Assignment Report of ADSP

Comparison of SRC in the time domain and in the frequency domain

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1 Comparison of the Basic Principles

Sampling Rate Conversion by a ratio I/D in the time domain is achieved by firstly performing interpolation by the factor I and then decimating the output of the interpolator by factor D. The output sequence of the interpolator should be filtered by a low pass filter h_I to reject the images. Meanwhile an anti-aliasing filter h_D should be deployed before the decimator to prevent distortion from spectrum overlapping. Because both filters h_I and h_D are operated at the same sampling rate (=IF_x) and can be combined into a single low pass filter, which is operated at the place that has the highest sampling rate in the system. The cascaded structure is shown below.

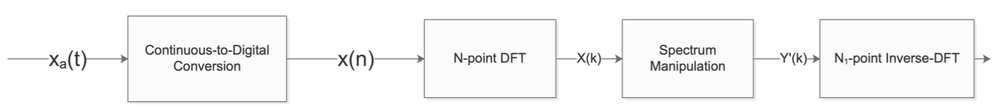

Figure 1: Block Diagram of Time Domain SRC

In the frequency domain, according to the spectrum equations, the spectrum Y(ω_y) of the desired y(m) can be obtained by scaling the magnitude of the spectrum X(ω_x) and the frequency in the horizontal direction with constant factors.Therefore to realise sampling rate conversion in the frequency domain, the first process is to the calculate the N-point DFT X(k) of the input sequence x(n). Then a spectrum manipulator should be employed to scale X(k) in both axes to obtain the desired spectrum of N_1-point DFT $\hat{\text{Y}}$(k) of the output sequence $\hat{\text{y}}$(m) where N_1 = IN/D. The desired time-domain sequence $\hat{\text{y}}$(m) is then obtained by preforming an inverse-DFT on $\hat{\text{Y}}$(k). The cascade structure of SRC in the frequency domain is shown below.

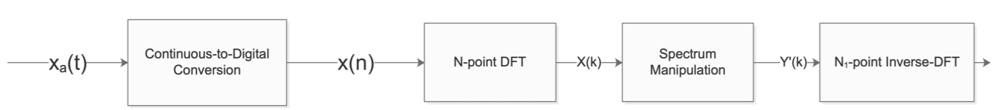

Figure 2: Block Diagram of Frequency Domain SRC

These two SRC processes in the time domain and in the frequency domain are different in many ways, but the root cause is the basic process of TD-SRC is to manipulate the input sequence directly in the time domain by interpolation and decimation, while the FD-SRC process is to manipulate the spectrum of the input sequence in frequency domain. All other processing units are different because they exist to incorporate the different basic processes to improve their accuracy and performance or reduce computational complexities, such as the combined lowpass filter in the time domain to reject images and aliasing, and the inverse-DFT transformer to retrieve the output time-domain sequence.

2 Discussion of the Sources of the Distortions

The distortions in SRC processes in the time domain may have the following sources:

1. The image-rejecting lowpass filter following the up-sampler. The up-sampler requires to be followed by an cooperative lowpass filter to reject residual images and meanwhile remain the desired spectrum. An ideal lowpass filter with perfect impulse response spectrum will reject images without cutting off the high-frequency components. However a practical lowpass filter will cause distortions by distorting the spectrum of the input signal or remaining some parts of images more or less because of the non-ideal impulse response.

2. The anti-aliasing lowpass filter before the down-sampler. The down-sampler requires an anti-aliasing lowpass filter deployed before it to remove spectrum overlapping of the input signal. But this anti-aliasing filter will cause distortion simultaneously if it is required to work, because the anti-aliasing process is actually to remove the high frequency components. And similarly to 1., the distortions may also come from the non-ideal impulse response of a practical lowpass filter.

Since the combined filter in a integrated SRC system incorporates the filtering operations for both image-rejecting and anti-aliasing filters, it could cause both types of distortions.

SRC processes in the frequency domain have the possibilities to cause distortions for the following reasons:

1. The decimation and interpolation in the process of spectrum manipulation. In the spectrum manipulation process: (1) In the case of sampling rate decreasing, where D ¿ I, the original spectrum needs to be compressed horizontally, causing aliasing. To get the desired output spectrum, the aliasing part need to be removed and decimate a value in the median frequency where k = $N_1/2$. Similarly to the case of the anti-aliasing filter in the time domain process, there exist distortions by losing high frequency components, where ($N_1/2$) $\leq$ k $\leq$ (N/2)-1 and (N/2)+1 $\leq$ k $\leq$ N-($N_1/2$); (2) In the case of sampling rate increasing, where I ¿ D, the original spectrum needs to be stretched horizontally, causing

2. Inaccuracy of the overlap approach.

3. The inherent errors of the DFT and IDFT converters.

3 Comparison of the Required Computational Complexities

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