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Deep augmented physical models: application to reinforcement learning and computer vision

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Modelling and forecasting complex physical systems with only partial knowledge of their dynamics is a major challenge across various scientific fields. Model Based (MB) approaches typically rely on ordinary or partial differential equations (ODE/PDE) and stem from a deep understanding of the underlying physical phenomena. Machine Learning (ML) and deep learning are more prior agnostic and have become state-of-the-art for many prediction tasks; however, modeling complex physical dynamics is still beyond the scope of pure ML methods, which often cannot properly extrapolate to new conditions as MB approaches do. Combining the MB and ML paradigms is an emerging trend to develop the interplay between the two paradigms. In this talk, we will present a principled training scheme called APHYNITY [1] for augmenting incomplete physical models with machine learning, with uniqueness guarantees. We will also present an application of augmented models to model-based reinforcement learning [2], where we show gains of performances compared to simplified physical models and data efficiency compared to pure data-driven models. We will also present an application to optical flow estimation [3], where we leverage the classical brightness constancy assumption.

[1] Yuan Yin, Vincent Le Guen, Jérémie Dona, Emmanuel de Bézenac, Ibrahim Ayed, Nicolas Thome & Patrick Gallinari. Augmenting physical models with deep networks for complex dynamics forecasting. International Conference on Learning Représentations (ICLR) 2021.

[2] Zakariae El Asri, Clément Rambour, Vincent Le Guen and Nicolas Thome, « Residual Model-Based Reinforcement Learning for Physical Dynamics », NeurIPS 2022 Offline RL workshop.

[3] Vincent Le Guen, Nicolas Thome, Clément Rambour, « Complementing Brightness Constancy with Deep Networks for Optical Flow Prediction », European Conference on Computer Vision (ECCV) 2022

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