Neutron/Gamma Pulse Discrimination Using Recurrent Deep Neural Networks

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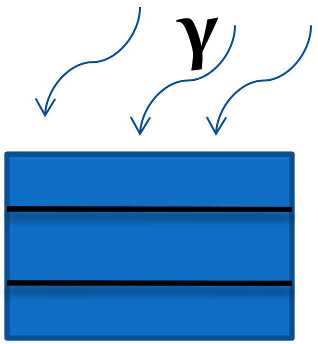
Outlines

- Motivation
- Detection System
- Pulses Imitations
- PSD Techniques
- Recurrent Deep Neural Networks
- Results
- Conclusion

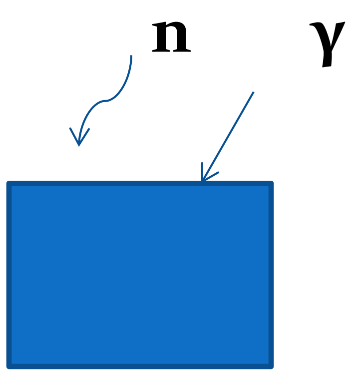
Motivation

Development a PSD technique for improving:

1. The spatial resolution of images in PET system (**crystal identification**).



2. **Particle identification (PID)**



Detector

Figure 1 **CLYC:Ce Gamma / Neutron Scintillators**

https://www.berkeleynucleonics.com/clycce

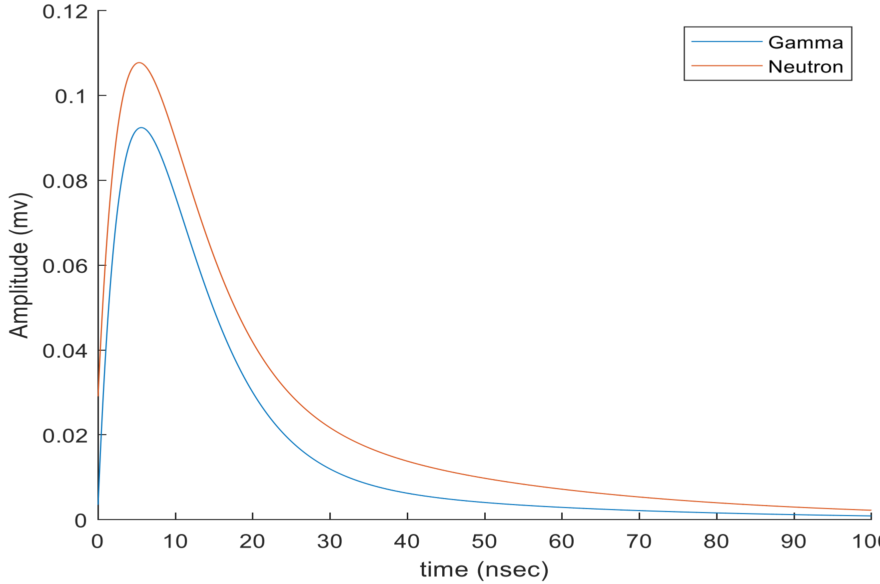
PSD Important for:

- Differentiating Between Types of Radiation
- Identification of Neutrons.
- Reducing False Alarms
- Optimizing Radiation Protection Measures.
- Nuclear Security Applications
- Emergency Response and Monitoring

Pulses Modeling

Marrone's Model.

$$y(t) = A\left(exp-\left(\frac{t-t_0}{\tau_1}\right)-exp-\left(\frac{t-t_0}{\tau_s}\right)+\frac{B}{A}exp-\left(\frac{t-t_0}{\tau_L}\right)\right)$$

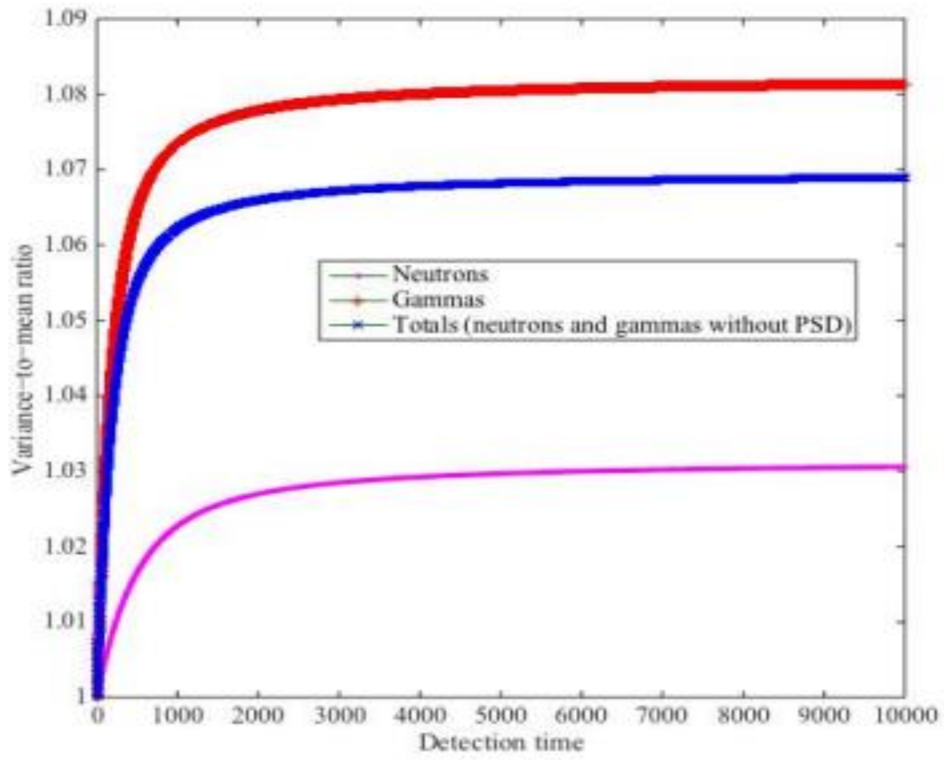


PSD Results Accuracy

Method	Discrimination Percentage		
	Gamma	Neutron	Total
A. Arafa [7]	95.5	87.3	91.4
A. Arafa [7]	97.3	84.1	90.7
H. Song [8]	85.88	89.25	87.56
Proposed	**96.88**	**90.33**	**93.65**

$$FOM = \frac{\left|max_n - max_g\right|}{FWHM_n + FWHM_g}$$

the variance to mean of the number of neutron, gamma and total detections on the detection time.



Neural Network for PSD

1. Multilayer Perceptron (MLP)
2. Convolutional Neural Networks (CNN)
3. Recurrent Neural Network (RNN).
4. Long Short-Term Memory (LSTM) network (variation of RNNs).

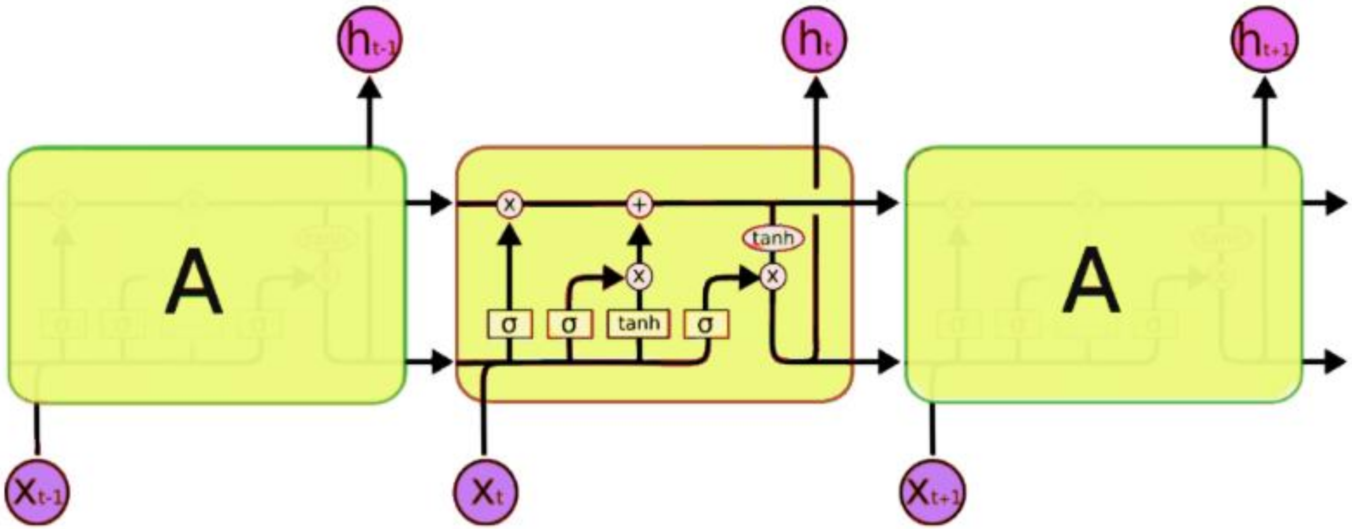
Long Short-Term Memory (LSTM)

Effective for learning long-range dependencies in sequential data suitable for various applications, including :

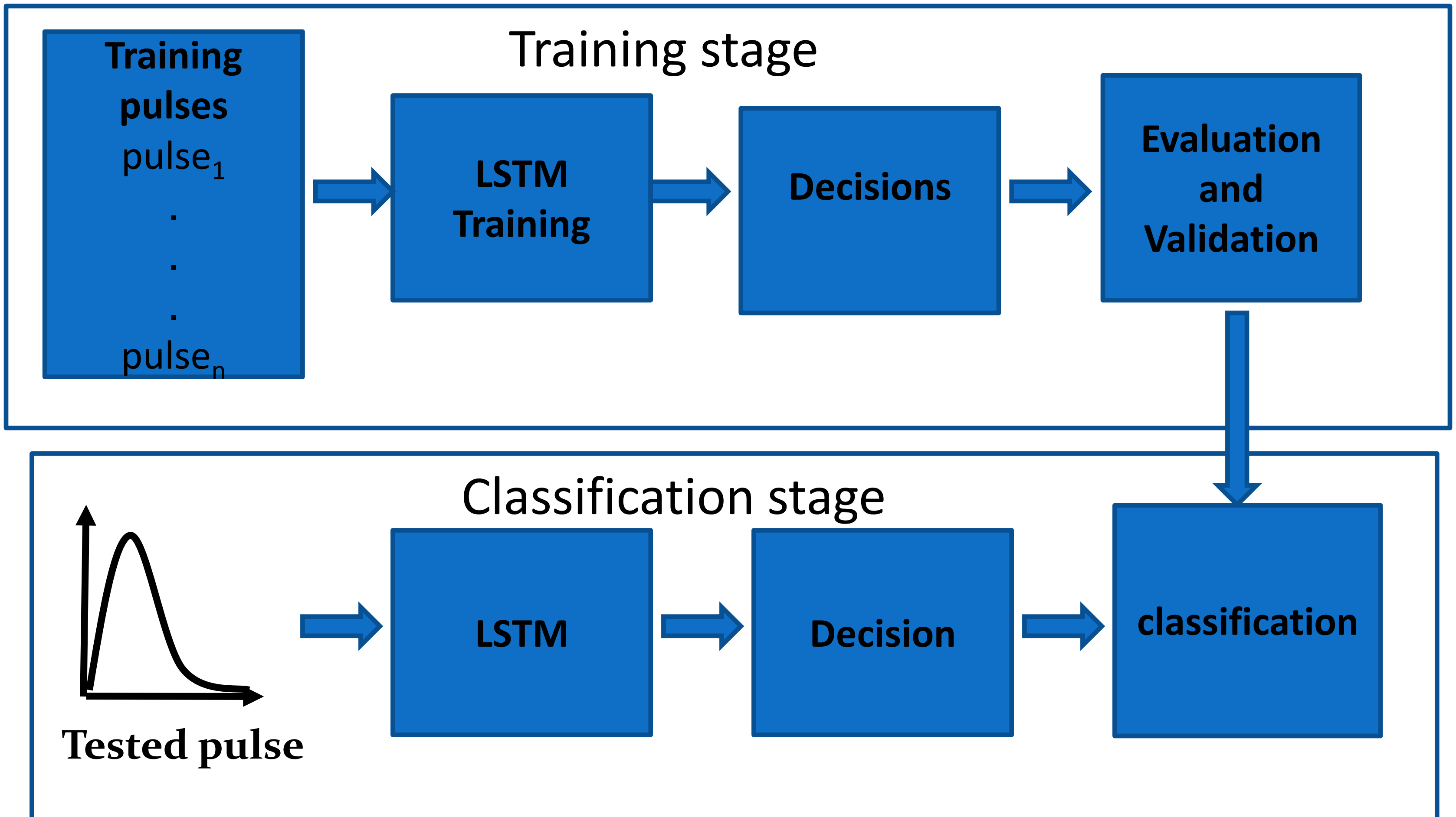
1- natural language processing,

2- time series analysis, and

3- pulse shape discrimination in radiation detection



Discrimination Process Using PCA



Conclusion

- The proposed technique improves the spatial resolution of Detection system.
- The performance of LSTM based technique is 93.6 % for the Gamma/Neutron simulated pulses.
- The proposed LSTM-PSD is fare superior to the other compared techniques.

Thank you