Applying Automatic Tuning to Hyper-parameter Optimization of Machine Learning Programs for Super-Resolution

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1. Introduction

To optimize hyperparameters for better learning results of machine learning programs, we applied our developed software auto-tuning tool "DSICE" (d-spline Iterative Collinear Exploration). In order to reduce the execution time, we propose a two-step learning method of pre-learning and fine-tuning, and run multiple jobs in parallel on the GPU cluster.

2. The automatic tuning tool DSICE

We propose an automatic tuning tool "DSICE"[1].DSICE repeats the following three processes until it obtains a performance parameter that results in the optimal performance evaluation value. (i)Select and set the values of performance parameters that have not yet been examined. (ii)Execute the user program. (iii)Obtain the performance evaluation value.

3. Machine learning program for SR

Super-resolution (SR) is a technique that converts low-resolution images into high-resolution images. The super-resolution procedure used in this study is Dense Deep Back-Projection Networks (D-DBPN)[2]. Each side of the low-resolution image can be converted to 2x, 4x, and 8x high-resolution images. In this study, we aimed for 4x magnification. Image quality is evaluated by Perceptual Index (PI) and Root Mean Square Error (RMSE). The Perceptual Index is an indicator of whether a person sees it as beautiful. The smaller the Perceptual Index, the better the performance. RMSE measures the deviation between the observed value and the true value.

4. Methods to reduce program execution time

In D-DBPN program, one execution takes 92 hours. In order to use DSICE for automatic tuning, D-DBPN program needs to be repeatedly executed, and the execution time of D-DBPN program needs to be greatly reduced. To this end, the following two measures have been taken.

(1) *Two-step learning*: Pre-learning and fine-tuning methods are used. First, set the values of hyperparameters to perform 1000 pre-learning times to obtain the trained model. Then adjust the value of the hyperparameter, set the epoch number to 2000, and perform 1 fine-tuning based on the trained model. According to the loss of fine-tuning and the image quality of the resulting image, the appropriate number of epochs for fine-tuning is determined to be 250.

(2) *Run in parallel*: DSICE manages to simultaneously select plural different performance parameter values and in parallel, set them to user programs and execute user programs. We use the supercomputer "Flow" II subsystem of Nagoya University with multiple GPUs as the environment to execute multiple jobs in parallel.

5. Estimated result

According to the 2018 PIRM Challenge[3], set RMSE<12.5, and explore the minimum Perceptual Index within this range. It has been shown in Figure1 that the best attainable Perceptual Index improves as the allowable distortion level increases. The red point is the point with the lowest Perceptual Index value in the range of RMSE. This point corresponds to the 6th level in this challenge. Figure 2 shows the execution status of the program. A total of 545 jobs were executed. Logically, sequential operation takes 4905 hours while parallel execution only takes only 182 hours.

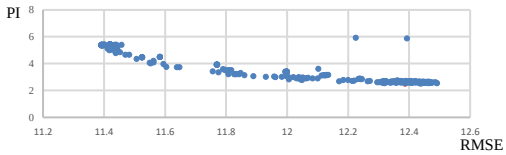

Figure 1. Relationship between RMSE and PI

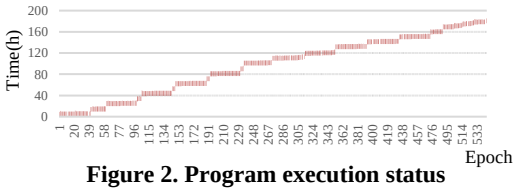

Figure 2. Program execution status

6. Conclusion

In this study, hyperparameter estimation was performed by applying the parallelized automatic tuning tool "DSICE" to the super-resolution program D-DBPN. We applied re-learning and fine-tuning to reduce each execution time to 1/8. We used the parallel processing environment of GPU cluster supercomputer, which reduced execution time to 1/27. Overall, the execution time was reduced to 1/216 of the original.

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References

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