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Application of Gaussian Processes for predicting tritium breeding ratio in the helium cooled pebble bed breeder blanket

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Assuring self-sufficient tritium production is of critical importance to prospective Deuterium Tritium (DT) fusion power plants.
Achieving a tritium breeding ratio in excess of 1.1 has been identified as a key requirement for future DT fusion power plants.
Tritium breeding ratio values are typically calculated via computationally expensive neutronics simulations as an integral stage in the development of breeder blanket designs.
This paper reports on an application of machine learning which is able quickly predict tritium breeding ratios for different variants of the helium cooled pebble bed breeder blanket.
Previous research in this area has used simplified 1D and 2D models to simulate a broad range of neutronics parameters for variants of the helium cooled lithium lead \cite{Jaboulay20132336}; machine learning (neural networks) was then used to make predictions.
In this research, detailed 3D neutronics fusion reactor models were simulated to find tritium breeding ratio values.
Breeder blankets with different neutron multiplier pebble bed heights, lithium ceramic pebble bed heights, lithium-6 enrichments and neutron multiplier materials were created as part of the model.
Training data was formed from these input parameters along with the resulting tritium breeding ratio for 2200 simulations.
A form of machine learning (Gaussian Processing) was then applied to the training data using the scikit-learn Python library.
The result of this research is a predictive function that is able to provide accurate predictions for the tritium breeding ratio for a range of different blanket designs.
Additionally any prediction of tritium breeding ratio also returns the associated standard deviation.
In cases when the returned standard deviation is too large the system is able to perform an automated neutronics simulation which calculates the tritium breeding ratio at the point of interest.
Resampling techniques (jackknifing and cross sampling) were performed on the training data to estimate the variance of the estimator and the error involved in making predictions across the dataset.

Eligible for student paper award?

No

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