OAK RIDGE National Laboratory

Machine Learning for Nuclear Data

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U.S. DEPARTMENT OF ENERGY

Machine Learning for Nuclear Data

REVIEWS OF MODERN PHYSICS

Colloquium: Machine learning in nuclear physics

Amber Boehnlein, Markus Diefenthaler, Nobuo Sato, Malachi Schram, Veronique Ziegler, Cristiano Fanelli, Morten Hjorth-Jensen, Tanja Horn, Michelle P. Kuchera, Dean Lee, Witold Nazarewicz, Peter Ostroumov, Kostas Orginos, Alan Poon, Xin-Nian Wang, Alexander Scheinker, Michael S. Smith, and Long-Gang Pang

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Transforming the Nuclear Data Pipeline

- **Measurements**
  - **design** experiments / detectors with BO, emulators, GPs, NNs …
- **Theory**
  - **speed up** large-scale calculations with HPC resources and emulators
  - **determine uncertainties** in theory model using BNN
- **Compilation**
  - **choose keywords** in NSR with NLP
  - **extract** tables / plots / text with CNNs
- **Evaluation**
  - **update** ENDF using BN and GPs
  - **extract** GDR energies & widths using NNs and MTL
  - **identify outliers** using RF, and using experimental info w/ SVM, LR …
  - **combine data** differential / integral / theory using RFs
- **Processing / Validation and Verification**
  - reaction evaluation processing / V&V using BN and GP
  - **design** validation experiments with BO
- **Applications**
  - **identify** criticality factors using RF
  - Uncertainty Quantification (UQ) using emulators

ML projects are already improving the pipeline

they have the potential to transform it …

GLOSSARY

BO Bayesian Optimization
GP Gaussian Process
NN Neural Network
BNN Bayesian NN
NLP Natural Lang. Proc.
CNN Convolutional NN
BN Bayesian Network
MTL Multi-Task Learning
SVM Supp. Vector Mach.
LR Logistic Regression
RF Random Forests

Transforming the Nuclear Data Pipeline

future trends…

Reaction pipeline formulated as a BN	UQ and radiation transport with emulators	Physics-driven loss terms in NNs	Validation &Verification using BO

- Recommend that the potential of ML to transform Nuclear Data Pipeline be discussed in NSAC LRP and NSAC-Nuclear Data Subcommittee Report
- Recommend that ML be a part of future Funding Opportunity Announcements from NDIAWG / DOE NP
- Recommend that USNDP establish a "Machine Learning Task Force" to share approaches / algorithms / strategies
- Recommend development of toolkits for non-experts on ML for nuclear data