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Gesture and Sound Analysis:
Virtual Instruments for an Interactive Composition

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Abstract

This project is focused on a description of most important actions related to playing a string instrument and allows us to build an interface simulating the playing actions needed to produce a sound and to compose a music piece in real time.

To obtain these results and to map the interface we analyzed:
   1- the bow strokes used to play a string instrument
   2- the partial components of violin sounds
   3- the formal structure of a violin important composition (in this case a *Caprice* of N. Paganini)

With the interface we can also:
   1- to use the same gesture and procedures used on the instrument to producing sound
   2- to produce instrumental sounds simulating these of the real instrument
   3- to compose a music piece with references to the historical repertoire of the simulated instrument
   4- to compose a new musical piece or to improvise music

The interface used is a Nintendo-Wii controller simulating a violin bow to perform music with sound synthesis in real time.

Sound examples are built using frequency modulation synthesis and granular synthesis in a first version of the project. In a second one recorded audio files modified in real time are used too. In the first version of the project the formal reference for a new composition was the form of the Caprice in particular, Paganini's Caprice for re-compose a new music piece. The second version is more oriented to improvisation. The following table shows the different kinds of analysis and their relation with the map of the interface.

Gesture Analysis	Bow movements map	Interface's definition
Spectral Analysis	Partials component map	Algorithm's definition
Formal Analysis	Piece's sketch	Piece's re-composition

In an analytical point of view of the project we obtain:
   1- a specifically analysis of the movements producing sound on a string instrument
   2- a spectrum analysis of partial components of the violin sounds

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In an aesthetic point of view we obtain:
  1- the possibility of a re-composition of a musical piece starting from an historical example
  2- the possibility to create a new composition or improvisation

Introduction and chronology of the project

It is well known that performing a musical work or anyway producing sounds with an instrument requires a multiplicity of different actions involving mental and physical processes. Particularly significant are the several movements necessary in order for an instrument to produce sounds. From this point of view, every performer must, first of all, bear in mind the movements, together with their special features, necessary to produce the sound, in order for this sound to possess specific characteristics.

An initial idea of the project of building an interactive interface aimed at live composition and performance, imitating an instrument, in this case the violin, was born out of those observations.

From the synthesis of the diverse experiences of performance, composition and analysis, the idea of the interface was then realized through a particular object that could be used like a violin bow and that could perform in real time a musical work, that could be either recomposed with reference to a specific form already existing in musical repertoire, or independent of it, that is, a work of free invention or an improvisation.

The first version of the project was completed between 2010 and 2011 and presented as a poster in Rome (EUROMAC, 29 September -2 October 2011).

In this first version the interactive composition started from the formal analysis of a work belonging to the historic repertoire of the instrument. This work was ideally kept as the outline to be reproduced both with regard to its form and its sounds and gestures.

Subsequently, in 2012 I realized a second version based on the results already obtained from the analysis of the gestures and of the sound spectrum, while the formal reference model was abandoned in favor of improvisation or of a composition anyway independent of any preexisting reference.

Aims of the project

Within the perspective of realizing a virtual instrument through which compose, re-compose or improvise, the project then originated from the analysis of several elements of a musical event and mainly:
  1- the gestures aimed at the production of the sound
  2- the characteristics of the sound produced
  3- the form of the work that is performed

The interface was therefore used by performing gestures analogous to those performed to make the instrument play, in order to reproduce:
  1- the same gestures and movements used to produce the sound on the instrument
  2- sounds imitating the sound qualities of the instrument

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3- a work that keeps a formal structure and some reference characteristics of a work from the instrumental repertoire of the chosen instrument (version 1)

4- a work of free invention or an improvisation (version 2)

Instruments and reference points

The reference instrument chosen for this work was the violin and the object acting as an interface was a Nintendo-Wii controller used like a violin bow with which it was possible to perform real time sounds when composing a work or improvising. The sounds produced were obtained through various techniques such as FM (frequency modulation) synthesis, granular synthesis and various processes of elaboration of fragments recorded and modified in real time through several transpositions.

In the first version of the project (2010-2011) the formal reference of the composition was *Caprice n° 20*, from *24 Caprices for solo violin op. 1* by N. Paganini.

The choice of the interface was dictated by the fact that the Nintendo-Wii controller is, on the one side, a very well known object commonly used for electronic games and therefore it is quite popular and easy to be found, while on the other hand, it can be held and moved imitating very closely the main bow strokes used to play a violin and, in general, a bowed instrument.

Finally, the choice of Paganini's *Caprices* as the formal reference for a composition was due to the fact that Paganini's works, and his *Caprices op. 1* in particular, are compositions certainly emblematic of violin repertoire and, at the same time, present a defined structure that is simple to reproduce

Methodologies employed for the analysis

The typologies of analysis employed in the project were essentially three:
   1- Analysis of the gesture producing the sound, in particular, the different bow strokes found in *Caprice n° 20* by Paganini
   2- Spectrum analysis of the sounds of the violin open strings in order to define the starting sound spectrum and be able to create a synthesis producing sounds similar to those produced by the reference instrument
   3- Formal analysis of *Caprice n° 20* by Paganini in order to reproduce a work with a similar structure by using the interface

From these three typologies of analysis we obtained:
   1- a mapping of the bow strokes from which to draw the definition of the interface, that is, the movements to be reproduced through it
   2- algorithms for the realization of the sound
   3- the formal outline for a new composition

The table of figure 1 summarizes what just stated, that is:
   - From the analysis of the gesture we obtained the mapping of the bow strokes and the ensuing mapping of the interface.

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- From the analysis of the sound spectrum we obtained the mapping of the partial components from which to deduce the values for the construction of the synthesis algorithms of the sound.
- From the formal analysis we obtained an outline of the composition, which was used to compose a new work to be performed through the interface.

Analysis of the gesture	Mapping of bow strokes	Definition of the interface
Spectrum analysis	Mapping of the values of the partial components of the sound	Construction of the algorithms
Formal analysis	Formal outline of the composition	Re-composition of a new work

Figure 1: map of analysis results

Bar number	Bow direction	Bow position	Contact point on the string	Bow stroke
Bb:1-2	down	Central strings	tastiera	legato

Figure 2: map of bow strokes and musical characters in bars 1-2 of Paganini's *Caprice n° 20*

Figure 2 shows the mapping of the bow strokes of the initial 2 bars of the *Caprice* with the values related to the direction of the bow, the point of contact of the bow on the strings, the strings and the type of strokes used (legato, staccato, balzato, etc.) In these bars a down stroke was used, on the two middle strings and the bow was used over the fingerboard with a legato bow stroke.

Figure 3 shows the mapping of the partial components of the sound of an open string G of the violin, produced by the fourth string, from which we drew the values for the construction of the algorithms.
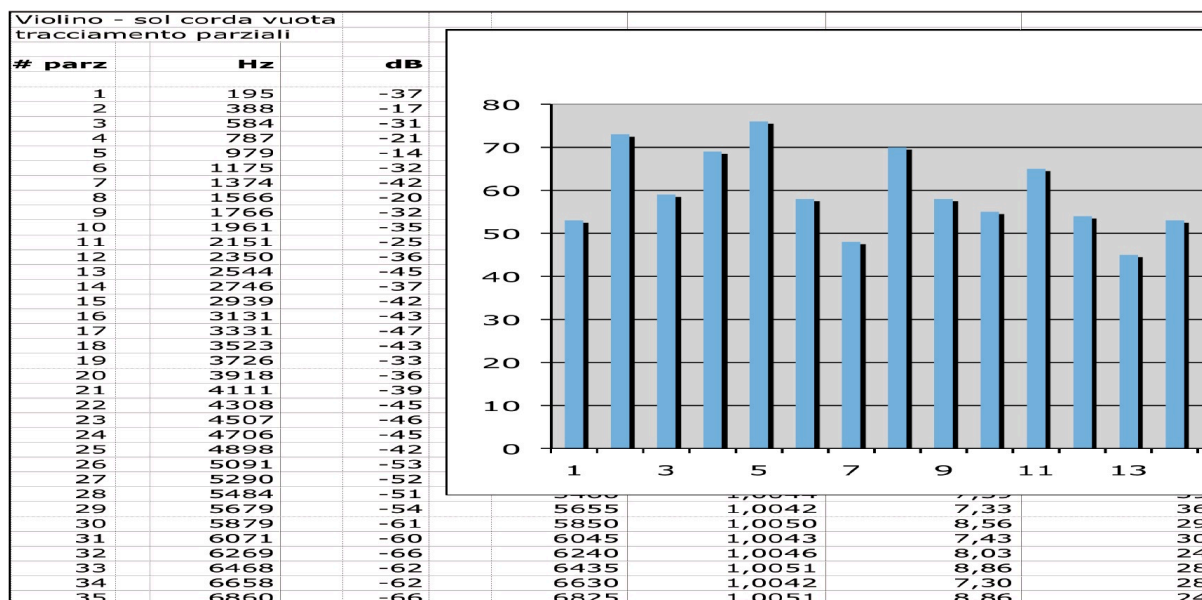

Figure 3: partial components of the sound of an open string G of the violin

Finally, in figure 4 we find the formal outline of *Caprice n° 20* by N. Paganini, subdivided into two sections of a different character and the corresponding outline of the re-composition of the new work realized through the controller Wii.

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We can notice that the piece is divided into two sections characterized in different ways with regard to their sonority, key, expressive idea. All these elements were reproduced in the interactive composition.

	Caprice	Re-composition
Section A	Introduction, legato, pastorale D major	FM modulation sounds Wii controller movement simulating the bow stroke legato
Section B	Brillante, balzato B minor	Sounds obtained with granular synthesis of the second section of the *Caprice*

Figure 4: map of correspondence between *Caprice n° 20* and his interactive recomposition

The second version

Following the experience of the first version, I realized a second version of the project, having as a basis the same typologies of gesture and spectrum analysis that were employed in the first version. However, instead of reproducing a pre-established formal outline, I opted for a free composition or, rather, an improvisation.

The techniques used for the production of the sound were:
1- FM synthesis employed for the sounds of the open strings and for tremolos, trills and glissando effects.
2- For the improvisation, a series of recorded audio files, including also fragments of Paganini's *Caprice n° 20*, were employed, modified in real time through the use of the interface. Among these audio materials, there are both the violin's own instrumental sounds, such as chords, tremolos, melodic hints, and sounds taken from the everyday reality, such as noises from the streets, from domestic life and so on. Any type of sounds could be included in the project.

Conclusions

At the present, the conclusions that we can draw from this experience are not definitive, as we expect to further develop the project.

So far we can say that, from the analytical point of view, it is interesting to notice how the various typologies of analysis concur to the definition of the interface and of its operative possibilities. From this point of view, the results obtained through the analysis of the gesture and of the sound spectrum are particularly satisfying.

From the aesthetical point of view, the functionality of the interface certainly needs to be improved. However, when used without any reference to a work to be re-composed but, instead, for the improvisation, it gave some appreciable results.

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