Convolution Brother's Instrument Design

Zack Settel
Zeep.com
4319 Esplanade, suite 1
Montral QC, CA
zack@zeep.com

Cort Lippe
Department of Music
Hiller Computer Music Studios
222 Baird Hall
Buffalo, NY, USA 14260
lippe@buffalo.edu

ABSTRACT

The subject of instrument design is quite broad. Much work has been done at Ircam, MIT, CNMAT, Stanford[1] and elsewhere in the area. In this paper we will present our own developed approach to designing and using instruments in composition and performance for the authors' "Convolution Brothers" pieces. The presentation of this paper is accompanied by a live Convolution Brothers demonstration.

1. INTRODUCTION

To be sure, instrument design has always been a rich source of inspiration and discovery for the authors. We continue to be fascinated by the relationship between instruments and the music written for them. The piano is worth considering in this light. It was born from an idea: an improvement to the harpsichord, which introduced the concept of note-independent dynamic range to keyboard music. Repertoire for the instrument only emerged once the piano had been in the hands of performers and composers for a certain time, after its appearance around 1700. In short, the sound and nature of the piano inspired or induced both pianists and composers to discover new kinds of music for the instrument: "piano music" (i.e. the kind of music written by Mozart, Chopin or Debussy). One could say that the instrument had a particular innate musical potential, based on its design, just waiting to be tapped. The same appearance of instrument-inspired music followed the introduction of the saxophone, or electric guitar. The playing and music of Charlie Parker and Jimi Hendrix cannot be separated from their respective instruments.

Harry Partch and John Cage are two excellent examples of composers whose work deeply integrated instrument design in the compositional process. Harry Partch produced compositions that integrated new scales, notation, and instruments (including playing techniques). The resulting music remains quite distinctive and refined; his music is easily identified and consistent with his other works. Even more impressive is Cage's works for prepared pianos, where Cage takes the piano as an instrumental point of departure, and builds a completely new instrument with an extremely wide expressive range (discussed later). Very little of the piano's original sound is retained. Rather, the instrument is completely revisited, based on the concept of an ensemble of percussion instruments under the control of a single musician. Cage's works for prepared pianos represent an unparalleled example of creative expression, innovation and elegance in composition. While the "instrument" and resulting compositions are in many ways (starting with the timbre) unprecedented, much of the underlying compositional "implementation" (i.e. instrumental technique, and writing/scoring) was squarely based on the tradition and practice of piano music. From our point of view, in terms of compositional approach, the prepared piano instrument serves as a vehicle for discovery, a source of ideas, inspiration and compositional curiosity. It is at the root of the inspiration of the music composed for it. In our approach to composing, the choice (or development) of instrument can be at the root of compositional inspiration, and is a crucial stage in the rendering of the piece. It is as if the music for a piece were "reverse-engineered", given the instrument it is composed for. Otherwise said, in inventing an instrument, one invents a piece. Thus, we attach a great deal of importance to instrument design, and have developed an approach to composing in this way.

[1]The following individuals are quite active in this area: B. Rovan (IRCAM), T. Machover (MIT), M. Mathews (Stanford) and D. Wessel (CNMAT).

2. DEVELOPING INSTRUMENTS

One of the most important considerations we have come to recognize in designing instruments for composition is what we would call "instrumental expressive range"; i.e. to what extent the designed instrument is able to transmit the "musical message" of the performer, and to what extent the instrument is able (versatile enough) to handle a wide range of musical messages. The ideal instrument would be totally responsive and completely transparent, consistently translating the musician's playing actions instantly into sound, arbitrarily without interference or distortion. Though not ideal, it is worth referring to Cage's prepared piano instrument; sure, it lacks the stylistic versatility of the clarinet, but it is remarkably transparent, capable of transmitting even the finest playing gestures (based on piano technique, acquired over the years).

2.1 Instrumental expressive range

The expressive range of a given instrument tends to determine its musical potential with respect to style (i.e. types of musical expression that it lends well to), or compositional application. While the piccolo is a fine ensemble instrument, it is rarely chosen by composers for solo works; to imagine an evening of piccolo music is terrifying. The violin, on the other hand, lies at the other (complex) end of the "instrumental complexity" continuum, and would be a fine instrument to be marooned on a deserted island with. The number of music cultures around the world that include violin, or violin-like music is substantial. Based on its design, the violin is capable of a vast range of musical expression. The same can be said of other instruments of a similar degree of complexity, such as the saxophone or clarinet. Cage's prepared piano, mentioned above, would occupy a position on the instrumental complexity continuum (shown below) much closer to the violin than to the claves.

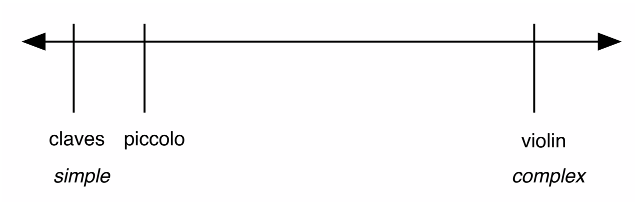

Figure 1: Instrumental complexity

2.2 Instrument structure

In general, a complex instrument holds the greatest potential for musical (including, but not limited to compositional) discovery-especially instruments that are unusual, since the music they "embody" tends to emerge without being subject to habits of hearing or musical expectation. What makes for a complex instrument?

1. High resolution and wide range with respect to dynamics, timbre and pitch (when applicable), though a wide range is less important for pitch.
2. "Instrumental depth" or responsiveness: the degree to which the instrument can consistently render a sonic response specific to a particular instrumental manipulation.

For example, the claves don't qualify as a complex instrument. While they have excellent dynamic range and resolution, the timbre never really changes. You can bang on them any which way you please, but the resulting sound is pretty much always the same.

The instruments we design for the "Convolution Brothers" pieces tend to be complex, and typically involve acoustic instruments with electronic extensions for signal analysis, signal processing, and sound generation. In each case, the acoustic instrument is used as a sound source, and a controller providing control signals derived via event detection. Here's how it looks on paper:

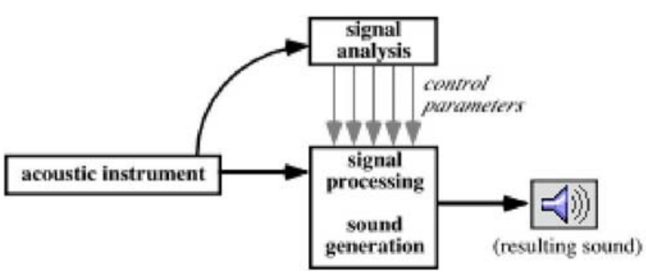

Figure 2: Electroacoustic instrument

The use of acoustic instruments in the design provides a "built-in" degree of instrumental complexity and richness, and a high-resolution "musical interface" for controlling the instrument via event detection. It's a good way to get around the limitations of (usually low and) finite-resolution controllers (i.e. all electronic controlling devices, and particularly those with 7-bit MIDI implementations). In this way, the control resolution can approach that of the audio (e.g. the envelope follower, that produces a 32-bit intensity parameter). Additionally, the acoustic instrument's dynamic spectrum (or fundamental aspects of it) is often present in the instrument's output, usually transformed. Thus, the player's technique and initial expression, as manifest in the dynamic spectrum, are retained. An excellent simple example of this is singing into a ring modulator; while the output sound is completely transformed, all changes (no matter how fine) to the singer's spectrum at the input of the ring modulator will produce corresponding degrees of change in the modulator's output spectrum. From this point of view, the processing technique is highly transparent to the singer. Finally, the acoustic instrument's spectrum can be combined with additional sound sources, whose behavior is analogous in one or more ways to the acoustic instrument's behavior, and a hybrid sound results. For example, an FM generator's frequencies can be mapped from the acoustic instrument's detected pitch, while the FM generator's dynamic spectrum is spectrally gated (as in vocoding) by the acoustic instrument's spectrum. The resulting sound's behavior is quite similar to that of the acoustic instrument. However the spectral content can be radically different.

2.3 The instrument and its context

The higher the degree of an instrument's sophistication (i.e. the instrument's ability to produce a wide range of timbral responses, based strictly on the musician's input), the less it needs to be updated via "external" (non-player based) parameter or configuration changes. Typically, these kinds of "external" updates are based on the player's position in the score (or musical situation), and executed via manual triggering, control tracks, or score followers. With the ability to design a sophisticated instrument and predict how it will respond (sound) to a performer's particular musical input, the performer's score can be written with the instrument's response in mind, and material can be written in the score to provoke certain responses from the instrument when played by the performer. No score following is required. Instead, the performer's score serves as a sort of control track, containing a sequence of events that will ultimately determine (via event detection and parameter mapping) how the instrument is to sound . This relationship between the instrument and the music intended for it is central to our approach to instrument design and score crafting (or improvisation applications).

3. IMPROVISATION

Designing instruments for use in specific compositions is already a lot of work. However, the realm of possibilities is limited by the demands of the given composition during the course of its execution; the requirements of the instrument are "defined" as a single sequence specifying the instrument's behavior and state at any given moment during the piece. The sequence itself often consists of references to patches to be activated at a particular time, with associated context-specific data, such as harmonizer transpositions or what have you. Score following is a well-known technique which is employed for this kind of functional sequencing, and can be effective as long as the sequence of functionality for the instrument is pre-defined-and as long as there's someone watching the score follower. Designing instruments for use in compositions with "structured improvisation" is more work; the instruments are not designed for use in a highly circumscribed through composed musical situation. Rather, they are designed to be "run away with", in the "hands" of a virtuoso performer.

The amount of complexity required of an instrument for improvisation is significant-especially if the player expects to play for more than five minutes without getting bored. The trouble with our finite electronic instruments is that they usually only go as far as the imaginations of the designers. Unlike an empty oil barrel, you can bang on a synthesizer any number of ways, the resulting sound will always be within the realm of its specified, “programmed” behavior, intended or not. The oil barrel delivers an infinite number of variations for each “whack”. This brings us back to the above discussion on instrumental depth: If you are going to have to spend some time on a desert island with an instrument, or are planning to improvise, you better make sure your instrument is not easily exhausted. Designing instruments for arbitrary style-independent improvisation situations is not obvious. Even a saxophone would have a hard time living up to such an ideal. But let’s say that even when the style is somewhat defined, such as the “out there” experimental electroacoustic free-jazz, like the kind of stuff you hear at festivals in Victoriaville, Quebec or in Vandoeuvre, France, a “suitable” instrument’s potential range of expression is still enormous.

3.1 The instrument interface

The instruments described above, particularly the ones used for virtuoso passages in the Convolution Brothers’ works, serve as good points of departure for improvisation instruments. Rather than going into endless descriptions of variations on the coupling/combining/piloting of unit generators, we will emphasize an additional aspect of the improvisation instrument: the interface. Unlike the instruments in “through composed” works, that resemble timelines more than anything else, the interface for an improvisation instrument needs to be intuitive and allow for on-the-fly enabling of the instrument’s features (e.g. percussion sound triggering, reverse-gate reverb, triggered harmonization, sampler source material choices, etc.). Everything (all the DSP) must be able to run at the same time! The interface also needs to be modularized, so that subsets of it can be mixed and matched. Below is the interface that the authors have been developing over the past few years, and are currently using for improvised performance:

The interface provides two input meters, corresponding to DSP sends A and B. The DSP sends feed their respective unit generators. Many, but not all the types of unit generators in DSP A exist in DSP B. Using this “parallel” DSP implementation, the same input signal can be routed to both DSP A and DSP B, for extensive processing. Alternatively, two independent inputs can be routed to either DSP send, and thereby be processed independently of each other, as in the case of a duo. The functional parts of the interface are broken down into the following parts:

3.1.1 *Recall via PRESET*

Contains a preset object, which allows the state of all the principal graphical parameter displays on the interface to be captured and recalled, snapshot fashion. This feature is invaluable, allowing for last-minute and/or in-concert modifications/additions to the instrument.

3.1.2 *“Sub States"*

Consists of labeled switches (1A-16A) that represent enabled/disabled sub states (audio and control routing and DSP states, defined elsewhere, see fig 4), in which arbitrary control sources for the unit generators of DSP A are defined. These sources include parameter data, control algorithms, and event detection control-stream mappings to DSP parameters. For example, sub state “3A” activates a sampler in DSP A, and routes the triggers and amplitude envelope (from the event detector) to the sampler. Sub states are constructed add-hoc, as needed, addressing one or more unit generators; there is no one-to-one correspondence between sub states and particular unit generators. Thus, any combination of sub states can be active, however, certain enable/disable the same unit generators, so care must be taken when cooking up combinations of them. An input meter displaying the input level of the each of the two DSP sends is included.

3.1.3 *Event Tracking Assign*

Routing of the computer’s three audio input signals to the event detector, DSP A and DSP B is specified here. There is only one tracking block to which any or all of the audio inputs can be assigned.

3.1.4 *Special Unit Generator Parameters*

Particular unit generator parameters, including sample names, are located here for quick access in performance, or convenience during pre-concert preparation.

3.1.5 *Output Mixer*

Provides access to output gain levels for all the unit generators-a mixer of sorts. The “trim” slider controls the gain of the overall DSP output, and is quite indispensable since its value often varies from preset to preset in order to maintain a uniform global “mix” level across them.

3.1.6 *DSP States*

Displays the state of the unit generators for both DSP A and B. For convenience and rapid access to parameters, external MIDI controllers can be used to control certain parameters of the interface such as feedback gain levels, trim, and master gain. Typically those parameters are related to mixing, not to the “instrument” per se.

The preset bank mentioned above provides instant recall of any combination of sub states. The fundamental behavior and functionality of the improvisation instrument(s) is defined in the sub states, and combinations of them. New sub states are added to the instrument from time to time, as necessity or inspiration has it. But for the most part, designing an instrument involves the combination of sub states rather than the creation of new ones. Below, a code example of a sub state defining the “gap-fill” reverb mentioned earlier. The performer’s amplitude gates his send level to the reverb unit, and inversely gates the reverb proportion (dry/wet mix) in the unit’s output.

4. USING THE INSTRUMENT

Normally, only a handful of presets are really used since each preset represents a complex instrumental configuration that can be used for some time before “timbral exhaustion” occurs. But minor changes to these basic presets are often made either before, or during, performance-mostly for mixing balance purposes. Thus, the majority of the many presets shown above are just modified copies of the basic handful. On stage, the instrument spends most of its time waiting for, responding to, and combining with the microphone input. Some preset changes are recalled from time to time when major musical “gear shifts” are required (such as going to a specific “bell triggering” effect for a moment).

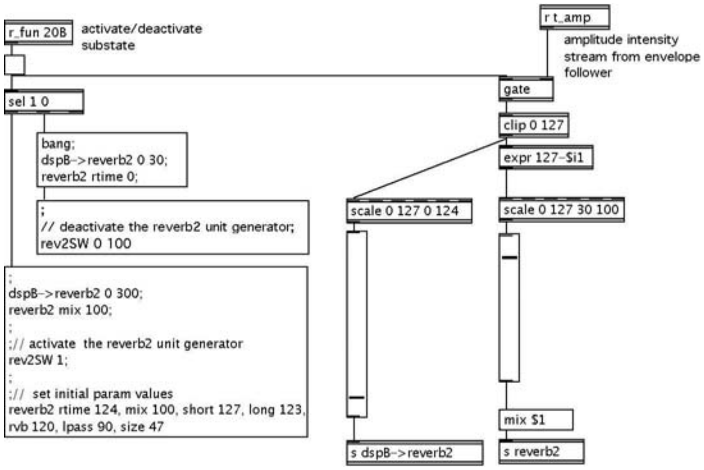

Figure 3: Code example of a "sub state"

However for the most part, it is the musician who evokes the timbral changes in the instrument simply through his modes de jeux, and not through major changes to the instrument's topology, signal routing or control mapping.

5. CONCLUSION

The strong emphasis on the "instrument" in this paper reflects our longtime preoccupation with composing with instruments for live performance. In our approach, the instrument is present in the composition process at its very inception-as a source of musical expression, wonderment, curiosity, discovery, and inspiration. The approach to electroacoustic instrument design presented in this text provides for the invention and reinvention of new instruments, which themselves can lead to new musical expressions, from which compositions eventually emerge-which, in turn, inspire the invention of still newer instruments. This iterative process embodies composition and performance in a continuous cycle of creation and expression, where the underlying techniques serve simply as a vehicle for the imagination and as a source for the musical spirit.

6. ACKNOWLEDGMENTS

Our thanks to Miller Puckette, Bennett Smith and David Zicarelli.

7. REFERENCES

[1] C. Lippe. "Getting the Acoustic Parameters from a Live Performance" . In *Proceedings of the 3rd International Conference for Music Perception and Cognition*, pp. 328-333, Liege, 1994.

[2] C. Lippe. "Music for piano and computer: A Description". In *Information Processing Society of Japan SIG Notes*, vol. 97, no. 122, pp. 33-38, 1997.

[3] R. Rowe. *Interactive music systems: machine listening and composing*. Cambridge, Mass.: MIT Press, 1993.

[4] D. Wessel. "Timbre Space as a Musical Control Structure" Computer Music Journal, vol. 3, no. 2 , 1979.

[5] D. Wessel, D. Bristow, and Z. Settel "Control of Phrasing and Articulation in Synthesis" In *Proceedings of the International Computer Music Conference*,1987.

[6] D. Zicarelli. "Music Technology As A Form of Parasite". In *Proceedings of the International Computer Music Conference*, pp. 69-72, 1992.