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META-INSTRUMENT AND NATURAL USER INTERFACE: A NEW PARADIGM IN MUSIC EDUCATION

Abstract:

Music is gaining a growing role in children and teenager education, but playing music is not as natural as listening, requiring a large amount of time to spend in learning how to play a music instrument. Since a number of technical skills should be acquired through practice, this is a strong limitation for educational contexts where student's time is a limited resource. The meta-instrument is a new paradigm for music instruments that overcomes these limitations and enables the student to instantly execute a music score without a specific training. Thanks to the natural ability of the human beings to tap the music, the meta-instrument moves the interaction level to the timing, the interpretation, and the natural interaction, embedding the pitch control in its smart logic implementation. The typical interaction of a natural user interface is applicable to a meta-instrument because it can emulate both a traditional music instrument and a virtual one. The student can play a music instrument regardless to the interaction mode, thus focusing on interpretation rather than on playing. The proposed meta-instrument framework refers to multiple and heterogeneous contents applying the specification of IEEE 1599, an XML-based standard for full representation of music.

Keywords:

Meta-instrument, intuitive learning, natural user interface, music interpretation, music play, Muscic-XML, IEEE1599.

1. Premises

Music has an important role in education and mood regulation of children and adolescents (Saarikallio, 2007), but playing music is not as natural as listening (Wechsler, 1975). The abilities needed to play an instrument may require spending a large amount of time in practicing. Even if some aspects of music education are common (e.g., sense of rhythm, expressiveness, sight reading, etc.), some specific skills learned through long study sessions can be applied to a specific instrument or to an instrumental family at most. For instance, the piano play technique can be extended to other keyboards with weighted keys, and it is somehow helpful for similar music interfaces such as harpsichord or organ, but it is completely different from bowed instruments or drum technique. The large amount of time required to acquire playing abilities on a specific instrument is a strong limitation for educational contexts where student’s time is a scarce resource. All these limitations inhibit the natural aptitude of young people to perform music intuitively.

On the other side, human beings have the natural ability to tap the music, which enables almost everyone to follow the rhythm of a music piece. Going beyond the common sense, it is worth citing a number of experiments, such as the “ritual” hand-clapping by the audience during the performance of the Radetzky March played as the last piece at the New Year's Concert of the Vienna Philharmonic. Besides, researchers and musicians as Christiane Karam and Bobby McFerrin demonstrated that you can lead people who have no idea what the time signature is into complex and irregular meters by trusting their sense of rhythm, which is one of the innate music abilities (Trevarthen, 2011).

A meta-instrument is a new paradigm for music instruments that enables the performer to instantly execute any music score on any type of instrument without specific playing skills except tapping (Miranda, 2006). The meta-instrument exploits this natural aptitude moving the interaction with the music instrument from the pitch control to timing and interpretation. The meta-instrument implements a natural user interface that can emulate either a traditional instrument or a virtual one. The music learner can play regardless a specific technique, thus focusing primarily on music interpretation rather than on music playing.

Musical games (Denis, 2005) are an example of how music playing can be approached in a simplified mode to let the learner focus mainly on higher information levels such as gesture, texture, style, and so on. Needless to say, technology plays a fundamental role in the design and implementation of innovative learning tools like the meta-instruments, in particular as regards the sensing and logic functions required by smart natural interfaces (Barbosa, 2001).

2. The Meta-instrument Framework

As mentioned in Section 1, the meta-instrument is a new paradigm that enables the music performer to interact with the instrument via sensing technologies (Malcangi, 2013), starting from basic sensing devices like switches to more advanced tools oriented to gesture and emotion recognition (Wanderle, 2000). The music performer is part of a sound-generation process very similar to an automatic control system.

In an ordinary context, the way the performer can control pitch, intensity and timing depends on the nature of his/her music instrument. However, if the instrument is virtual (e.g. computer-based), it can implement the logic and the processing required to be compliant with the performer's ability. As shown in Fig. 1, a multisensory feedback plays the fundamental role of automatic regulator of the interaction, compensating the weakness of the feed-forward action of the performer (Zimmermann, 2012).

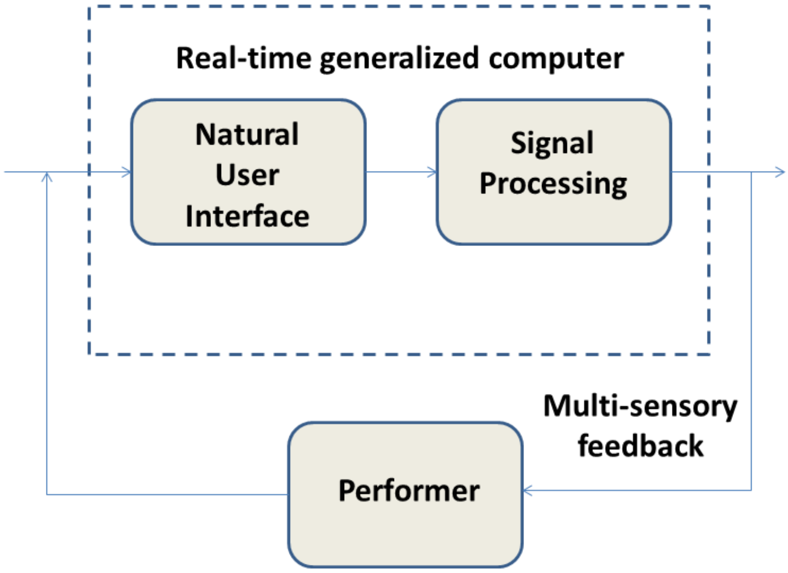

Figure 1. A performer and a music instrument form a multisensory (auditory, visual, tactile, physical, and physiological) feedback-based system.

The meta-instrument can be considered as an extension of the traditional music instrument. As shown in Fig. 2, it allows the performer either to have full control over performance, like a natural instrument, or to experience a reduced interaction complexity. This can be realized through the adoption of natural and intuitive interfaces that do not require training.

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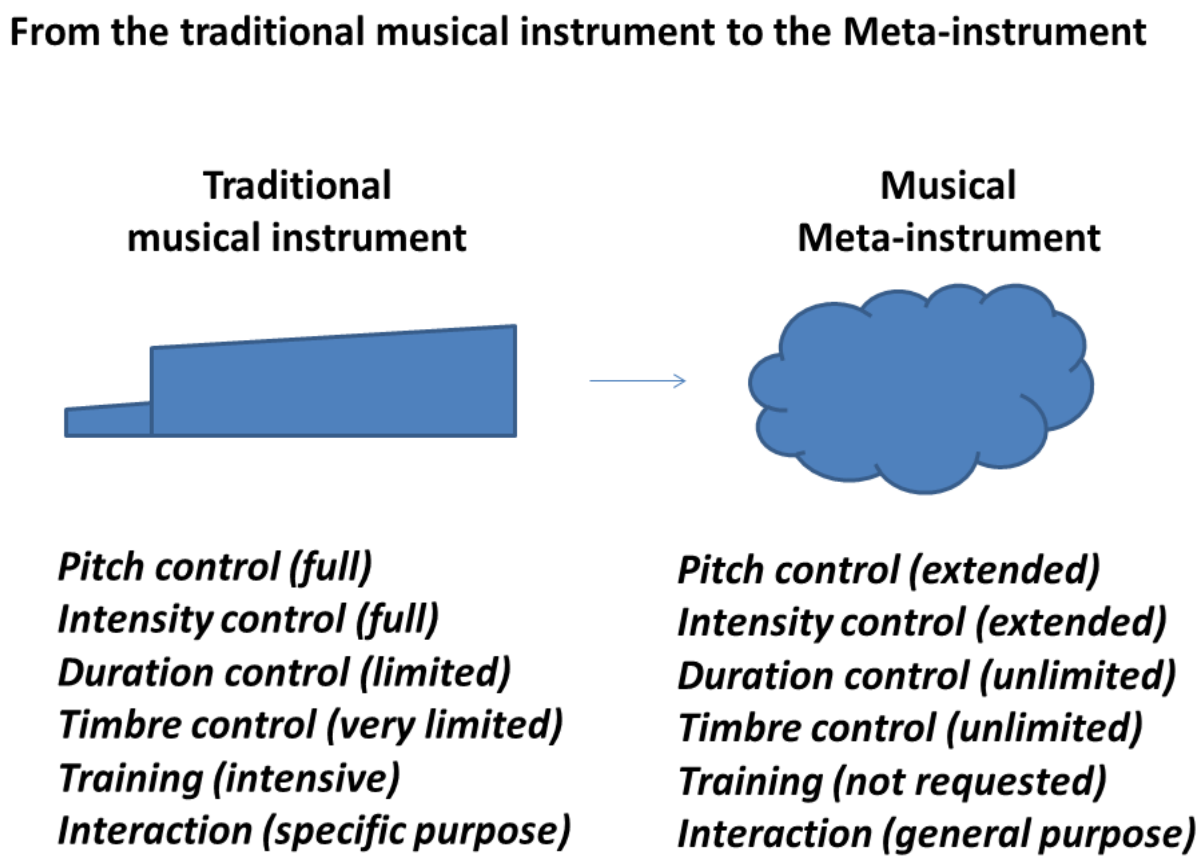

Figure 2. The meta-instrument can be considered an evolution of the traditional instrument.

Since the meta-instrument is a computer-controlled music instrument, there is virtually no limitation to the interaction between the performer and the instrument itself. The meta-instrument has the same system architecture of the traditional instrument, but the interaction and the sound generation are computer controlled. A real-time dedicated processor implements the functionality for the natural user interface and the control of the sound production.

A computer is a generalized processing system capable of real-time performance: from this point of view, the traditional instruments can be considered like a subset of all the possible instruments that can be implemented. Fig. 3 provides a schematic description of this concept.

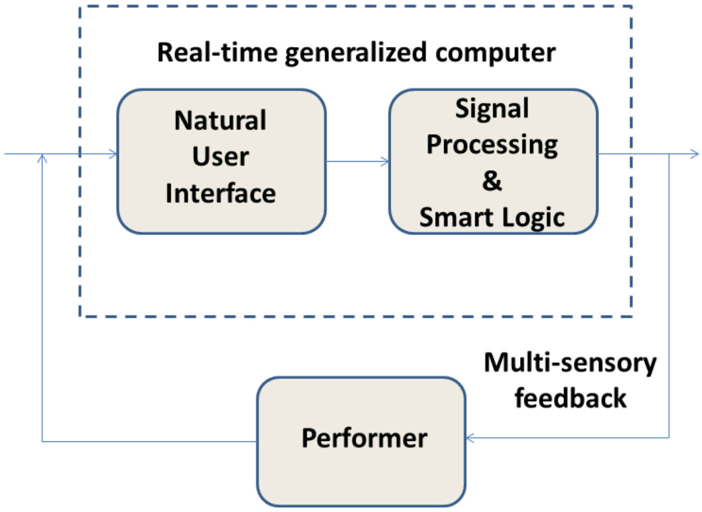

Figure 3. Traditional instruments are a subset of all the possible instruments that can be implemented through a computer-based approach.

3. Music Learning by Meta-instrument

The meta-instrument is able to adapt itself to the performer since it embeds the information required to play a score. The score is encoded into the meta-instrument memory so it can be executed by a player engine that interprets the gesture coming from the interface. In this way, a performer without specific skills can be enabled to interact intuitively with the meta-instrument.

Score encoding is a key step of the meta-instrument framework. The score to be executed can be inputted from any media (either physical or electronic) and encoded in a meta-code specifically designed for the meta-instrument.

An example adopted in some existing implementations is event-driven encoding. Several degrees of event-driven encoding can be applied to allow different levels of interaction between the performer and the meta-instrument. The finest encoding concerns each note of the score that can be executed individually by each triggered gesture (Caramiaux, 2013). This level implies that the performer is aware of the music texture. Higher encoding levels can be applied to comply with the awareness of the music score by the performer: the lower the knowledge, the higher the encoding. Consequently, the meta-instrument capabilities span from the fine and full control of a traditional music instrument to the almost null control of an auto-player music instrument (i.e. “push button and play”).

Another important peculiarity of the meta-instrument framework is that it can refer to multiple and heterogeneous contents. To accomplish this goal we propose to apply the specification of IEEE 1599, an XML-based international standard for the representation of music. The key characteristics of such a format will be summarized in the following section. The idea is transforming the concept of musical meta-instrument into a real tool to play intuitively by embedding the meta-instrument notation into the IEEE 1599 format.

4. The Meta-instrument and the IEEE 1599 Music Standard

IEEE 1599 (Baratè, 2009) is an internationally recognized standard potentially able to describe a music piece in all its aspects (Baggi, 2009). Its key feature resides in the possibility to encode both music and music-related materials within a unique framework. When we talk about music encoding, it is worth recalling that symbolic score in Common Western Notation is only one of many possible descriptions: in general, for a given music composition a number of graphical and audio instances are available, corresponding to different scores and performances; in addition, text elements (e.g. catalogue metadata, lyrics, etc.), still images (e.g. photos, playbills, etc.), and moving images (e.g. video clips, movies with a soundtrack, etc.) can provide more information about the music piece. Comprehensiveness in music description is realized in IEEE 1599 through a multi-layer environment reflected by an XML hierarchical structure. Music and related contents are arranged within six layers, each corresponding to a different type of description:

- *General*
- *Logic*
- *Structural*
- *Notational*
- *Performance*
- *Audio*

Music events (e.g. notes, rests, etc.) are univocally identified in the encoding, but they can be described in different layers and multiple times within a single layer.

The implementation of the meta-instrument framework according to the IEEE 1599 standard has been proposed as a case study (Ludovico, 2014) based on the Metapiano paradigm proposed by Jean Haury (Haury, 2013). This implementation concerned the development of a score transcoder (Bruni, 2014) from MusicXML to the Metapiano encoding (Haury, 2013).

Figure 4. The nine-key Metapiano by Jaen Haury allows to play any music score without specific playing skills.

The Metapiano is the latest implementation of the meta-instrument framework. From a historical point of view, the first implementation probably dates back to 1928, when Leon Theremin invented the Theremin meta-instrument. The Metapiano consists of a reduced size piano keyboard, made of only nine keys. The idea is allowing a performer to play a piano score without any knowledge of the piano playing technique and without a full size piano keyboard. The performer’s gesture is a sort of rhythmical trigger that refers to an already-known score. In other words, since the meta-instrument has knowledge about some music information (mainly melodic and harmonic data), the performer has only to concentrate on rhythm, articulation and expression. As demonstrated by a number of test sessions, no limitation comes from the reduced size of the keyboard, even for complex scores.

The meta-instrument does not bind the player to a specific sequence of gestures. For instance, it is possible to provide timed information both using a single finger acting on one key only as well as tapping through all fingers. This is the reason why the triggering interface conceived by Jean Haury is not a simple button but it provides a small keyboard portion.

4. Final Considerations

The proposed meta-instrument framework - if properly developed - can be a powerful tool to enhance the learning abilities of young students who approach music studies and the instrumental practice. The meta-instrument capitalizes the natural ability of children to play music intuitively by implementing a natural user interface that shifts the learning efforts of the performer from practice to music interpretation. This feature of music meta-instruments improves learning processes such as first-sight score reading and music texture comprehension, accelerating also the acquisition of playing techniques related to a specific traditional music instrument.

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