

# 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 approximately 11.4 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: 32
  - 6) epochs: 60, learning rate: 0.001, batch size: 64



Fig. 2. Experiment 2 with ResNet18

## III. TRAINING CURVES

### A. ResNet18

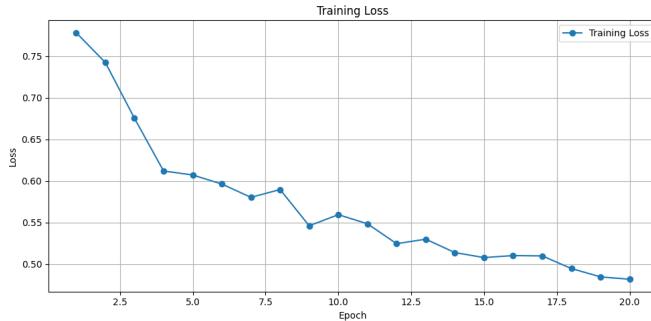


Fig. 1. Experiment 1 with ResNet18

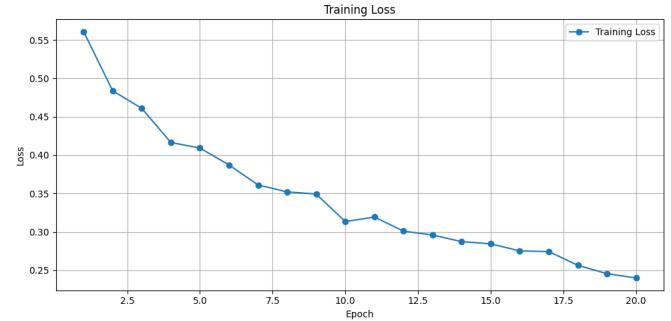


Fig. 3. Experiment 3 with ResNet18

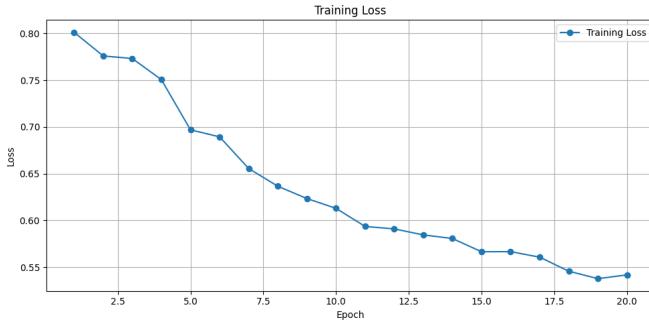


Fig. 4. Experiment 4 with ResNet18

### B. ResNet34

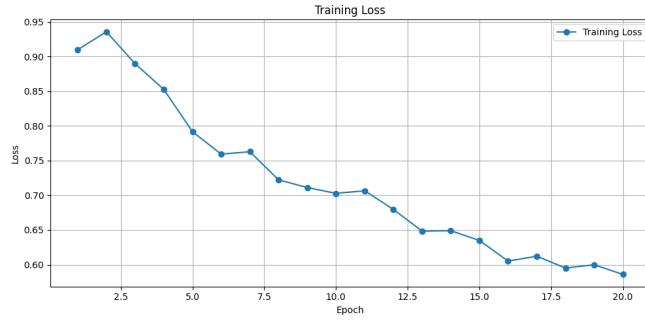


Fig. 5. Experiment 1 with ResNet34

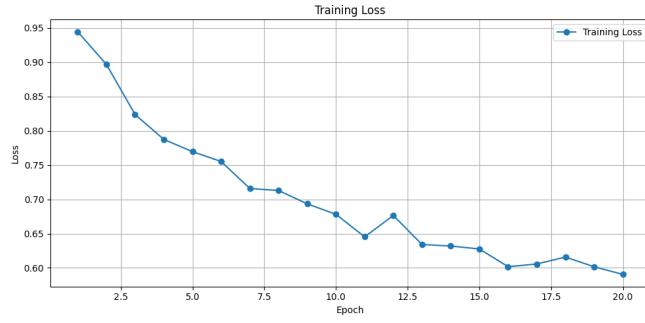


Fig. 6. Experiment 2 with ResNet34

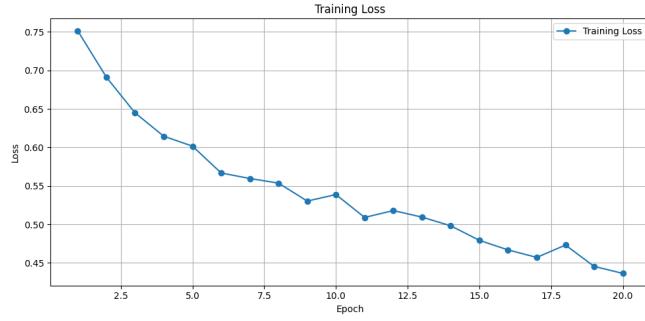


Fig. 7. Experiment 3 with ResNet34

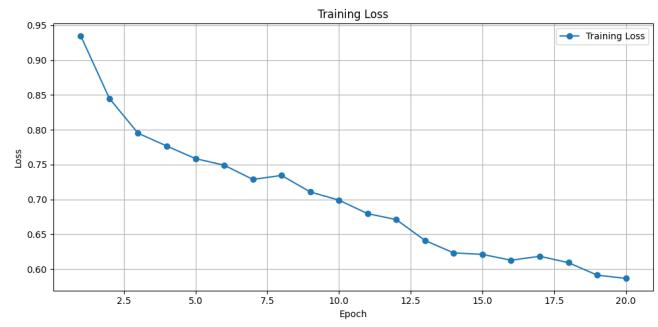


Fig. 8. Experiment 4 with ResNet34

## IV. EMBEDDING VISUALIZATIONS

### A. ResNet18

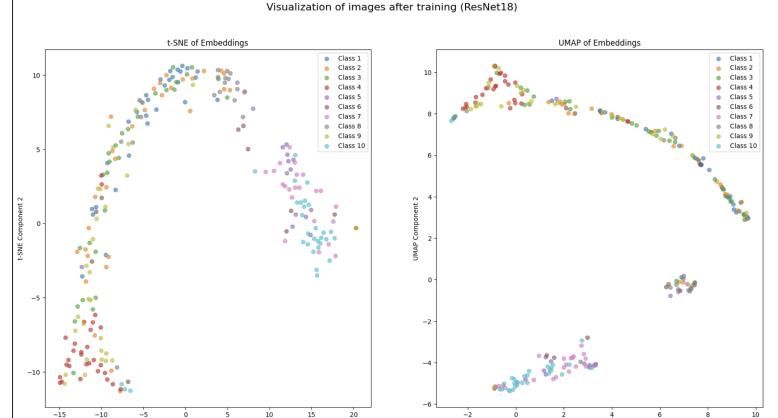


Fig. 9. Experiment 1 with ResNet18



Fig. 10. Experiment 2 with ResNet18

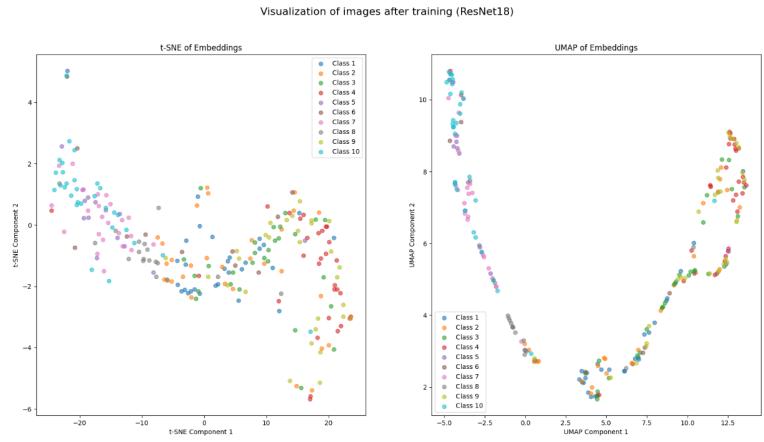


Fig. 12. Experiment 4 with ResNet18

### B. ResNet34

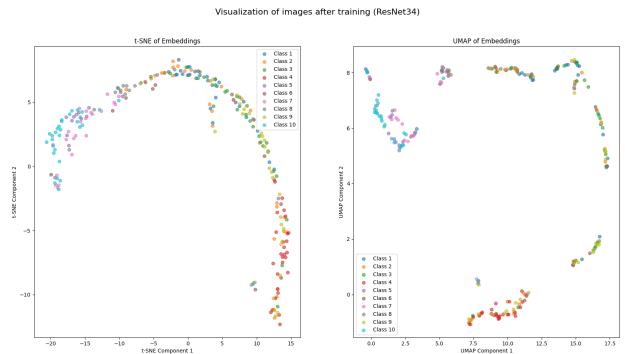


Fig. 13. Experiment 1 with ResNet34

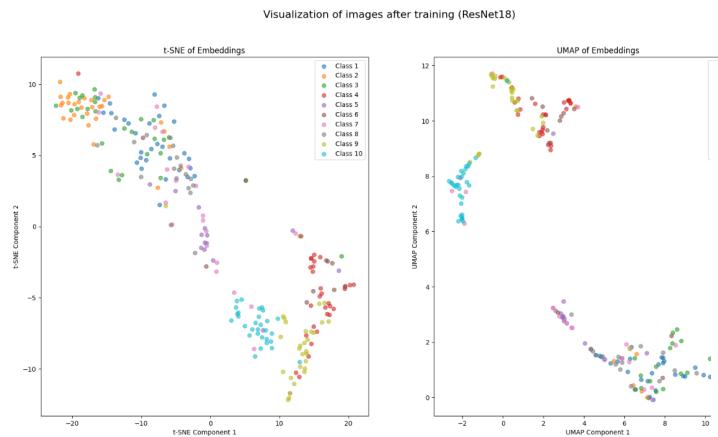


Fig. 11. Experiment 3 with ResNet18

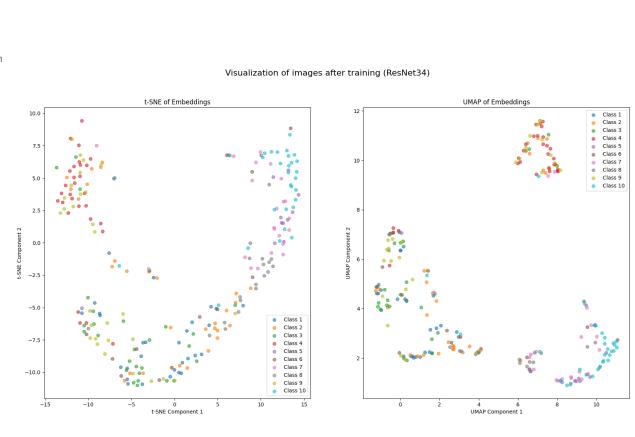


Fig. 14. Experiment 2 with ResNet34

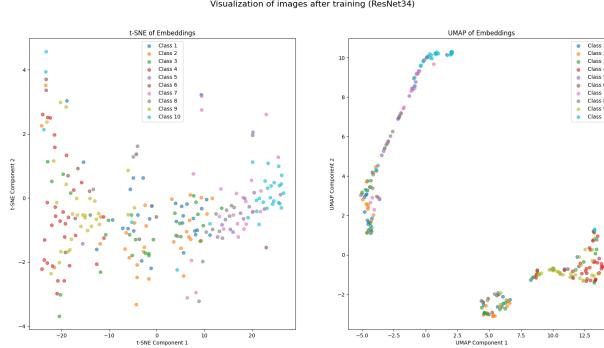


Fig. 15. Experiment 3 with ResNet34

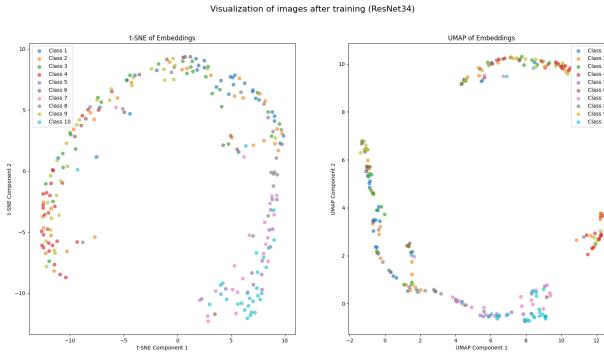


Fig. 16. Experiment 4 with ResNet34

## 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

### VI. EXPERIMENT 2 - RESNET18

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

### A. 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

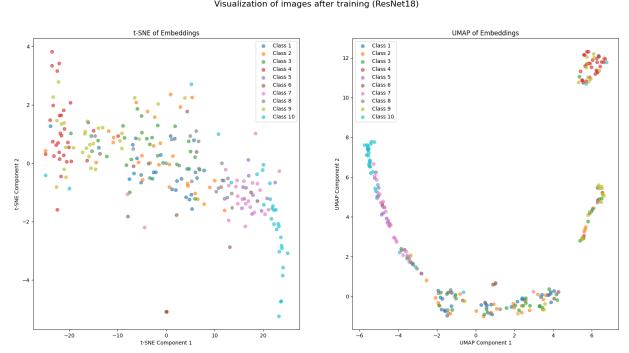


Fig. 18. Experiment 5 with ResNet18

TABLE XV  
LOSS AND ACCURACY METRICS FOR EXPERIMENT 5

Metric (Average)	Value
Loss	0.4344
Top-1 Accuracy (%)	83.53
Cosine Similarity Anchor-Positive	0.7268
Cosine Similarity Anchor-Negative	0.0781

## VII. Extended Training with ResNet18

A. epochs: 60, learning rate: 0.001, batch size: 32

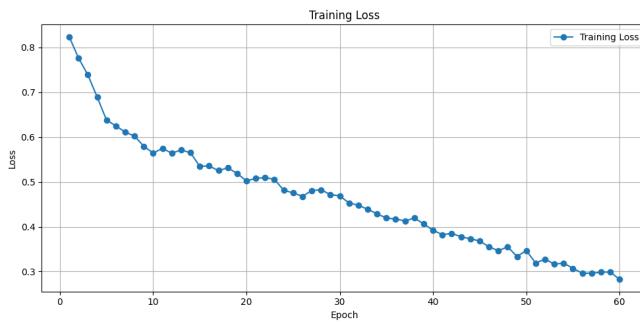


Fig. 17. Experiment 5 with ResNet18

TABLE XVI  
PRECISION METRICS FOR EXPERIMENT 5

Metric	Value (%)
Precision@1	33.74
Precision@5	35.97
Precision@10	34.86

B. epochs: 60, learning rate: 0.001, batch size: 64



Fig. 20. Experiment 6 with ResNet18

TABLE XVII  
LOSS AND ACCURACY METRICS FOR EXPERIMENT 6

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



TABLE XVIII  
PRECISION METRICS FOR EXPERIMENT 6

Metric	Value (%)
Precision@1	
Precision@5	
Precision@10	

Fig. 19. Experiment 6 with ResNet18