# FROM SNOW [TO SPACE TO MOVEMENT] TO SOUND

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## ABSTRACT

The current paper concerns a 'work in progress' research and design project regarding a forthcoming mixed media interactive performance, which integrates 'space design', sound, visuals and snowboarding. The aim is to create a playful and even provocative experience to the users-/performers and to the spectators of the final event by mixing and blending music, sound design, architecture, visual projections and freestyle snowboarding. It is a collaborative effort between a French freestyle snowpark development, a snowboarding events company named H05, and three researchers and practitioners in computer music, architectural design and electronic engineering. Computer motion tracking techniques, a variety of spatial and body sensors and sonic transformations of pre-composed material have been and are currently explored for the realization of the musical part of the piece.The fundamental and key concept is to map sound features and interactively composed sound objects to snowboarding full body gestures.Architectural design plays a critical role in the project, since the composed space shapes the snowboarding movements, which then form the corresponding musical and visual elements that will be introduced to our work in the future. The current paper describes our initial designs and working prototypes used during a test period in the HO5 snowparks in the Alps.

## 1. INTRODUCTION

Interactivity in art, design and performance is experiencing a growth in exploitation of late and is considered as a significant element in contemporary creative practice [1, 2, 3, 4]. An interesting example of a design field where novel paradigms of interactivity are constantly introduced is the design of new digital musical instruments [5]. Another example, which is equally relevant to our project, is the technologically mediated interactive dance/music systems and performances. [6, 7, 8]

In this paper, we are using technology to make a responsive environment for snowboarders. The users experience an immediate engagement with the space through the sound that their own movements generate. Therefore, through exploration of their environment, they realize that their bodily effort and snowboarding tricks are integral to the composition of sounds and music. It is worth mentioning that so far, interactive performances in theatre and dance are widely known, but as far as the authors are aware of, there is no interactive performance related to snowboarding.

Our aim is to "control" music and visuals through movements and through freestyle snowboarding in specifically designed snowpark. Of course, mere control is not synonymous to interaction. According to Robert Wechsler "Interaction relates to spontaneity, openness and communication" [6]. Therefore, in our designs, we consider as interaction something more than using a designed physical and spatial interface from a number of snowboarders performing a standard show, event or a competition. We are designing an environment for creativity, exploration and play; not a task oriented interactive system.

This paper presents all the elements of the working process that will contribute towards the future realization of an interactive multimedia snowboarding event. It summarizes all the project phases; viz., conception, research, design, construction and testing. The first part explains the concept and covers the architectural aspects. The second part focuses on the snowboarding "choreography" and the tools and techniques employed for motion tracking. The last part introduces the interaction design and aims to provide some insight in the composed musical material.

## 2. DESIGN AND PROTOTYPING

### 2.1 From Snow to Space

"Architecture is frozen music" and "music is architecture in movement", two statements by Novalis together with Xenakis' "architecture becomes an art of time and music an art of space" in Polytopes are the main influence for this project [9].

Similar landscape or outdoor architectural projects using snow and ice as the main construction material, apart from vernacular architecture projects, can be seen in [10]. Many interactive art/architecture projects focus on interior spaces- [4][11][12]. However a project of this sort, which is developed outdoors, in a natural landscape, has to deal with the inherent difficulties of the weather conditions such as wind, insufficient snow etc.

The main architectural concept of the project was a synthesis of structures, modules and volumes, which would allow movement as well as projections on them. A controversial dialogue is created between moving snowboarders and solid, simple static modules. Figure 1 shows the basic snowpark modules.

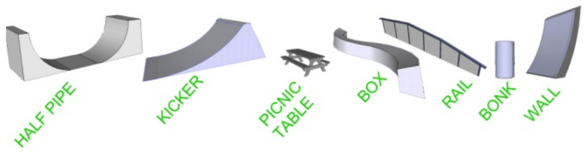


**Figure 1**. Basic Snowpark Modules

The site for the event is in the 7 Laux Ski Resort, in the French Alps. However, due to the weather conditions the test took place in Meribel ski resort, not far from the final event site, in the snowpark freestyle zone, which is a space for snowboarders to perform tricks.

Collaborating with HO5 [13], an events and snowpark development company responsible for both sites - 7 Laux and Meribel - we could propose different designs that were built for them as well as tested by their snowboarders.

As far as the architecture is concerned, there are two design phases: the first one is a simple design to be built for the interaction tests. During the first tests, it was important to explore the gestures and sounds as well as their interactivity using the technologies. For this reason a familiar environment was important, in order to qualify the basic movements.

For the tests, a very simple module arrangement was used; four modules are integrated to the design: a kicker, a box, a 'bonk', and a wall; modules which snowboarders already use for tricks and jumps. Using modules and surfaces familiar to the snowboarders helped us decide on which ones we would choose to redesign for the future event.

The choice of the modules depended not only on the variety of movements that each snowboarder facilitated but also on the modules' size and weight. The latter proved to be very useful since during the tests it was easy to move and re-arrange them. The idea was to have a common starting point and later three different options – either a box or a wall or a little kick and a bonk(Figure 2).

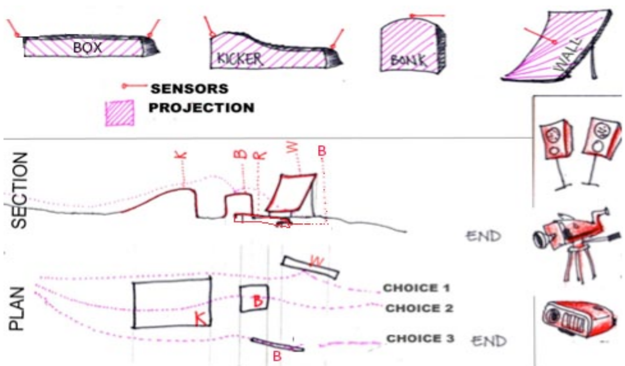


**Figure 2**. Sketches of the Modules Used for the Tests.

The starting point was 25m before the modules and the total area where the tricks took place, up to the ending point, was $40m^2$.

A different architectural design is being introduced for the next phase of this project to encourage more tricks and therefore more interesting sound compositions. Figure 3 shows a sketch idea discussed with HO5. Although the initial idea was to use snow as our main construction material, after discussing it with HO5 we realized that it would not be financially feasible. A sibstantial volume of snow is expensive to produce and to maintain. The idea then is to utilize a composition of several little boxes, much smaller in length than the ones that they already use, scattered on a sloped area totalling $100m^2$. Small kickers would facilitate the landing on the boxes. LED lights would be emitted from inside each box and would turn on or off interactively each time a snowboarder lands on them.

Four cubes made out of snow would be placed close alongside and the modules and interactive videos would be projected on the side more visible to the audience.

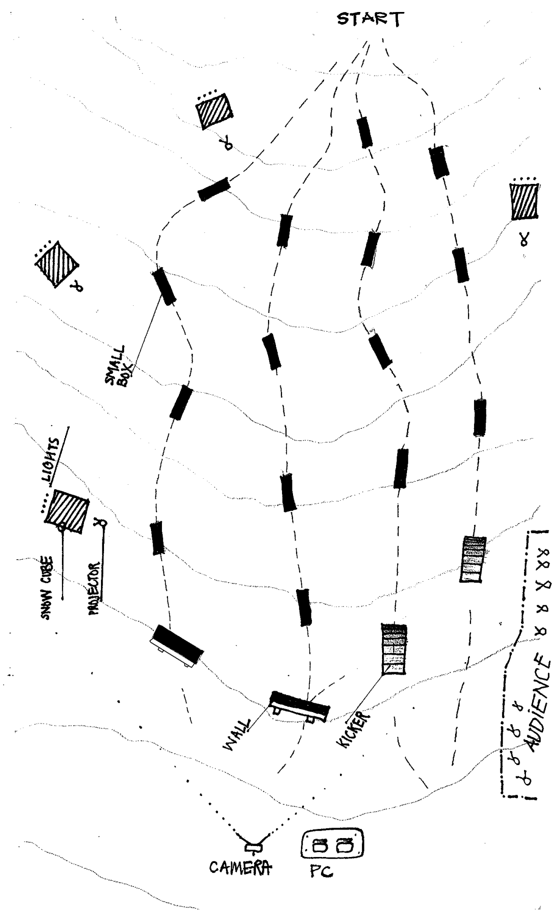


**Figure 3**. Sketches of the Proposed Snowpark for the Final Outdoor Event.

### 2.2 From Space to Movement

Snowboarding is a quite new winter sport and for some of its pioneers is considered an art form [14]. Ever since its inception as a sport, it has never stopped evolving and developing new styles. 'Freestyle' snowboarding on snowparks created a number of novel snowboarding tricks and aerial maneuvers. In the current project, a few of them have been selected, modified and blended with the media aspects of the interactive performance.

When dealing with an environment used by the users/performers, it was important to research the different actions that one can take within the space. We wanted to give more choices to each snowboarder and not just restrict them with one and only path of progression. For this reason, the design consists of a modular arrangement, which would give them the choice and therefore the production of different and interesting sounds through their body gestures.

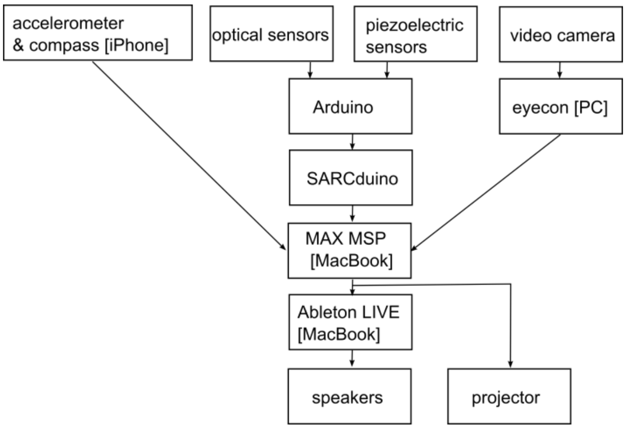


**Figure 4**. Schematic Representation of the Performance Setup

In order to capture the snowboarders' motion and realize an expressive dialogue between the elements of our piece, i.e. snow, space, movement and sound, it was necessary to use a set of tools and systems coming from a wide range of technologies [15, 3]. Basic features of the snowboarding performance such us motion, presence, position, orientation, velocity, acceleration and rotation had to be detected and tracked. Therefore electronic circuits, a range of sensors and transducers including a camera, microcontrollers, a computer and software have been employed largely for the connection between the physical and the digital world (figure 4).

Camera based motion tracking is very common in interactive art and design [16]. A computer system, software running computer vision algorithms and video cameras are essentially mandatory for every project that make use of video tracking technology. For the proposed site-specific interactive performance, high-end expensive motion trackers were considered inappropriate due to the outdoor nature of the project and for financial reasons. More appropriate modular software solutions including the Eyeswebplatform, MAX MSP Jitter with cv.jit library, 'Processing' programming language with the openCV library and the openFrameworks framework with the ofxOpenCV have been discarded too due to the programming complexity involved in order to make those environments work easily with the architectural elements of the project.

It became evident during the tests, that the most interesting interactions were based on the presence of the snowboarders at specific locations of park. Therefore, Eyecon software, a commercial computer vision system specifically developed for interactive dance performances by Palindrome Inter-Media Performance, has proven itself useful in our setup [17]. Particularly, Eyecon offers a highly intuitive feature that lets you graphically define lines, zones and fields wherein the conceived interaction is to take place. For example a snowboarder can touch one of these virtual lines, which are drawn according to the architecture of the performance space and trigger or modulate graphics, videos and elements of the musical composition. A simple webcam positioned along the snowpark and a laptop running Windows XP has been used during the tests.

A variety of sensor technologies have been considered for prototyping too. Piezoelectric sensors have been used to transduce shock and vibration into an electric voltage. These sensors have been mounted on *bonk* and *wall* surfaces to detect when a snowboarder hits them. A custom analogue signal conditioning circuit has been designed and built to produce an accurate and reliable signal output.

Photoelectric switches have been considered too, in order to detect the snowboarders' presence on different points throughout the available paths in the snowpark. A small number of optical retroreflective sensors have been placed and tested in our designed installation space, which give accurate information about both the snowboarders' temporal- and spatial-presence at those particular positions.

Figure 5 shows the piezoelectric, sensor-based, impact sensing and pulse-stretching signal conditioning sub-circuit and figure 6 shows the retroreflective optical sensing signal-conditioning sub-circuit. Both of them have been designed to provide clear detectable pulses to the Arduino board, which is used as a sensor interface in our project, without damaging its input circuitry. The limited space of the article does notthe authors permit to explain the details of their operation.

All the sensors worked well during the tests but probably will not remain in the final version of the installation, since the number of modules and the dimension of the space make this solution financially impossible for the time being. Moreover their cabling -wireless communication was too expensive and their size proved to be problematic when used in outdoor spaces.

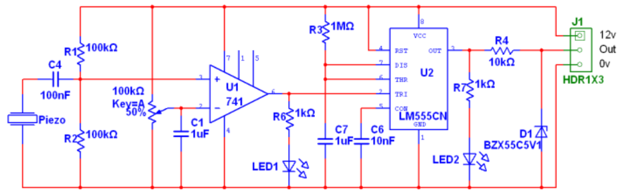


**Figure 5**. Piezoelectric Transducer Analogue Signal Conditioning Circuit.

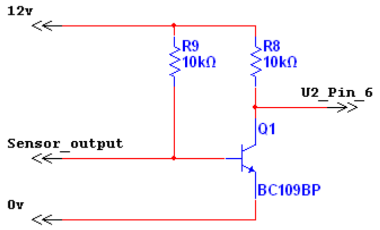


**Figure 6**. Retroreflective Optical Sensor Input Interface Circuit.

Accelerometers and electronic compasses have also been also employed for motion tracking purposes. For the tests, we have used an iPhone, which offered a wide range of sensors including the previous ones. The c74 application has been used in order to transmit the data from the smartphone to the computer[18]. Spins, turns and ‘ollies’ were detected with these sensors.

All the digital signal conditioning and the gesture analysis form the sensors signals, from the iPhone and the Arduinoboard, have been processed in the MAX MSP software [19]. The SARCDuino sensor acquisition protocol has been used to communicate between the Arduino and MAX MSP [20]. Basic digital signal processing operations like scaling, smoothing, averaging, debouncing, edge detection mapping a given input range to a desired output range and low-level motion feature extraction has been programmed graphically using this intuitive block based programming language. A number of interesting and useful MAX MSP objects have been obtained by the *The Digital Orchestra Toolbox* developed by researchers at the IDML laboratory in McGill University [21].

### 2.3 From Movement to Sound

In every interactive multimedia project, which relies on physical computing, it is beneficial to be able to describe what actually happens in plain language. Moreover it is essential to break the project down into the stages of input, output and processing [15]. Table 1 summarizes and Figure 2 ‘sketches up’ some of the basic interaction designs we have used and tested so far. The following paragraphs explain and try to offer an insight on the depicted interaction decisions.

As we have already mentioned, making music and media art through movement is not novel. Interpreting movement data collected through a variety of electronic sensors and mapping them into composition procedures that generate, sequence and transform music and every kind of media material is the core of interactive art and interactive design [22][23].

| **Input** | **Output** | **Processing** |
|---|---|---|
| start | play clip | when he starts moving |
| stop | stop clip | when he stops moving |
| take off | reverb on | when he is in the air |
| landing | reverb off | when he hits the ground |
| location | change clip / play a new clip | when he crosses some predefined points |
| sustain | retrigger clip | when he stays on a certain point |
| hit bonk/jib/wall | play sound effects | when the board touches these surfaces |
| accent | granulation | when he is doing fast and big nervous gestures |
| speed | tempo | - |
| grind / slide | distortion / bit reduction | the contact point works like a slider |
| spin | tremolo | like a rotary potentiometer |
| flip | flanger | like a rotary potentiometer |
| carving | panorama | like an envelope |
| shifty | volume | like an envelope |
| grab | turn off the volume | when he touches the board |

**Table 1.**Table of Some Basic Interactions.

How can snowboarders organize and structure musical and visual material through their physical gestures? The answer in our approach was to find an effective interaction, musical and visual material that maximizes the chances of aesthetic interesting results from the point of view of both the performers and the audience. It has been strongly considered that an understandable mapping from snowboarding to music and visual projections should reach everybody in the performance in a straightforward manner. Hence elementary research concerning the snowboarding culture and events has been carried out in the design phase. Particularly, the compositional strategy of the piece has been strongly based on the snowboarding, street and urban cultures, which are characterized by musical genres such as hip-hop, rap, dub, pop and electronica. A very useful resource, which immediately reflects the aesthetic qualities of this particular group of people, are the snowboarding films/documentaries and the web site of our partner HO5parks [11, 24].

From a musical point of view, the initial material of the composition was a database of sound samples obtained from commercial recordings, field recordings, sample libraries and other musical material sequenced and performed by the first author of the paper. Acapella sections and refrain sections from songs, drum and percussion loops, base line patterns, guitar motifs and pure recordings from the Alpine environment, all form this mid-size database of pre-composed, unstructured musical elements.

The musical idiom used is rhythmical, repetitive and tonal. The structure is open, non linear and unfolds during the performance. Clearly the piece is a remix of preexisting musical material relevant to the snowboarding culture. Elements of the music, like arrangement, form and timbre qualities of each sequenced sample are indeterminate.

The scenario followed for the predetermined and indeterminate actions, based on Winkler's four basic categories, is that of "*performer improvisation and predetermined computer sequences*" [23]. Aspects of indeterminacy are used only to choose specific samples from the collection and for timbre modification through the use of digital audio effects. Mapping of performance gestures to the parameters of classical signal processing algorithms (granulation effects, filtering, pitch shifting, reverberation, distortion, etc) has been regularly employed in every part of the piece. Simple timing processes i.e. quantization, delaying and speed change have been used as well. Sections of the piece documented during the tests will hopefully be uploaded soon on the HO5 website [11] and will be presented in the conference.

Core to the design of the musical interactions was the understanding that simple, immediate and straightforward motion-sound relations were essential for the snowboarders. It has been verified during the tests that, generally, the sonic modifications were necessary to explicitly follow the flow of motion. Hence simple cause-effect relationships were designed; i.e. start music when movement starts, create harsh sounds when big nervous gestures are produced. In general, it was difficult to engage the snowboarders with interactions that generated subtle timbre variations and make them concentrate on fine audio outcomes. However interactions that augmented directly their snowboarding performance i.e. tricks that require equilibrium linked to digital audio effects like 'spectral freeze', inspired them and motivated them for further exploration.

The short duration of their movements, 1- 2 sec approximately, indicated that continuous control of sonic elements was not very easily perceived. Even from the audience point of view, it became clear that only long movements like smooth slow turns could be mapped to dynamic audio modifications. Jumps and every possible module riding had to be mapped to obviously distinguishable sound effects like triggered music clips.

From a technical point of view, a laptop computer and two software environments have been used for the realization of the musical piece. As we have explained in the previous section of the paper, sensor data acquisition from wearable and spatial sensors, have been realized with the help of an Arduino board and an iPhone. Then, all the analysis and mapping of sensors' output data, including the ones from the video tracking system, have taken place in Max MSP graphical programming language. Simple explicit strategies were sufficient to control the compositional procedures [25]. As mentioned above, the computer vision algorithms are running on a separate computer linked with the previous one through Ethernet by the OSC protocol. All the control events were transmitted via MIDI to an Ableton Live-equipped digital audio workstation, which performed all the sound related real-time processing [26].

## 3. CONCLUSIONS AND FUTURE WORK

The project, even at this early testing phase provided interesting results and offered us a very informative experience, thought beneficial for the design of the future event. Every difficulty we experienced, production-wise at the location and particularly during the collaboration period with the HO5 has already started shaping and forming our ideas and designs regarding the final version of the multimedia piece.

A night performance with artificial lights will be much more controllable and robust compared to the unexpected lighting conditions that were experienced during the daytime tests. Use of infrared illumination is planned, in order to integrate the visual projections with the music, the movement and the architecture, without disturbing the video tracking procedure. Retroreflective tape placed on the snowboarders' legs or even powered infrared sources will improve the visibility of the tracked objects and the overall performance of the computer vision algorithms. So far, colored LED lights have been tested, as seen in Figure 7, in order to track multiple points in the dark or under low-light conditions. This solution will not, in all probablility, be implemented in the final event, since it is not well adapted to the visual aesthetics of the performance.

It became clear during the tests that when snowboarders learn from the experience of play, they react and later redefine the sense of place. We tried to raise the awareness of the dialogue between them and the environment. According to Fox and Kemp, the environment can be either an entity or a discrete organization of devices and systems, and the behavior can be a direct response or emergent. Users become participants either willingly or unwillingly, and their behaviors are translated not only to themselves and others within a particular space, but also to those on the outside looking in. [4]

**Figure 7**. Tests with LED Lights

The sense of sound is much underrepresented in discussions of architectural experience and it is very often only dealt with from a design standpoint, relative to the negative aspects [4]. Interactive performances in designed spaces, as well as interactive architecture, have begun to question this. We believe that in the future there will be a stronger relationship between architecture, music and movement through projects of this type.

A series of events is envisaged to take place next winter in the HO5 snowparks and soon after in an indoor venue in Paris.

**Acknowledgments**

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