Metric Learning: Triplet-Loss

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I. The Triplet-Loss Pipeline

In this supervised similarity or metric learning, the Triplet-Loss pipeline consists of

1) Retrieve images from CUB200_2011 dataset within `TripletCUBDataset` class
2) Transform images into tensors and apply additional augmentations to the training set only
3)
4)

II. Training Hyper-parameters

We conducted 4 experiments using two pre-trained models: ResNet18 and ResNet34
ResNet18 contains million parameters
ResNet34 contains approximately 21.5 million parameters

1) epochs: 20, learning rate: 0.001, batch size: 32
2) epochs: 20, learning rate: 0.002, batch size: 32
3) epochs: 20, learning rate: 0.001, batch size: 64
4) epochs: 20, learning rate: 0.002, batch size: 64

Extended Training with ResNet18:

5) epochs: 60, learning rate: 0.001, batch size: 64
6) epochs: 60, learning rate: 0.001, batch size: 32

III. Training Curves

A. ResNet18

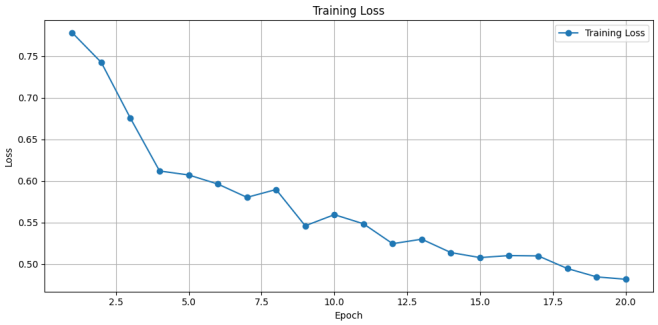

Fig. 1. Experiment 1 with ResNet18

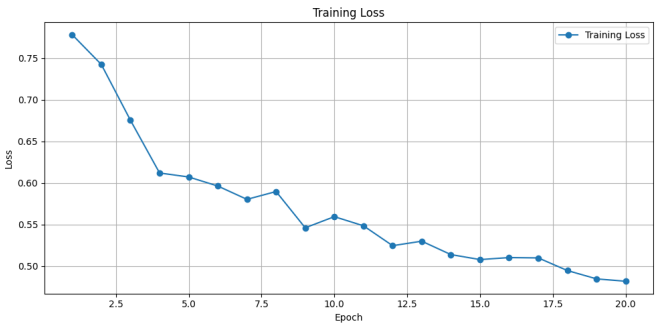

Fig. 2. Experiment 2 with ResNet18

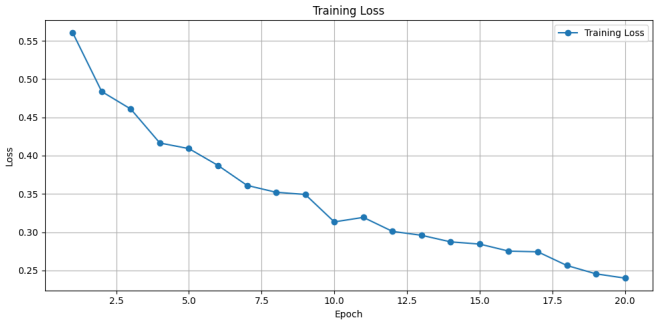

Fig. 3. Experiment 3 with ResNet18

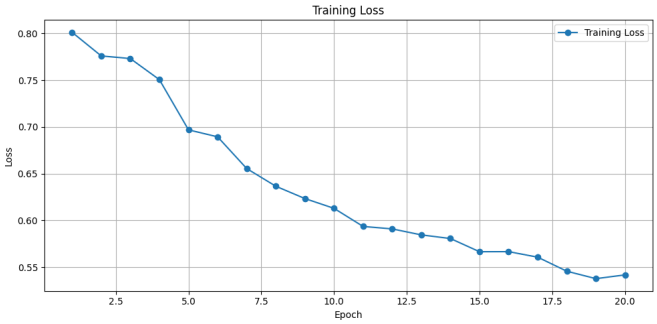

Fig. 4. Experiment 4 with ResNet18

B. ResNet34

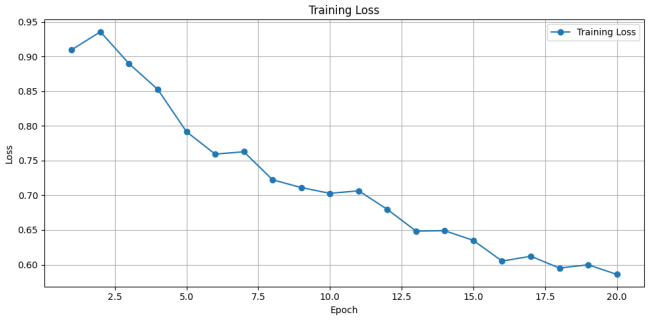

Fig. 5. Experiment 1 with ResNet34

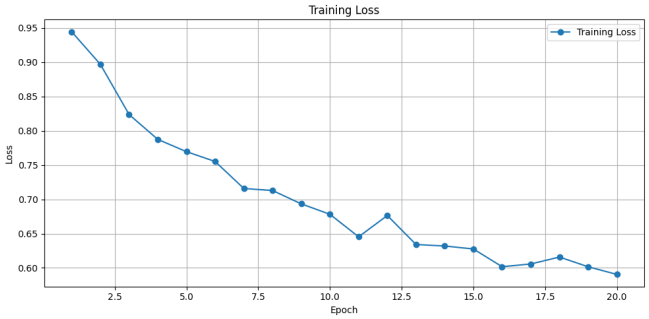

Fig. 6. Experiment 2 with ResNet34

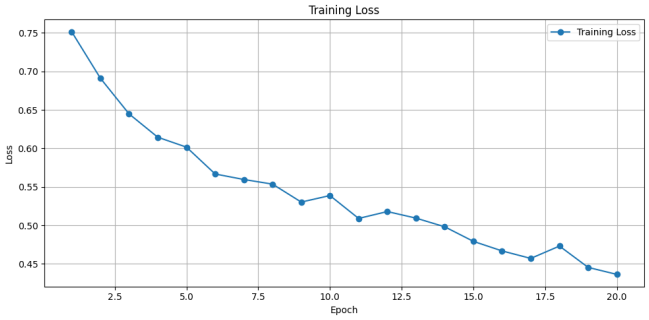

Fig. 7. Experiment 3 with ResNet34

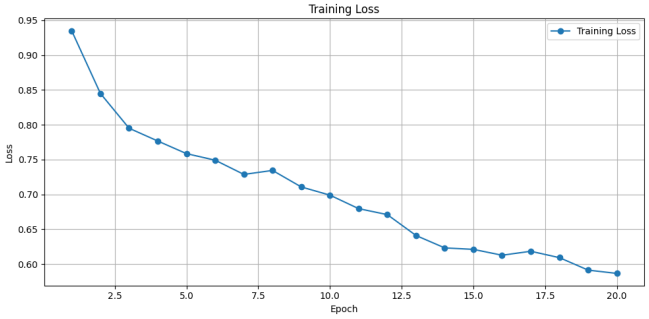

Fig. 8. Experiment 4 with ResNet34

IV. Embedding Visualizations

A. ResNet18

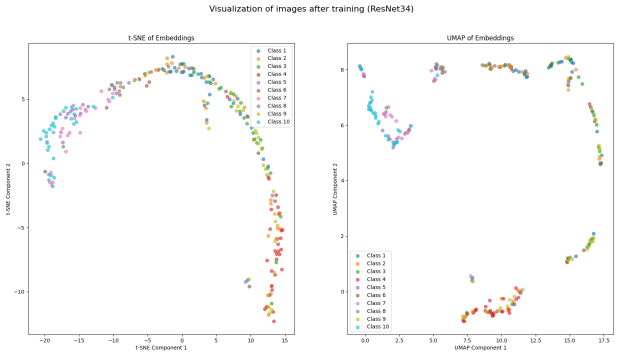

Fig. 9. Experiment 1 with ResNet18

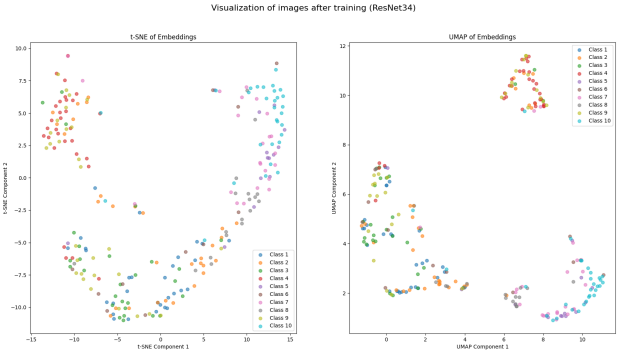

Fig. 10. Experiment 2 with ResNet18

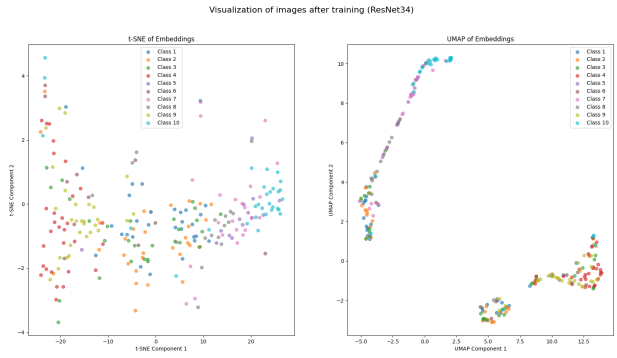

Fig. 11. Experiment 3 with ResNet18

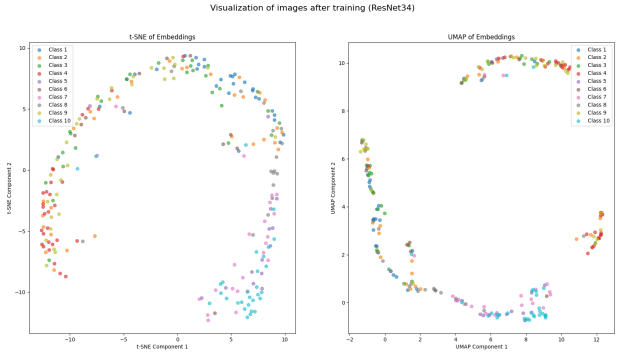

Fig. 12. Experiment 4 with ResNet18

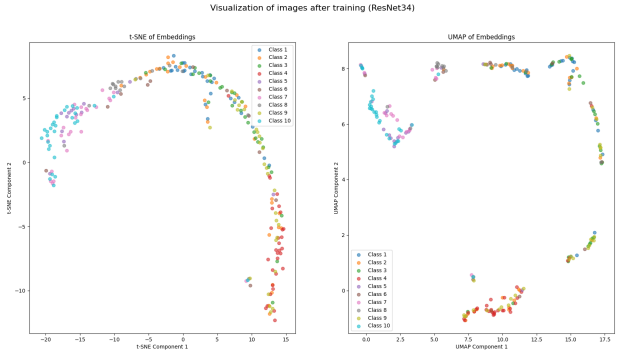

Fig. 13. Experiment 1 with ResNet34

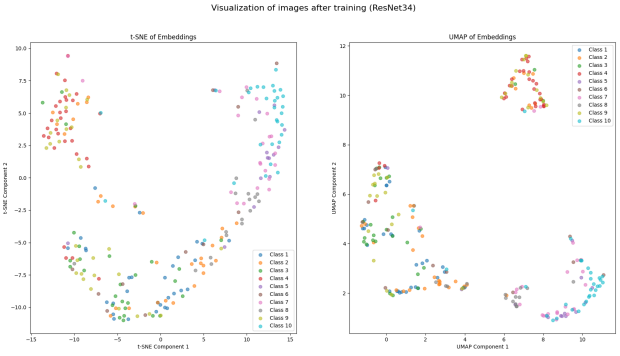

Fig. 14. Experiment 2 with ResNet34

B. ResNet34

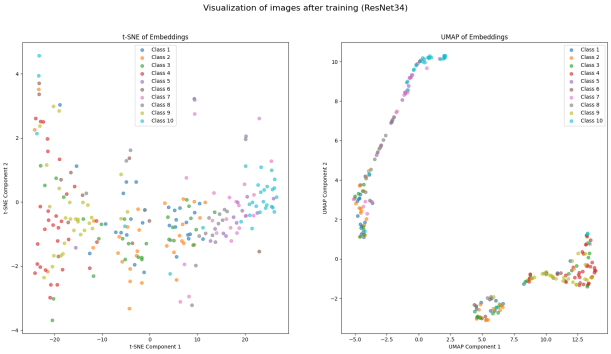

Fig. 15. Experiment 3 with ResNet34

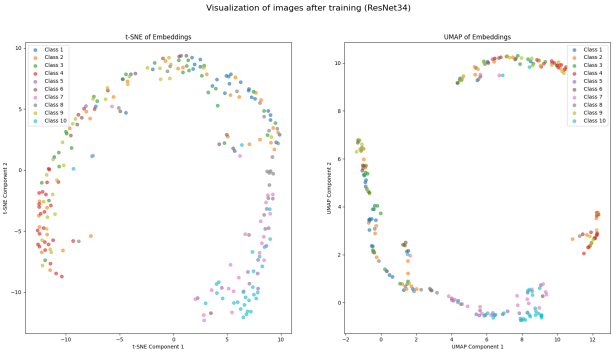

Fig. 16. Experiment 4 with ResNet34

V. Evaluation Results

A. ResNet18

TABLE I
LOSS AND ACCURACY METRICS FOR EXPERIMENT 1

Metric (Average)	Value
Loss	0.5020
Top-1 Accuracy (%)	79.60
Cosine Similarity Anchor-Positive	0.6735
Cosine Similarity Anchor-Negative	0.0359

TABLE II
PRECISION METRICS FOR EXPERIMENT 1

Metric	Value (%)
Precision@1	33.74
Precision@5	33.83
Precision@10	32.55

TABLE III
LOSS AND ACCURACY METRICS FOR EXPERIMENT 3

Metric (Average)	Value
Loss	0.3277
Top-1 Accuracy (%)	89.11
Cosine Similarity Anchor-Positive	0.7762
Cosine Similarity Anchor-Negative	-0.0004

TABLE IV
PRECISION METRICS FOR EXPERIMENT 3

Metric	Value (%)
Precision@1	39.92
Precision@5	44.03
Precision@10	42.51

TABLE V
LOSS AND ACCURACY METRICS FOR EXPERIMENT 4

Metric (Average)	Value
Loss	0.5633
Top-1 Accuracy (%)	76.53
Cosine Similarity Anchor-Positive	0.6284
Cosine Similarity Anchor-Negative	0.0632

TABLE VI
PRECISION METRICS FOR EXPERIMENT 4

Metric	Value (%)
Precision@1	31.69
Precision@5	28.48
Precision@10	27.04

B. ResNet34

TABLE VII
LOSS AND ACCURACY METRICS FOR EXPERIMENT 1

Metric (Average)	Value
Loss	0.5902
Top-1 Accuracy (%)	75.85
Cosine Similarity Anchor-Positive	0.6200
Cosine Similarity Anchor-Negative	0.0994

TABLE VIII
PRECISION METRICS FOR EXPERIMENT 1

Metric	Value (%)
Precision@1	31.69
Precision@5	30.12
Precision@10	30.37

TABLE IX
LOSS AND ACCURACY METRICS FOR EXPERIMENT 2

Metric (Average)	Value
Loss	0.5829
Top-1 Accuracy (%)	75.63
Cosine Similarity Anchor-Positive	0.6727
Cosine Similarity Anchor-Negative	0.1282

TABLE X
PRECISION METRICS FOR EXPERIMENT 2

Metric	Value (%)
Precision@1	26.34
Precision@5	29.14
Precision@10	29.42

TABLE XI
LOSS AND ACCURACY METRICS FOR EXPERIMENT 3

Metric (Average)	Value
Loss	0.4440
Top-1 Accuracy (%)	83.28
Cosine Similarity Anchor-Positive	0.7201
Cosine Similarity Anchor-Negative	0.0272

TABLE XII
PRECISION METRICS FOR EXPERIMENT 3

Metric	Value (%)
Precision@1	34.98
Precision@5	30.86
Precision@10	29.55

TABLE XIII
LOSS AND ACCURACY METRICS FOR EXPERIMENT 4

Metric (Average)	Value
Loss	0.6131
Top-1 Accuracy (%)	73.66
Cosine Similarity Anchor-Positive	0.6504
Cosine Similarity Anchor-Negative	0.1431

TABLE XIV
PRECISION METRICS FOR EXPERIMENT 4

Metric	Value (%)
Precision@1	25.51
Precision@5	28.31
Precision@10	27.08