's interface. A new design necessitates an observer beyond the specialized user and expert system. During play, for example, a series of clues could assist the player navigate the Gametrak. Movements' localization in space can become complex. A point repeated will always follow different trajectory. The flux that results from points in space is here referred to "emergence." Holland (1998) defines "emergence" "the product of coupled, context-dependent interactions" giving birth of a "nonlinear" system. (p.122)

The behavior of the overall system cannot be obtained by summing the behaviors of its constituent parts (i.e. various trajectories where every point belong). *We can no more truly understand strategies in a board game by compiling statistics of the movements of its pieces than we can understand the behavior of an ant colony in terms of averages. Under these conditions, the whole is indeed more than the sum of its parts. (Holland 1998, p.122)*

In his discussion "emergence" Holland (1998) proposes that it can "reduce the behavior of the whole to the lawful behavior of its parts, if we take the "nonlinear" interactions into account" (p. 122). The *Gametrack* necessitates a teaching method of the system during performance.

Literary computer's scholar Aarseth (1997) proposes a different perspective "emergence" complexes "by intention, fault…and produce results that could not be predicted by the system's designer." Aarseth's fantasized example is "a chess program that plays better than its programmer" and argues "even if there is no reason to suspect that anything but meaningless operations of shifting zeroes plays a significant behavior - that is not be anticipated by its programmer." Aarseth concludes, "the ability to predict (i.e. the winning chess program) and counter its opponent's strategy is a form of interpretation (the machine) that involves something (the signal) that stands for something else (the move) giving rise to a third something (an estimation of the opponent's strategy)" (pp. 22-23). This is Aarseth's speculative interpretation on the machine threshold. A program will outperform the player *Gametrak* movement semantics.

The Interface Models

In all music there is manifestly implied the rational relationship between the chaotic image of an unlimited, unconditioned, and disordered universe of all audible phenomena and a tentatively defined image of an equally disordered but artificially limited and conditioned subsystem that we at a given time consider our temporary acoustical all. (Brun 2004, p.192)

Brief introduction

The interface is the low level-processing unit between an instrument and a controller, performer and interactivity and interactivity and spatiality.

A well-designed interface requires 3 main considerations: 1) association, 2) repeatability and 3) immediacy.[6] Miranda & Wanderley (2006) layout a scheme for the steps needed to design a new digital music instrument:

a. Decide on the gestures that will be used to control the system.

b. Define gesture capture strategies that will best translate these movements into electrical signals.

c. Define sound synthesis algorithms that will create the sounds to be played.

d. Map the sensor outputs to the synthesis and music-control inputs.

e. Decide on the feedback modalities available. (p.4)

If these strategies are successfully implemented the use of the interface sparks the chain reaction performer using technology to provoke audience engagement. *Gametrak* has had its moment of golden opportunity, just like the *Theremin*, all technologies age.

How and where the interface is conceived in the process of music making in relation to audience experience was explored in Parker and Jordan (2001) as the 5 keys model to study the vast field of electronics arts, *integration*, *interactivity*, *hypermedia*, *immersion*, and *narrativity*, these are described:

1. *Integration*: is the hybrid form of expression.

[6] In conversation with Peter Elsea 2012.

2.*Interractivity*: interpreted as the user's ability to manipulate and affect one's experience.

3. *Hypermedia*: is the linking of separate elements to create a trail of personal association.

4. *Immersion*: is the experience into the simulation of a three-dimensional environment.

5. *Narrativity*: concerns the aesthetic that derive from the above concepts which result in non-linear story.

(Parker and Jordan 2001, p.35)

Interactivity and *Immersion* appear more specific to interfaces design of the *Gametrak*. *Narrativity* would most likely be the initial stage, specially, new controllers that involve music. Inspired by Wagner's total theater *Gesamtkunstwerk*, the interface is most compelling if it has features of each *Integration, Interactivity*, *Immersion, Hypermedia,* and *Narrativity*. It is a futurist model where the natural (i.e. human flesh) is intrinsically and extrinsically linked to the virtual and synthetic technological man made artifacts.

An alternate controller that has been successfully applied and has managed to capture some of the key *Gametrak* considerations, is Pendphonics installations: " *Gametraks* are ceiling mounted with balls attached to the tethers designed as counterweights to the spring-return force of the tethers reels and to create physical dynamics that are engaging for users."[7] The ball has the advantage of pulling the *z*-tether far enough to maximize the full range of the x/y coordinates "multiple channels of loudspeakers are used to spatially

[7] SMC 2009, *Gametrak* Conference Paper.

distribute the sounds that are generated, enhancing the sense of physical immersion in the space."[8] The ball effectuates all movements x/y/z.

Parker and Jordan illustrate *Interactivity* with classic essays from Wiener (1954) on the cybernetic's feedback "message" a form of pattern and organization. The cybernetic "message" is a way the interface signals a musician's feedback motion patterns. The patterning is conditioned to a deterministic algorithm. Using the four multi-speaker channel system *Gametrak* controller, for example, a performer experiences and identifies his movement with the panning of sound around the room. The Feedback of *Gametrak* is a series of differentiated trajectories with statistically repeated points in space. In music these trajectories project different feelings, accentuating many inflections of expression. Some recent developments Smalley's recent music[9], in this area, explore sound in narrow spectral space locations in a room. Music is spacious.

In contrast Ascott's (1966-1967) essay is concerned with randomness or chaos algorithms " purposive" behavior. In the deterministic concept of art "was centered upon the structuring, or *composition*… by contrast modern art is concerned to initiate events and with the forming of concept of existence" (Parker and Jordan 2001, p.97). Similar to Ascott, Krueger's (1977) essay considers the body both as a "concept of existence" and "form of patterns." Krueger is known for her design "sensitive" responsive environments. In her work *Psychic Space* (1971) participants' footsteps triggered sounds, "with high

---

[8] Ibid.
[9] In conversation with Rodrigo Sigal.

notes at one end and low notes at the other." The environment is "turning the participant's body into an instrument" (Parker and Jordan 2001, p.117).

In Pendphonics this is exactly the situation, or participants are invited to play with a ball, a familiar situation. The game algorithm in essence is a dance between the controller interface and the performer. But this dance can also lead to confrontation. The game board is spatially designed. If one-dimensional axis is a temporarily constant, the axis y/z is a temporary checkerboard. The duel between performer and parameter mapped give form of "emergent" behavior and uncertainty music phenomena. An attractive element of Pendaphonics with *Gametrak* is to perform this game in a 3-dimensional space in "diverse ways of throwing and catching sounds."[10]

Below is an attempt to retrieve main characteristics of the interface designs in augmented instrument. The table is a model to examine affordance variants. In computing "affordance" is defined "as a visual cue to the function of an object."[11] The table is organized according different familiar instrument. For example, a trumpet is subdivided in two forms, the instrument and corresponding controller. Both are interrelated. Miranda and Wanderley (2006) described the instrument as a "mapping of gestures to synthesis parameters of a physical model could be gestures to the synthesis parameters of a physical model could be considered more straightforward because the relation of these inputs to the synthesis algorithm already encompasses the multiple dependencies based on the physics of the particular model" (p. 15). The division devised between instrument

[10] SMC 2009, *Gametrak* Conference Paper.
[11] http://dictionary.reference.com/browse/affordance?s=t

and controller is presented here ad hoc and somewhat abstruse. The intension is to contrast the *Gametrack* with the diversity of controllers augmented instruments already available. These include on expanding the idea of an augmented orchestra and augmented environment controller. Doonrbusch (2002) contrasts composition "the physical and abstract" modeling of gestures simulation algorithmic, deterministic, chaotic and game. *Mapping in algorithmic composition is different from mapping in instrument design because composition is a process of planning and instruments are for real-time music production. The use of mapping which is integral to an instrument has both differences and similarities to the mapping that is an inherent part of algorithmic composition. (Miranda, Wanderley 2006, p.15)*

It is a fact that the space and time of sound and performer in controller is not a direct line from *A* to *B* but many intermediary stages. Acoustic instruments always play the same scales. The ideal is to merge the electronics, gestures interaction and instrument. For some controllers and instruments interface, the algorithm is the composition itself. The interface is designed to enhance the flexibility of actual performance. The act of composition is the real-time manipulation of instrument with controllers. Improvisation with the system is the preferred medium of music making.

Conductor

The Controller:

Hofmann (1994) *Sensor Glove* was designed with a tracking 24 finger ankles and 3-hand acceleration for extraction values. Sensors variable mapped sound, video and animation. The

Glove is a prototype to model some mechanisms of hand/arm and brain feedback system. It branches in the biotech field. It suggests new possibilities employing the "hand's paradigm" for the conductor, *Theremin* player, keyboardist or saxophonist. The *Glove* is an instrument for analysis, performance and a tool for research. Modler (1998) direction states "our focus on the mapping of these gestural variations into relevant musical parameters leads to the concept of symbolic and parametric subgestures (i.e. emotions)."

A straightened index finger indicates mouse down (symbolic subgesture) and moving the whole hand determines the alteration of the position of the mouse (parametric subgesture). (Modler 1998)

The qualities "to affect" emotions introduce a new subject area to mapping the Gametrak tactile interface with spatial parameters. Molder's system divides music emotions in two states: 1. static and dynamic, and 2. symbols and time variants. The static quality of music emotions associates pitch register (low and high) with colors and facial expressions. Dynamic emotions are experiential. Their affects are variations in tempi, phasing, mass (i.e. density), texture, timbre, and volume. Music "emotion" is equivalent to the expressive means to shape performers parameters trough the interface.

Violin Model

The Controller:

Overholt (2005) "overtone" violin is a hybrid-designed instrument. The body and feel of the instrument was preserved with the intension to enhance playing at a high level. The "overtone" violin was designed with six strings extension loaded with an assortment of sensors. The abundance of sensors enabled the composer to devise singular, multiple, and complex strategies aiming the fact that "traditional instrumental techniques are not well suited for the parametric control of audio signal processing, so gestural controllers are needed as well” (Overholt 2005).

a: the instrument:

Among sensors included:

-Miniature video camera: detects direction the violin is pointing.

-2 channels of sonar: detects whatever the violin is pointing at.

These sensors are useful for velocity parameters whereabouts of the violin, the “trajectory and points” aforementioned.

-A control unit was conceived in the backside of the head. It included a miniature joystick, two linear potentiometers, and two buttons “accessible with the knuckles while playing the violin strings—these are useful for changing modes without having to switch hand position” (Overholt 2005). Overholt and many other designers are expanding the gestural scope of performers. Like Boersen’s thesis (2008) the violin is perfect model for axial motion simulation. The subtlest movement maps all positions relative to a coordinate point. The instrument is “played with a bow, as the performer wears a glove with embedded gesture sensors on the right hand” (Overholt 2005). Many of the sensors can track similar parameters (i.e. the velocity). Their function within the design is to facilitate different degrees of precision, feedback and controls mapping. The accelerometer in the glove is for sensing “both acceleration and tilt (with respect to gravity) on two axes. This gives the performer a virtual x/y joystick and captures relative gestures of the bowing hand arm” (Overholt 2005). Many instrument designs, like the

Violin Overtone are kinematics in their nature that extract the physical parameters of playing rather than acoustics. “ The sonar sensor is used to capture absolute movements between the glove and the body of the violin” (Overholt 2005). The hand and violin body position introduces a new layer of non-linear spatial coordinates. There are many more micro and macro considerations in a performing model. Trying to determine a system that models movements’ attributes of a player will require the means and sums that are extracted from the sensors data acquisition network, violin and bowing motion.

Gametrak could be greatly enhanced from the above by adding a K Bow for example. Visually in a performance situation, the K Bow would not distract the effect of the *Gametrak.*

Saxophone Model

The Instrument:

Wanderley (2005) designed research to track gestures with a group of clarinetists performing the same music. Their performance was recorded on video and each frame was analyzed to observe consistencies pattern. A table showed the most common movements and their frequency. Higher ranks in the table are the bell, up down motion and head up down. In the middle is found arms flapping, waist and bend knees. These movements it had been observed that “when a clarinetist moves relative to a microphone, the amplitude and phase attributes of the direct sound change in relation to those of the floor reflection. A specific movement may cause sinusoidal partial amplitude modulations that play a subtle role in the resulting sound recorded at particular microphone positions" (Wanderley & Depalle, 2004). A gestural comptroller attached to the player would accentuate movements specially those that are found low ranked in the chart including the bell circle, back curl, and weight shift left and right.

A display could be set up to help performers track their positions with *Gametrak.*

Trombone Model

The instrument:

A special case of live electronics interface was Gordon Mumma's series *Cybersonic* (1966) unit augmented brass instruments. These units were mini analog circuits parts, amplifiers, delay, filters, phase shifters and ring modulators. They provided a limited gamut of real time input audio transformation. Many of the circuits did not work properly. Their accidents were a welcome part of the composition. These devises were further conceived to work in the ambits of the performing space. The circuit box was slung around the performer's neck or was attached to the performers ether belt or arm. In *Hornpipe* (1967) Mumma's *Cybersonic* unit included a computer analog technology. "It analyzed and respond through loudspeakers to the resonances of the performance space which are actuated by the sounds of the French Horn" (Appleton and Perera 1975, p.308).

Piano Keyboard Model

The Instrument + The Comptroller:

The "Joystick" was built in the early digital keyboard synthesizers. Some parameters of "expressivity" used to affect musical phrasing and "form" are examined. The strategy is to expand the scope of gestures acquisition. The keyboard synthesizer has a very old performance history. The musicians interface familiarity will always enhance the exploration of new “gestural” acquisition. In this sense, gestures are like features of everyday language. They need to be taught and practiced. Gestural messages are a natural human endowment. Gestures are: 1. symbolic or passive, the hand sign of praying, 2. active and functional, the traffic lights controller or 3. dynamic or interactive, the baseball game players strategies. Sapir (2001) proposes the following two poles in gestures acquisition; “the problem is not to play with an instrument, but to interpret a score with different levels of interaction from the complete automatic performance” to the free choice “improvisation.”

Controller modules on the synthesizer “criteria of automation to none” identifies “timing” and “value” in the following manner:

1. Direct Acces (the keyboard): “time comes from” gesture, “value comes from” gesture (i.e. midi velocity and pitch number).
2. Sample and Hold: “time comes from” score (i.e. the noise generator or sweep wave oscillator), “value” comes from gestures (e.g. signal sources, modifiers, and controllers patching).
3. Sequencer: “time comes from” gesture (i.e. keyboard performance), “value” comes from score.

(Sapir 2001)

The synthesizer is a mixing box[12] where "a staccato touch may produce a legato sound" (Pressing 1992, p.136).

Gestures are a felted (the tone body) and seen, "Pollick (2004) investigated the expressive content of actions like knocking or drinking.[13]" Many gestural parameters can be analyzed from a performance mode that is associated with a particular music genre. These gestures are identified with their associated rhythmic and durational formulas.

Glissandos are common instrumental gestural articulation (clarinet portamento or violin). They enhance "gestural" dynamics. Synthesis parameters can mimesis the cause and effect of these gestures. The *Gametrak* could effectuate a variable rate portamento in both axes. The x-axis portamento glides to pitches during the joystick travels. The y-axis can add glissandos in pitches-y position or intervals deviation in the continued motion. Interval deviations can be mapped to narrow intervals from diverse tuning system. The resulting movement leads to a curved space combining both portamento and glissando point to point from an origin to a targeted destination. In performance expressive parameters timing constrains otherwise continuous controls value. For example:

The main factors characterizing vibrato include depth, speed, waveform, polarity, and onset point, where polarity refers to whether the pitch deviation is to one side of nominal

---

[12] See *The Pacom, can be considered a "control desk." Similar shape to a mixing console, it houses…linear and rotary potentiometers, shaft encoders, joysticks, and trackballs. In total, the Pacom has 24 sliders of various sizes, 2 multiturn potentiometers, two joysticks (with two and three degrees of freedom), 1 linear touch sensor, 6 shaft encoders (4 positioned vertically and 2 horizontally), 72 switches (of two different types), and 1 trackball. These amounted to 108 control devices, both discrete (on-off or step output) and continuous. (Miranda and Wanderley 2006, p.36)*

[13] See (Camurri, Polli, Friberg, Leman, Volpe 2005).

note pitch (monopolar), as the classical guitar, or on both sides (bipolar), as is common with the human voice. In playing "traditional" vibrato correctly the performer should bring in the vibrato effect a variable amount of time after the note begins to sound: rather slowly on long notes, more rapidly on medium duration notes, and not at all on passages of quick notes. (Pressing 1992, p.176)

An elementary factor of the LFO used to make the vibrato has reached its critical band, sound changes its spectral characteristic. *Gametrak* can be mapped to explore these different areas of perceptions. Gestures feedback is intertwined with psychoacoustics, both micro and macro spectral variations.

Conclusion

A lot could have been said on how *Gametrak* can be mapped with sounds and images. For clarity of this paper it was necessary to avoid suggestions, although many have been implied. Technologies come and go, need innovation and revisiting why they were made in the first place. What this paper has tried to accomplish is to present a vigorous expose of controllers in which *Gametrak* belongs. The Theremin is about the performer being in a system. With *Gametrak*, the player is in essence trapped into the system with the tethers. If the feedback of this system is internalized the computer and music co-exist a space. In this space the computer is a vital organ of the performer. Computer is still in this context the most powerful instrument that control and generate sounds and images and influence the performers' actions.

VIII. Bibiography

Aarseth, Espen J. (1997), 'Cybertext : perspectives on ergodic literature'.

Appleton, John, H. and Perera, Ronald (1975), The development and practice of electronic music (Englewood Cliffs, N.J.: Prentice-Hall).

Boersen, Ronald (2008),), 'Musical Expression, Exploring a Virtual Analogy of Interactive Performance', MA Thesis, Royal Conservatory, The Hague.

Camurri, Antonio, et al. (2005), 'The MEGA Project: Analysis and Synthesis of Multisensory Expressive Gesture in Performing Art Applications', Journal of New Music Research, 34 (1), 5-21.

Collins, Nicolas (2006), Handmade electronic music : the art of hardware hacking (New York: Routledge).

Dan, Overholt 'THE OVERTONE VIOLIN: A NEW COMPUTER MUSIC INSTRUMENT', <http://hdl.handle.net/2027/spo.bbp2372.2005.003>.

Dean, R. T. (2003), Hyperimprovisation : computer-interactive sound improvisation (Middleton, Wis.: A-R Editions).

Erickson, Robert (1975), Sound structure in music (Berkeley: University of California Press).

Fels, Sidney, Gadd, Ashley, and Mulder, Axel (2002), 'Mapping transparency through metaphor: towards more expressive musical instruments', Org. Sound, 7 (2), 109-26.

Frank, Alexandre R. J., et al. (2006), 'An architectural framework for interactive music systems', Proceedings of the 2006 conference on New interfaces for musical expression (Paris, France: IRCAM \&\#8212; Centre Pompidou), 150-55.

Goudeseune, Camille (2002), 'Interpolated mappings for musical instruments', Organised Sound, 7 (2), 85-96. Goudeseune, Camille Martin Anthony (2001), 'Composing with parameters for synthetic instruments'.

Holmes, Thom (2002), Electronic and experimental music : Pioneers in technology and composition (New York; London: Routledge).

Hunt, Andy and Wanderley, Marcelo M. (2002), 'Mapping performer parameters to synthesis engines', Org. Sound, 7 (2), 97-108.

Hunt, Andy, Wanderley, Marcelo M., and Lazzarini, Victor (2007), 'Eduardo R. Miranda and Marcelo M. Wanderley: NewDigital Musical Instruments: Control and Interaction Beyond the Keyboard',Computer Music Journal, 31 (4), 75-77.

Leman, Marc, et al. (2005), 'Prediction of Musical Affect Using a Combination of Acoustic Structural Cues', Journal of New Music Research, 34 (1), 39-67.

Manning, Peter (1985), Electronic and computer music (Oxford; New York: Clarendon Press ; Oxford University Press).

McDermott, Vincent (1972), 'A Conceptual Musical Space', The Journal of Aesthetics and Art Criticism, 30 (4), 489-94.

Miranda, Eduardo Reck and Wanderley, Marcelo M. (2006), New digital musical instruments : control and interaction beyond the keyboard (Middleton, Wis.: A-R Editions).

Mulder, Axel G. E. (1999), 'Design of virtual three-dimensional instruments for sound control', (National Library of Canada = Bibliothèque nationale du Canada).

Pressing, Jeff (1992), Synthesizer performance and real-time techniques (Madison, Wis.: A-R Editions). Roads, Curtis (1995), The computer music tutorial (Cambridge, Mass.: MIT Press). Rowe, Robert (2001), 'Machine musicianship'.

Roads, Curtis (1995), The computer music tutorial (Cambridge, Mass.: MIT Press).

Sapir, Sylviane (2002), 'Gestural Control of Digital Audio Environments', Journal of New Music Research, 31 (2).

Wanderley, Marcelo, et al. (2005), 'The Musical Significance of Clarinetists' Ancillary Gestures: An Exploration of the Field', Journal of New Music Research, 34 (1), 97-113.