Commentary: With Shifting Joints

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The present text discusses my electro-acoustic composition *With Shifting Joints*. The text outlines my composition techniques, explains the global form of the composition and lists the technical means I applied.

1 Basic Information

Title With Shifting Joints

Instrumentation Eight-channel tape piece

Duration approx. 11 min.

Date of Composition Composition completed in March 2003

Commissioned by Komponistenverband Thüringen e.V. (composers society of Thuringia, Germany)

Production Studio Sonic Arts Research Centre at Queen's University Belfast

First Performance 30 October 2003 in Morelia (Mexico) by Dr. Ricardo Climent

2 Introduction

In the multi-channel tape piece *With Shifting Joints*, I composed instrumental articulations and placed them around the listener.

I applied virtual instruments, physical models comprised of cells and their connections. Such instruments allowed me to realise unconventional articulations with high precision and extreme parameter changes.

For example, I bowed an instrument with such a sharp attack that it almost sounds like hitting the instrument with a hammer. I further disturbed the decay of that attack by tremolo bow movements.

Some of the articulations are impossible to perform in the real world. For instance, I coupled two freely vibrating strings by a spring, which results in a combined instrument with a complex spectrum. Now, while bowing one of the strings, I shifted the joining spring along the strings to shape spectral evolutions. This articulation technique became such an important feature that I named the piece accordingly.

The resulting sound events are rich and complex, therefore I have choosen a simple formal arrangement.

The spatialisation underlines the musical form. Re-occurring sound events have their typical position or movement in a two-dimensional plane around the listener. Highly structured sound sequences are unified by a common moving direction.

3 Creating the Instruments

In acoustic compositions, composers usually select their instruments out of the number of instruments already existing. In electro-acoustic music, on the other hand, the composition process often starts with the definition of instruments for the composition. This section sketches the instruments I defined for the composition *With Shifting Joints*.

3.1 Three Instruments

For the composition I defined three main physical-modelling instruments. During the composition I used variations of these instruments.

The most simple instrument is a plate with elliptical shape. The plate is fixed along its perimeter, similar to a drum skin. However, the sound of the plate decays slower and is more gong-like. Figure 1 shows a variation of the instrument in motion.

The second instrument consists of eight circular plates. The plates are tuned at eight different pitches (intervals correspond the first eight partials of the harmonic series). However, the plates don't have clearly perceivable pitches. Seven of the plates are connected to the eighth and highest plate. These connections happen by seven springs. Each spring bidirectional leads the vibrations of one connected plate to the other connected plate. That way, the eight inter-connected plates act as a single musical instrument. Exciting one of the eight plates sets the whole instrument in motion. Nevertheless, exciting different parts of the instruments results in different sounds.

The third and most important instrument in the composition inter-couples two strings by a spring. When the instrument is played, the spring can be moved along each string. Figure 2 shows the two strings (of different length) in motion. Two different moments are shown in two pictures. The pictures mark the positions where a the spring is connected to a string with dots labelled connector (the spring itself is not shown). Usually, I bowed one of the two strings and at the second string I 'recorded' the string movements at two positions. Sometimes I connected the ends of two additional loose strings at the second string and recorded the movements of the other end of these two additional strings.

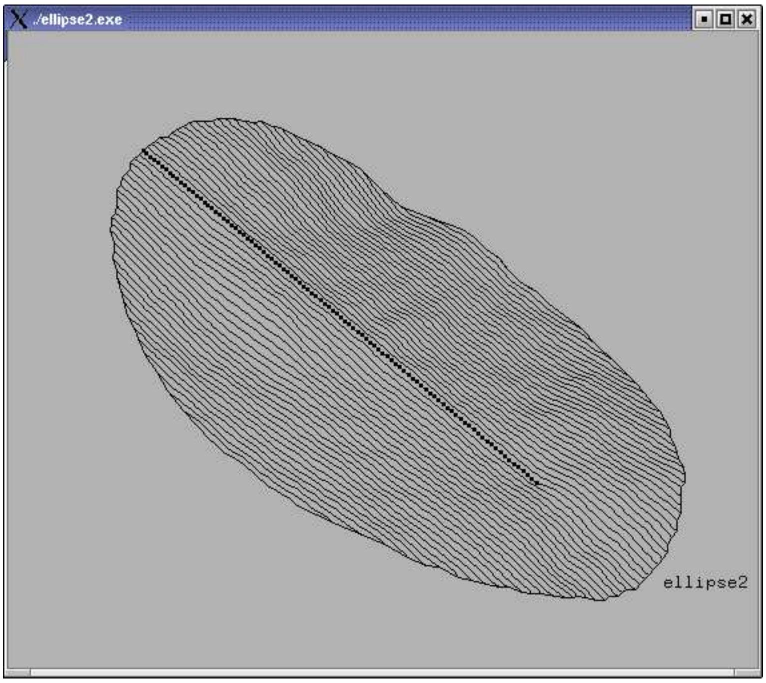

Figure 1: Vibrating Ellipse

3.2 Three Articulations

The three instruments introduced in section 3.1 are played by three different excitation techniques or articulations.

An instrument is either bowed normally (arco ordinario), an instrument is bowed in a special tremolo technique which almost sounds like a sequence of hits, or an instrument is hit by a bouncing hammer. During the composition process I called the bow-tremolo technique 'bow-grains', because the articulation results in a stream of sound-grains.

In the composition, some of the instruments defined above are always used with the same articulation, some are used with different techniques. The simple elliptical plate is always bowed normally. The inter-coupled circular plates are hit by a bouncing hammer. The two inter-coupled strings are either bowed normally or bowed by the special bow-grain technique mentioned.

4 Global Form of the Composition

I evolved the plan for the global musical form of the composition *With Shifting Joints* by grouping my musical instruments and articulations. I decided that the inter-coupled strings will be my main instrument. Playing this instrument by the two different articulations for the inter-coupled strings – normal bowing and bow-grains – I constituted two

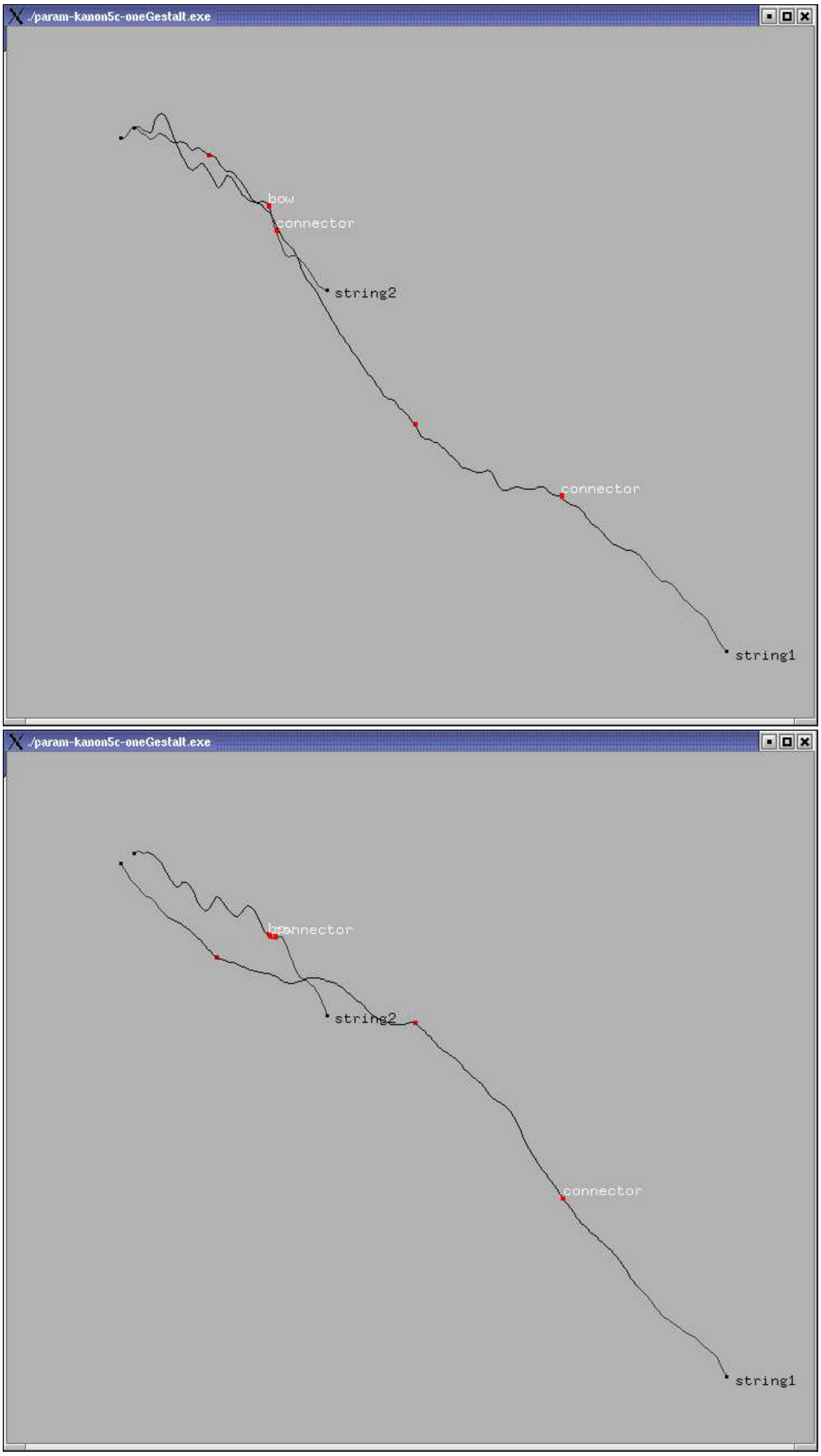

Figure 2: Vibrating Inter-Coupled Strings (two frames of a film)

main characters of the composition. These two characters play an important role for the musical form of the piece, their role remotely resembles the role of two musical themes.

I complemented each main character with a secondary character. I played each secondary character with a plate-instrument. The figure 3 shows the two character groups, each member of each group is constituted by its instrument and its articulation.

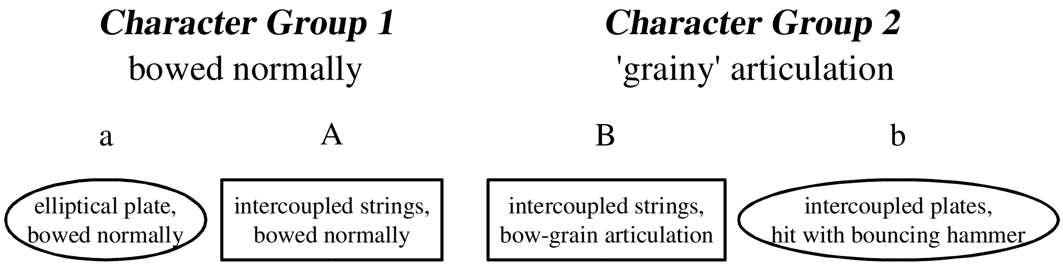

Figure 3: Two Main Character Groups

Each section in the composition applies a single instrument and a single articulation and thus belongs to one of these four characters. My compositional plan (see figure 4) shows the chronological arrangement of the sections to describe the global musical form of the composition.

All sections of the main character of first group (normally bowed inter-coupled strings) is marked by an upper case A, the secondary character (normally bowed elliptical plate) is marked by a lower case a. The main and secondary characters of the second group (bow-grain articulation on inter-coupled strings and bouncing hammer on inter-coupled plates) is marked by B and b.

A few sections in the compositional plan are not further marked. These sections serve as 'accompaniment': they are highly reverberated and very soft variations of $A3$ and add spacial depth.

The secondary character of each group tends to bring in the main character of its group. Section $a1$ proceeds section $A1$, $a2$ proceeds $A2$, and $b1$ proceeds $B1$. However, the secondary character $a3$ of the first group introduces $B1$, the main character of the second group. Section $A3$ has no proceeding secondary character, instead it is introduced by a reverberated variant of itself. The section $B3$ is introduced by the secondary characters of both groups. Finally, the the secondary character a does not only begin but also end the composition.

All sections of the same character (e.g. the four sections $A1$, $A2$, $A3$, $A4$) are variations of each other. The techniques to compose the sections of the composition themselves is outlined in the following section 5 of this text.

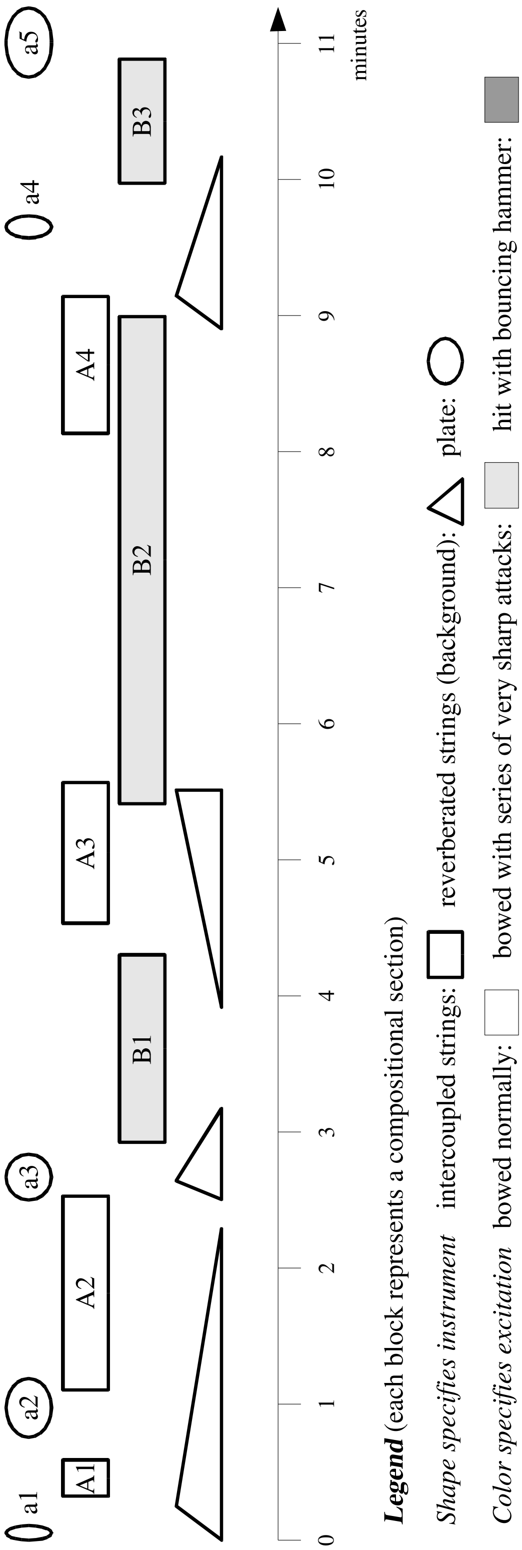

Figure 4: Plan of the Composition

5 Composition of the Sections

While I did the arrangement of sections for the global form mainly 'by hand', I used techniques of algorithmic composition to compose each section.

Many parameters of the physical-modelling instruments defined for the composition can be changed while playing the instruments. The instruments don't know the concept of a single note: each parameter can be variated at any time during the performance. Introducing the note concept makes reasoning over the score more easy, however, this also forces each instrumental action into the note frame.

I avoided thinking in notes while composing *With Shifting Joints*. Instead, I composed instrument actions like 'apply the bow x to the string y' or 'set the bow force to z'. These actions may happen concurrently. Actions involving numerical values like 'set the bow force to z' can be controlled by envelopes.

I composed the sections of the composition mainly by composing envelopes which control the numerical parameters of the instrument. For the main instrument, the inter-coupled strings, important parameters which I controlled by envelopes are:

- Position along the first string where the bow is touching the string
- Force applied to the bow
- Velocity of the bow movement
- Position along the first string where the spring is attached
- Position along the second string where the spring is attached

While preparing the composition I developed programming means to generate, combine and transform envelopes in very flexible ways.

The figure 5 presents the envelope score data for the section $A3$ of the composition (in this section, inter-coupled strings are bowed normally). The graphs shows the envelopes for the instrument parameters bow force (force), bow velocity (velo), the spring position at the first string (access1) and at the second string (access2). The x-coordinates of the graph show the time in seconds.

Changing the spring positions results in the 'spectral glissandi' in section A3 (as well as in many other sections of the composition). The graph also shows that these spring positions change in a simple pattern, while the bow force and velocity change very gradually over two minutes. This approach results in recognisable pattern of 'spectral glissandi' in the sound while the overall quality of the sound changes gradually.

In every A-section in the composition I use a similar approach and I always change another parameter slowly. For instance, in section $A4$ (see figure 6) I change the overall damping of the string very gradually, which results in a slow but clearly perceivable

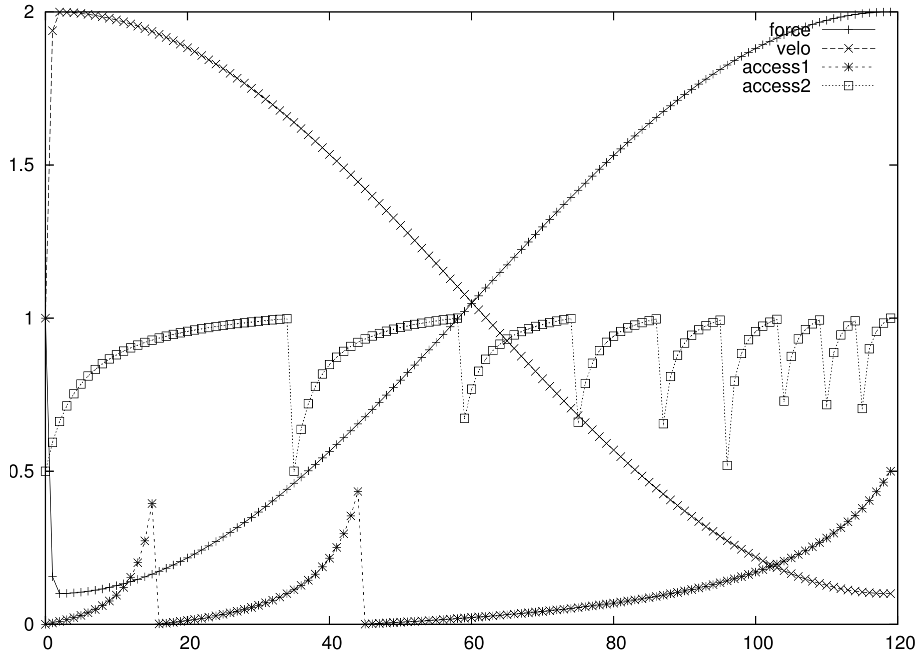

Figure 5: Tao Score Data, section $A3$: normally bowed inter-coupled strings, slowly decreasing bow force while increasing bow velocity

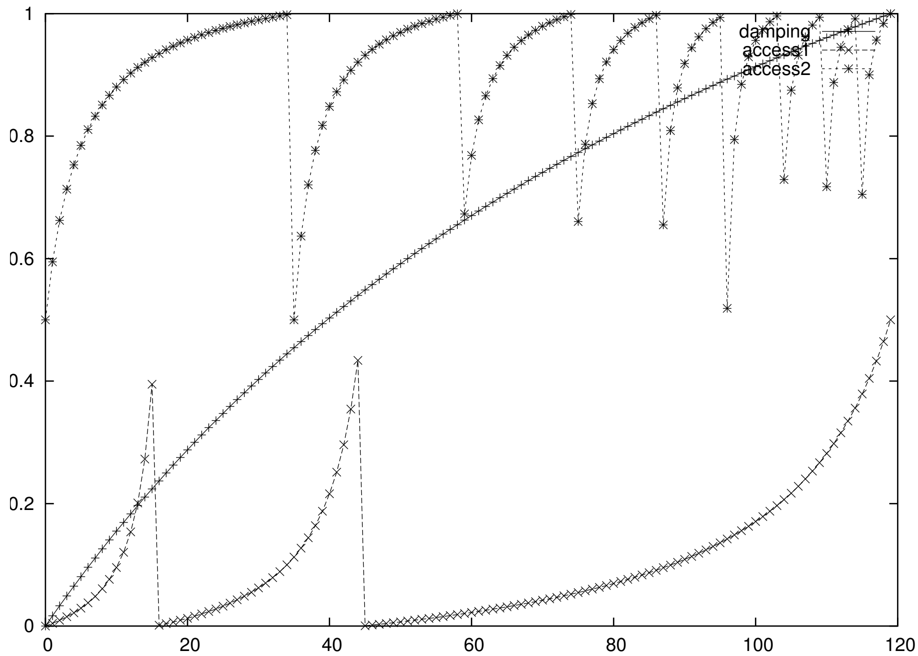

Figure 6: Tao Score Data, section $A4$: normally bowed inter-coupled strings, increased string damping causes glissando downwards

glissando downwards. However, section $A1$ does not slowly change its 'own' parameter. Instead, this section sightly variates the beginning of $A2$.

When we compare the graphs of the sections $A3$ and $A4$ (figures 5 and 6), we notice that both sections (as all A-sections) are close variations of each other. The graphs of the envelopes controlling the inter-coupled string instrument of the section mainly differ in the parameter which is gradually changing (i.e. the bow force and velocity in section $A3$ and the damping in section $A4$). In fact, the envelopes controlling the movement of the spring along the strings are identical (parameters not shown in the graph stay constant). This similarity results in similar 'spectral melodies' caused by the spring movement. However, these 'melodies' are also effected by the parameters which differ and therefore these 'melodies' are not identical.

I composed the scores for the five sections $a1--a5$, the secondary character of the first group, as well mainly by composing envelopes. In these sections, the envelopes control, for instance, the position where the bow touches the plate (this point has two dimensions: I can bow the plate at any point of its plane). The bow position on the plate is highly influential for the resulting timbre. Nevertheless, the scores for the a-sections are more simple than for the A-sections.

I also composed envelopes while composing the B-sections. However, theses envelopes are much more complex then the envelopes of the A-section. The three figures 7, 8 and 9 visualise only the first seconds of the score of section $B1$.

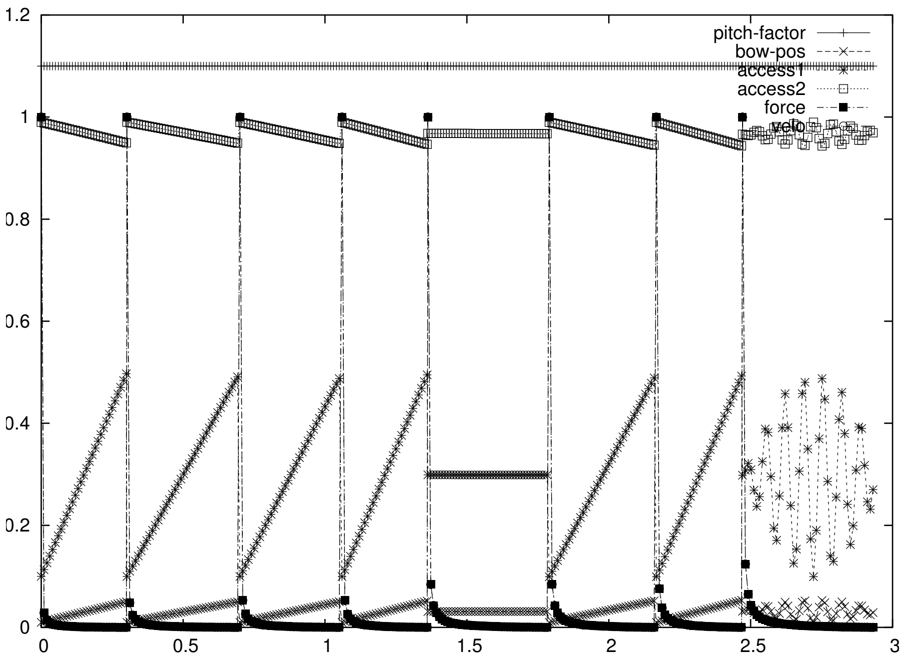

Figure 7: Tao Score Data, section $B1$ (beginning): tremolo-liked bowed inter-coupled strings

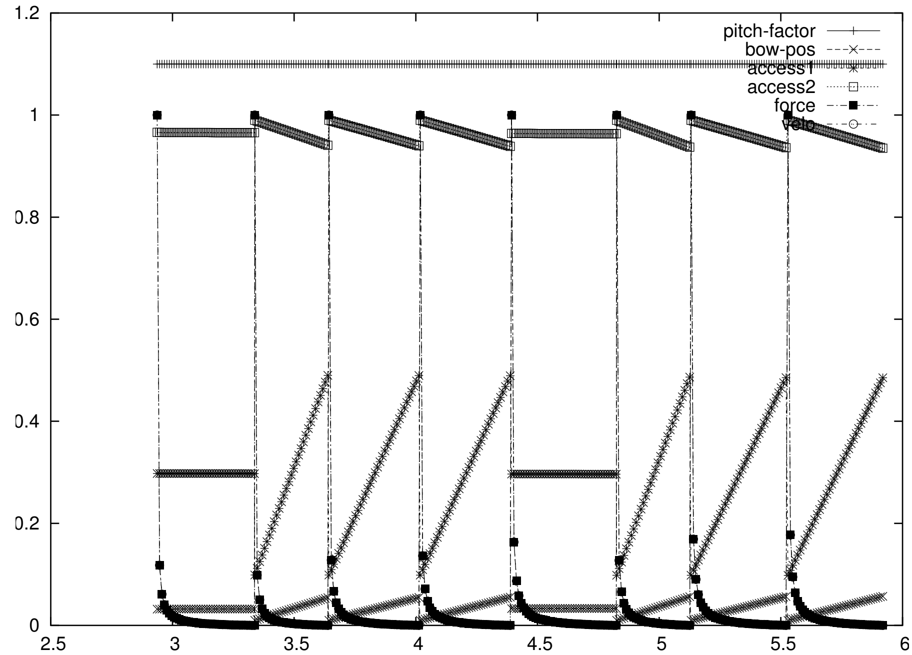

Figure 8: Tao Score Data, section $B1$ (continuation 1)

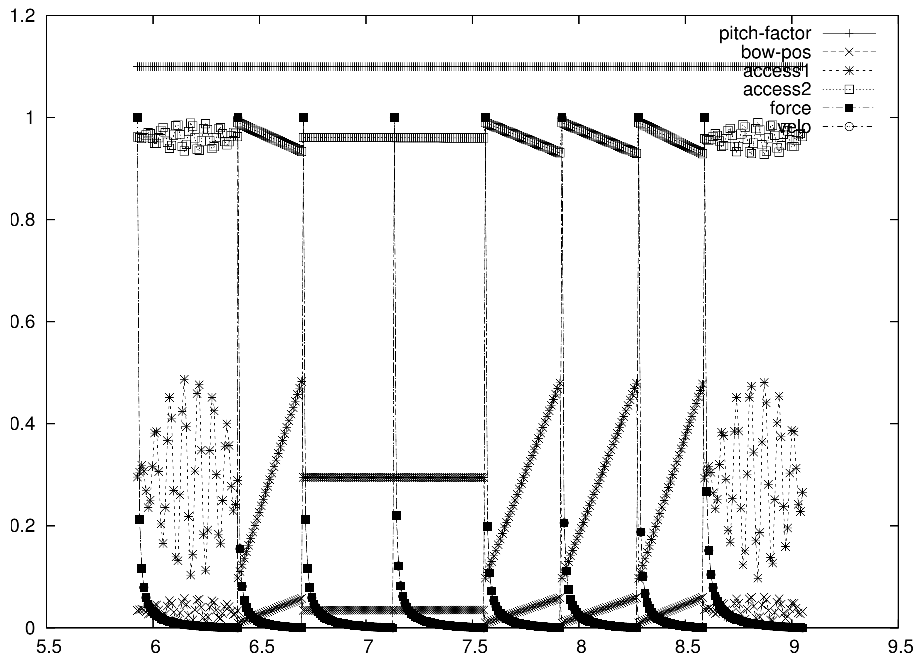

Figure 9: Tao Score Data, section $B1$ (continuation 2)

The graphs show the short bow force and velocity 'grains', which result in the bow-grain articulation. The graphs shows also the complex pattern of the envelopes for the parameters controlling the spring positions (conn-access1, conn-access2). These patterns are composed by algorithmic composition means based on a generalisation of rewrite pattern streams (see [Taube, 2003]) which I developed preparing the composition. I also developed means to fuse pattern streams and envelopes.

The seven sections $b1 - -b7$ (see figure 4) are all generated in a single performance. The instrument of these sections consists of eight inter-connected circular plates, which are excited by a bouncing hammer (see section 3). In the sound synthesis process I 'recorded' each plate separately. In this performance, I hit the instrument once and let the hammer bounce. The seven b sections in the composition are all recordings taken at the same time at the seven plates which are connected to the eighth plate. The plate where the 'microphone' was attached dominates the recording, which explains the seven different pitches of these section (I re-arranged the order to avoid a simple harmonic scale).

6 Spatialisation

The eight-channel spatialisation of the composition is an integral aspect of the composition. The purpose of the spatialisation is to underline the musical form of the composition. Re-occurring sound events have their typical position or movement in a two-dimensional plane around the listener. Highly structured sound sequences are unified by a common moving direction.

For the spatialisation process I mainly employed the *room in a room* model by F. Richard Moore [Moore, 1990]. In this model, the loudspeakers are interpreted as holes in a virtual inner room, through which sounds radiate from a virtual outer room. A sound processed by the spatialisation articulates this outer room (during a performance, the real room in which the piece is played is articulated as well). The spatialisation of Moore models sounds very authentic, because the amplitude differences and time differences are modelled. The model also models the Doppler effect. I extended the original four-channel model by Moore to an eight channel setup. The eight loudspeakers for *With Shifting Joints* are positioned in a circle around the audience as shown in figure 10.

In the composition, I moved each channel of each sound independently along a three dimensional envelope (dimensions x, y and time). To create a higher formal coherence, I used similar envelopes for similar sections of the composition. For instance, I recorded two channels when playing the bowed plate sections $a1 - 5$ (see figure 4). In the spatialisation process, I always moved the two channels of these sections from front to back (one channel at the left hand, the other at the right hand), although not directly.

Some reverberant sounds in the composition "colour" the background. The eight-channel spatialisation of these sounds is done by another technique. I convolved these sounds with an impulse response of a cathedral recorded in ambisonics B-format. The resulting

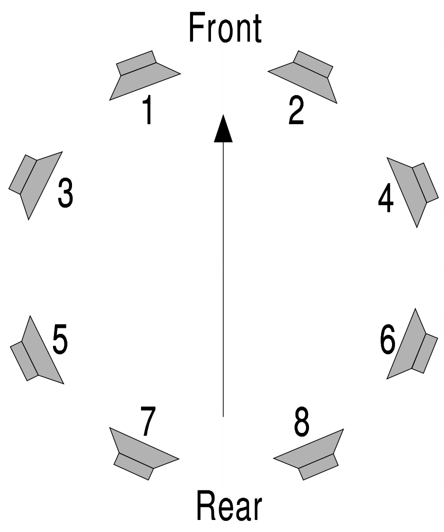

Figure 10: Loudspeaker Positions

reverberated sound in B-format is further processed (e.g. rotated) and transformed to an eight-channel sound.

The stereo version of the piece simply plays two channels of the total number of eight, resulting in a less clear but coherent presentation.

7 Technical Means

For the production of *With Shifting Joints* I utilised the following software: the Tao sound synthesis package [Pearson, 2000], SuperCollider [McCartney, 2002], the SuperCollider extension CrucialLibrary [Sattinger], the Common Lisp [Pitman] implementations CMU-CL and MCL, Common Music [Taube, 1997, 2003], the GNU C++ compiler, Nuendo [Steinberg], and some of my own programs. I used the software on computers running Linux and MacOS 9.

In the following, I shortly explain the own programs I used.

Spatializer implements the room in a room model (F. Richard Moore) in SuperCollider. In this model, the loudspeakers are interpreted as holes in a virtual inner room, through which sounds radiate from a virtual outer room. The implementation defines a data type hierarchy of virtual loudspeakers, microphones and two-dimensional room characteristics as well as means to place and move loudspeakers and microphones in a room.

control-tao allows to generate and transform a script for the Tao physical modelling sound synthesis program. control-tao offers Lisp equivalents to all Tao score constructs and defines higher abstractions for Tao score actions.

score represents an hierarchic score data structure in which the container hierarchy determines the timing of their elements. The data structure is implemented in both Lisp and SuperCollider, the Lisp implementation can express Tao scores nested in SuperCollider scores.

text-changer changes a text (string or file) as specified by the user in a clause-like manner. The program was used to transform Tao script files.

func-env uses numeric functions to represent envelopes and defines a rich set of Lisp functions to generate, combine and transform these envelopes.

lisp->gnuplot provides a means to generate 2D and 3D plots of Lisp data by calling the Gnuplot program (Thomas Williams and Colin Kelley et. al.).

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