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Machine learning in designing fusion magnets for tokamak-type machines

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In recent decades, a pioneering field of research has been investigating to reproduce the enormous power of the sun nuclear fusion reactions in a relatively small apparatus, i.e. a tokamak. This machine generates a closed magnetic field configuration able to supply and control an ionised plasma. The magnetic system is made by three main components: the Toroidal Field (TF) Coils for the primary confinement, the Poloidal Field (PF) Coils for the plasma vertical stability and the Central Solenoid (CS) which induces a toroidal current on the ionised particles.
Currently, physical-computational models and system codes have been introduced and gradually improved to complete the electromagnetic and the structural assessment of the system components in a more and more efficient way. Further, at this stage, efficient parametric tools are of fundamental importance, since numerous configurations and different approaches are under investigation to theorize and attain nuclear fusion in tokamak devices.
In this paper, the Magnet Design Explorer (MADE) algorithm [1] is exploited as a foundation for developing a machine learning (ML) approach. In detail, first MADE is used to construct the database necessary to train suitable artificial neural networks (ANNs). Second, the supervised learning method is employed to build a model based on the sample data, capable to make reliable predictions with a very good numerical performance. Neural nets properly trained can be the key to access a vast portal of enhanced solutions with a high efficiency in terms of costs and computational time.

[1] L. Giannini et al., The MAgnet Design Explorer algorithm (MADE) for LTS, Hybrid or HTS toroidal and poloidal systems of a tokamak with a view to DEMO, *submitted*.

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