Adaptive Neural Spike Detection

MSc. Communications and Signal Processing
Zheng Zhang

Supervisor: Dr. Timothy Constantinou

Content

- Background
- Proposed Method
- Experiment Results and Evaluations
- Future Work

Background

Innovation

- Massive Amount of Data
- Limited Bandwidth
- Limited Battery Life
- Time varying Noise Level
- …

Golden Standards

- Spike Emphasis
  - Operator Based (NEO)
    $y(n) = x^2(n) - x(n-1)x(n+1)$
  - Pattern Matching
  - Wavelet Based
- Thresholding
  - RMS, $\mathrm{T} = c\sigma$
  - Mean, $\mathrm{T} = c\mu$
  - Hybrid, $\mathrm{T} = \mu + c\sigma$

Proposed Method

NEO (Nonlinear Energy Operator) $\propto E \propto V^2\omega^2$

$$y(n) = x^2(n) - x(n-1)x(n+1)$$

- 2 multiplication, 1 addition (subtraction)

Proposed Method

NEO (Nonlinear Energy Operator)

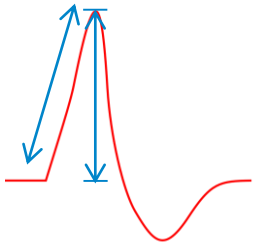
$$y(n) = x^2(n) - x(n-1)x(n)$$

- 2 multiplications, 1 addition (subtraction)

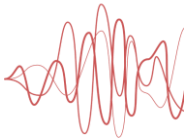
Proposed Method

ASO (Amplitude-Scope Operator)

$$y(n) = \underbrace{x(n)}_{\text{Amplitude}}\underbrace{(x(n) - x(n-1))}_{\text{Scope}}$$



Spike



Noise

Proposed Method

ASO (Amplitude-Scope Operator)

$$y(n) = x(n)(x(n) - x(n-1))$$

- 1 multiplication, 1 addition (subtraction)

Experiment Results and Evaluation

- Computational Cost
  - Flops
  - Execution Time
- Detection Accuracy
  - Different Noise Level

Computational Cost (10^{11} input data points*)

Methods	Float Point Operations	Executation Time
NEO	4×10^{11}	46.3s
ASO	2×10^{11} ↓ 50%	36.9s ↓ 21.6%

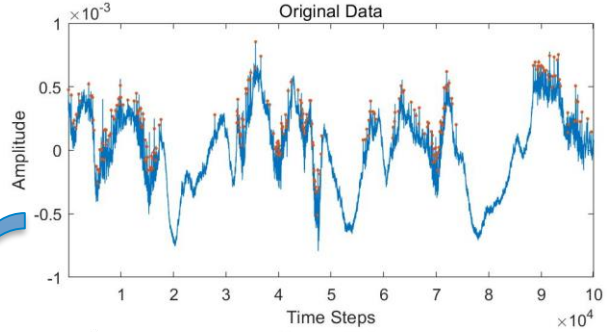
* Achieved by processing $\mathbf{10^5}$ data for $\mathbf{10^6}$ times in MATLAB

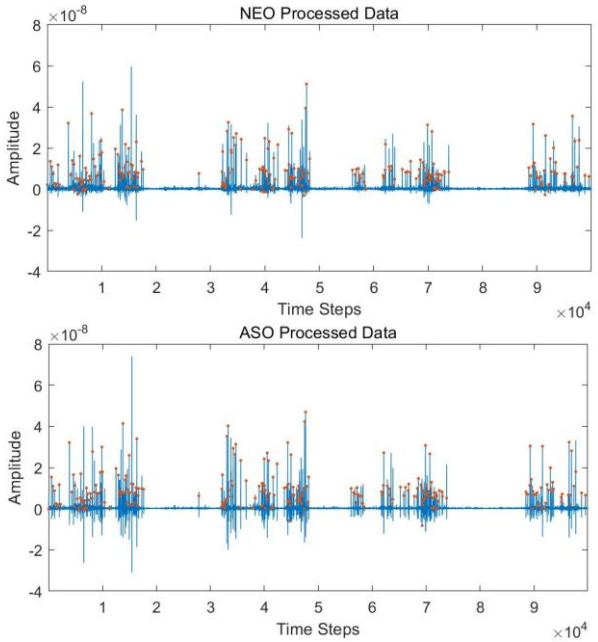
Evaluation Metrics

- Faults Detection Rate (FDR) = $\frac{FP}{FP+TP}$, Rate of Unfound Spikes
- Sensitivity = $\frac{TP}{FN+TP}$, Rate of True Spikes in Found Locations
- Accuracy = $\frac{TP}{FN+TP+FP}$

Experiment Results-No Additional Noise

Subtracting the Average Calculated from a Window With Length16.

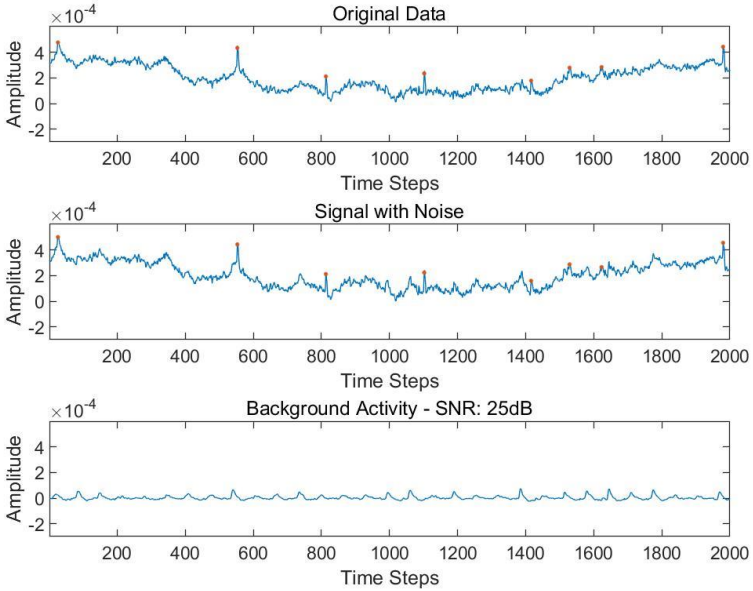


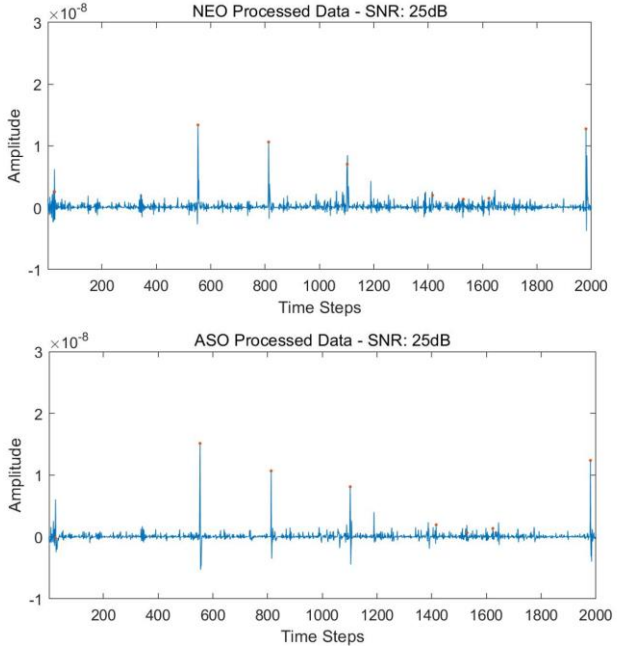


Spike Detection Performance- No Additional Noise

	Data A			Data B		
	Sens	FDR	ACC	Sens	FDR	ACC
ASO-RMS	0.8257	0.1943	0.6886	0.8414	0.1757	0.7135
NEO-RMS	0.7935	0.2065	0.6577	0.8255	0.1689	0.7069
ASO-mean	0.7992	0.1781	0.6812	0.8146	0.1689	0.6986
NEO-mean	0.7795	0.1984	0.6535	0.82	0.1689	0.7029

Experiment Results- 25dB Additional Noise

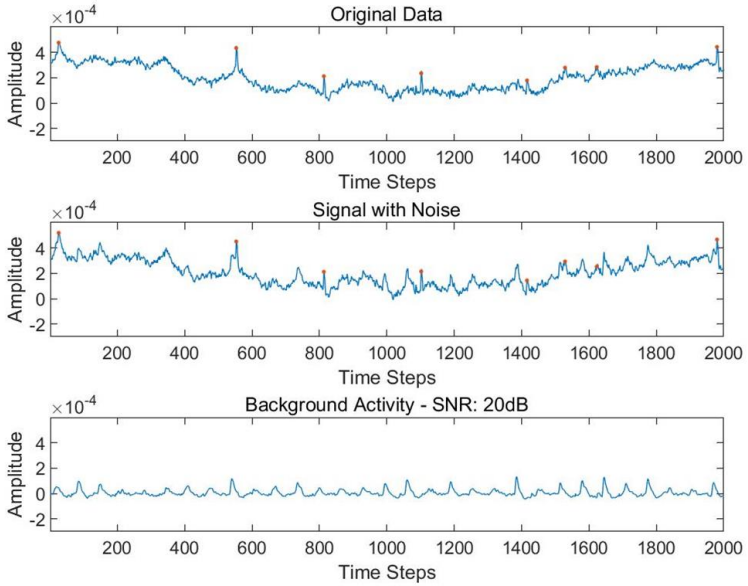


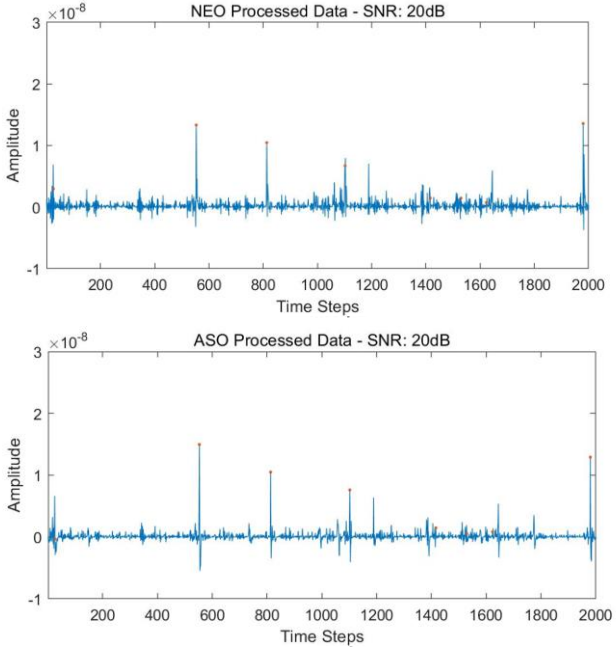


Spike Detection Performance- 25dB Additional Noise

	Data A			Data B		
	Sens	FDR	ACC	Sens	FDR	ACC
ASO-RMS	0.8190	0.2308	0.6574	0.8243	0.1757	0.7011
NEO-RMS	0.7833	0.2389	0.6288	0.8052	0.1622	0.6955
ASO-mean	0.8112	0.1822	0.6871	0.7987	0.1689	0.6872
NEO-mean	0.7796	0.2267	0.6346	0.7848	0.1622	0.6813
Best-Before	0.8257	0.1781	0.6886	0.8414	0.1689	0.7135

Experiment Results- 20dB Additional Noise





Spike Detection Performance- 20dB Additional Noise

	Data A			Data B		
	Sens	FDR	ACC	Sens	FDR	ACC
ASO-RMS	0.8130	0.2429	06448	0.7806	0.1824	0.6648
NEO-RMS	0.7778	0.2632	0.6087	0.68	0.1959	0.5833
ASO-mean	0.8025	0.2105	0.6610	0.7219	0.1757	0.6256
NEO-mean	0.7733	0.2267	0.6304	0.6436	0.1824	0.5628
Best-25dB	0.8190	0.1822	0.6871	0.7987	0.1622	0.6872

Conclusion

- ASO is more computation-efficient.
- ASO are able to give higher detection accuracy in different noise level.
- The same parameter are able to adaptive to different data and noise level.
- However, when noise is too large, the detection performance can be degraded severely.

Future Work

- Label Real Data
- New Thresholding Scheme
- Adaptive Spike Emphasis Algorithm

Thank You