Dhirubhai Ambani University

Biometric Security – IT 499

Lab – 04 : Face Recognition

REPORT

Name: Manish Prajapati

Student ID: 202411012

Branch: MTech ICT ML(2024 - 26)

Date: 13/04/2025

Submitted To: Prof. Shruti Bhilare

Objective:

- ⇨ Implement and visualize the effects of different loss functions used in face recognition using a Convolutional Neural Network (CNN) on a small face dataset.

Dataset:

- ⇨ LFW cropped and funnelled dataset.
- ⇨ Source: - Kaggle LFW dataset
- ⇨ Test size: 20%
- ⇨ Number of classes = 20

Baseline CNN Classifier:

Architecture:

- ⇨ Model: Convolutional Neural Network
- ⇨ Layers:
  - 3 Convolutional layers (2 Dimensional)
    - Activation: RELU
    - Max-pooling enabled
  - Fully connected linear layer
  - Fully connected classification layer

Hyper-parameters:

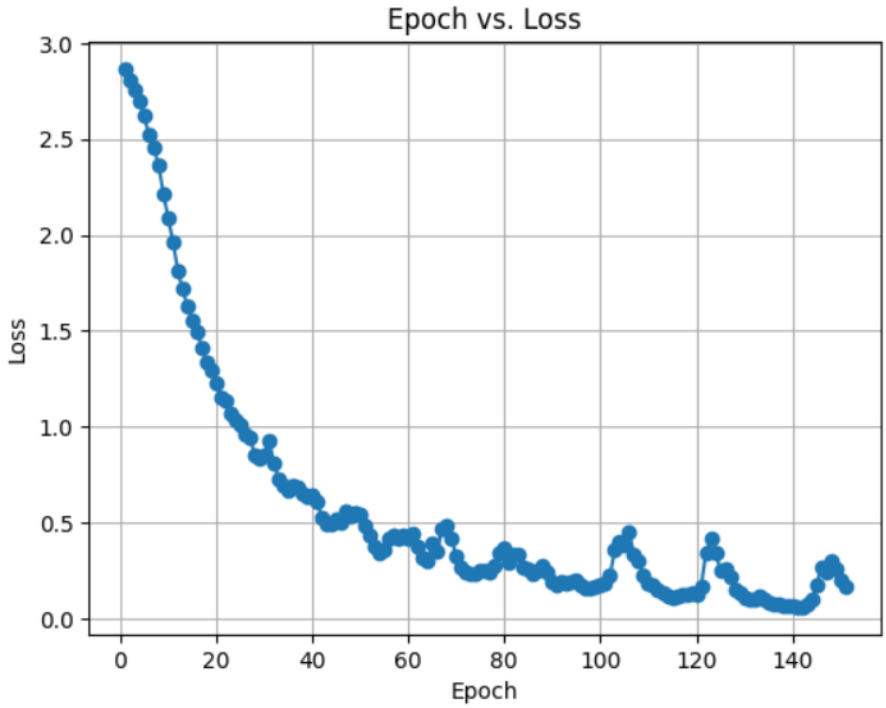
- ⇨ Loss function: Cross-entropy loss function (Soft-max)
- ⇨ Optimizer: Adam-optimizer
- ⇨ Batch size: 64
- ⇨ Learning rate: 1e-3 = 0.001
- ⇨ Epochs: 151

Results:

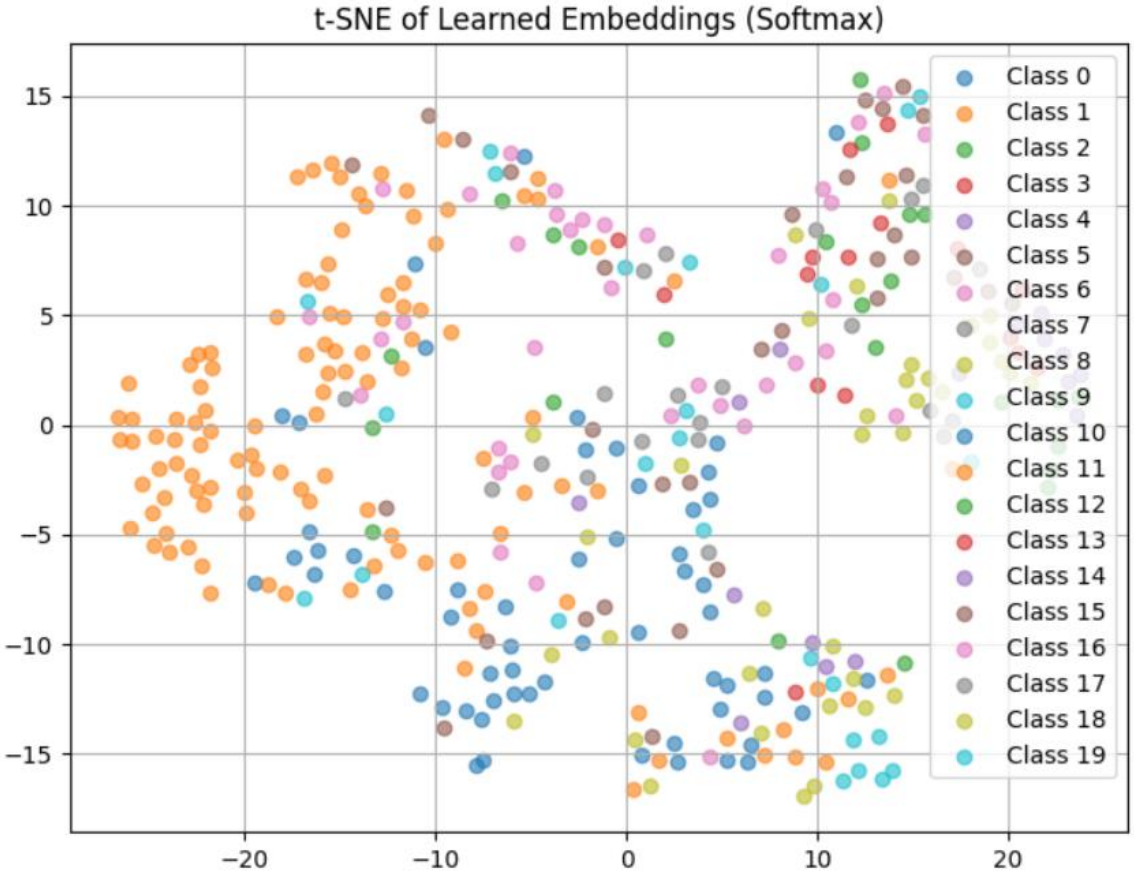
- ⇨ Final epoch training loss: 0.1626
- ⇨ Test set accuracy: 38.48%

Plots:

⇨ Epoch vs Loss



⇨ t – SNE of learned embeddings (soft-max)



1.) CNN Classifier with Contrastive Loss

Hyper-parameters:

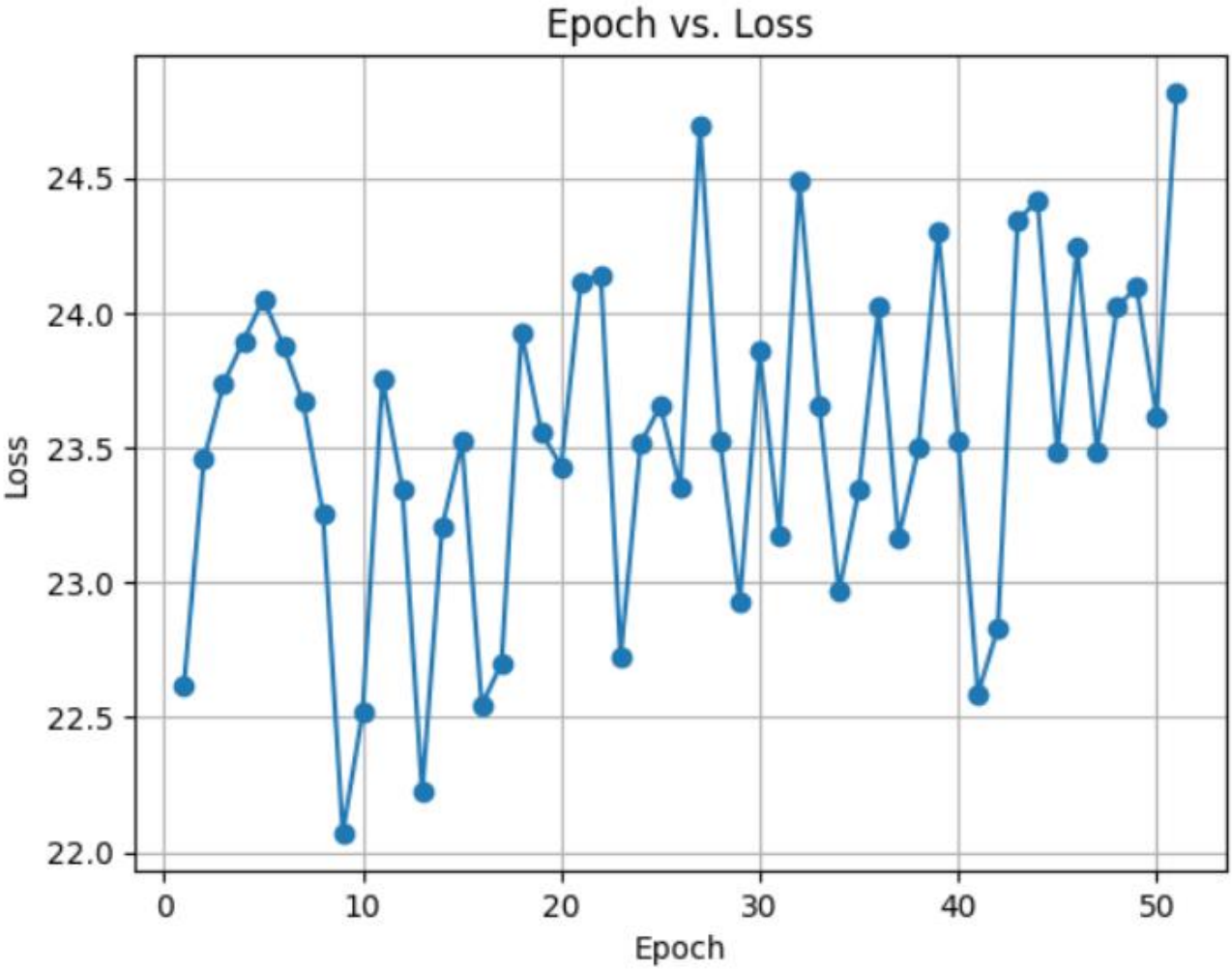
- ⇨ Loss function: Contrastive loss function
- ⇨ Optimizer: Adam-optimizer
- ⇨ Batch size: 32
- ⇨ Epochs: 51

Results:

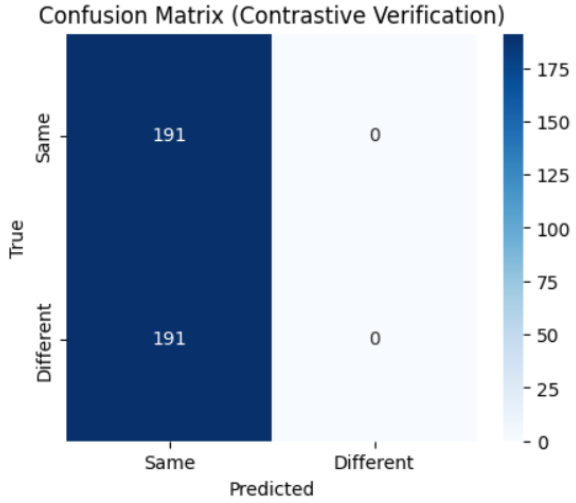
- ⇨ Final epoch training loss: 0.5170
- ⇨ Test set accuracy: 50.00%

Plots:

- ⇨ Epoch vs. Loss



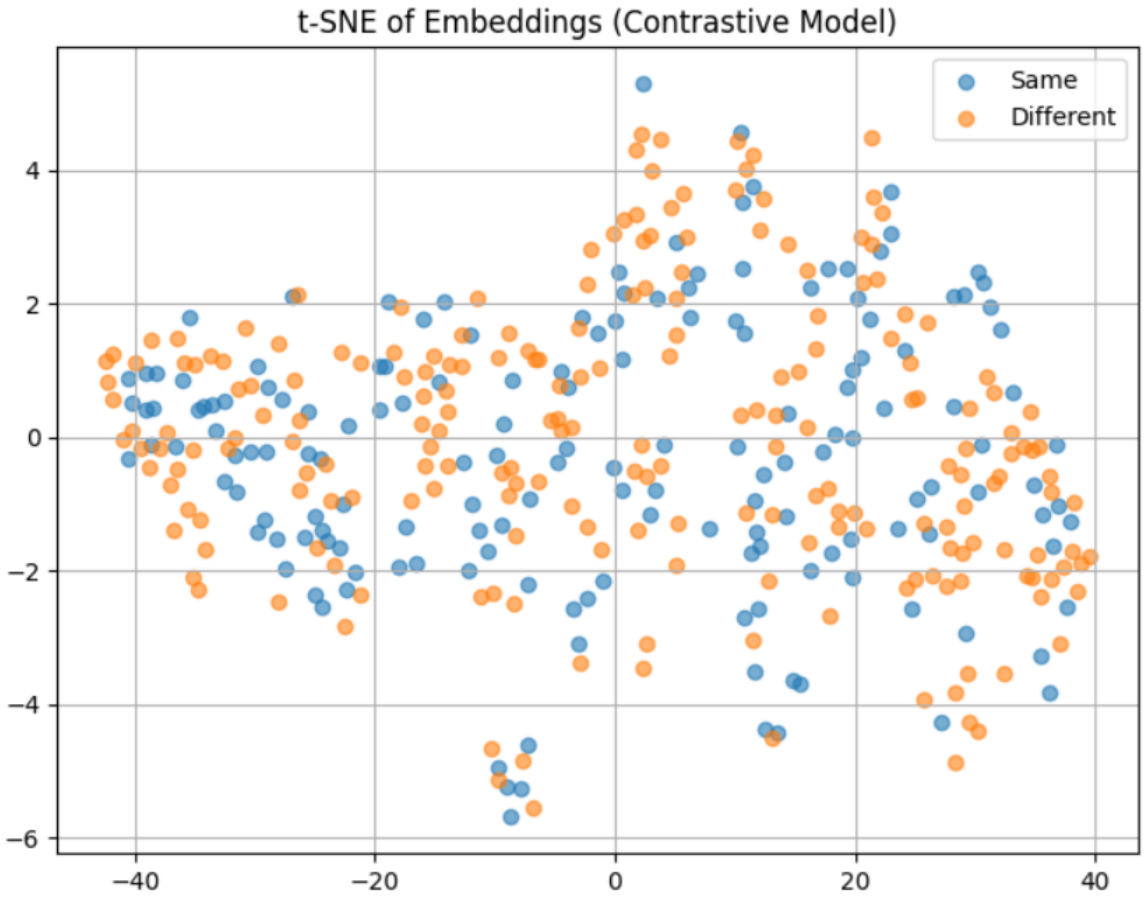
⇨ Test results



Classification Report:

	precision	recall	f1-score	support
Same	0.50	1.00	0.67	191
Different	0.00	0.00	0.00	191
accuracy			0.50	382
macro avg	0.25	0.50	0.33	382
weighted avg	0.25	0.50	0.33	382

⇨ t – SNE plot of embeddings (Contrastive Model)



2.) CNN Classifier with Triplet Loss

Hyper-parameters:

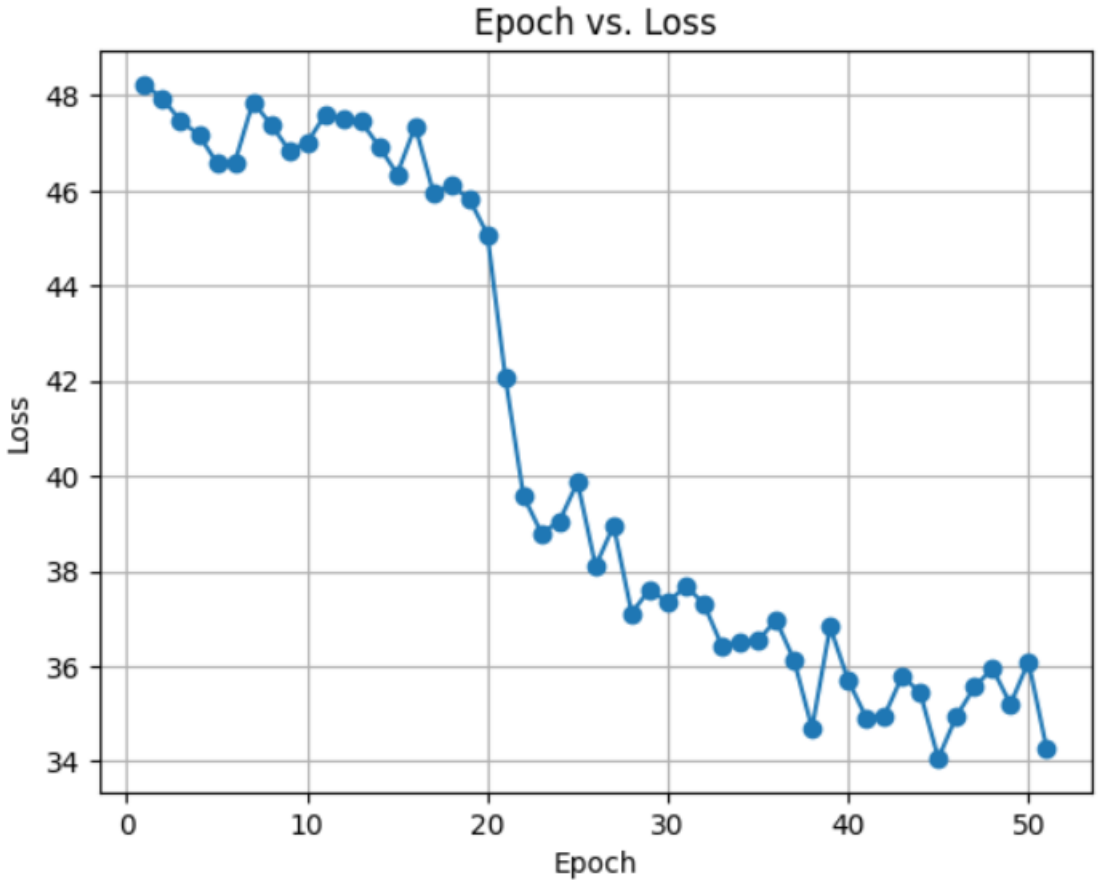
- ⇨ Loss function: Triplet loss function
- ⇨ Optimizer: Adam-optimizer
- ⇨ Batch size: 32
- ⇨ Learning rate: 0.001
- ⇨ Loss Margin: 1.0
- ⇨ Epochs: 51

Results:

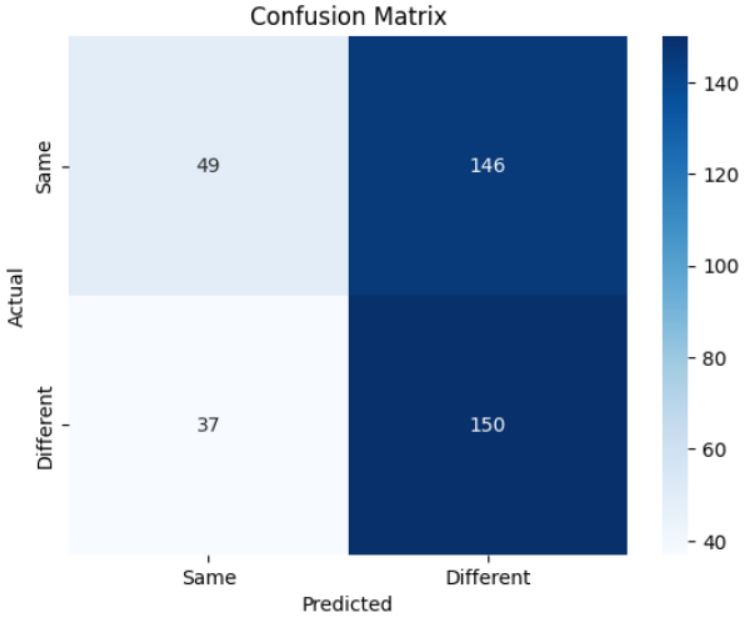
- ⇨ Final epoch training loss: 0.7141
- ⇨ Test set accuracy: 52.09%

Plots:

- ⇨ Epoch vs. Loss

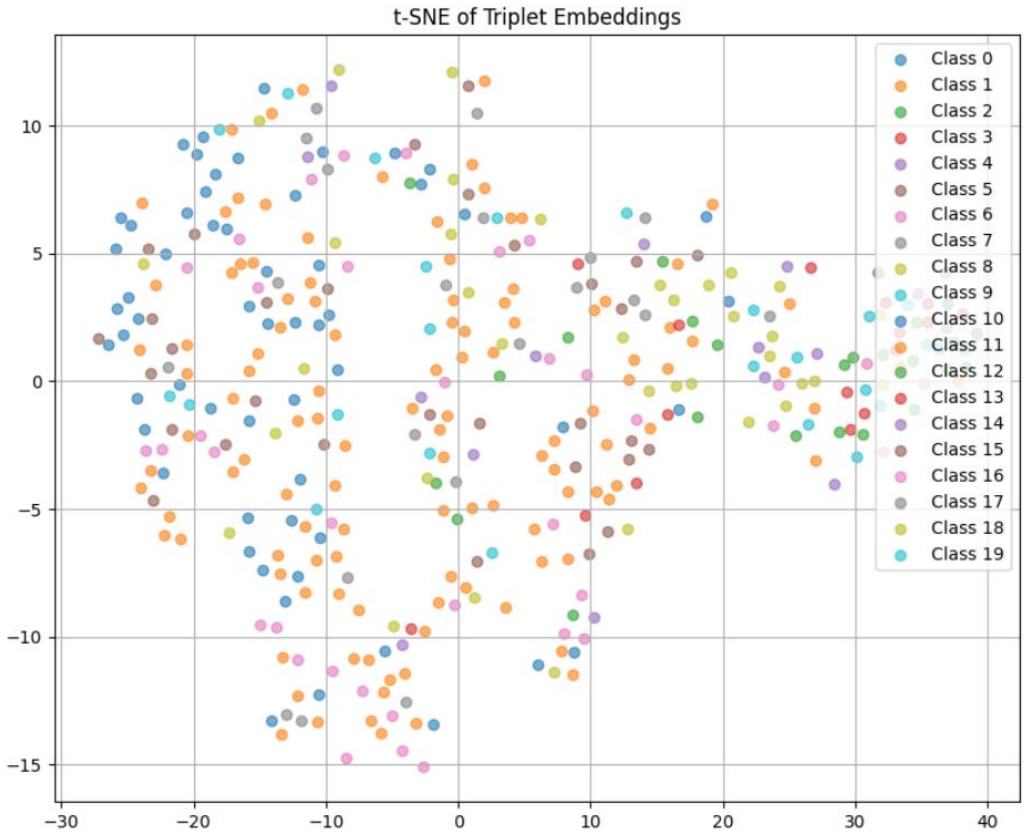


⇨ Test results



	precision	recall	f1-score	support
Same	0.57	0.25	0.35	195
Different	0.51	0.80	0.62	187
accuracy			0.52	382
macro avg	0.54	0.53	0.48	382
weighted avg	0.54	0.52	0.48	382

⇨ t – SNE plot of embeddings (Triplet Model)



3.) CNN Classifier with Center Loss

Hyper-parameters:

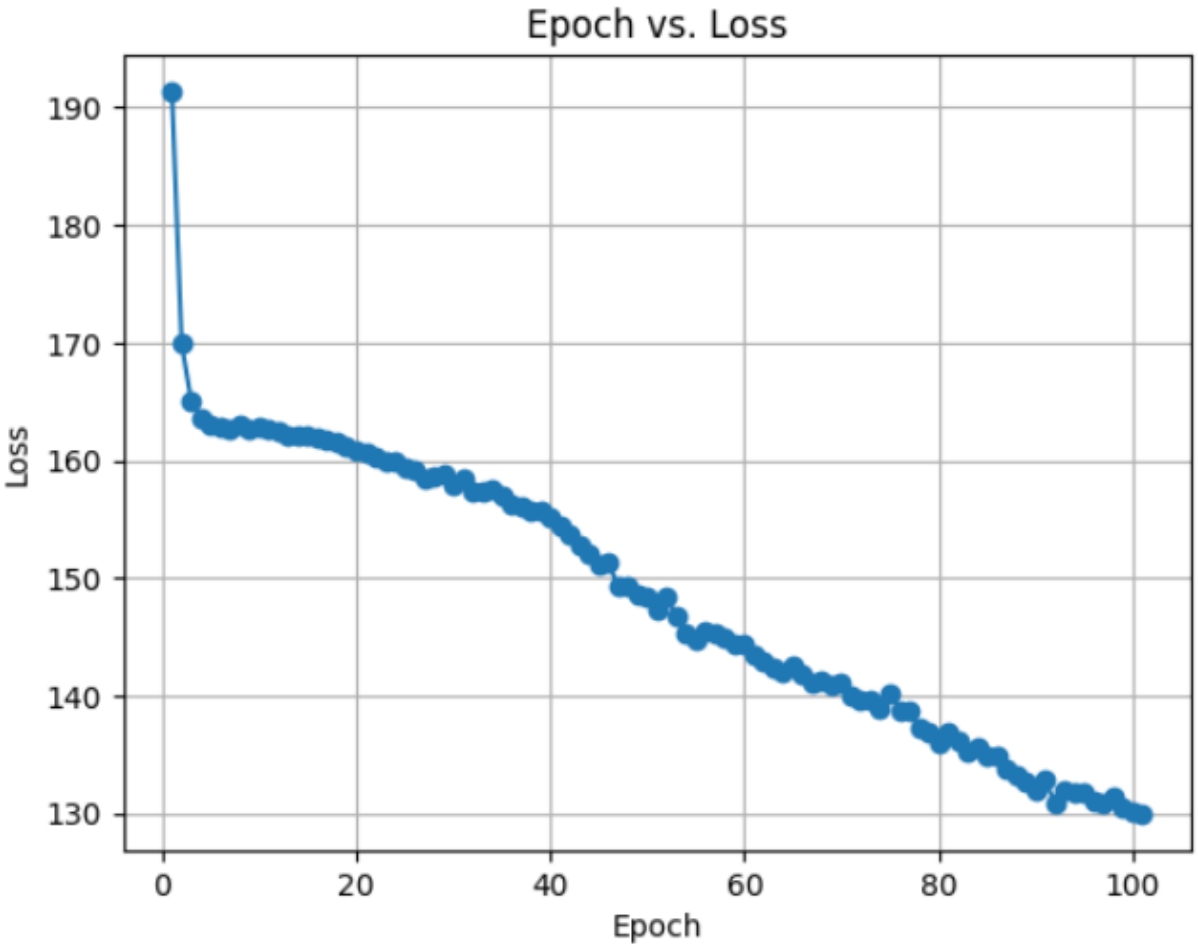
- ⇨ Loss function: Center Loss function
- ⇨ Optimizer: Adam-optimizer
- ⇨ Batch size: 32
- ⇨ Learning rate: 0.01
- ⇨ Alpha: 0.5
- ⇨ Epochs: 101

Results:

- ⇨ Final epoch training loss: 2.7075
- ⇨ Test set accuracy: 29.84%

Plots:

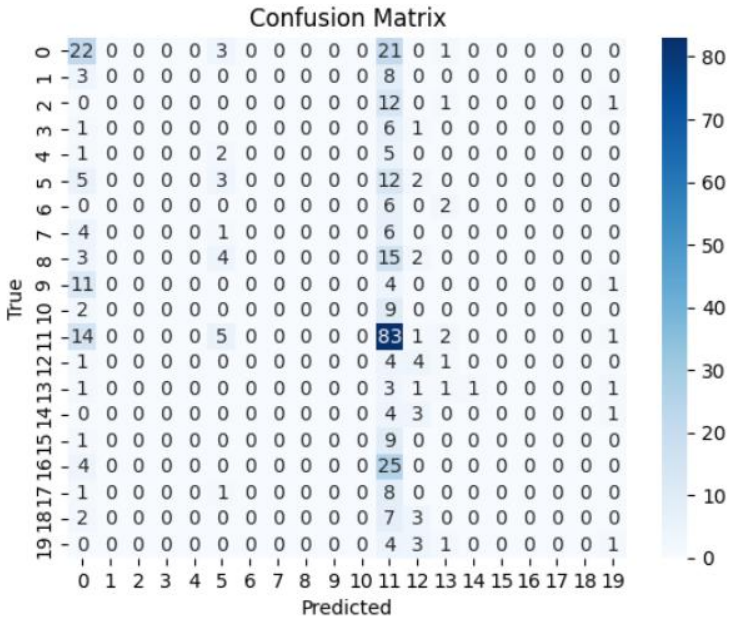
- ⇨ Epoch vs. Loss



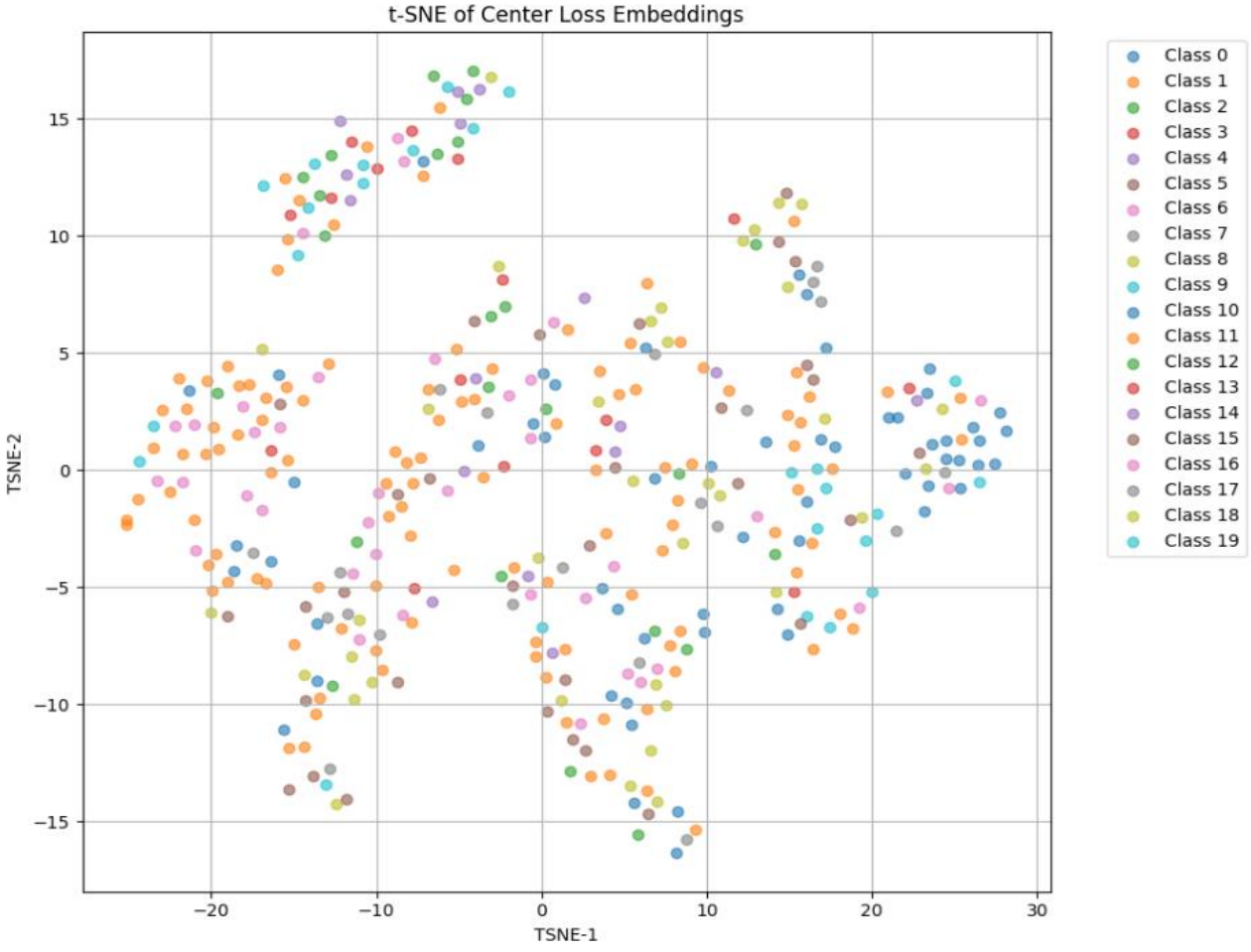
⇨ Test results

Accuracy: 29.84%

	precision	recall	f1-score	support
0	0.29	0.47	0.36	47
1	0.00	0.00	0.00	11
2	0.00	0.00	0.00	14
3	0.00	0.00	0.00	8
4	0.00	0.00	0.00	8
5	0.16	0.14	0.15	22
6	0.00	0.00	0.00	8
7	0.00	0.00	0.00	11
8	0.00	0.00	0.00	24
9	0.00	0.00	0.00	16
10	0.00	0.00	0.00	11
11	0.33	0.78	0.46	106
12	0.20	0.40	0.27	10
13	0.11	0.12	0.12	8
14	0.00	0.00	0.00	8
15	0.00	0.00	0.00	10
16	0.00	0.00	0.00	29
17	0.00	0.00	0.00	10
18	0.00	0.00	0.00	12
19	0.17	0.11	0.13	9
accuracy			0.30	382
macro avg	0.06	0.10	0.07	382
weighted avg	0.15	0.30	0.19	382



⇨ t – SNE of Center Loss Embeddings



4.) CNN Classifier with A-Softmax Loss

Hyper-parameters:

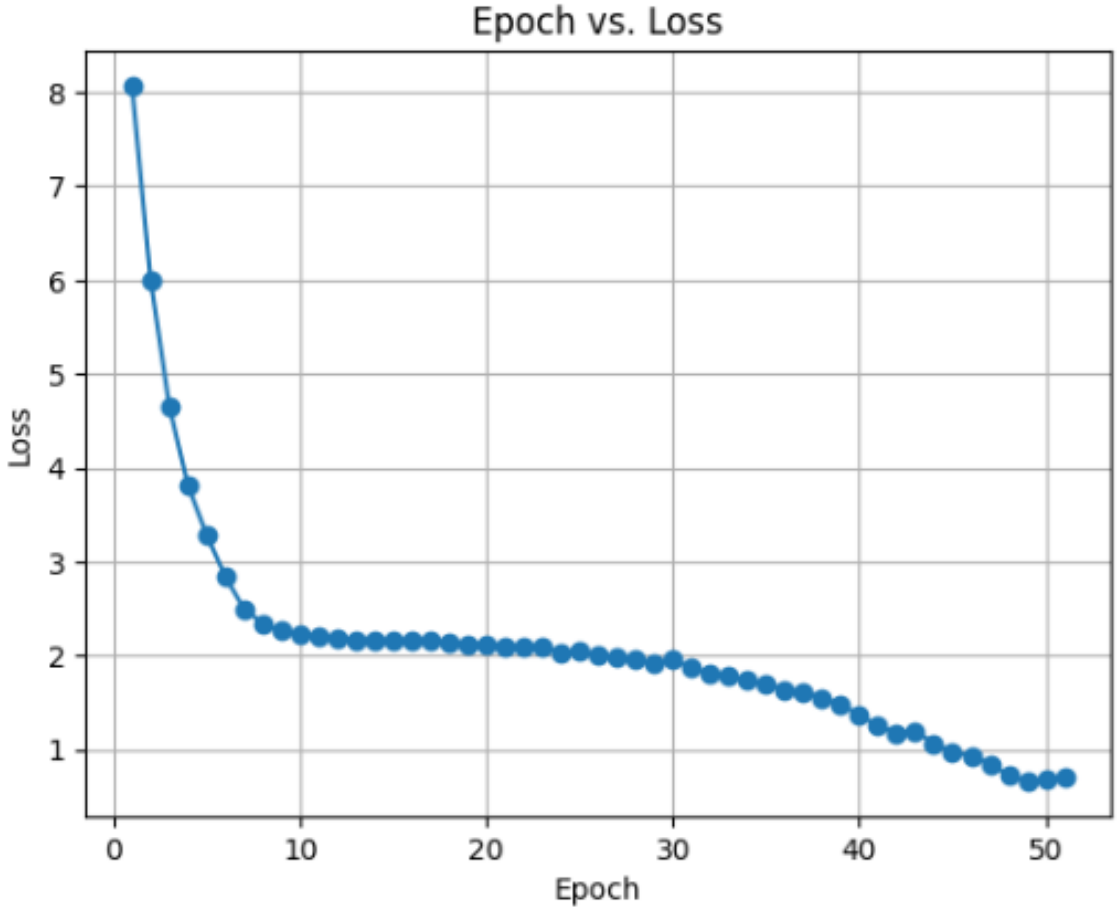
- ⇨ Loss function: Center Loss function
- ⇨ Optimizer: Adam-optimizer
- ⇨ Batch size: 64
- ⇨ Learning rate: 0.01
- ⇨ Epochs: 51

Results:

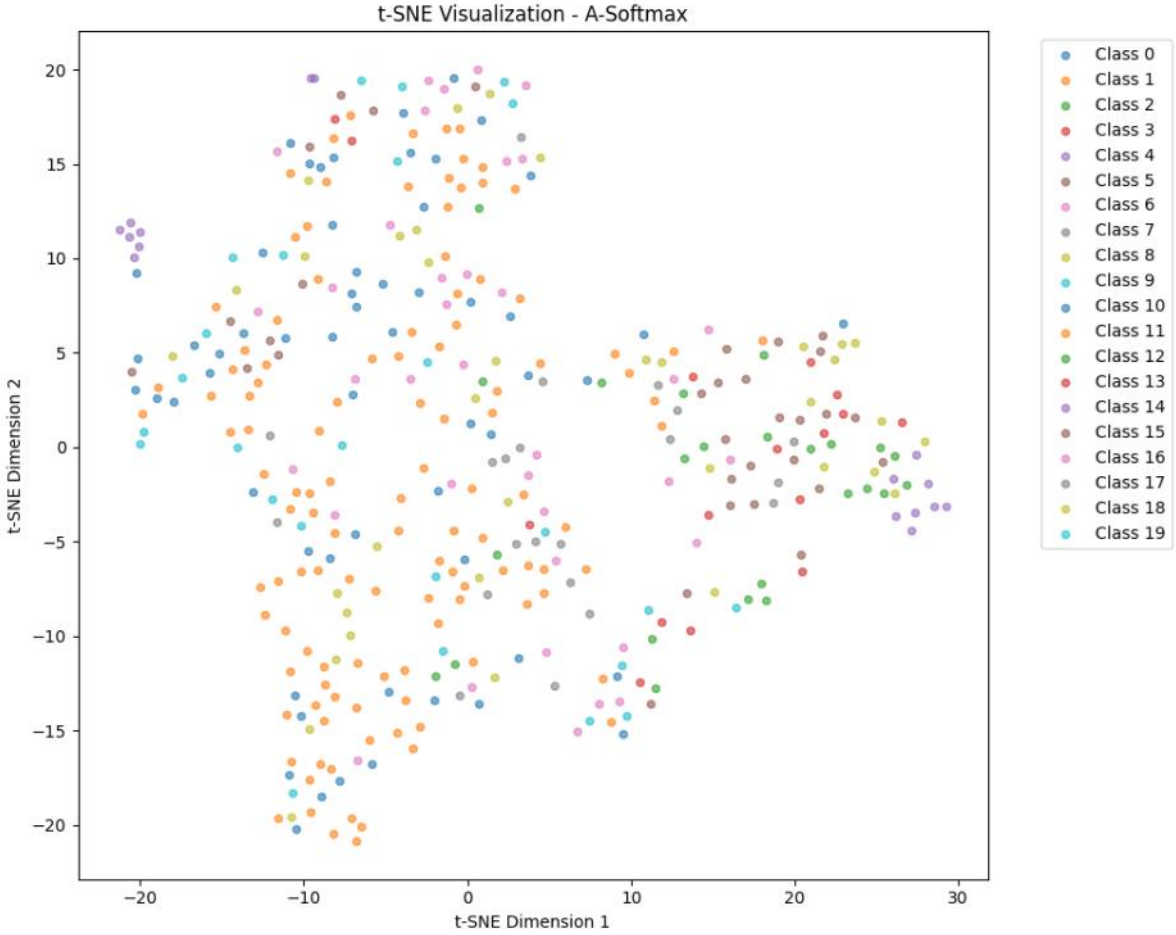
- ⇨ Final epoch training loss: 0.3783
- ⇨ Test set accuracy: 2.36%

Plots:

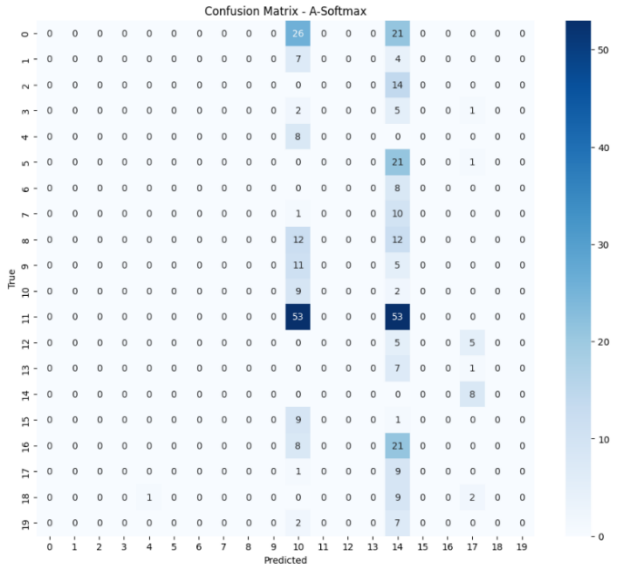
- ⇨ Epoch vs. Loss



⇨ t – SNE Visualization (A-Softmax)



⇨ Test results



Accuracy for A-Softmax: 0.0236

Classification Report for A-Softmax:

	precision	recall	f1-score	support
Class 0	0.00	0.00	0.00	47
Class 1	0.00	0.00	0.00	11
Class 2	0.00	0.00	0.00	14
Class 3	0.00	0.00	0.00	8
Class 4	0.00	0.00	0.00	8
Class 5	0.00	0.00	0.00	22
Class 6	0.00	0.00	0.00	8
Class 7	0.00	0.00	0.00	11
Class 8	0.00	0.00	0.00	24
Class 9	0.00	0.00	0.00	16
Class 10	0.06	0.82	0.11	11
Class 11	0.00	0.00	0.00	106
Class 12	0.00	0.00	0.00	10
Class 13	0.00	0.00	0.00	8
Class 14	0.00	0.00	0.00	8
Class 15	0.00	0.00	0.00	10
Class 16	0.00	0.00	0.00	29
Class 17	0.00	0.00	0.00	10
Class 18	0.00	0.00	0.00	12
Class 19	0.00	0.00	0.00	9
accuracy			0.02	382
macro avg	0.00	0.04	0.01	382
weighted avg	0.00	0.02	0.00	382

5.) CNN Classifier with AAM-Softmax Loss / ArcFace

Hyper-parameters:

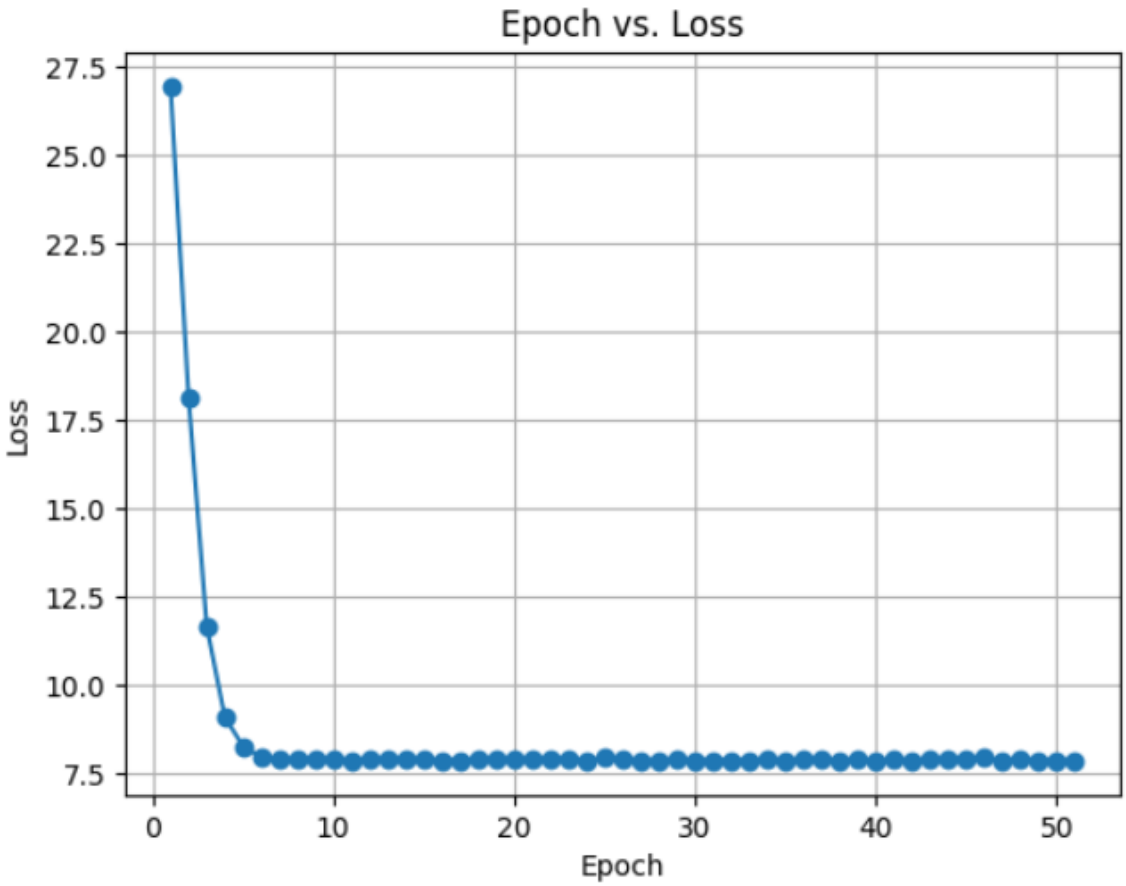
- ⇨ Loss function: AAM Loss function
- ⇨ Learning rate: 0.01
- ⇨ m (angular margin) = 0.5
- ⇨ s (scale) = 30.0
- ⇨ Epochs: 51

Results:

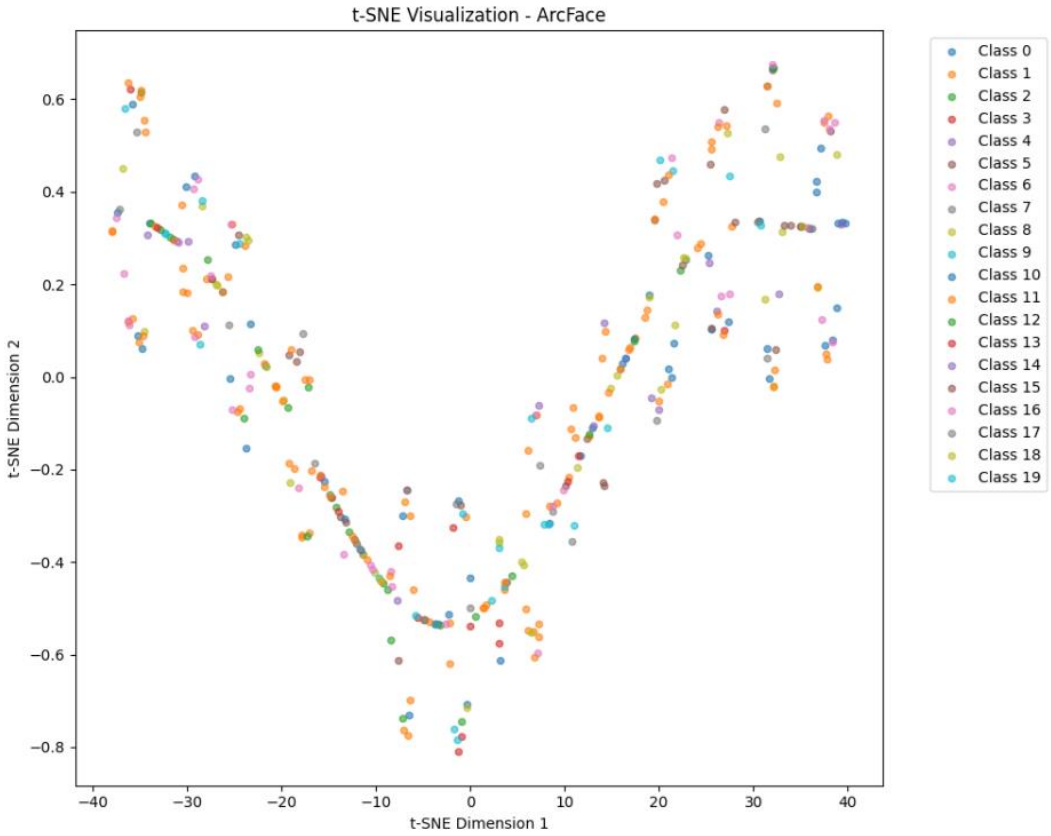
- ⇨ Final epoch training loss: 7.8510
- ⇨ Test set accuracy: 2.62%

Plots:

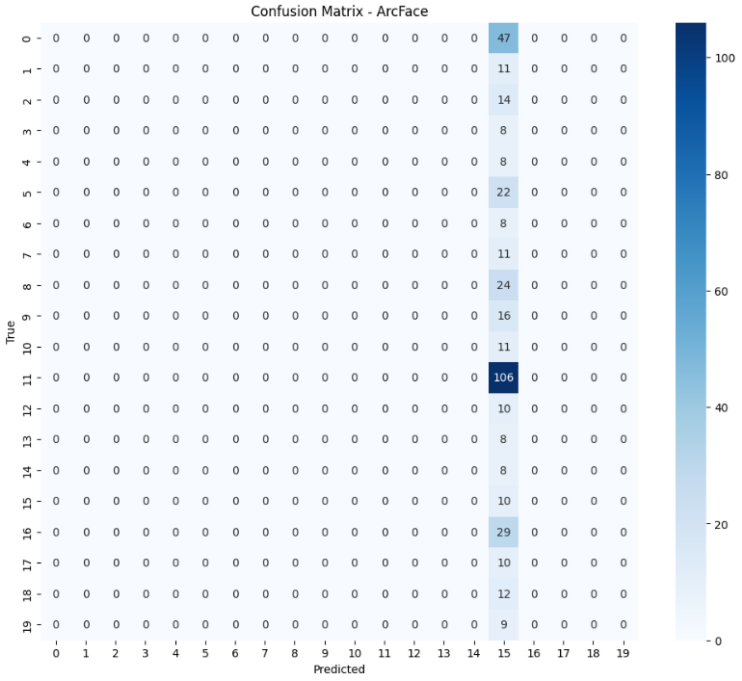
- ⇨ Epoch vs. Loss



⇨ t – SNE Visualization (ArcFace)



⇨ Test results



Accuracy for ArcFace: 0.0262

Classification Report for ArcFace:

	precision	recall	f1-score	support
Class 0	0.00	0.00	0.00	47
Class 1	0.00	0.00	0.00	11
Class 2	0.00	0.00	0.00	14
Class 3	0.00	0.00	0.00	8
Class 4	0.00	0.00	0.00	8
Class 5	0.00	0.00	0.00	22
Class 6	0.00	0.00	0.00	8
Class 7	0.00	0.00	0.00	11
Class 8	0.00	0.00	0.00	24
Class 9	0.00	0.00	0.00	16
Class 10	0.00	0.00	0.00	11
Class 11	0.00	0.00	0.00	106
Class 12	0.00	0.00	0.00	10
Class 13	0.00	0.00	0.00	8
Class 14	0.00	0.00	0.00	8
Class 15	0.03	1.00	0.05	10
Class 16	0.00	0.00	0.00	29
Class 17	0.00	0.00	0.00	10
Class 18	0.00	0.00	0.00	12
Class 19	0.00	0.00	0.00	9
accuracy			0.03	382
macro avg	0.00	0.05	0.00	382
weighted avg	0.00	0.03	0.00	382

6.) Large Margin Cosine Loss (LMCL / CosFace)

Hyper-parameters:

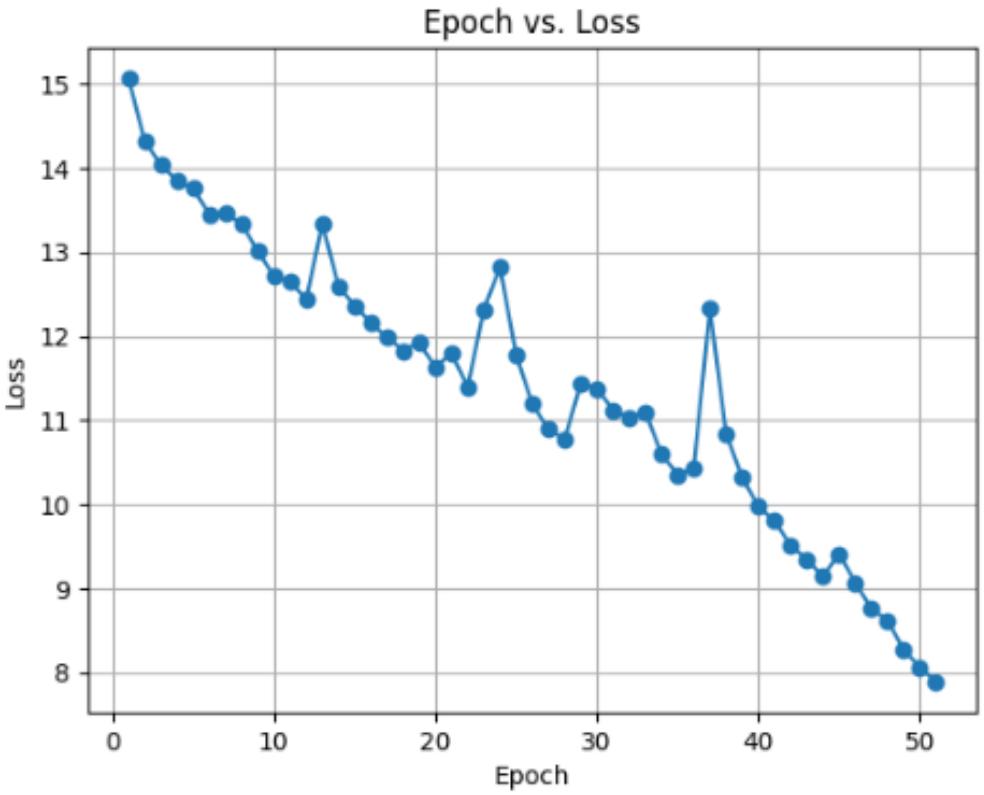
- ⇨ Loss function: LMCL Loss function
- ⇨ Learning rate: 0.001
- ⇨ m (angular margin) = 0.35
- ⇨ s (scale) = 30.0
- ⇨ Epochs: 51

Results:

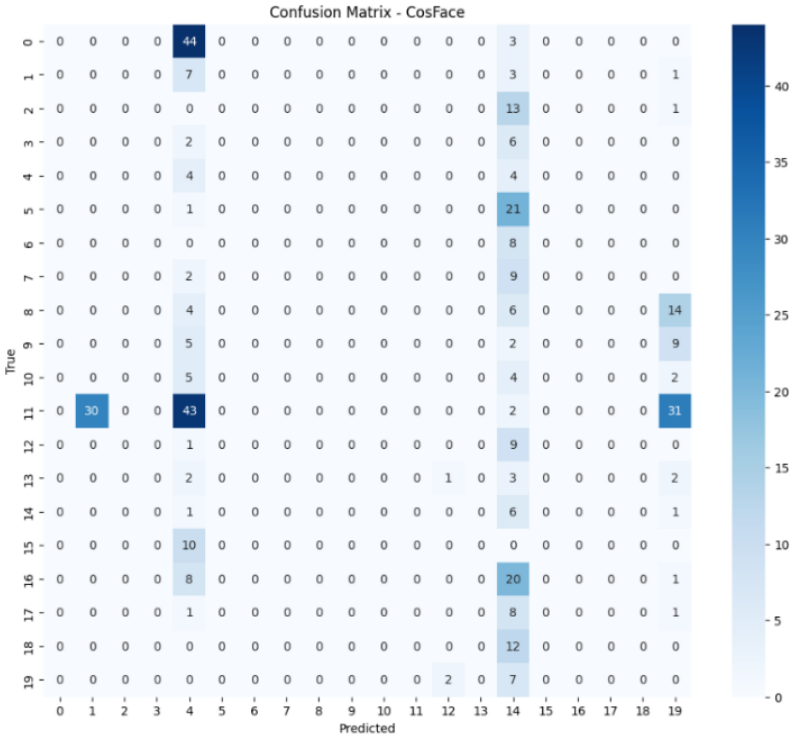
- ⇨ Final epoch training loss: 7.8895
- ⇨ Test set accuracy: 2.62%

Plots:

- ⇨ Epoch vs. Loss



⇨ Test Results




```
Accuracy for CosFace: 0.0262

Classification Report for CosFace:
              precision    recall  f1-score   support

     Class 0       0.00      0.00      0.00        47
     Class 1       0.00      0.00      0.00        11
     Class 2       0.00      0.00      0.00        14
     Class 3       0.00      0.00      0.00         8
     Class 4       0.03      0.50      0.05         8
     Class 5       0.00      0.00      0.00        22
     Class 6       0.00      0.00      0.00         8
     Class 7       0.00      0.00      0.00        11
     Class 8       0.00      0.00      0.00        24
     Class 9       0.00      0.00      0.00        16
    Class 10       0.00      0.00      0.00        11
    Class 11       0.00      0.00      0.00       106
    Class 12       0.00      0.00      0.00        10
    Class 13       0.00      0.00      0.00         8
    Class 14       0.04      0.75      0.08         8
    Class 15       0.00      0.00      0.00        10
    Class 16       0.00      0.00      0.00        29
    Class 17       0.00      0.00      0.00        10
    Class 18       0.00      0.00      0.00        12
    Class 19       0.00      0.00      0.00         9

    accuracy                           0.03       382
   macro avg       0.00      0.06      0.01       382
weighted avg       0.00      0.03      0.00       382
```

⇨ t – SNE Visualization CosFace

```
Evaluating CosFace...
```