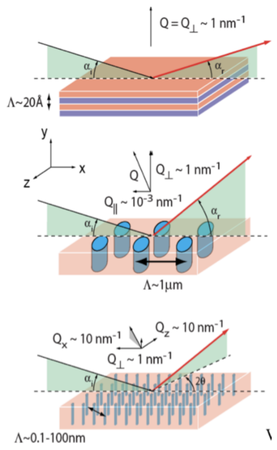
# Neutron Event Detection Using Machine Learning

R.Brink[2], S.-A. Chong[1], M. Wyatt[1], Dr. M. Taufer[1]
1 Department of Electrical Engineering and Computer Science, University of Tennessee, Knoxville
2 Bredesen Center, University of Tennessee, Knoxville

## Introduction

- Neutron scattering is a powerful probe to study the atomic structure and dynamics of materials in a broad range of applications.
- Accurate determination of neutrons is important in neutron detection system to ensure accurate studies of materials



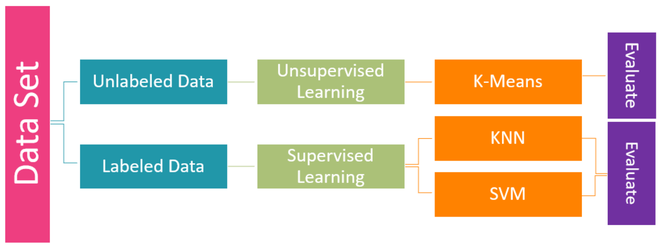

Source: Pynn, Roger. "An Introduction to Neutron and X-Ray Scattering: SANS ..." *Neutron Science*, ORNL, neutrons.ornl.gov/sites/default/files/Pynn_2019_part_2.pdf..

## Motivation

- Detection of neutron events are usually accompanied by other events such as gamma events, noise and background radiation.
- We want to explore the potential of machine learning in improving neutron event detection to enhance the performance of neutron detectors.


## Methodology

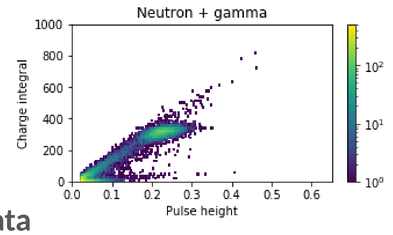
- Started with unlabeled dataset
- Implemented unsupervised learning
- Annotated data based on domain knowledge
- Applied supervised learning
- Evaluated the performance of all classifiers




## Data

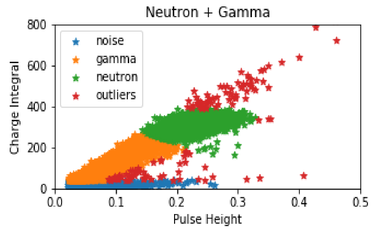
### Unlabeled Data

- Number of Features: 2
- Number of Samples: 60,000
- Missing Values: None
- Data Preprocessing: Min-Max Normalization




### Labeled Data

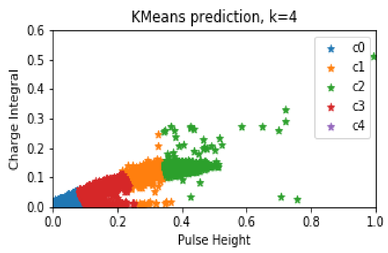
- Annotation of data is needed for supervised learning
- Using domain knowledge, linear boundaries were defined to assign label to each data point




## Models

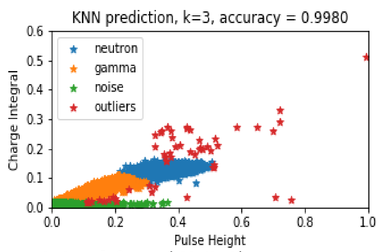
### Unsupervised: K-Means Clustering

- Using data after pre-processing but not annotations we ran K-means with 2, 3, 4, and 5 seed points.
- These attempts failed because K-means looks for circular clusters and we have more oblong clusters.



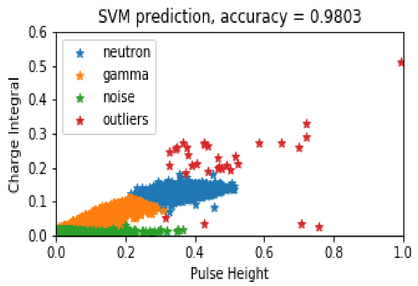

### Supervised: K-Nearest Neighbor (KNN)

- This method successfully classified the annotated data.
- We ran with k values between 3 and 10. K=3 was chosen as the optimal value as it achieved the best accuracy.



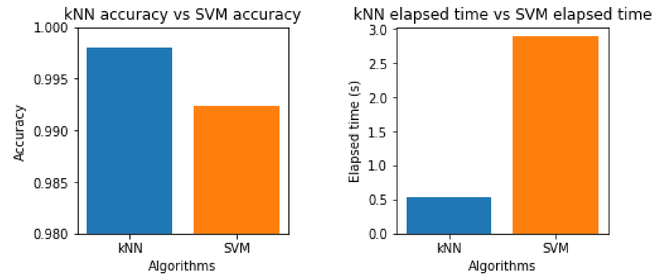

### Supervised: Support Vector Machine (SVM)

- This method is also successful at classification.
- Hyper parameters chosen:
  - Kernel = 'rbf'
  - Gamma = 'scale'
  - C = 1.0
  - Max_iter = -1 (no limits)

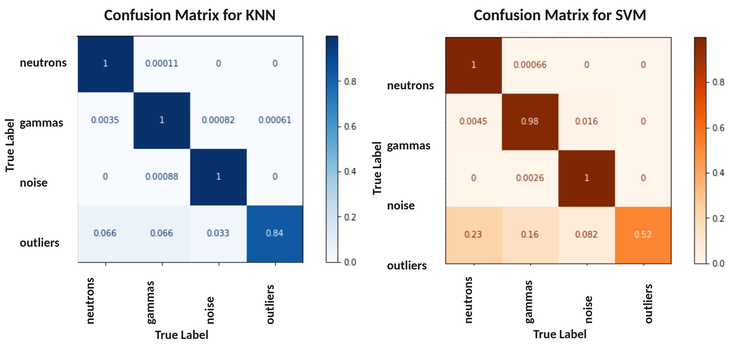


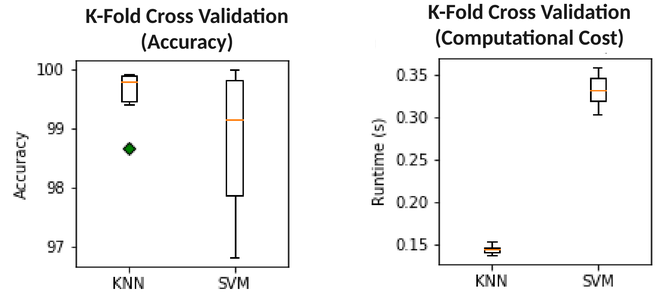

## Evaluation

- Accuracy and Computational Cost




- Confusion Matrices




## Conclusions

- K-Means clustering showed sub-par performance with unlabeled dataset.
- KNN and SVM both consistently perform classification with accuracy well above 95.0%. The stark difference between the two is the computational cost. KNN is significantly less computationally expensive compared to SVM. KNN is more preferred to SVM in this case.