New Electronic Musical Instruments
Restoring the Relationship between Sound Source and Control

Bert Bongers

The relatively new way of producing sound by using analog or digital electronics offers an opportunity to devise new user interfaces or instrument forms. This article describes some of these controllers and explains more about the problems that occur in their development. Possible solutions are suggested.

Introduction

Electronic sound sources like synthesizers and samplers are usually controlled (i.e. played) through a keyboard, which has proved to be a versatile user interface. In traditional musical instruments, the sound source (e.g., strings being plucked or strung, air vibrating in tubes) and the control part form one indivisible instrument. The form of the instrument, and therefore the way it is played, is mainly imposed by the sound source. The electronic sound source however, does not impose *any* limitations on the instrument form. The whole realm of sensors and actuators are at the designers' disposal. This makes it possible to devise new instrument forms for this (relatively) new way of producing sound. Around 1920, the Russian scientist Leon Theremin invented the instrument that bears his name. It is controlled by waving ones hands near two antenna's to control pitch and volume, and its typical sound can still be found on many records in popular music (from the Beach Boys' 'Good Vibrations' to Portishead).

After the introduction in the mid eighties of MIDI, a protocol through which electronic musical devices (including computers) can communicate digitally, the separation between sound source and user interface became more common. This has led to a number of interesting new forms of musical user interfaces. This article describes some of these, and explains more about the ideas behind it.

But due to this separation, the relationship between the sound properties and the feel (the 'action') of the instrument was lost which makes the instrument less intuitive and less expressive. Through the use of active tactile and force feedback, provided by actuators such as motors, shape-memory alloys, and piezo's, the sound properties can be made *tangible.* This will be described in the last section.

The Hands

One of the pioneers in this field is Michel Waisvisz, director of STEIM (Studio for Electro-Instrumental Music) in Amsterdam [**?**]. Around 1985, he devised an instrument form called The Hands, which consisted of small keyboards attached to the player's hand. With this instrument, the 'keyboard-player' was enabled to move freely across the stage, and thus make a better looking performance also because properties were sensed like the distance between the hands (by ultrasound transducers) and inclination (mercury tilt switches).

Over the years, several versions were built with all kind of improvements (one of the earlier pairs is displayed at the musical instrument exhibition in the 'Gemeentemuseum' in The Hague) and Mr. Waisvisz has performed with them all over the world. Several educational versions were derived from this concept, one for the Musikhochschule in Basel, and a series of six named 'The MIDI Conductor' (see Figure **??**) for the Conservatory in the Hague.

kader 5 x 6 cm
foto 5.5 x 6.5 cm

Figure 1: The MIDI Conductor.

Gloves

Developments in virtual reality industry enabled electronic musicians to make music with instrumented gloves; the Mattel Powerglove was commonly used for this. The PowerGlove was introduced at the end of 1989 to control Nintendo games, but it mainly found its way to scientists and artists [**?**].

At the Sonology Department of the Royal Conservatory in The Hague, students started working with PowerGloves, after some surgically customisation to make them more sensitive. Over the years, this evolved into a very sophisticated kind of SonoGloves which were made of golf gloves. It measures the distance between the hands, the position in space, orientation, and the bending of the fingers. The glove as shown in Figure **??** was made for Laetitia Sonami. It is made of lycra, with more than 20 sensors sown on. It can be covered with an outer glove.

kader 5.5 x 10 cm
foto 6 x 10.5 cm

Figure 2: The Glove.

The Web

Most sound sources have many more controllable parameters than a keyboard can generate. To make a more sensitive instrument, Michel Waisvisz came up with the idea of an instrument modelled after a spider's web. By measuring the tension in each string, and assigning these values to sound attributes it was possible to control about 24 parameters simultaneously. As a comparison, an ordinary key has two parameters at most (velocity and pressure) whereas it is believed that a trained violinist has about 27 ways to control timbre, though most players are not consciously aware of this. Due to the form of the web, these parameters are physically linked (just as with traditional instruments) to keep it manageable.

Later, Mr. Waisvisz came up with the idea of tying himself up on stage in these ropes, to make a better show as a sort of musical Hudini. This idea was (literally) further extended by the members of Sensorband [**?**], who built a giant web in which they could climb to control the music (see Figure **??**).

kader 6.5 x 9.5 cm

foto 7 x 10 cm

Figure 3: Sensorband in the Soundnet.

Bio-electrical control

A fascinating possibility to control an electronic sound source is by means of the electric signals that are generated in or on the human body. For instance, Atau Tanaka is using The BioMuse (developed at Stanford University [**?**]) which reads the electric signals emitted by contracting muscles (Electromyographic or EMG signals). Other devices, such as the WaveRider and Psychic Lab's IBVA, use brain waves (EEG signals) to control music but that's quite difficult for our Western minds. The Australian performance artist Stelarc is a pioneer in this field, he has a robot arm attached to his body which is controlled by the muscles of his stomach.

At the Sonology Department, a system is used which was developed for medical applications. This system, K-Lab MyoVision, was developed for revalidation purposes which requirements resemble our needs: wearable, wireless, and measuring the signals while moving the whole body. Initial results look quite promising.

Sensitive Chords

For the University of Amsterdam, an instrument was developed to investigate the cooperative use of one single source. This instrument must be played by up to four (but no less then two) people simultaneously (see Figure **??**). Each player has his or her own 'voice', but due to the – intentional – mechanical linkage of all the actions of each of the players it is not possible to control the individual sound locally. The players have to work together to produce music, which proves in practice to be very difficult [**?**].

kader 6.5 x 9.5 cm

foto 7 x 10 cm

Figure 4: Cooperative music making.

Tactual feedback

Another very important thing that has been lost at the transition from acoustical to electronic musical instruments is tactile and force feedback. The relationship between sound and feel is distorted; any sound selected on your synthesizer will have the same keyboard action. Haptic cues, however, are very important as information on sound-parameters can be conveyed from the sound source to the player. Our tactual perception consists of two parts which work closely together: the tactile part (the mechanoreceptors in the skin) and proprioceptive part (force sensed in one's joints and muscles).

The use of active proprioceptive feedback has been explored by ACROE (Grenoble) [**?**] and at CCRMA (Stanford) [**?**], oddly enough again on keyboards. The force feedback of these keyboards can be programmed to emulate any action, for instance the feel of a Steinway concert grand piano or the feel of a harpsichord.

At the Sonology Department, experiments have been done with (MIDI-controlled) motors and electrically sensitive shape memory alloy Muscle Wires. These Muscle Wires, very appropriately called that way because they are very thin (typically 100 μm) and perform in a very organic way: the wire shortens in length when electricity is supplied. We have attempted to build these wires in the gloves to control the flexibility of the fingers, thus providing the instrument with force feedback.

With tactile feedback only, already a lot of information can be conveyed with modest power requirements. For instance, a ring with a tactile actuator (a small solenoid) have been constructed to give tiny cues on the skin of the finger to provide guidance while making gestures.

With these technologies, it is possible to restore the relationship between sound source and the interface. This feedback of sound properties can be called articulatory feedback. As with traditional instruments, this feedback gives the player more control over the articulation of the sound. It is a way of making electronic music more lively. □

References

[1] Claude Cadoz, Leszek Lisowski and Jean-Loup Florens. *Modular Feedback Keyboard.* Int. Comp. Music Conf. Proceedings 1990, pp. 379-382, 1990.

[2] Brent Gillespie. *The Touchback Keyboard.* Int. Comp. Music Conf. Proceedings 1992, San Jose, CA, pp. 447-448, 1992.

[3] Rich Gold. *It's Play time, Fun and Games with Interactivity.* In: Cyberarts, Exploring Art & Technology. Linda Jacobsen, ed, 1992.

[4] Jacqueline de Jong. *Interactive Interfaces; a Musical Metaphor*, PhD Thesis, University of Amsterdam (in preparation).

[5] Hugh Lusted and Benjamin Knapp. *Controlling Computers with Neural Signals.* Scientific American October 1996, pp. 58 - 63

[6] http://zeep.com/sensorband

[7] http://www.dds.nl/~steim/

Pasfoto Bonger

Bert Bongers has studied Electrical Engineering. He has worked for seven years at the Sonology Department of the Royal Conservatory in The Hague. He is a guest lecturer at the Interaction Design department of the Utrecht School of Arts. Currently, he is a researcher at the Institute for Perception Research (IPO) in Eindhoven.