MUMT605 Assignment 2

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Part 1

1 Given,

$$\omega[k] = \frac{ArgX[t,k] - ArgX[s,k] + 2\pi p}{H}$$

(Intuitive meaning: frequency is given by the phase difference at two time points, plus a potential multiple of 2π, divided by time between the two points in which this phase difference occurred)

When $t - s = 1 = H$, we have:

$$\omega[k] = ArgX[t,k] - ArgX[s,k] + 2\pi p$$

Now, since we're dealing with a sampled signal, we must have

$\omega[k] < \pi$ to satisfy the Nyquist criterion and since $t - s = 1$, it is impossible for a signal below this limit to increment more than 2π in the timespan of **one single sample** and still be adequately represented without aliasing, so the only possible value of p is *zero*.

2 As described in the paper, we need a hop size $H \leq \frac{N}{2K}$ where K is the bandwidth (in samples) of the window and N is the window size (in samples). Putting in $t - s = H$ and $C_w = K$ and M for window size gives

$$H \leq \frac{M}{2C_w}$$

(note: I'm not totally certain the definition of C_w, I assume its the same as 'K' based on my interpretation of notes taken in class)

This condition can also be satisfied when $t-s$ is 2π multiples of a given frequency (for that frequency).

3 Since $H = u_r - u_{r-1}$ and is the amount of time that a particular frequency $\omega(u_r, k)$ will have evolve for since the previous phase $ArgY(u_r, k)$, we have simply:

$$\lambda(u_r, k) = ArgY(u_r, k) + H\omega(u_r, k)$$

4 We still need to maintain the bandwidth-related limit from 2.) above, and in the stretched case, we essentially have a larger gap in the hop given by α. Hence, we have the following:

$$\alpha t_r - s_r \leq \frac{M}{2C_w}$$

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6 Looking at the original equation with $t_{r-1} - s_r \neq 1$ (in other words, $H \neq 1$:

$$\omega[k] = \frac{ArgX[t,k] - ArgX[s,k] + 2\pi p}{t_r - s_r}$$

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Part 2

Overview

For this part, I implemented a matlab function called `A2_func` in Matlab, with its help/description as follows:

```
% code here
% code here
```

The internal code comments provide explanation of the process, but the overall process is as follows:

- C

Putting it together

Below is a file listing of the submitted assignment:

- `A2_func`: the main time stretching function
- `runme.m`: the tester application that does the following:
  1. Generate sine wave samples, as well as a more complex waveform from file
  2. Calls the function with a few different values of time stretch
  3. Plays back original, and time stretched versions