NdLinear Test Report

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Problem Formulation

This is a classification task that uses an organic MNIST 3D dataset. It contains 11 classes of CT scan images of organs. NdLinear is benchmarked against a baseline model for this task. The criteria used are accuracy on the validation set, training time, and the number of trainable parameters inferred.

Architecture

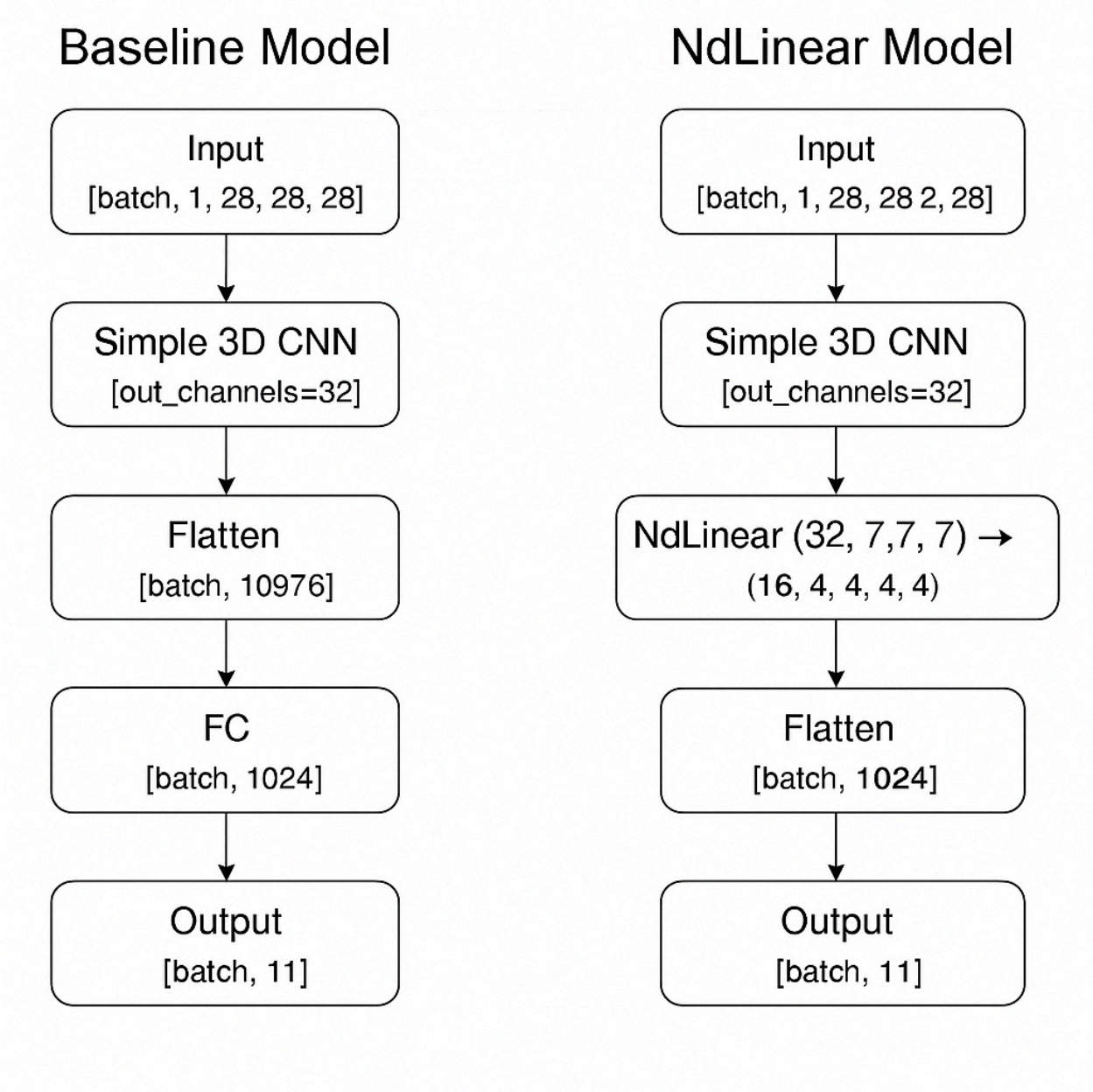
Both the models have the Simple3DConv class. It takes the input image and applies 16 filters (3x3x3 kernel) and outputs [batch, 16, 28, 28, 28]. Batch normalization is used for normalizing across 16 channels. ReLU activation is used for adding non-linearity along with MaxPool3d as the pooling function. Pooling is done to reduce the dimensions by half. Conv3d layer applies 32 filters and BatchNorm3d normalizes across the 32 channels.

Baseline

- The 1D vector is achieved by flattening the 3D vector.
- Two fully-connected layers follow that perform classification.
- ReLU activation function is used for introducing non-linearity.
- CrossEntropyLoss is used as the loss function since this is a classification task.
- AdamW optimizer is used for updating the gradients. Experimented with regular Adam optimizer, too.

NdLinear

- The fully-connected layers in the baseline model are replaced by the NdLinear layer.
- NdLinear seems to learn a low-ranked factorized transformation, retaining spatial and channel-wise information.
- The NdLinear layer is followed by a single dense layer that is used for classification.



The diagram illustrates the architecture of the two models.

Training

Experimented by tuning hyperparameters, but found that epochs had the most significance on improving the validation accuracy. Changing learning rate while keeping the epochs constant did not have much of an impact, and the models overfitted on the training set. This conclusion could

be drawn since both the models had a high training set accuracy while a low validation accuracy. Initial runs used Adam as the optimizer but later switched to AdamW, knowing it is the industry standard and improves upon regularization over Adam.

Results

The following results are for 50 epochs.

Metric	**Baseline model**	**NdLinear**
Validation accuracy	9.94%	94.4%
Trainable parameters	1,420,875	26,299
Training time	185 sec	188 sec

NdLinear performs significantly better than the baseline model on the validation set. The training time is slightly higher for NdLinear, though not significant. The number of trainable parameters for NdLinear is much lower than the baseline model. This can be attributed to the `NdLinear((32, 7, 7, 7) -> (16, 4, 4, 4))` structure over having a massive fully-connected layer.