Learning-based Control of Experimental Hybrid Fuel Cell Power Plant

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Abstract
Direct fired Solid Oxide Fuel Cell (SOFC) Turbine hybrid plants have the potential to dramatically increase power plant efficiency, decrease emissions, and provide fast response to transient loads. The US Department of Energy’s (DOE) Hybrid Performance Project is an experimental hybrid SOFC plant, built at the National Energy Technology Laboratory (NETL). One of the most significant challenges in the development and commercialization of this plant is control. Traditional control techniques are inadequate for this plant due to poor system models, high nonlinearities, and extreme coupling between state variables. Learning-based control techniques do not require explicit system models, and are well suited for controlling nonlinear and highly coupled systems. In this work, we use neuro-evolutionary control algorithms to develop a set-point controller for fuel cell flow rate in this plant, and demonstrate a controller that can accurately track a desired turbine speed profile within 50 RPM, even in the presence of 10% sensor noise. In order to ensure the neuro-evolutionary algorithm is computationally tractable, we develop a computationally efficient neural network simulator of the plant, using data collected from actual plant operation. We also present an iterative method to improve plant the controller and simulation performance based on plant run data allowing for expansion of the operation range of the plant in simulation, and control the plant for high efficiency operation.

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