CosFace: Large Margin Cosine Loss for Deep Face Recognition

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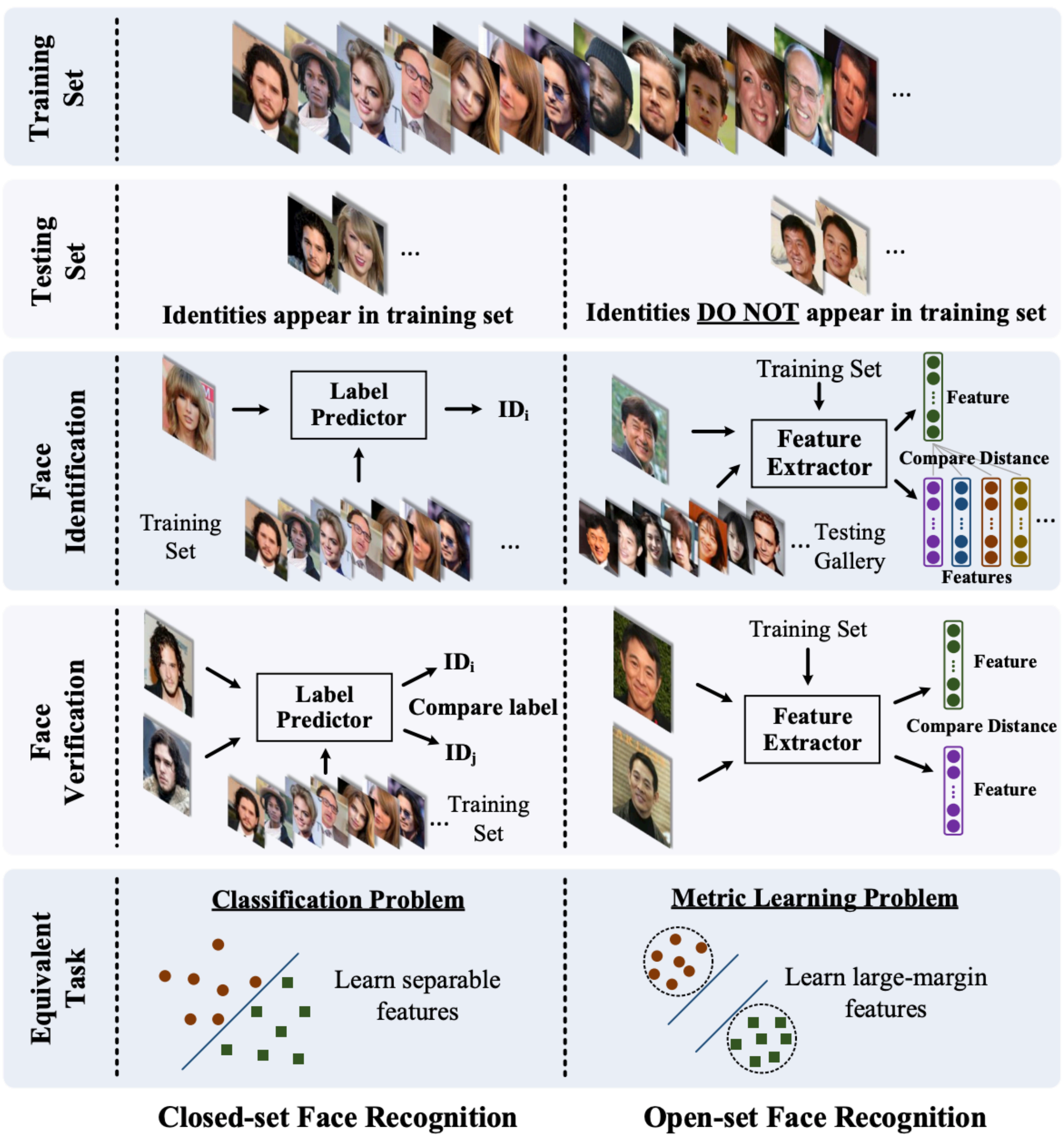
What is the task of face recognition?

The central task of face recognition, including face verification and identification, involves face feature discrimination.

Two ways to solve the problem



Open-set:

- Intrinsically large intra-class variation
- High inter-class similarity

Original Softmax Loss

$$L_s = \frac{1}{N}\sum_{i=1}^{N} -\log p_i = \frac{1}{N}\sum_{i=1}^{N} -\log \frac{e^{f_{y_i}}}{\sum_{j=1}^{C} e^{f_j}}$$

where p_i denotes the posterior probability of x_i being correctly classified.
N is the number of training samples and C is the number of classes

$$f_j = W_j^T x = \|W_j\|\|x\| \cos\theta_j$$

where θ_i is the angle between W_i and x_i

Normalized version of Softmax Loss (NSL)

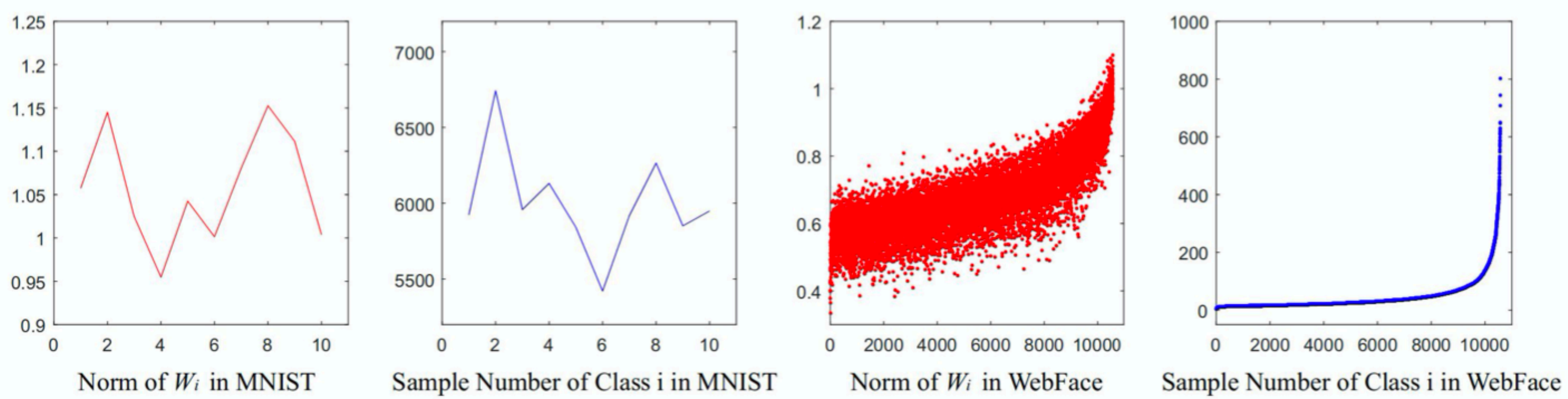
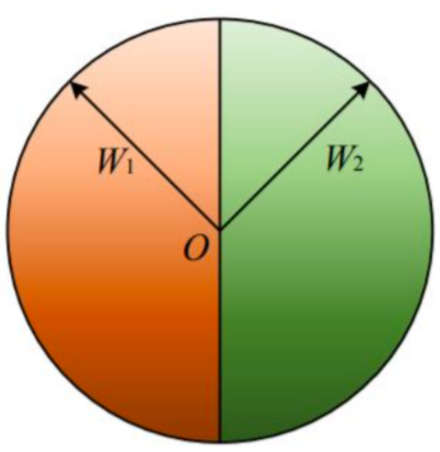


Figure 9: Norm of $\boldsymbol{W}_i$ and sample number of class i in MNIST dataset and CASIA-WebFace dataset.

$$\|\boldsymbol{W}_i\| = 1, b_i = 0$$

$$L_{\text{modified}} = \frac{1}{N} \sum_i -\log\left(\frac{e^{\|\boldsymbol{x}_i\| \cos(\theta_{y_i,i})}}{\sum_j e^{\|\boldsymbol{x}_i\| \cos(\theta_{j,i})}}\right)$$



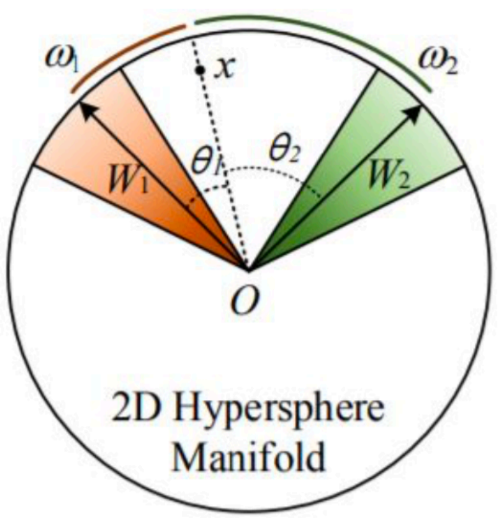
Angular Softmax (A-Softmax)

$$L_{\text{ang}} = \frac{1}{N}\sum_i -\log\left(\frac{e^{\|\boldsymbol{x}_i\|\cos(m\theta_{y_i,i})}}{e^{\|\boldsymbol{x}_i\|\cos(m\theta_{y_i,i})} + \sum_{j\neq y_i} e^{\|\boldsymbol{x}_i\|\cos(\theta_{j,i})}}\right)$$

$\theta_1 \in [0, \frac{\pi}{m}], m \geq 2$

$C_1 : \cos(m\theta_1) \geq \cos(\theta_2),$

$C_2 : \cos(m\theta_2) \geq \cos(\theta_1).$



$$L_{\text{ang}} = \frac{1}{N}\sum_i -\log\left(\frac{e^{\|\boldsymbol{x}_i\|\psi(\theta_{y_i,i})}}{e^{\|\boldsymbol{x}_i\|\psi(\theta_{y_i,i})} + \sum_{j\neq y_i} e^{\|\boldsymbol{x}_i\|\cos(\theta_{j,i})}}\right)$$

where $\psi(\theta_{y_i,i}) = (-1)^k \cos(m\theta_{y_i,i}) - 2k$ - monotonically decreasing, and

$\theta_{y_i,i} \in [\frac{k\pi}{m}, \frac{(k+1)\pi}{m}]$ and $k \in [0, m-1]$

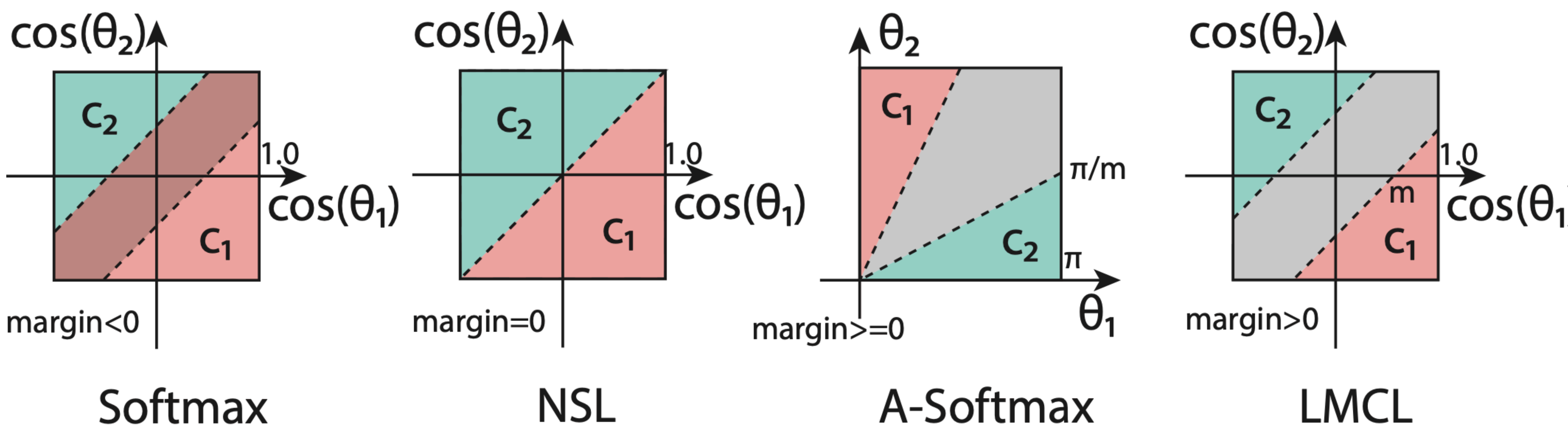
Large Margin Cosine Loss (LMCL)

$$L_{lmc} = \frac{1}{N}\sum_{i} -\log \frac{e^{s(\cos(\theta_{y_i,i})-m)}}{e^{s(\cos(\theta_{y_i,i})-m)} + \sum_{j\neq y_i} e^{s\cos(\theta_{j,i})}},$$

$$\|x\| = s$$

$$cos(\theta_j, i) = W_j{}^T x_i$$

The comparison of decision margins



Results

Method	LFW	YTF	MF1 Rank1	MF1 Veri.
Softmax Loss [23]	97.88	93.1	54.85	65.92
Softmax+Contrastive [30]	98.78	93.5	65.21	78.86
Triplet Loss [29]	98.70	93.4	64.79	78.32
L-Softmax Loss [24]	99.10	94.0	67.12	80.42
Softmax+Center Loss [42]	99.05	94.4	65.49	80.14
A-Softmax [23]	**99.42**	95.0	72.72	85.56
A-Softmax-NormFea	99.32	95.4	75.42	88.82
LMCL	99.33	**96.1**	**77.11**	**89.88**

All the methods in this table are using the same training data and the same 64-layer CNN architecture.

Thank you for your attention!