Multi-Rate Processing

Neural Networks: ECE 5630

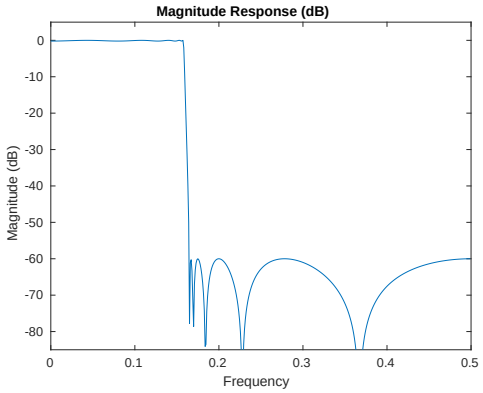

Figure: Linear Data Classifier

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1 Introduction

This paper shows how to perform multi-rate processing using decimation and interpolation. Matlab's `fdatool` was utilized to create the filters necessary for the sample rate conversion, and `C plus plus` for programming.

2 Filter Design

Problem 1: Design a linear phase FIR low-pass (prototype) filter $H(z)$ to be used in your sample-rate converter. Be sure that the cutoff of the filter is appropriate for the conversion.

To design the filter necessary for the sample-rate converter, I calculated the cutoff frequency necessary for the down-sampler and interpolator, and found that the narrower low-pass filter of the two was the interpolation filter ($L = 3 > M = 2$).

The coefficients for the filter are:

Listing 1: Test

```
Num = [0.00585700211848685, -0.0101050645904296, 0.0248390445383391, -0.0228929830964889,
       0.0346732733671082,  -0.0238512859600107, 0.0346732733671082, -0.0228929830964889,
       0.0248390445383391,  -0.0101050645904296, 0.00585700211848685 ];

Den = [1,                 -5.81770676287660, 17.4269969697500, -33.9484051722572,
       47.0576123759448,  -48.0956541934415, 36.5797794473643, -20.4099537116018,
       8.00548424863840,  -2.00036903049939, 0.244059567466600 ];
```

(a) The impulse response for the given filter is seen in Figure 1

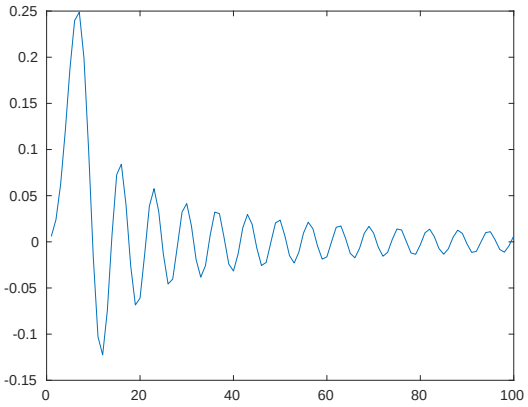

Figure 1: Impulse Response

(b) Plots the magnitude and phase response can be seen in Figure 2

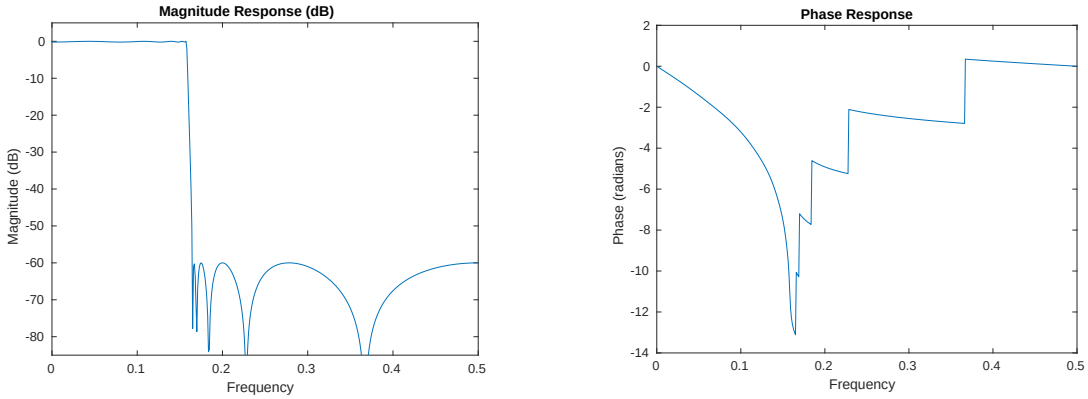

Figure 2: (a) Plot of Magnitude Response for Low-pass Filter. (b) Plot for Phase Response for Low-pass Filter

(c) The difference equation for the filter is of length 21 as seen in Listing 1.

(d) To design the filter I used the FDA tool in Matlab. Note that the Sample Frequency was input as 11025 because that was the sample rate of the original sound file. The low-pass filter needed to be the smaller of the low-pass filter needed for the interpolator and the decimator. The Decimator required a cutoff frequency of $\frac{\pi}{2}$ and the interpolator required a cutoff frequency of $\frac{\pi}{3}$, so I maintained the lower of the two cutoff frequencies. $\frac{\pi}{3}$ of F_s is equal to 1837.5, so I made 1838 the cutoff frequency.

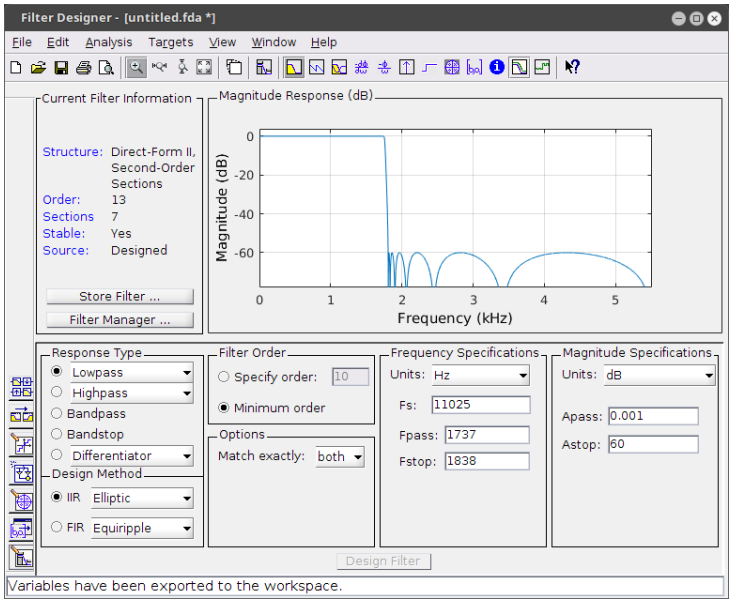

Figure 3: `fdatool` in Matlab

(e) The pass-band and stop-band edge frequencies are 1737 Hz and 1838 Hz respectively.

(f) The size of the ripple in the pass-band is 0.001 dB

(g) The peak side-lobe level is equal to -80 dB?

3 Conclusion

This is a conclusion paragraph.