Some applications of neural networks in the resolution of partial differential equations

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Abstract:

This work has been motivated by the study of a fluid flow model, with applications in solar power generation. Concentrated solar power (CSP) receivers consist of dozens of tubes with a very high aspect ratio, where a turbulent heat-receiving fluid flows at high temperatures (about 800^{O}C). The optimisation of CSP receivers to provide the highest energy concentration capacity depends on the number of tubes, their dimensions and the inlet flow rate. Due to the complexity of the geometry of CSP receivers, this optimisation is beyond the scope of standard turbulence models. This requires the development of techniques that allow resolution in reasonable time and with sufficient accuracy.

We will present a combined technique of domain decomposition, reduced order methods and neural networks for the resolution of the heat flux at the outlet of CSP receivers. In the offline phase, the parametric heat flux inside the tubes is modelled in terms of reduced boundary conditions. The reduction process is based on a POD approximation of the varieties of the traces at the subdomain boundaries, while the mapping between the traces at the different subdomain boundaries is constructed using deep neural networks. In the online phase, this will allow to replace the calculation of the flow within a large part of the pipes by a reduced mapping between the flow traces at the inlet and outlet boundaries. We will present some applications to realistic situations.