CEMRACS 2023 mini-project proposal

Data assimilation methods with Neural Galerkin schemes

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1. **Context**
   Neural networks trained with machine learning techniques are currently attracting great attention as nonlinear approximation methods to solve forward and inverse problems involving high dimensional PDEs. Addressing these problems efficiently requires particular architectures in order to best represent the differential operators involved. In particular, how to encode time-dependencies in the architecture arises as a key question in data assimilation problems.

2. **Description and objectives**
   In this project, our goal is to develop data assimilation methods using Neural Galerkin schemes. These schemes have recently been proposed in [1] to solve forward high-dimensional PDEs. They have potential to overcome classical bottleneck of data-assimilation methods such as obstructions to treat transport dominated problems.

3. **Proposed methodology**
   - Forward Problem: study [1] and reproduce some numerical results.
   - Inverse problem:
     - Formulate a data-assimilation method based on the Neural Galerkin scheme
     - Identify relevant PDE classes to address.
     - Implement the data assimilation method using synthetically generated data.

4. **Software requirements**
   Pytorch and/or Tensorflow ; JAX; PyTest ; notions of CUDA

5. **References**
   [1] Bruna J., Peherstorfer B. and Vanden-Eijnden E., Neural Galerkin Scheme with Active Learning for High-Dimensional Evolution Equations, preprint, 2022.