FLUTE VIBRATO SYNTHESIS (ASSIGNMENT 2)

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ABSTRACT
This report will look at a more detailed approach to flute vibrato synthesis and the possible future implementation of this synthesis.

(introduction?)

Problem Description:
The action of vibrato is a common ornamentation used in application for all musical instruments in order to generate interest in a piece. [1] For flute, vibrato is most noticeably a fluctuation in amplitude and timbre. However, there is significant trouble in trying to synthesise flute vibrato. Real world flute vibrato is something that trained flautists learn to apply within a piece almost intrinsically. [1] The finesse with which vibrato is applied becomes something that is different for each performance and each note. This makes it quite difficult to replicate through synthesis and appear to keep the veritas of the flute vibrato intact.

Synthesis of flute vibrato is limited directly by the real flute sample that is fed into the processor as input; it determines the scope for pitch output, frequency and amplitude modulation. If another pitch is needed for output, then a similar pitch is required for input, so that realism is kept. In order to replicate a true flute vibrato, a ‘pure’ flute sample needs to be used; one that has little or no existing vibrato and that is of enough duration in order to make the synthesis worthwhile.

I propose to design a code in which the direct reliance on the flute input is removed or at least minimised, while still being able to synthesise a vibrato.

Specification:
The proposed code is a continuation from already existent code, developed in Lab Report 2, which followed a simple model (figure 1). This code was originally taken from the Dafx textbook. [2]

Figure 1. Simple model showing the process of the vibrato code from Lab Report 2

Flute vibrato synthesis is applied to every flute input sample. This is done in stages to the input flute sample:
• All existing vibrato/modulation will be removed from the sample, stripping it to a steady, even sample.
• The sample will be transformed to the desired pitch.
• A vibrato window will be applied to the sample as the last process before output.
• The resultant output will be a flute sample at a pre-specified pitch, with vibrato applied.

This code would firstly be able to strip an existing input of any existing fluctuations in amplitude and pitch modulation, creating a completely ‘flat’ input sample in relation to any form of modulation. The code would then
generate an envelope over the input sample, creating a ‘warm-up’ period in the vibrato; it is most noticeable of the characteristics of flute vibrato that the implementation of the vibrato is not down straight away. There is a period of the note at the beginning that is without vibrato, however the pitch is still being determined. This particular period can be defined as a ‘warm up’ period. The created envelope will mimic this over the input in order to maintain the realism of the applied vibrato. An example of this was generated from Lab Report 2 (Figure. 2)

Figure 2. Example of vibrato ‘warm-up’ envelope

There will be a section of the code that will cross-synthesise the input using a modified Linear Predictive Coding (LPC) [3], into any pre-determined pitch required, within reason; it has to stay within the octave range of the actual flute input, as the code will be programmed to only function within the parameters of the real flute input. For example, an input of a standard concert flute sample will only be able to be outputted within the range of B3 – D7. This is in keeping with the approach of the code to maintain realism in synthesis.

Implementation:

Initial stages of experiments
Code was originally sourced from Dafx [2] and, while this code was satisfactory in providing an adequate vibrato synthesis, it does however assume that the input signal is a constant and recurring signal. Real flute vibrato does not behave in this way; flautists are trained to implement vibrato almost intuitively while playing, varying the vibrato as they see fit upon a melody line. The experiment is based on applying code to sustained flute notes, which when played by a flautist, have many undulations in them due to lung capacity and the action of the diaphragm.

The initial experiment aimed to find the parameters of the vibrato code provided by Dafx and what boundaries needed to be set in order for a synthesis of accurate flute vibrato. It was determined that the parameters of amplitude modulation (delay) to be 3 and 8 ms, while the frequency modulation has parameters of 5Hz and 7Hz. This left a window of possible options for vibrato synthesis. This was a good starting point for understanding the potential of synthesising flute vibrato. However, it was noted at this initial stage that there were several avenues in synthesis that need to be analysed further through experimentation.

Analysis through synthesis was the precursor for the second stage of experimentation. The primary problem with the original experiment was the code; the code assumed that the input signal was at a constant rate. However, as the input signal is real sustained flute notes, the input is not a constant. There are certain physical limitations (in both the structure of the instrument and the talent/physical limits of the performer) that mean there is a ‘warm up’ period for the note to hit the right frequency for the pitch and amplitude becomes a limited factor as well. [4] Given this, there is only a certain period of each input signal that the code should be applied to in order to synthesise a realistic flute vibrato. The approach that was taken in the 2nd experiment was that a window was applied to the signal in order to compensate for this ‘warm-up’ period and then the vibrato is to be applied.

The largest part of implementation involves tackling the Linear Predictive Coding (LPC) section properly so that the pitch transformation is accurate and realistic. As LPC is predicting where to reassign the input to an output that doesn’t already exist, the level of error is quite high. The most significant of these is in relation to the spectral image shift that revolves around the corresponding harmonies; it is imperative that the complimentary harmonics to the fundamental shift appropriately, so that the synthesised flute sample retains its ‘realness’. This can be combated slightly by including things like jitter at the beginning of the transform. [3]
Evaluation:

The resultant code was a positive precursor to potential direction for future direction. Basic vibrato necessities were set up in these previous experiments in order to allow further progression to be made. The need for a ‘warm up’ period was determined and synthesised. Now the focus needs to be on the referent itself; to eliminate the need for a constant reliance on the input signal to be at the right pitch in order for it to be processed. The way to go forward from here is to create code so that only one input signal ever is needed and it can be processed to output any pitch and vibrato and sound realistic.

There are a few things that need to be included in this code in order for it to be successful; LPC, jitter, frequency modulation, amplitude modulation, vibrato. However once these pieces have all been put together, the need for more than one input flute sample in order to produce another will be minimised. With the use of the modified LPC, any pitch can be dictated for the synthesis, with the safety net of the spectral shift, in order to ensure that the output will sound like a real flute vibrato.

The potential for this particular code is that the heavy reliance upon the referent samples in order to generate a synthesis will be minimized. If developed enough, the code will allow the creation of vibrato to become almost completely computational.

Extra credit:
The best way to test this code is to set up a listening test amongst a test group; featuring both real flute vibrato samples and synthesised flute vibrato samples. The best way to do this would be to use a wide octave range of samples from both the real and synthesised flutes. This test would need to be done using headphones, in a blind listening test.

References: