

pyCANS+コードの開発

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Development of pyCANS+

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Magnetohydrodynamic simulations have played important roles for understanding space and astrophysical phenomena. We have developed a high-order (greater than the fifth), shock-capturing code CANS+ (Matsumoto et al., PASJ, 2019), and shown its high-capability of solving shock waves and turbulence simultaneously both of which are inherently important in those circumstances. I recently proposed that CANS+'s heavy computational workload, which is mainly due to the high-order reconstruction and the approximate Riemann solver, can be replaced by simple matrix-vector computations of a pre-trained neural network prediction. In this idea, we have to prepare a large set of training data, with which the over-fitting problem must be addressed to construct a general-purpose neural network.

To overcome this difficulty, I propose a *on-the-fly* training during MHD simulations of a particular problem. A neural network is trained during the simulation run using the data during a time interval. After acquiring a sufficiently high prediction accuracy, the reconstruction and the numerical flux calculation procedures are then replaced by the neural network's prediction. The accuracy is continuously checked afterward, and the procedure returns to the training phase when the accuracy became lower than a threshold value. Because Chainer, which is the framework I use for constructing a neural network, is based on Python language and CANS+ and other common simulation codes are written in Fortran or C languages, we have to adopt mixed program languages for this strategy. We adopted f2py, which is a part of the Numpy library, to automatically generate an interface between Python and Fortran programs. By using f2py functionality, the main program of CANS+ written in Fortran can be replaced by a Python program. CANS+ code can benefit from this mixed programming in accessing not only Chainer but also other useful Python libraries such as the HDF5 data IO library. I present detailed implementation of Python programs into CANS+ code by using f2py library.