Synthesized Strings for String Players

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ABSTRACT

A system is introduced that allows a string player to control a synthesis engine with the gestural skills he is used to. The implemented system is based on an electric viola and a synthesis engine that is directly controlled by the unanalysed audio signal of the instrument and indirectly by control parameters mapped to the synthesis engine. This method offers a highly string-specific playability, as it is sensitive to the kinds of musical articulation produced by traditional playing techniques. Nuances of sound variation applied by the player will be present in the output signal even if those nuances are beyond traditionally measurable parameters like pitch, amplitude or brightness. The relatively minimal hardware requirements make the instrument accessible with little expenditure.

Keywords

Electronic bowed string instrument, playability, musical instrument design, human computer interface, oscillation controlled sound synthesis

1. INTRODUCTION

It is one of the current strategies in the development of new electronic musical instruments, to use modified traditional stringed instruments as interfaces. The motivations mentioned are the highly expressive possibilities of the instrument, the optimisation history of centuries and the extreme good ability to map virtuoso gesture to sound. Another motivation is the need of a growing number of string players who are willing to increase their sound-repertoire with electronic sounds.

What may the interested string player do if she/he wants to include electronic sounds into her or his musical expression?

Usually the traditional string player has no opportunity to get access to hardware like the developments presented by [11] Young, [9] Trueman or [1] Goudeseune. If one cannot manufacture the mentioned instruments oneself one has to deal with systems offered by the commercial market. The essential possibilities there are Zeta midi instruments with a midi-synthesiser device or an electric string instrument connected to a multi-effect unit. Purely midi-controlled sound synthesis results in a highly restricted playability since midi is not capable of mapping the string players' gesture adequately to sound. The use of an electric instrument connected to an effect-unit offers a lot of sounds, but in most cases stays inside the sound-range accompanying the electric guitar.

The work presented in this report is inspired by the idea to offer alternatives for the traditional string player that allows one to create a set-up suitable on stage, with which one is capable to play electronic sounds without the limitations of midified instruments. Developing an openness to traditional playing-techniques of a string player was an important issue.

In the following sections related developments are mentioned, basic construction principles are explained, the design and implementation is described and the results are discussed.

2. PRE THOUGHTS

Extending the sound possibilities of an instrument, brings up a multilayered challenge to an instrumentalist because the known working environment has to be modified in many ways. Besides questions of having musical concepts or compositions for the new instrument, having a teacher or examples, having suitable musical partners, having a platform to perform etc. the most obvious changes lay in the instrument itself. The sound of the instrument, the simple manageability, the string-specific playability, all these are aspects the musician will face immediately. When planning to use the instrument in concerts questions of mechanical stability and easy repair will arise. Facing these questions it seems to be obvious to think about the conditions the traditional string player needs in order to work in a satisfying way with electronic instruments. According to the experience of the author the following conditions need to be met:

1. The string player needs the possibility to inform himself thoroughly about the instrument.

2. The new instrumental equipment needs to be accessible, testable, affordable, and has to serve its purpose in the context of stage and performance.

3. The instrument has to offer the opportunity for the player to use the traditional playing/articulations techniques and to obtain corresponding sounds.

4. Necessary new instrumental techniques need to be learnable in an affordable amount of time.

5. The new instrumental equipment needs to be repairable with an affordable amount of time and money.

6. The sounds of the new instrument have to be interesting enough for the string player to go through the effort of getting hold of and learning the instrument.

2.1 Accessibility of the instrument

What would an instrument look like if it had to fulfil the above mentioned conditions? Trying to serve the second purpose, developments presented by Mathews [2], Machover [4], Young [11], Trueman [9,10] or Nichols [6] would not fit. The accessibility would be far to small because of the technical know-how needed to implement these devices. Commissions to a company would be expensive and would not solve the problem of replacements and easy repair. Additional to that comes the question of the string-specific playability and learnability. The vBow [6] and hyperbow [11] may decrease problems of unnatural feel of the instrument for a traditional player. The question of if the new instrument is playable and of how it feels, however, is usually answered by testing the instrument for some hours but extremely rare by reading a paper or a test report. Therefore the instruments have to be available *before* they are bought or built by the musician. Regarding these requirements the work done by Jehan and Schoner [3] offers an interesting possibility. They present a sound synthesis that is audio-driven. An electric violin, a laptop for example and demo software would fulfil the complete needs. Unfortunately demo software is not available.

2.2 String-specific playability

The importance of the playability and the feel of an instrument are pointed out by [7] O'Modhrain and [6] Nichols. According to their results, the implementation of haptical feedback into an interface for bowed instruments will increase playability of the system. The instrument offered by Jehan [3] would have this haptical feedback since it uses the traditional construction of stringed instruments. Also the hyperbow [11] and the vBow [6] offer the haptical feedback, however, a pizzicato will cause a problem since these systems track the bow, not the string. Regarding string-specific playability the author believes that the main focus of the string instrument interface has to be set on the string, its modulation by the player and the immediate resonance of the body. A problem in the string-specific playability of Jehahns [3] instrument can be seen in the latency and mistakes that may be expected by using the pitch, noise and brightness follower. There would obviously be a lack of representation of sounds having the most meaningful musical content in other parameters than the analysed ones. This could be the case in bowing techniques like sul ponticello or col legno.

By summarizing these observations string-specific playability is understood in this work as the possibility of an instrument to broadcast the musical articulation of a traditional string player (which is mapped via gestures to the string) adequately to the resulting sound. The playing techniques therefore are: vibrato, finger pressure left hand, glissando, flageolet, double and triple stops sf., cresc., decresc., changing of bow position, legato, détaché, martelé, spiccato, pizzicato, tremolo, scratching, sul ponticello, and col legno.

In terms of playability the violin of Mathews [5] seems to be very good. The pickup audio signal is the constituent signal giving the musician the ability to create new sounds by applying that signal to various analogue filters. Nearly all the gestures the instrumentalist performs to control the sound via the string will be broadcasted to the output. A variation of that system may be found in a part of [1] Goudeseunes system where the pickup audio signal is mapped to resonance filters. The drawback using these kinds of systems is the inability to map data to common methods of sound synthesis like FM Synthesis, waveshaping or physical modelling.

2.3 Demands on the instrument

Summarizing the advantages of the mentioned instruments a method meeting the following demands could be seen as ideal:

1. It uses a synthesis engine consisting of algorithms mainly controlled by the audio signal of the instrument.

2. The synthesis algorithms may run on a laptop computer and create interesting sounds.

3. The created sounds adequately contain the string-specific properties of the input signal.

An instrument fitting these demands would be highly string-specific playable, reachable by means of hard- and software, affordable and could be tested thoroughly before it is build or bought.

3. BASIC CONSTRUCTION PRINCIPLES

Usually researchers try to build better interfaces to increase the playability of existing synthesis methods. The present work turns the tables. It is based on the idea of modifying existing synthesis methods to be playable with a satisfying interface.

What we get from the interface is the pickup audio signal, containing all the necessary information about the instrumental articulation. However, information is not offered in the form one needs to control known synthesis methods. Analyzing the audio signal in order to get these values has the disadvantages described in 2.2. In order to get rid of these disadvantages and to come closer to the demands described in 2.3, existing synthesis methods are modified. They are made controllable by an audio signal oscillation. This method is called Oscillation Controlled Sound Synthesis (OCSS). The raw and unanalysed audio signal controls the main part of the synthesis engine.

In this report an implementation using OCSS is presented. The modification principle used here is the replacement of central oscillators in the synthesis by the pickup audio signal.

Since this is an unusual use, the following simple methods of synthesis have been chosen for the first experiments:

1. Simple FM Synthesis

2. Subtractive Synthesis

The pickup audio signal primary controls the synthesis engine. Additionally this signal is analysed in pitch and envelope. The results are mapped to modify the synthesis algorithm indirectly. Figure 1 shows the set-up.

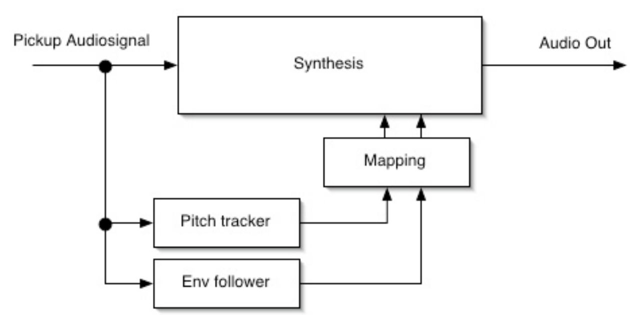

Figure 1: basic principle of the algorithm

The hardware used was a Macintosh PPC running MaxMSP. To verify the results different input devices were used:

- A traditional viola equipped with Zeta Jazz Series Pickup System. Only the audio signal was used.

- A Yamaha silent violin.

- A Harms silent viola (build by the violin-maker A. Harms, Cremona) equipped with a Shadow SH 941 pickup.

Figure 2: Example of the complete hardware needed: Mac PB G4 and Harms silent viola with pickup

4. IMPLEMENTATION AND RESULTS

4.1 Simple FM Synthesis

A simple FM Synthesis algorithm was modified by replacing the modulating oscillator with the pickup audio signal. To control the volume of the carrier oscillator the envelope follower signal was mapped to control its amplitude. To avoid unnatural sharpness in the resulting sound on heavy bowstrokes, the signal of the envelope follower was mapped to control the index as shown in figure 3. To use the ratio of FM Synthesis a pitch tracker was implemented to provide the needed pitch information of the pickup audio signal. Figure 3 shows the resulting algorithm.

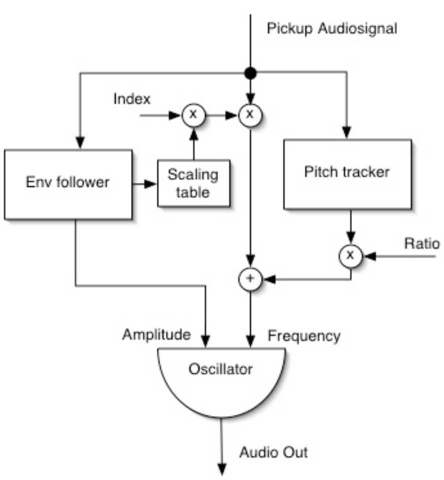

Figure 3: modified FM Synthesis

Sound results were interesting because the typical simple FM-sound could now be played string-specifically. Sound-variations could be obtained by modifying the index (sharpness of sound), ratio (changing to other octaves and to enharmonic spectras) and the waveform in the carrier oscillator (changing the amounts of harmonic parts in the spectra).

Using the pitch tracker it has to be examined how the indirect control affects the sound in terms of latency and pitch analysing mistakes.

Because the envelope follower controls the amplitude of the oscillator a sound already occurs when the envelope follower measures a signal. This shortens latency. The wrong spectrum in the beginning of the tone is a minor problem. The changing of the spectrum after the pitch tracker has sent its actual value is not perceived as a changing of sound but as a little different attack phase. Wrong pitch estimations do not generate a wrong pitch but produce enharmonic spectra. This is less disturbing than a wrong pitch.

The playability in terms of broadcasting articulations from the input to the output is very good. Scratching or modifying of sound-colour by changing bow/bridge distance is well represented in the output.

4.2 Subtractive Synthesis

According to the subtractive synthesis the basic idea was to modify the spectrum by filtering a signal. The usual oscillators placed before the filters were changed by the pickup audio signal.

Bandpassfilters were used which could be assigned to any of the partials of a tone. The pitch tracker controlled the centerfrequencies of these filters. Bandwidth and volume of each filtered harmonic could be set. The complete flowchart is shown in figure 4.

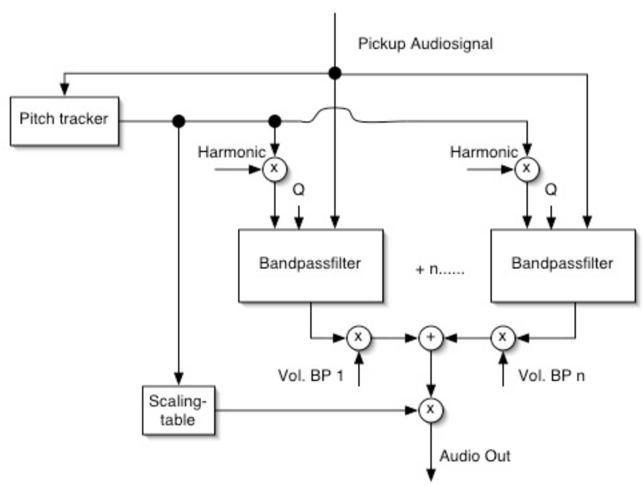

Figure 4: modified Subtractive Synthesis

How do the mentioned problems in pitch tracking affect the sound result?

- If a wrong pitch is detected the actual played pitch is still heard but with a different spectrum than expected. That won't matter as much as a general wrong pitch in the sound result would do. Latency is reduced to system latency because of the indirect mapping of the pitch to sound.

- A problem are the "plopping" sound artefacts. They occur if the pitchtracker jumps during a tone from one to another pitch. They result from the filters making large changes in center frequency. Smoothing the frequency jumps reduces the problem. It causes a flangesound during smoothtime, which is sometimes disturbing. A sound variation that covers the „plopping“ problem is obtained by mapping small range random LFOs to the volume of the harmonics. The resulting bubbling sound makes the plops less audible.

4.3 Soundexamples and Software

Soundexamples and a demosoftware to test the present work by playing may be found on the following website:

http://www.khm.de/~cp

In order to be able to compare the pickup audio signal with the synthesized sound, the soundexamples are presented in stereo format with different sources for the two channels. The left channel contains the raw pickup signal and right channel is the synthesized sound.

The examples present sounds produced with the in 4.1 and 4.2 described synthesis forms and sounds produced by augmented forms of these. A more thorough description about examples and demosoftware is found on the website.

5. CONCLUSION

By listening to the sound examples or playing the instrument, it is made clear that the presented method offers useful results. The sound examples show that the string-specific input articulations are well represented in the output. The system’s drawback is its inability to use methods of sound synthesis, which are controlled by discrete input values like pitch, envelope or brightness. Its advantages come from either having synthesis algorithms that would not need these values or cause little problems in dealing with mistakes in these values. In principle the output sound is based primarily on the raw input signal and is – if necessary - secondarily modified by discrete values of pitch and envelope.

Regarding the conditions elaborated in section 2 it may be said about the presented implementation:

- The new instrument is accessible as soon as an instrument with pickup and a laptop with audio I/O are available. These elements are available at little costs and serve their purpose in the context of stage and performance.

- The sound examples show the ability of the system to broadcast essential string-specific articulations mentioned in 2.2 excepting double and triple stops.

- The system enables the player to use the traditional playing/articulation techniques. The sound results of the system differ little from the corresponding sounds of a traditional instrument. Only small modifications of playing techniques are needed by traditional string players.

- Body and strings are durable/easy to repair similar to a traditional instrument. Hard- and software are durable/easy to repair similar to the instrument of a laptop-musician. Thus the system corresponds with common qualities of durability and easy repair.

The question is left open whether a string player will value the sound possibilities as interesting enough to go through the effort of obtaining and learning the instrument. The technical backgrounds of traditional string players and the personal sound preferences will greatly vary. However, experiences are encouraging. Most of the musicians testing the instrument were amazed by the string-specific playability, possible sounds and construction simplicity of the instrument. Presenting the instruments to composers resulted in requests for cooperation.

6. Outlook

The sound possibilities of the implemented instrument may be broadened in many ways. Other synthesis methods could be modified using principles similar to those used in the methods shown in section 3. More ways to analyse the audio signal could be used. Multidimensional parameter mapping could be brought in. The system could be augmented for playing double or triple stops.

It would be interesting to translate the construction principles to other interfaces based on traditional instruments. Combinations of the presented and related systems would also be desirable. Fingerposition of the left hand or bowposition e.g. could be used for the indirect modification of the synthesis engine.

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