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Physical Inspired Data-Driven Models using Evolutionary Approach

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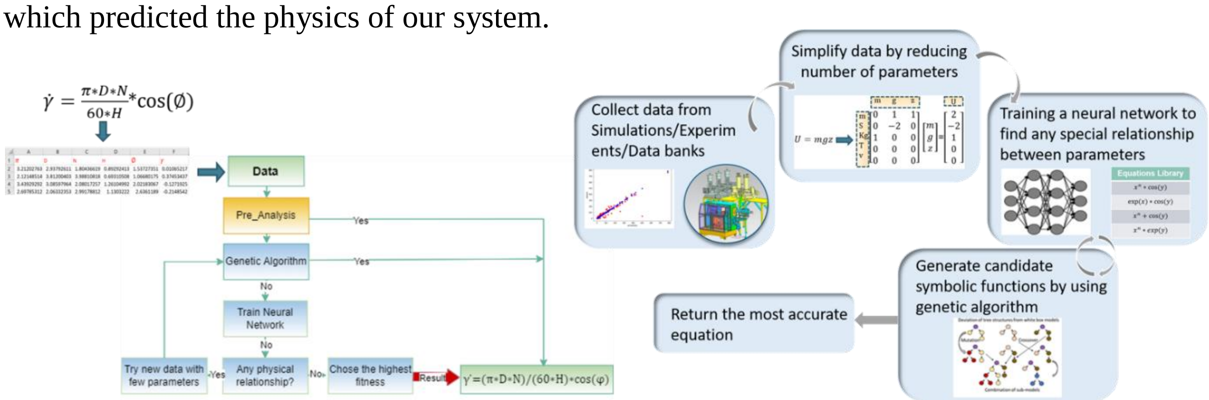
Governing equations are foundational in the process engineering field. Accurate models enable the understanding of physical processes, which in turn create an infrastructure for technology development. The traditional derivation of governing equations is based on first principles such as conservation laws, or universal laws such as gravity. Due to the limitation in knowing equations for many processes, reliance on first-principles derivations is rendered unreasonable. One of the most challenging tasks for both physics and artificial intelligence (AI) is finding a symbolic expression that fits the data of an unknown function (symbolic regression). Modern machine learning methods allow data-driven models to be obtained in a variety of ways. However, the more complex the model, the more difficult it is to interpret. Functions that exist in many scientific processes often have some common properties. Discovering and exploiting these properties, existing physical or mechanistic models can help us to facilitate the modeling effort.

More precisely, in this work, a table of data whose rows are of the form {x1, ..., xn, y}, where y = f (x1, ..., xn) is prepared, and the goal is to determine the correct symbolic expression for the unknown function f by using a genetic algorithm.

Firstly, simplifying the data was attempted by applying a pre-analysis and finding the dimensionless parameters. Secondly, an attempt was made to find any existing physical properties among the data by taking advantage of a neural network. Finally, by using a genetic algorithm, different symbolic functions were generated and the most accurate one was returned as the final expression. Next, the obtained function was applied as a white-box model which predicted the physics of our system.



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