

DLiP – Assignment 3:

Transfer Learning on Galaxy Zoo 2 Dataset

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Introduction

Galaxy Zoo 2 is a large-scale dataset of galaxy images labeled by morphological features. The decision tree for classification is detailed in Willett et al. [1]. Kaggle hosted a competition 12 years ago to predict galaxy morphologies from these images [2].

Methods

ConvNeXt Model

I used the tiny variant of the ConvNeXt model [3], a modern convolutional neural network for image classification. Its architecture includes a convolutional feature extractor, fully connected layers, and an output layer (see Fig. 1). A ConvNeXt block consists of a depthwise convolution, layer normalization, pointwise convolution, and GELU activation.

Transfer Learning

I fine-tuned a pre-trained ConvNeXt model on Galaxy Zoo 2 by updating only the final layer, efficiently adapting it to the new task. I also compared this to curriculum learning, where training examples increase in difficulty over time.

Curriculum Learning

Curriculum learning [4] is a strategy where a model is first trained on easier examples and gradually exposed to harder ones. For this project, I split the training data into three stages based on label confidence: high (> 0.94), medium ($0.85-0.94$), and low (< 0.85), each about 33% of the data. I trained sequentially: 3 epochs for high-confidence, 3 for high and

medium, and 6 for the full dataset, totaling 12 epochs to match the normal model.

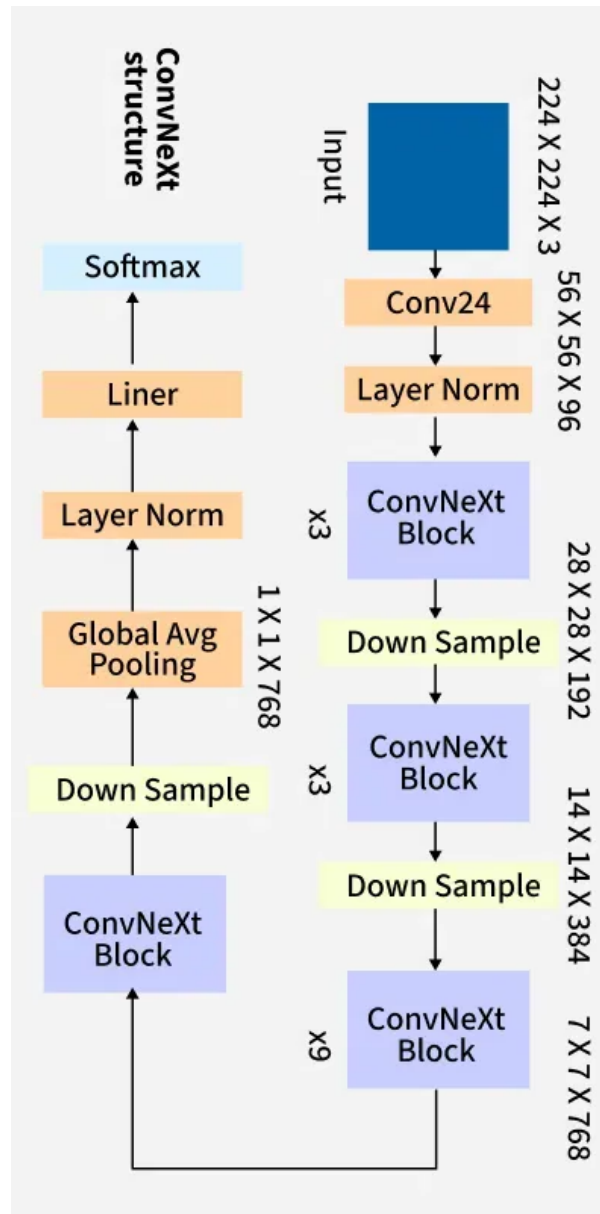


Figure 1: ConvNeXt architecture [5]: convolutional feature extractor, fully connected, and output layers. Only the final layer is trained.

Results

The classification performance of the ConvNeXt model without curriculum learning is shown in Fig. 2 in gray, while the performance with curriculum learning is shown in shades of

green/blue. The results indicate that curriculum learning can improve classification performance by allowing the model to learn from easier examples before tackling more difficult ones.

This competition uses Root Mean Squared Error as the evaluation metric. The normal and curriculum learning models achieved final Kaggle test scores of 0.12475 and 0.12416, respectively. For comparison, the competition winner scored 0.07491 twelve years ago.

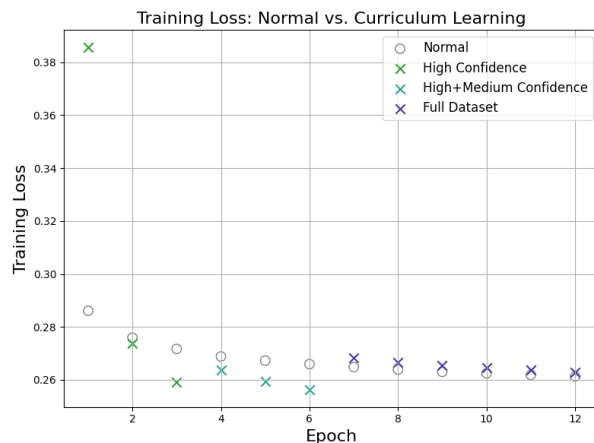


Figure 2: Classification performance of the ConvNeXt model with and without curriculum learning.

Discussion

Curriculum learning begins with only high-confidence data, so the initial loss is higher due to limited diversity. As more data is added, loss decreases significantly faster than the normal training. My training was limited by hardware constraints, with each epoch requiring approximately 30-40 minutes. Extending training or fine-tuning additional layers will improve the performance of curriculum learning over normal learning. I regret not training on the full dataset; due to time constraints, I only used 80% of the data to validate the pipeline and did not retrain on all data.

Conclusion

Transfer learning with ConvNeXt enables efficient galaxy morphology classification on Galaxy Zoo 2. Further improvements could be achieved by: training on the full dataset, increasing training duration, or fine-tuning more layers. Or, of course, using a bigger model. My results show that data selection strategies also impact results, with direct transition from high-confidence to full dataset showing promise.

References

- [1] K. W. Willett *et al.*, “Galaxy zoo 2: detailed morphological classifications for 304,122 galaxies from the sloan digital sky survey,” *Mon. Not. of the Royal Astronomical Society*, 2013.
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- [3] Z. Liu, H. Mao, C.-Y. Wu, C. Feichtenhofer, T. Darrell, and S. Xie, “Convnext: A convnet for the 2020s.” [Online]. Available: <https://arxiv.org/abs/2201.03545>
- [4] Y. Bengio, J. Louradour, R. Collobert, and J. Weston, “Curriculum learning.” [Online]. Available: <https://arxiv.org/abs/0804.0866>
- [5] GeeksforGeeks, “Convnext.” [Online]. Available: <https://www.geeksforgeeks.org/computer-vision/convnext/>