Dynamic Tuning:

Implementation and Control

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Introduction

Modern Western music is typically based around the 12 tone to the octave equal temperament scale. This particular tuning has a number of advantages over past tuning schemes, such as being in tune irrespective of the key that the piece is in. This is useful for physical instruments that have a number of physical restrictions imposed on them. However, with the advent of computer music, there is a lot more freedom available for experimentation. What is proposed is a two part system that allows the exploration of adjusting an instruments tuning and also the adjustment of the instruments timbre dynamically, or whilst the performer is performing. This is a unique combination that promises exciting potential for expanding the performer's musical pallet.

Essentially there are two parts:

i. The Tuning control engine, and
ii. The Additive Synthesis engine,

Both of which are linked, as the additive synthesis engines timbre is intended to be linked (or not, depending on the performers wishes) to the tuning scale manipulation by the performer.
The main basis of this project is the as-yet unpublished paper titled "X_System" [1]

Phases of project:

-1- Research of intonation, tuning and temperament.

Tuning is the method of organising an instruments pitches (or frequencies) that it produces whilst being played by a performer. Intonation is the "treatment of musical pitch in performance"[2] of these pitches. Over man's history, there have been many tuning schemes that he has used, from ancient Greek tuning schemes such as Pythagorean tuning, to the tuning schemes used in Gamelan and Arabic tunings to the experimental micro-tunings currently being used by some modern composers. These various tuning schemes have been "discovered" or "invented" to help produce pleasing, or *consonance* sounds when played.

It has been noted through the ages, as made evident by a number of the tuning schemes that exist, that humans find small whole number ratios or pitches to be pleasing to the ear. An example is the perfect 5th, which is a ratio of 3:2. (I.e. a note of frequency 100Hz, and a second at 150Hz). However, problems arise if one tries to use these perfect whole number ratios to tune an instrument, as only the original combination of notes that one has tuned the instrument for will sound in tune, and other pairs of notes will sound less pleasing. This can be solved by retuning the instrument for the key that the piece is being played in, but another solution is available, which is *tempering*. Tempering is the adjusting of these pure tunings so that notes are only slightly out of tune with the "perfect" tuning, yet remains pleasing to the ear for other notes. This is what the current "standard" 12 note-per-octave equal temperament tuning is based.

The aim of dynamic tuning is to be able to, as one is playing, adjust the intonation or tuning of the instrument. This doesn't appear to be a popular effect in modern electronic instruments, and is almost impossible to implement in a physical instrument, however the pedal steel guitar does a limited version of this. The study and understanding of tuning schemes is important to understand what makes a successful tuning scheme and the implications it has for dynamic tuning.

Timeframe for completion: End of September

-2- Research of additive synthesis methods, and control methods.

Additive synthesis is the earliest computer based synthesis method, and one of the earliest electronic synthesis methods that was used. Additive synthesis is the process of producing an interesting timbre by adjusting the levels and values of the harmonics or partials of a note. (i.e., with a base note of 70Hz, one would generate the frequencies 70Hz, 140Hz, 210Hz, 280Hz... etc.) To produce musically useful timbres, these partials need to be adjusted in level over time. Mathematically, additive synthesis is easy to understand and implement, which is why it was popular with early computer music research such as that used in the MUSIC line of software for IBM mainframes. [3].

Additive synthesis fell out of favour due to the complexity of controlling the sound produced. If one has say 64 partials, which means that the user has to control 64 sets of synthesis parameters. There have been other methods of control of additive synthesis, such as analysis-resynthesis [4], though these then require a user to again add useful performance controls so the user can adjust the sound in a musically meaningful manner whilst playing. The dynamic tuning system has the potential to reduce the amount of control required to produce interesting sounds.

There is also the tuning of the partials. Most additive synthesis techniques assume that one will be using the standard of having the partials all based around the octave. (i.e. F, 2F, 3F etc.) One of the Parts of dynamic tuning is that these partials will be moved around as one changes the tuning scheme.

Timeframe: Mid October.

-3- Implementation of dynamic tuning.

This stage involves the implementation and testing of the dynamic tuning part of the project. It would be best to approach this section by breaking it down as follows.

> **i)** A simple proof of concept and testing of the control methods by writing a module for an existing flexible sound generation platform such as Max/Msp, CSound, or Pure Data. Preliminary studies into the usefulness of dynamic

tuning could be carried out at this stage, especially focusing on the performer's interaction with the instrument.

ii) Taking the concepts explored above and then moving them to a host-independent platform such as VSTi. This is a popular format for software instruments, though it is more restricted for experimenting.

The first section will allow for exploration of user control schemes of the instrument to be developed without becoming too involved in the development of writing computer code. These experiments of user control will refine the control system for implementation in the later VSTi system.

Timeframe: Proof of Concept: Mid November.
VSTi based system: December.

-4- Implementation of additive synthesis and partials control.

This stage is the development of an additive synthesis engine that responds to detuning of its tuning scales as well as its partials. This should be undertaken as a separate stage to the dynamic tuning implementation initially as the control of the partials and the technique used to generate the partials will require some thought and experimentation to produce a user-friendly method of control. It must however be planned to have the dynamic tuning parts built in, otherwise the combination of the two sections will be troublesome and difficult. The engine will again be done using the VSTi API because of their standardised cross-platform support and availability of support.

Timeframe: Mid December.

-5- Combine control of additive synthesis partials and dynamic tuning

This step is the combination of the two parts into a single user-playable instrument. This will involve taking the tuning control schemes developed in part 3 and then controlling the additive synthesis engine developed in part 4. This stage will link the two parts and allow full exploration to be made of the dynamic tuning controls and also the control of the instruments timbre. This stage will hopefully be relatively trouble free; however, the combination of the two sections means that there are a number of unknown issue points that could arise. During this stage, refinements to the UI and control system should be made to make the instrument as accessible as possible to the potential users and to expose to them the workings of the system.

Timeframe: Mid February.

-6- Experimentation to the human perception to dynamic tuning and timbre.

Once the instrument is completed, it is important to test how it is used by its intended audience, which is in this case, musicians. A study of how people approach the instrument would be very useful for the refinement of the user interface. A separate study into the musical application of the instrument would be also enlightening as it will reveal how human perception of tuning and timbre are linked.

-7- Write-up of dissertation.

The writing of the final report should be an ongoing process through the whole project to reduce the load during the final stages of the project.

First Draft: End of January

Problems and Concepts to be Addressed

The main goal of this project is to develop a computer-based instrument that implements the dynamic tuning scheme proposed in “X-System” [1]. This will require the development of a method of interpreting a users control input into the system and then adjusting the output of a sound generation system to reflect this input.

The development tools for the project need to be studied and decided on. As mentioned above, for the testing of the concepts, high level audio scripting languages such as CSound, Pure Data or Max/MSP can be used. These all have been used successfully for additive synthesis [5].

After initial feasibility studies have been done, a more complete and robust system should be developed. I believe that the VSTi system that has been developed by Stienberg as the most appropriate solution, as this has widespread industry support and is a well established standard for computer based synthesis.

The final problem that the project aims to solve is the control of additive synthesis systems. A number of commercial and non-commercial products have been released over the past 30 years to varying success, however, they are on the whole regarded as being difficult to use. It is hoped that with the control concepts introduced by the Dynamic Tuning system it will be far simpler for people to control and be more accessible to the average person.

References

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[3] P. Manning, "Electronic & Computer Music", Clarendon Press, 1985.

[4] J. W. Beauchamp, "A Computer System for Time-Variant Harmonic Analysis and Synthesis of Musical Tones", in "Music by Computers", H. von Foerster & J. W. Beauchamp, Editors. John Wiley and Sons, Inc. 1969. P19-62

[5] K. Jensen, “Noise upon the Sinusoids”, in “Applications of Signal Processing to Audio and Acoustics, 2005. IEEE Workshop On”. Oct. 2005. Pp.287-290.

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