Progetto di ricerca/Titolo assegno:

"Machine Learning based Predictive forecasting and risk assessment for CO2 transport in pipelines – PRIN2022 - CUP J53D23002000006 "

Descrizione breve delle attività di ricerca

Surrogates are computationally efficient models, such as polynomial functions or deep neural networks, calibrated on datasets generated by running the original model multiple times. They are used in place of the original model to accelerate computationally onerous probabilistic analyses, including global sensitivity analysis and risk assessment, which would otherwise be infeasible for most, if not all, modeling tools of practical relevance.

In this context, the overall objective of the project is to develop a rigorous framework for uncertainty quantification and risk assessment capable of handling the many (and diverse) sources of uncertainty affecting CO_2 transport in pipelines. In relation to the PRIN 2022 research project "Predictive forecasting and risk assessment for CO_2 transport in pipelines", the developed framework will be employed to provide new insights into the mechanisms governing the transition to two-phase flow during CO_2 transport and to support engineers in the design and off-design control strategies for pipeline operations.

In this project, the quantity of interest (QoI) is the spatial and temporal evolution of the relevant flow characteristics, with particular attention to pressure drop and two-phase transition. The governing parameters include key pipeline features, such as diameter and inclination, as well as boundary conditions, including ambient temperature and input flow rate. These parameters, typically used in design, are treated as random variables to account for their variability ranges and to reflect the degree of uncertainty associated with them. Neural networks of the Kolmogorov–Arnold type will be employed due to their ability to handle a large number of parameters while maintaining high predictive accuracy. The proposed methodology will enable the investigation of open challenges, such as identifying optimal parameter combinations that minimize the cost of CO_2 transport.

Piano delle attività

The research activity will focus on developing the methods necessary to achieve the goals described above and applying these methods to the case study of CO_2 transport in pipelines. The planned steps are:

1. Development of the neural network surrogate for specific case studies (3 months)
2. Global sensitivity analysis and uncertainty quantification (1.5 months)
3. Definition of design and off-design control strategies to support transport operations (1.5 months)