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ANN-RECONSTRUCTION OF NONLINEAR OPERATOR IN PROJECTION-BASED ROM FOR ELASTIC STRUCTURES

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The study deals with the projection-based reduced order modelling of engineering problems involving elastic structures with large displacements. This type of nonlinearity can be encountered in applications where highly flexible structures are subjected to a strong external load [1] (e.g., aeronautic or aerospace applications).

The governing equations for the structure may contain different types of nonlinearities. In particular, even with the linear elastic Saint-Venant Kirchhoff material, the resulting cubic nonlinear term arising from the internal forces poses a challenge for projection-based reduced order modelling (ROM) [2]. To overcome this issue, we propose to use an artificial neural network (ANN) [3] to reconstruct the reduced nonlinear operator, which constitutes the originality of the study.

The approach is based on four off-line steps. The first step consists in generating the data from a high-fidelity finite element solution (static or dynamic) considering the evolution of load factors as parameters. Secondly, a basis is obtained using the proper orthogonal decomposition (POD) from selected snapshots. Then, a dataset is generated with the nonlinear reduced operator numerical values (the outputs) associated with the generalized coordinates (the input) for each known solution. Finally, the ANN model is trained to reconstruct the nonlinear operator from the projection on the POD basis. This ANN model can be differentiated which enables the use of the ROM in various applications requiring an approximate solution in real time (e.g., digital twins, sensitivity analysis or feedback control loops).

Preliminary results obtained from nonlinear static analyses show the capabilities of the approach to generate a projection-based ROM independent on the size of the high-fidelity problem. Further studies which consider dynamic problems and additional material parameters are under investigations.

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