CHAOTICCOUNTERPOINT: AN ALGORITHMICALLY ASSISTED IMPROVISATION

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ABSTRACT
ChaoticCounterpoint is an algorithmically assisted improvisation for disklavier piano, two synthesized plucked string instruments, and digital audio processing. Rather than requiring the performer to focus on each individual musical event, these elements are generated using a chaos algorithm, freeing the performer to focus on larger structural and sonic aspects of the piece. It is proposed that such an approach would facilitate performances based on melodic and rhythmic forms and structures, while giving the performer the capability to generate and manipulate complex material, and focus on the sonic qualities of the sounds produced.

This paper presents the motivations behind the composition of ChaoticCounterpoint, in addition to a number of explorations into the design of digital instruments and performance systems, culminating in its development. The various instruments and interfaces covered explore a variety of control interfaces and synthesis techniques, and it was their strengths and limitations that ultimately influenced the design of the performance system for ChaoticCounterpoint.

1. INTRODUCTION
In the improvisation of electroacoustic music, performances are often structured around the sonic qualities of the sounds produced. This is a practice which is in contrast to that of much of jazz and many other improvised musics, where melodic and rhythmic structures usually provide the foundation for the improvisational ideas. It is the author’s belief that there is much scope for experimenting to consolidate both of these approaches, and that current technologies provide the perfect means to realise this.

ChaoticCounterpoint aims to explore some of these possibilities through an algorithmic performance system which controls the micro elements of the performance, such as individual pitches and note lengths, while the performer shapes the larger structures. As such the performer acts on a continuum between conducting the output, composing the material, and interpreting that material, with the role changing throughout the piece.

The process leading to this work consisted of explorations into various methods and approaches to interfacing with the computer. The intent was to create instruments and performance systems allowing flexible performance practice using melodic and rhythmic structures, and enabling the performer to have the freedom to focus on the expressive sonic aspects.

2. MOTIVATION
ChaoticCounterpoint is a semi-structured improvisation which uses a chaos algorithm, based on May’s logistic map[3], to generate melodic and rhythmic material. The piece was composed for a disklavier piano, two Karplus-Strong [2] physical modelling synthesizers, and digital audio processing. It aims to reveal and capture inherent patterns in the material generated by the algorithm, and to explore similarities and contrasts between the synthesized sounds and those of the piano. Finally, digital processing of both layers is used to transform and integrate the material. Conceptually it was important to unify the work by using the chaos algorithm to control any parameters of the performance which the performer would not have direct control of.

As such the chaos algorithm is also used to determine the digital audio processing and spatialization throughout the piece.

As mentioned above the performer is the conductor, composer, and interpreter. These differing roles are explored throughout the piece as the performer moves from influencing the overall dynamics, to triggering changes in the underlying scales, to changing the parameters for an individual instrument. This affords the improviser with extensive freedom, while still incorporating melodic and rhythmic structures.

Since the chaos algorithm is extremely sensitive, slight changes in the inputted variables result in dramatic differences in the output. This was exploited in order to generate contrasting material. By independently mapping different instances of the chaos algorithm to different parameters, such as rhythmic or melodic values, variable textures are created, all based upon one underlying concept.

3. RESEARCH AND EARLY DESIGN
3.1. The disklavier piano and random number generators
Research for ChaoticCounterpoint began with the design of a system which enabled a performer to control a disklavier piano. This early prototype was driven by random number generators mapped to a selected scale or collection of pitches.

The user was given the ability to choose the probability of chords occurring, and the probable density of notes within these chords. In addition to this, one could pick a velocity range for the notes played. Both of these facilities were included in order to create a more musical performance from the system, and both would subsequently be incorporated into the performance system for ChaoticCounterpoint.

Although this initial system allowed the user to easily control the disklavier and provided them with a reasonable range of controls over the performance, ultimately it was found to be too limited. Of particular note was the fact that the user had little control over the rhythm and, as no provision had been made to record the output of the random number generators, the melodic material became quite tiresome.

3.2. Frequency Modulation and the chaos algorithm
As this system was outputting mid i information the subsequent evolutions were initially used to drive a polyphonic FM synthesizer [1]. It was at this stage that the random number generators were replaced by the chaos algorithm. The use of this algorithm within the existing structure guaranteed that the output would, given identical settings, produce identical results each time. In addition to this the concept of patterns emerged, and from what at first appear to be random processes fitted nicely with the overall aesthetic of the work: to derive meaningful musical material from chaos.

Much of the design process at this stage focused on the ability to exploit specific transformations, including envelope, synthesis parameters, and spatialization. A further improvement was to allow the user to set probabilities for rhythmic values. Rhythms were thus created by mapping the output of the chaos algorithm to this probability table, allowing for far more rhythmic diversity. This interface also incorporated a function which enables users to record and playback patterns output by the chaos algorithm. Due to the independence of the underlying algorithm and the various parameters onto which it maps, this enables the performer to work with multiple patterns, and thus generate more complex material. Both of these features would also be incorporated into the performance system for ChaoticCounterpoint.

3.3. Touch screen control and plucked string synthesis
The initial systems used the computer keyboard and mouse as input devices. This severely limited the flexibility of the performance, so alternative interface possibilities were explored. The first involved the design of a touch screen interface, using TouchOSC on the iPad, to control a basic Karplus-Strong physical modelling synthesizer. Unlike the previous work, this design aimed to facilitate precise control of individual pitches and note lengths.

The interface consisted of rectangular XY sliders, each of which was directly linked to a specific midi pitch (see Figure 1). Once a slider was touched, the horizontal and vertical positions were mapped to the decay and damping of the note, and the related midi pitch was subsequently played. By then tying the accelerometer values from the iPad for vertical motion pitch, expressive pitch bends were also achievable. Values for lateral motion from the accelerometer were then mapped to an eight channel paning algorithm, and finally a polyphonic version was implemented. This resulted in an instrument which combined precise control over the “individual pitches and rhythms produced, while also incorporating gestural controls.

In addition to focusing on presenting the user with much finer control than that of the previous systems, much of the work done at this stage focused on creating an ergonomic and easily utilisable interface for the iPad. The weight and dimensions of the iPad necessitated that it be held with both hands, and that notes be played with the thumb of each hand, similar to the performance technique for a thumb piano. This was initially seen as a limitation, as performance is essentially limited to a maximum of two notes at a time, which the computer interface would not be able to simulate.

4. Motion Capture and additive synthesis
The next stage in the research involved the use of the Kinect motion capture device in order to further explore the possibilities of gestural control. Initially this instrument was largely modelled on a theremin, with the vertical position of the left hand being directly mapped to the frequency of the note produced. However, as unwanted glissandi were almost unavoidable,
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In addition to focusing on presenting the user with much finer control than that of the previous systems, much of the work done at this stage focused on creating an ergonomic and easily intelligible interface for the iPad. The weight and dimensions of the iPad necessitated that it be held with both hands, and that notes be played with the thumb of each hand, similar to the performance technique for a thumb piano. This was initially seen as a limitation, as performance is essentially limited to a maximum of two notes at a time, while the speed at which it is played and any intervallic leaps are also limited. However, it was also this very performance technique which allowed for the gestural controls mentioned above, and while technically limited was found to afford a very expressive performance practice.

3.4. Motion Capture and additive synthesis

The next stage in the research involved the use of the Kinect motion capture device in order to further explore the possibilities of gestural control. Initially this instrument was largely modelled on a theremin, with the vertical position of the left hand being directly mapped to the frequency of the note produced. However, as unwanted glissandi were almost unavoidable,
meaningful melodic lines were extremely difficult to achieve. The following stage thus involved limiting the possible range of pitches to specific collections, which provided the performer with far finer control over the melodic output.

In addition to this the performer could control the timbre of the sound, with the vertical and horizontal position of the right hand being mapped to the amplitudes of the partials, while the distance between the right hand and the Kinect was used to control the amplitude of the sound. As such the performer was given very flexible control over many of the melodic and sonic characteristics of the sounds produced.

4. CHAOTICCOUNTERPOINT

Following on from this research, the desire was to create an improvisational piece in which the performer controlled the larger structures and sonic qualities of the work, rather than focusing on each individual pitch and note length. It was this idea that inspired the return to the chaos algorithm, as it provided an ideal means for the performer to be freed, from concern about individual notes, to shape the sounds and materials created.

Even with limitations on pitch in place, fine control over musical material was still found to be quite difficult while using the Kinect. It was determined that, without significant changes to the mapping approach and extension of the algorithm, the Kinect would probably be more suited to controlling the shape of the sounds produced, through panning or digital audio processing for example, rather than directly triggering or arranging them. As the research moved towards the culmination project it was apparent that there was a lack of fine control over the material which influenced the decision to return to the iPad as the interface device (see Figures 2 and 3).

At this point the intention had been to combine both the Karplus-Strong and FM synthesizers in a creative project. However, it was felt that the contrast between the attempted real-world of physical modelling synthesis and the noticeably digital sound of frequency modulation was too great, and that for the purposes of this piece the synthesised plucked string was far better suited to combination with the real world struck strings of a piano.

Figure 2. Individual Voice Module: Both the disklavier and synthesizer are controlled using a copy of this interface.

Figure 3. Master Module: This section of the interface controls parameters relating to both the disklavier and synthesizer.

Initially a collection of heptatonic scales, each starting on a different pitch class, were used. However, despite the variety in scales chosen, the intervallic relationships within each, and thus the melodic lines, remained quite similar. As such it was decided to allow the performer to choose a subset of notes from the chosen heptatonic scale. In addition to this the performer could change the transpose position and scale independently. This created a far greater range of intervallic, and therefore melodic and harmonic, possibilities, and thus afforded a great deal of freedom in performance.

As previously stated, the rhythmic material in Chaotic-Counterpoint is generated by using the output of the chaos algorithm to reference a probability table, containing user defined probabilities for possible note lengths. This wide range of rhythmic possibilities, ranging from rhythmic to arhythmic, and these, when combined with the equally wide range of possible note choices described above, provided the ideal melodic material to base the work on.

Formally Chaotic-Counterpoint is inspired by the Miles Davis piece Flamenco Sketches.1 Rather than specify chord changes within a strict form, Flamenco Sketches is based on a sequence of modes, with the performers determining the number of bars each mode would be played for during their solo, by signalling to the rest of the group when they were ready to proceed to the next mode in the sequence. It was this open approach to structure, and the freedom it gives to the improviser, that was most influential when deciding the form and structure of Chaotic-Counterpoint.

In Chaotic-Counterpoint the performer is presented with a sequence of 5 scales, and, as in Flamenco Sketches, the duration for which each of these scales forms the basis of the melodic output is left to the performers discretion. The performance consists of two cycles through the entire sequence, and the performer is expected to synchronize significant events, the introduction of new voices or sudden increases/decreases in texture for example, with changes through these scales. Other than these formal signposts the performer is free to improvise using any of the combinations of scales.

While not indebted to any particular piece, the emphasis on improvisation in Chaotic-Counterpoint was also influenced by jazz music. However, as the system controls the individual pitches and note lengths, the focus of the improvisation was shifted to the qualities, such as texture and timbre, of the sounds produced and the generation and manipulation of larger phrases and materials. This frees the performer from the concerns of following underlying harmonies, and facilitates an approach to improvisation closer to that of a typical electronic improviser, while still incorporating melodic and rhythmic structures. All of these factors result in a piece that provides extensive freedom to the improviser, allowing them to explore complex materials and the sonorities produced, and still enforce rhythmic and melodic structures when desired, leading to contrasting sections of order and chaos. The enforcing of rhythmic and melodic structures on the material also leads to a sense of tension at points, while a contrasting sense of motion is achieved through abrupt changes in the pitch collection, orchestration, and processing. The transitions between these contrasting sections help to create tension and release, resulting in an exciting and highly improvisational piece of music.

5. CONCLUSION AND FUTURE WORK

This paper has presented a semi-structured improvisation named Chaotic-Counterpoint. By using a chaos algorithm to generate melodic and rhythmic material, the piece aims to create a performance scenario where the performer shapes the larger structures and musical phrases of the work. By mapping the output of the chaos algorithm to specific pitch collections and rhythmic probabilities the piece aims to create musical order from the underlying chaos.

It was found that by designing an instrument or performance system which focusses primarily on giving the user precise control over each musical event that happens, the ability to influence the macro elements of a piece can become limited. Similarly a design which presented less possibilities for precise control was found to be suited to the shaping and spatialization of the sound, but less useful for the control of individual musical events. It was for these reasons that an algorithmic system which controlled the individual musical events and provided the performer with the ability to shape and manipulate this material was chosen.

While the method for mapping the output of the algorithm to pitches was found to be effective, the probability based system which was used to determine the timing between notes was quite unpredictable, and it would perhaps be difficult to utilise this method of generating rhythm in works where a more structured rhythmic base was desired. In response to this a new method is being developed which incorporates evolutionary algorithms applied to rhythm groups within metric structures. This creates equally complex and more coherent relationships in the rhythmic material.

6. REFERENCES

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As previously stated, the rhythmic material in Chaotic Counterpoint is inspired by the Miles Davis piece Flamenco Sketches. Rather than specify chord changes within a strict form, Flamenco Sketches is based on a sequence of modes, with the introduction of new voices or sudden increases/decreases in texture for example, with changes through these scales. Other than these formal signposts the performer is free to improvise using any of the combinations of voices or timbres. While not indebted to any particular piece, the emphasis on improvisation in Chaotic Counterpoint was also influenced by jazz music. However, as the system controls the individual pitches and note lengths, the focus of the improvisation was shifted to the qualities, such as texture and timbre, of the sounds produced and the generation and manipulation of larger phrases and motifs. This frees the performer from the constraints of following underlying harmonies, and facilitates an approach to improvisation closer to that of a typical electronic improviser, while still incorporating melodic and rhythmic structures. All of these factors result in a piece that provides extensive freedom to the improviser, allowing them to explore complex materials and the sonic possibilities, and thus afforded a great deal of freedom in performance.

As such it was decided to allow the performer to choose a subset of notes from the chosen harmonic set. In addition to this the performer could change the transposition and scale independently. This created a far greater range of intervallic, and therefore melodic and harmonic, possibilities, and thus afforded a great deal of freedom in performance.

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For example, rather than directly triggering or arranging the sounds produced, through panning or digital audio processing. Originally it had been intended that a third layer of sound would be created through sampling the piano live. However during the development stage it was found that the addition of digital processing applied to both the synthesizer and piano was sufficient for this aim, and created a sense of depth and richness, with clear fore-ground and ambience.

The processing used consisted of a modular multi-effect processor and a pitch shifter program. The system allowed the performer to choose the volume of this processing, and change some of the parameters for its output, the actual processes being performed at any moment are determined by the chaos algorithm, thus furthering the connections between each layer of the work. Similarly the octophonic delay effect was chosen largely on the fact that it took advantage of the fact that such onsets were very suited to localisation, and as with the multi-effects patch the actual output, i.e. the delay time and spatialization, is also determined by the chaos algorithm.

Once the instrumentation had been decided much of the focus centred upon the form and material to be used. Initially a collection of heptatonic scales, each starting on a different pitch class, were used. However, despite the variety in scales chosen, the intervallic relationships within each, and thus the melodic lines, remained quite similar. As such it was decided to allow the performer to choose a subset of notes from the chosen harmonic set. In addition to this the performer could change the transposition and scale independently. This created a far greater range of intervallic, and therefore melodic and harmonic, possibilities, and thus afforded a great deal of freedom in performance.

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