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Deep Learning Model Operating on Graph Structured Data for Assisting Multiphase Flows

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Artificial intelligence in general, and deep learning in particular, are gaining large popularity mainly due to the current advances in computational capacities and the increased availability of data resources. Throughout the past decade, the potential of deep learning has been demonstrated in multiple interesting domains including speech recognition, computer vision, machine translation, and natural language processing. However, the interest of benefitting from its merits, in approximating complex functions and performing challenging tasks, was not only limited to the above domains but intensively diffused throughout the scientific community. In recent years, deep learning has invaded the world of computational mechanics and particularly that of fluid mechanics [1, 2] where different models have been introduced to assist in turbulence modeling, conjugate heat transfer, flow fields inferring, shock formations, and drag and lift predictions. Moreover, a new type of model, known as graph neural networks [3], has lately emerged and broadened the range of problems on which neural networks can operate by tackling graph-structured data without preprocessing them into 1D vectors or 2D images. These models are able to preserve the information encoded in the discretized domain topology and are employed directly on the unstructured mesh, allowing to tackle new problems with complex changes and unsteady flow characteristics. Therefore, in this work, a deep learning model, based on graph convolutions, is exploited for multi-phase flow problems [4] that are governed by the fluid flow Navier-Stokes equations along with the level set equation responsible for the evolution of the separating interface. The benefits of the introduced coupling framework, between the traditional CFD solvers and the deep learning model, will be highlighted and exposed for multiple different benchmarks.

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