Port-Hamiltonian

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***Abstract*—**

I. Introduction

Basic Introduction Port-Hamiltonian Systems (PHS) has been given in [1]. Survey papers on learning control techniques including reinforcement learning (RL), iterative control and for PHSs [2]–[4].

Reduced-order PHs [5], [6]

Gassian Process approach for modelling PHSs [7], [8] and then Bayesian Control for PHSs [9].

Appyling physics-informed neural network (PINN) with well-chosen learning biases for modelling PHSs has established foundation of port-Hamiltonian neural network (PHNN) [10]–[13].

Data-driven identificaiton of PHSs [14], [15]

A. Related Works

Only input-ouput output [15].

Composite learning [10], [15]

Noise data [7].

B. Contribution

References

[1] A. Van Der Schaft, "Port-Hamiltonian systems: An introductory survey," May 2007, pp. 1339–1365.

[2] S. P. Nageshrao, G. A. D. Lopes, D. Jeltsema, and R. Babuška, "Port-Hamiltonian Systems in Adaptive and Learning Control: A Survey," *IEEE Transactions on Automatic Control*, vol. 61, no. 5, pp. 1223–1238, May 2016.

[3] R. Rashad, F. Califano, A. J. van der Schaft, and S. Stramigioli, "Twenty years of distributed port-Hamiltonian systems: A literature review," *IMA Journal of Mathematical Control and Information*, vol. 37, no. 4, pp. 1400–1422, Dec. 2020.

[4] K. Cherifi, "An overview on recent machine learning techniques for Port Hamiltonian systems," *Physica D: Nonlinear Phenomena*, vol. 411, p. 132620, Oct. 2020.

[5] Y. Wu, B. Hamroun, Y. Le Gorrec, and B. Maschke, "Reduced Order LQG Control Design for Infinite Dimensional Port Hamiltonian Systems," *IEEE Transactions on Automatic Control*, vol. 66, no. 2, pp. 865–871, Feb. 2021.

[6] P. Schwerdtner, T. Moser, V. Mehrmann, and M. Voigt, "Optimization-based model order reduction of port-Hamiltonian descriptor systems," *Systems & Control Letters*, vol. 182, p. 105655, Dec. 2023.

[7] T. Beckers, J. Seidman, P. Perdikaris, and G. J. Pappas, "Gaussian Process Port-Hamiltonian Systems: Bayesian Learning with Physics Prior," in *2022 IEEE 61st Conference on Decision and Control (CDC)*, Dec. 2022, pp. 1447–1453.

[8] T. Beckers, T. Z. Jiahao, and G. J. Pappas, "Learning Switching Port-Hamiltonian Systems with Uncertainty Quantification," *IFAC-PapersOnLine*, vol. 56, no. 2, pp. 525–532, Jan. 2023.

[9] T. Beckers, "Data-Driven Bayesian Control of Port-Hamiltonian Systems," in *2023 62nd IEEE Conference on Decision and Control (CDC)*, Dec. 2023, pp. 8708–8713.

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[10] C. Neary and U. Topcu, "Compositional Learning of Dynamical System Models Using Port-Hamiltonian Neural Networks," in *Proceedings of The 5th Annual Learning for Dynamics and Control Conference*. PMLR, Jun. 2023, pp. 679–691.

[11] S. Eidnes, A. J. Stasik, C. Sterud, E. Bøhn, and S. Riemer-Sørensen, "Pseudo-Hamiltonian Neural Networks with State-Dependent External Forces," Jan. 2023.

[12] S. A. Desai, M. Mattheakis, D. Sondak, P. Protopapas, and S. J. Roberts, "Port-Hamiltonian neural networks for learning explicit time-dependent dynamical systems," *Physical Review E*, vol. 104, no. 3, p. 034312, Sep. 2021.

[13] T. Duong, A. Altawaitan, J. Stanley, and N. Atanasov, "Port-Hamiltonian Neural ODE Networks on Lie Groups for Robot Dynamics Learning and Control," *IEEE Transactions on Robotics*, vol. 40, pp. 3695–3715, 2024.

[14] J. Rettberg, J. Kneifl, J. Herb, P. Buchfink, J. Fehr, and B. Haasdonk, "Data-driven identification of latent port-Hamiltonian systems," Aug. 2024.

[15] G. J. E. van Otterdijk, S. Moradi, S. Weiland, R. Tóth, N. O. Jaensson, and M. Schoukens, "Learning Subsystem Dynamics in Nonlinear Systems via Port-Hamiltonian Neural Networks," Nov. 2024.