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Architecture and Hyperparameter Search for Super-Resolution Networks Operating on Medical Images

Thursday 23 March 2023 16:40 (20 minutes)

Super-resolution networks (SRNs) are employed for enhancing the resolution of Computer Tomography (CT) images. In previous works of the JSC group, respiratory flow simulations were integrated into a data processing pipeline to facilitate diagnosis and treatment planning in rhinology [1]. However, obtaining accurate simulation results is often hindered by low CT image resolutions in clinical applications. SRNs have the potential to increase the CT image resolution, from which computational meshes are generated and used for simulations. The baseline SRN for the project has a U-net architecture with residual learning blocks and is trained with fine CT images as ground truth and down-sampled coarse CT images as input. The performance of the SRN is validated by comparing Computational Fluid Dynamics (CFD) simulations results based on its predictions, fine, coarse, and interpolated CT data of three test patients. The pressure loss between the inflow regions (nostrils) and the outlet (pharynx) of the simulations based on the SRN's predictions deviate by only 1.6%, 0.9%, and -0.3% from the case with fine CT data, compared to deviations of -8.5%, -8.7%, and 10.8% for coarse CT data, and -20.5%, -85.0%, and -0.5% for interpolated CT data.

The collaboration between Juelich Supercomputing Centre (JSC) and Argonne National Laboratory (ANL) focuses on SRN optimization and uncertainty quantification using DeepHyper [3] and AutoDEUQ [2], which are frameworks developed at ANL. Finding the optimal architectures and hyperparameters is limited by computational resources as the search space is often too large to explore exhaustively. DeepHyper tackles the challenge by employing an asynchronous Bayesian optimization approach at HPC scale. The SRN of the previously mentioned baseline case will be further optimized with DeepHyper, and the performance, scalability, and accuracy of DeepHyper will be analyzed and juxtaposed to similar tools, such as Ray Tune [4]. Best-practice for using DeepHyper will be collected and shared among other users and it eventually will be deployed as a standard module on JSC's HPC systems. The findings of the current project will further help to increase the number of CT recordings that are usable for flow simulations, and therefore help to improve CFD-based diagnoses and treatments of pathologies in the human respiratory system.

References
[1] Rüttgers, M., Waldmann, M., Schröder, W., & Lintermann, A. A machine-learning-based method for automatizing lattice-Boltzmann simulations of respiratory flows. Applied Intelligence (2022), 1-21.
[2] Egele, R., Maulik, R., Raghavan, K., Balaprakash, P., & Lusch, B. AutoDEUQ: Automated Deep Ensemble with Uncertainty Quantification. In 2022 International Conference on Pattern Recognition (ICPR).
[3] Balaprakash, P., Salim, M., Uram, T. D., Vishwanath, V., & Wild, S. M. DeepHyper: Asynchronous hyperparameter search for deep neural networks. In 2018 IEEE 25th international conference on high performance computing (HiPC), pp. 42-51. IEEE, 2018.
[4] Liaw, R., Liang, E., Nishihara, R., Moritz, P., Gonzalez, J. E., & Stoica, I. Tune: A research platform for distributed model selection and training. In 2018 International Conference on Machine Learning (ICML) AutoML workshop

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