Using Artificial Intelligence to Predict and Validate Nuclear Data

Overview

Nuclear data underpins all of nuclear science and technology. Even the most complex and concisely written nuclear data analysis tools are unreliable and untrustworthy if they use old or un-benchmarked nuclear data. Nuclear data are comprised of cross sections, angular scattering probabilities, outgoing energy probabilities, reaction product multiplicities, fission yield data, reaction products and more. All of which are vitally important in the design and safety cases of nuclear devices.

The most common problems encountered in nuclear data are:

- **Missing data** - There are many cases where little or no data has been experimentally measured for reactions of interest or data doesn’t exist in the energy ranges of importance.
- **Conflicting data** – Experimental data points often do not agree, even within their uncertainty limits.
- **Large uncertainties** – Quoted uncertainties are often large, as a result of the challenges encountered in experimental nuclear physics, which is not ideal when trying to constrain or optimise the design of a nuclear device.
- **Untrustworthy uncertainties** – Due to each experimentalist using different techniques and taking different variables into account when performing uncertainty analysis, experimental nuclear data uncertainties often vary considerably; which can skew the evaluators’ judgement when fitting data from multiple sources.

The best way to tackle these problems is via targeted experiments. However, nuclear data experiments are complex, expensive and the lifecycle time to plan, perform and analyse the results is relatively long. Hence, the current approach involves the use of statistics and theory in conjunction with experiments. To date, the use of artificial intelligence (AI) and machine learning (ML) in the field of nuclear data evaluation has not been fully explored. Hence, this project aims to explore whether or not it would be advantageous to use AI/ML in conjunction with other nuclear data evaluation methods to assist and enhance the evaluation process.

Potential Research Projects

- Predicting the functional form of \((n,2n)\), thermal, scattering cross sections, with little or no measurements, based on learning (many papers could be written based on the same methodology)
- AI cross section lookup table based on learning cross section forms
- AI uncertainty analysis – learn to predict cross sections of well characterised cross sections within bounds of uncertainty. Use variation of synapse weights to create a cross section probability distribution function, which can be converted to a statistical uncertainty.

Prerequisites

- A STEM degree with an AI taught and/or project component.
- An understanding of the theory behind AI methods, such as neural networks
- Excellent programming skills, with the ability to code in C++ and/or PYTHON

Project Contact

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**Industrial Supervisor:** Dr Lee Morgan, AWE
Nuclear data, such as cross sections and reaction products, underpins all of nuclear science and technology. Even the most complex and concisely written nuclear data analysis tools can be unreliable and untrustworthy if they use old or un-benchmarked nuclear data. Common problems encountered in nuclear data are missing and conflicting data and large and untrustworthy uncertainties. The best way to tackle these problems is via targeted experiments. However, nuclear data experiments are complex, expensive and the lifecycle time to plan, perform and analyse the results is relatively long. Hence, the current approach involves the use of statistics and theory in conjunction with experiments. To date, the use of artificial intelligence (AI) and machine learning (ML) in the field of nuclear data evaluation has not been fully explored. Hence, this project aims to explore whether or not it would be advantageous to use AI/ML in conjunction with other nuclear data evaluation methods to assist and enhance the evaluation process.