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Machine Learning Applications in Mechanical Engineering

Camilo Andres Manrique Escobar

MSc, University of Salerno, Italy

Data-driven research is currently revolutionizing how to model, predict, and control complex systems. This because many of the most pressing open issues in the literature do not adapt well to the traditional analytical approaches based only on scientific principles. For instance, modern dynamical systems theory is currently undergoing a renaissance, with analytical derivations and first-principles models giving way to data-driven approaches. It is clear that data science will not replace physical mathematics but will complement it to solve modern problems. The traditional engineering approach consists of manually deriving the system governing equations and plugin the measured physical parameters to it. It is then required advanced expertise in applied mathematics, dynamic systems theory, computational methods, mathematical modeling, optimization frameworks, and operator-assisted algorithmic tuning of control parameters. However, this approach is restrictive for systems with a high degree of complexity or uncertainty, where the reality gap caused by the model's bias yields an unfeasible system. This, usually, due to uncertainties in physical parameter values or mathematical modeling assumptions. The pattern reproduction capability of machine learning (ML) models has attracted the attention of engineers. In particular, Neural networks (NNs) are universal function approximators, which means that they can be used as a black-box estimator applicable to the systems with parametric uncertainties and nonlinearities. Researchers are applying ML models to analyze and control complex dynamical systems with the potential to revolutionize our ability to interact and manipulate such systems. Data-driven control applications include the Model Predictive Control (MPC) with a surrogate NN plant model and reinforcement learning (RL), which does not require obtaining surrogate models of the system to be controlled, in contrast to MPC or feed-forward approaches.

Manufacturers are using distributed and supervisory control systems to enhance process efficiencies in their plants. However, it requires rigorous monitoring and relies on the experience, intuition, and judgment of the operator. AI is capable of improving and standardizing the knowledge and knowledge of experts to form decision support systems effective. Industries are keen on developing in-house AI capabilities and that's why the demand for mechanical engineers with knowledge of AI is rapidly increasing. Currently, organizations are searching for process and automation engineers, data scientists, IT & Data engineers and AI creation experts from mechanical and electronics background.

Note: This work is partly presented at Webinar on AI & Robotics (February 26, 2021 Dubai, UAE)