Audio-driven Augmentations for the Cello

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Abstract

This paper presents the design and development of a suite of audio-driven sonifications and effects for the acoustic cello. Starting with a survey of existing augmented string instruments, we discuss our approach of augmenting the cello, with particular focus on the player's gestural control. Using features extracted from the audio input we maintain the player's normal interactions with the instrument and aim to provide additional possibilities to allow new expressions with technology. The system is developed in Max/MSP. It comprises analysis and processing modules that are mapped through virtual layers forming effects for either live improvisation or composition. The paper considers the musicality of the effects and pedagogical applications of the system.

1. Introduction

This project aims to extend the sonic possibilities of a cello with minimal physical obstruction through exploiting the normal interaction between the player and the instrument. The main objective is to augment the cello with audio effects; extending the sonic possibilities of the instrument without interfering with the playing. We make use audio gestures/features that are extracted from the sound generated by the playing to control real-time parameters for the effects.

The system is designed to be modular, easy to use, and adaptable to the player's needs, as if it were a collection of hardware effects pedals. The system can be used for both improvisation and written music.

2. Related works

A survey on different strategies to augment a string instrument can be found in [1]. It distinguishes three types of augmented instruments: *natural instrument, representational instrument* and *virtual instrument.*

Systems such as [2, 3] use representational instruments i.e. an electronic instrument/interface especially designed to retain only the basic gesture and playing technique of the original instrument, while the sound source and controllability rely on electronic interface and processing. This strategy typically modifies the link between the gesture and the sound production.

A *hybrid* approach between *natural* and *representational instrument,* chosen in [4, 5], captures the movements of the player with sensors and/or motion tracking devices. The physical movements detected by the sensor/motion devices are used to control the sound production (cf. 3.2 and Figure 1).

As the name implies, *virtual instrument* does not utilise physical interfaces and hence it is not considered for this project.

For this project, we aim to preserve the inner relation between the player and the resonant instrument whist providing new audio possibilities as an intimate augmentation of the cello. Hence, this project can be categorised under the *natural instrument* strategy.

3. Approach and realization

3.1. Acoustic cello

The design of the acoustic instrument was developed and improved over the centuries together with playing techniques and styles. In this section, we detail some of the key considerations and factors for the design of this project:

- *sound source*: The richness and complexity of the acoustic sound includes several physical parameters such as body modes, string coupling and bow noises that a skilled player is able to take into account.

- *interface*: Over years of practice a player acquires intuitive understanding/feeling with her/his instrument with a level of instinctive perception. We take advantage of this control mostly based on the direct feeling of the vibrating strings and body of the instrument.
- *feedback and learnability*: The feedback between movements and sound excitation constitute a basis for the learning process of an acoustic instrument. Hence, preserving this direct feedback can offer a natural feel to the control of our system as well as using this loop for pedagogical applications. Precise controls over the effects can be acquired without adding any new movement to be learnt.

3.2. Audio gesture control

There is a wide range of research that focuses on extracting and analysing audio features [6, 7, 8]. We utilise some of these algorithms, especially those available in real time (cf. 3.3.1) to produce control parameters.

Figure 1 illustrates a more concentrated link between the player and instrument to offer a better focus and closer feedback-loop between playing and sound. This is precisely what a teacher would like a student to do during practicing.

3.3. Setup

A cello is connected to a computer through a pickup or microphone. We use Schertler Stat-C ® bridge microphone [11] to minimize feedback and other environment noises. Figure 2 shows an overview of the system.

Modules, performing analysis or modification on the input, are connected through scaling stage and mapping layers. The audio routing is controlled by an input/output matrix.

To improve the responsiveness the audio connections are made as direct as possible while float-streams are sent using the OSC protocol.

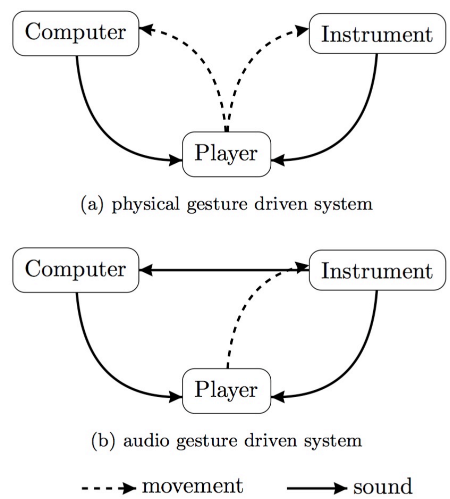

Figure 1. Functional diagram of the control

3.3.1. Modules. Each module implements a specific algorithm. Currently, the analysis section comprises a pitch follower [9], an envelope follower, an attack detector and a bow segmentation algorithm. The processing section includes effects such as a two-pole frequency-shifted filter (*wahwah* effect), delay, spectral delay, spectral looper and others.

3.3.2. Layers. Layers encapsulate scaling and mapping of the analysis modules with the output to be routed to the processing modules (cf. Figure 2). As highlighted in [10], the importance of mapping should not be underestimated. The implementation includes a switching and mixing system between the different mappings to achieve a rich control of the effects.

3.3.3. Routing matrix. Effects are routed one to another over a reprogrammable matrix. Parallel routings among the effects are possible to layer various augmentations at once. Real-time changes do not provoke any break in the audio chain allowing more flexibility whilst performing.

3.3.4. Configuration and presets. Every module, the main patch and the routing matrix embed a preset management system based on the Max/MSP *pattrstorage* object. Controlled by a specific interface, the presets can be stored, recalled and interpolated either separately for each effect or globally.

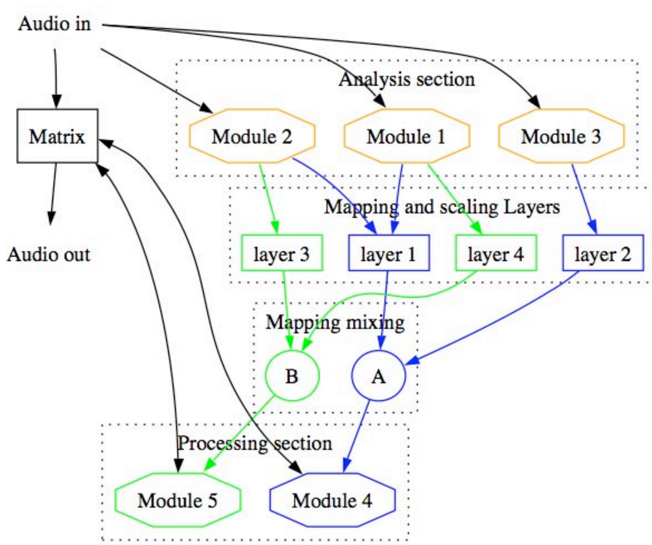

Figure 2. An overview of the system

4. Pedagogical applications

The analysis and processing sections can offer "*sonic highlight*" possibilities that can be used for educational purposes. For example:

- A player who wants to acquire more awareness of the regularity of her/his bow can set the *autowah* effect to be controlled by the envelope of the sound. Whilst playing normally (e.g. on a music passage with regular note duration such as a scale), the filtered output of the system, modulated in real-time, highlights the fluctuations of the bow strike with a shift in frequency. With the highlighted fluctuations, the student and hear the inconsistencies clearly
- A teacher who wants to bring to the attention of a student the harmonic organisation of the sound can use the *spectral looper*. This feature will periodically amplify the different harmonic so that the student is then able to hear in real-time the sequence of partials which shape the sound of each note being played.

5. Conclusion and next steps

In this paper, we presented the augmented cello to extend the sonic possibilities of the *natural instrument* with real-time effects.

The system can easily be extended to add more effects with additional modules. By default, it is designed for real-time improvisation. In the case of a composition, the presets can also be controlled by a simple timeline system. Additional external control parameters (e.g. from other sensor/motion capture system) can be fed in to allow further interaction or collaborative creations.

Currently, the prototype is being tested and optimised while more effects and analysis modules are also being added.

6. References

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