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Fast adaptation of physics-informed hybrid models for pneumatic artificial muscles

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Abstract-

Recent advances in foundation models and physics-informed neural networks have demonstrated remarkable generalization and adaptation capabilities across diverse domains. Inspired by these properties, we investigate the adaptation potential of a previously proposed physics-informed hybrid model (PIHM) designed for pneumatic artificial muscles (PAMs). Through a series of experiments, it is demonstrated that, by incorporating an adapter based on physical prior knowledge, the PIHM model can be fine-tuned to transfer across different entity types while significantly reducing training time and maintaining competitive accuracy. The optimization efficiency of the proposed adapter has also been validated through comparison with other transfer learning techniques, such as full fine-tuning (FFT), partial fine-tuning (PFT), and low-rank adaptation (LoRA). These results suggest that embedding structured prior knowledge within hybrid architectures offers a promising solution for fast adaptation of PIHMs in dynamic system modeling.

Index Terms- fine-tuning, foundation model, model adaptation, physics-informed neural networks, pneumatic artificial muscles, transfer learning

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