robustDiff

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differentiator using smooth noise-robust differentiator formula

```
y_dot = robustDiff(y, dt, N)
```

Inputs

- **y** - signal/vector
- **dt** - time or distance between points in y
- **N** - Number of points to use in differentiation. This value must be positive odd integer greater than 5.

Outputs

y_dot - differentiated signal/vector

Description

robustDiff differentiates a signal/vector numerically using N points. Both future information and past information are used to calculate the derivative. In signal processing, this is called non-causal. The larger the value of N, the more high frequency noise is suppressed unlike Savitsky-Golay (Lanczos differentiation) filters and Central Difference methods (see references). Note that the derivative is not estimated at the edges of y. This means that (N-1)/2 points at the beginning and end of y are NaN. See the example.

Example

```
dt = 0.001; % sampling rate of 1000Hz
t = 0:dt:3; % sec
noiseFrequency = 450; % Hz
noise = 10*rand(size(t)); % Noise is 10% of signal
frequency = 1; %Hz
y = 100*sin(2*pi*frequency*t) + noise;
N = 21; % Number of points to use to estimate derivative
y_dot_estimate = robustDiff(y, dt, N);
y_dot_actual = 100*2*pi*frequency*cos(2*pi*frequency*t);
figure('position',[1000 628 834 710]);
subplot(211);
plot(t, y);
title('y vs. t');
```

```
subplot(212);
plot(t, y_dot_actual, 'DisplayName', 'y''_{actual} of sin(t)','lineWidth',3);
hold('all')
plot(t, y_dot_estimate, 'DisplayName', 'y''_{estimate} of sin(t) + noise');
a = legend('show');
set(a,'position',[0.6653 0.4068 0.2410 0.0761])
hold('off');
disp(['Beginning and ending (N-1)/2 points of ' ...
    'y_dot_estimate are NaN']);
y_dot_estimate(1:(N-1)/2)
y_dot_estimate(end-(N-1)/2+1:end)
```

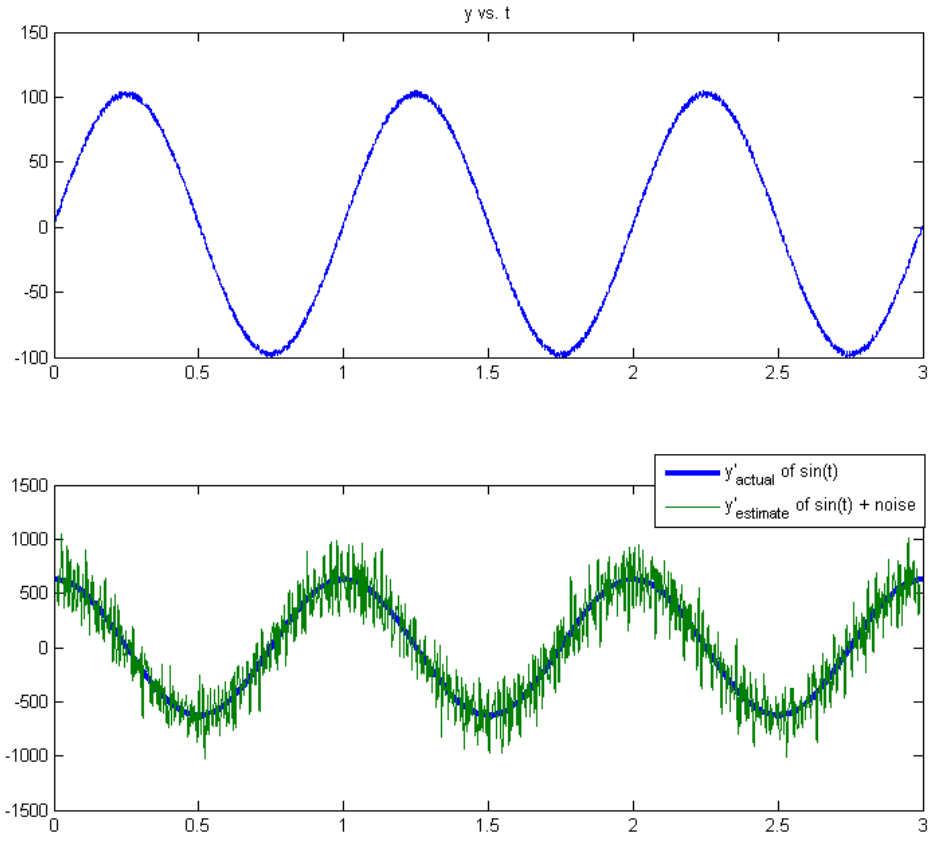
```
Beginning and ending (N-1)/2 points of y_dot_estimate are NaN


ans =

   NaN   NaN   NaN   NaN   NaN   NaN   NaN   NaN   NaN   NaN


ans =

   NaN   NaN   NaN   NaN   NaN   NaN   NaN   NaN   NaN   NaN
```



Formula

This is the the formula that robustDiff implements. This is a direct quote of Pavel Holoborodko's website. Please, refer to the link for more information.

$$f'(x^*) \approx \frac{1}{h}\sum_{k=1}^{M} c_k \cdot (f_k - f_{-k}),$$

where

$$c_k = \frac{1}{2^{2m+1}}\left[\binom{2m}{m-k+1} - \binom{2m}{m-k-1}\right], \quad m = \frac{N-3}{2}, \quad M = \frac{N-1}{2}$$

- **N** - Number of points used to estimate derivative
- f_k - k points in front of current point
- f_{-k} - k points behind current point
- **h** - Time or distance between points

References

This function is based on the formulas by Pavel Holoborodko from his web-site: http://www.holoborodko.com/pavel/numerical-methods/numerical-derivative/smooth-low-noise-differentiators/ A big thanks is due to Pavel Holoborodko for developing this family of formulas.

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