A NEW LOW-PASS FIR FILTER FOR SIGNAL PROCESSING

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ABSTRACT

In this paper a new digital low-pass FIR (*finite impulse response filter*) for the purpose of low-phase shift signal smoothing is proposed. The filter is implemented via convolution, by using a kernel calculated from a sine wave series and introduce a degree N parameter that allow for a better fit to the signal. The filter will be applied to several signals in order to test for reactivity.

***K*eywords** FIR · Filter · Digital Filter · Filtering · Kernel · Digital Signal Processing

1 Introduction

Low-pass filters are widely used in signal processing in order to remove the noise from a specific signal, the most common FIR filter is the simple moving average *(SMA)* who return good performance in the time domain, however the *SMA* tend to respond slowly to abrupt change in a signal and have a relatively high phase-shift, the *SMA* also has difficulties retaining the original shape of the signal, therefore other filters must be used when shape conservation and reactivity are required . The proposed filter will use a kernel designed from a sine wave series and aim to have quick reactivity while filtering noise and conserving the original shape of the signal..

2 Filter Design

The proposed low-pass filter of period window M and degree N posses a kernel h defined as $h = \Delta f(N)$ where :

$$f(N) = x^2 + \sum_{i=0}^{N} \frac{1}{n} sin(x_i n\pi)$$

$$\text{with } n = 1, 2, 3, 4 \cdots N \text{ and } x = \frac{1, 2, 3, 4 \cdots M}{M}$$

Then the filter is calculated via convolution with : $x[n] * h[n]$. An higher degree N provide a better fit to the signal. The step response of the filter is equal to $f(N)$ and is shown in figure 1.

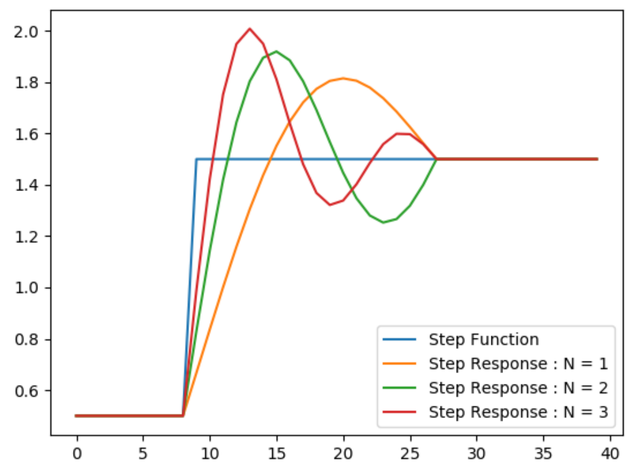

Figure 1: *Step response of the proposed filter using kernel h*

3 Filtering Using The Proposed Filter

The proposed filter posses the following frequency response for $N = 1, 2$ and 3 :

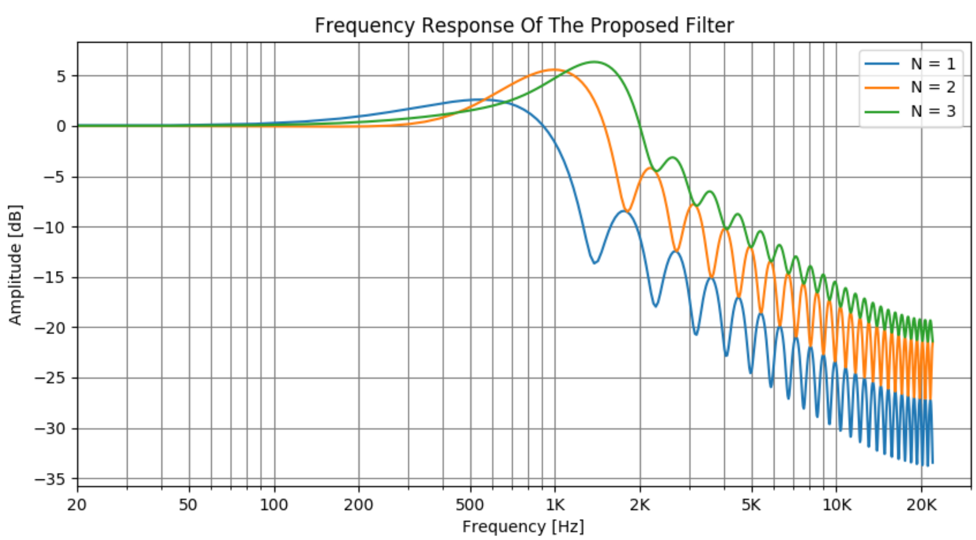

Figure 2: *Frequency Response Of The Proposed Filter With Period Window $M = 50$ And Different Degrees N*

From the frequency response it can be seen that the filter amplify certain frequencies before the transition band, which is the cause of its reduced phase shift, this amplitude increase as N increase. The reactivity of the proposed filter is tested by using a noisy sinusoidal signal in in figure 3 and a random signal generated by a random walk in figure 4 , higher values of N provide a better fit to the signal at the cost of reduced smoothness.

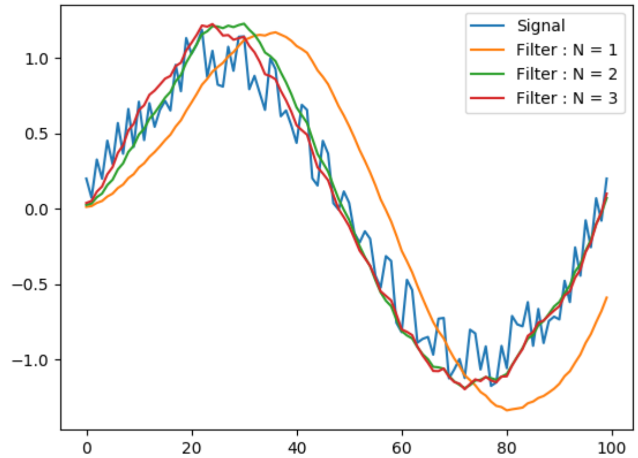

Figure 3: *Proposed Filter With Period Window* $M = 100$ *And Different Degrees N*

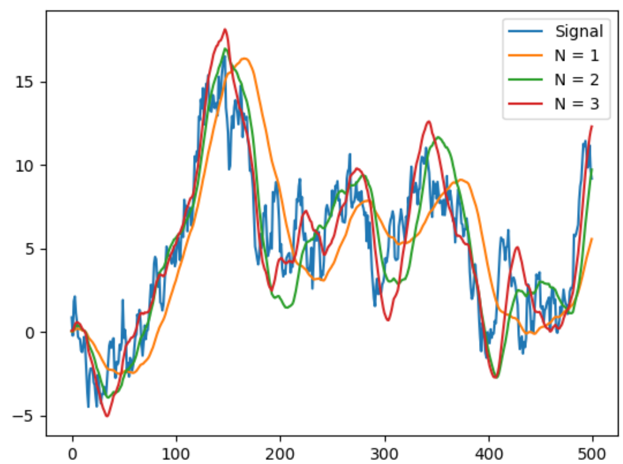

Figure 4: *Proposed Filter With Period Window* $M = 100$ *And Different Degrees N*

4 Conclusion

In this paper a new low-pass filter based on a sine wave series has been proposed. Fields requiring low phase shift filters for signal denoising might get advantage of the proposed filter, one field in particular being technical analysis which make use of a wide variety of filters *(SMA, EMA, VWMA...)* with some of them requiring a low phase shift in order to better fit with the input price *(DEMA [1], TEMA [2], HMA [3], ZLEMA [4])* .

5 Python Code

```python
import numpy as np

def kernel(M, order) :
    n = np.linspace(0, 1, M)
    x = 0
    for i in range(1,order+1):
        x += 1/i * np.sin(n * i * np.pi)
    a = n*n + x
    return np.diff(a)

def filt(src, M, order) :
    return np.convolve(src, kernel(M, order))
```

6 Pinescript Code

```
kernel(x, order) =>
    sum = 0.
    b = 0.
    pi = atan(1)*4
    a = x*x
    for i = 1 to order
        b := 1/i * sin(x*i*pi)
        sum := sum + b
    pol = a + sum
//----
F(src, M, order) =>
    sum = 0.
    for i = 1 to M
        w = kernel(i/M,order) - kernel((i-1)/M,order)
        sum := sum + src[i-1] * w
    sum
```

References

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