Identity-Preserving Low-Resolution Face Recognition

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Introduction

LFW

Algorithm

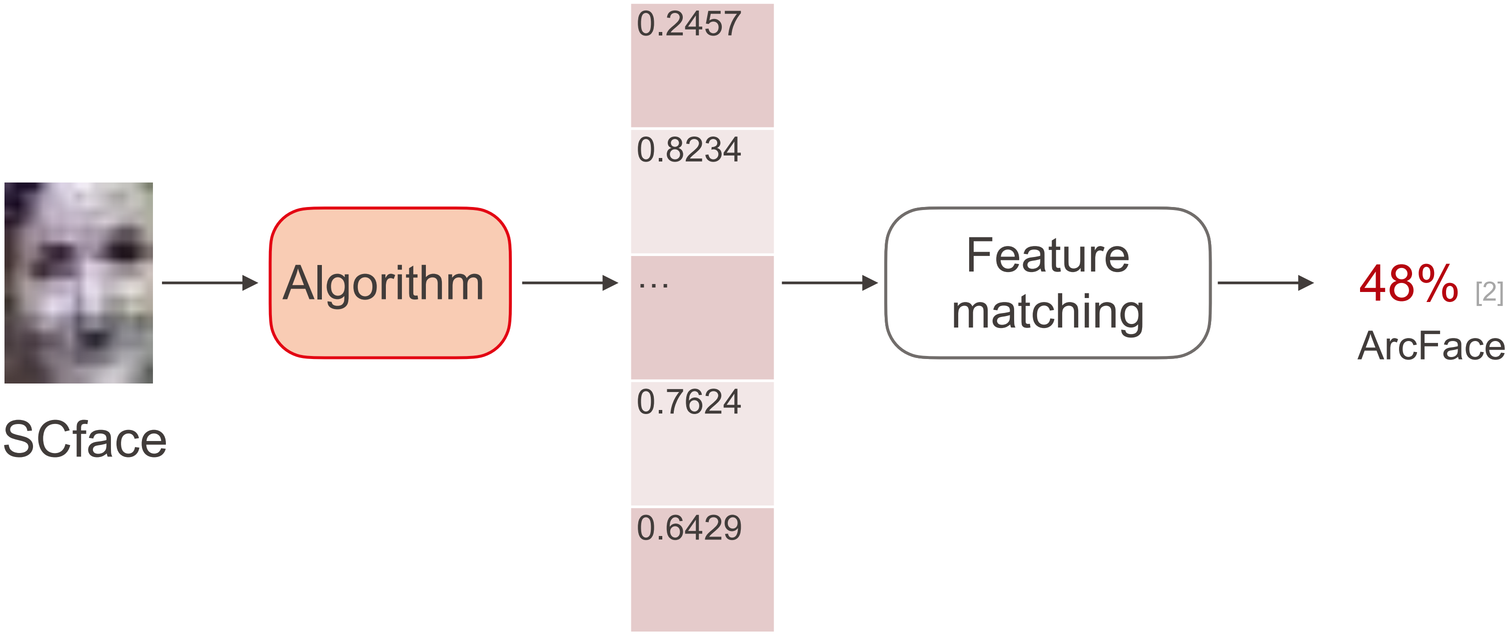
0.2457
0.8234
…
0.7624
0.6429

Feature matching

99.81% [1]
ArcFace

Face Recognition (FR) problem

Introduction



Low Resolution Face Recognition (LRFR) challenge

Face Recognition Pipeline

Face detection and alignment →

Feature extraction →

0.4689
0.4723
…
0.9863
0.1629

Feature matching →

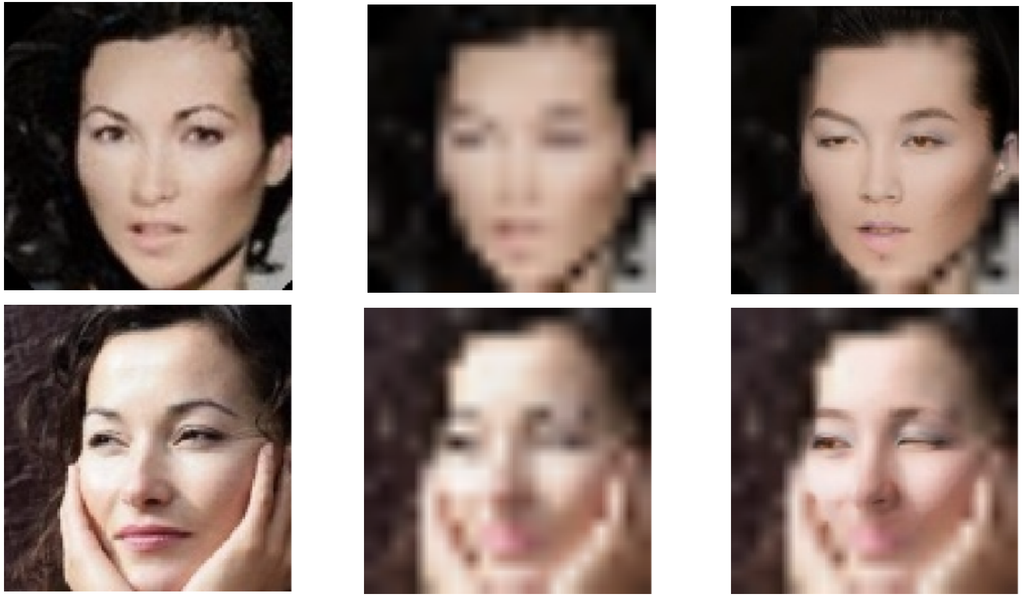
ID

LRFR Methods

Resolution-invariant

- Adapting HRFR techniques
- Finetuning
- Cross Resolution Loss Functions

Super Resolution



Original — Downsampled — GPEN[3] results

LRFR Datasets: LFW

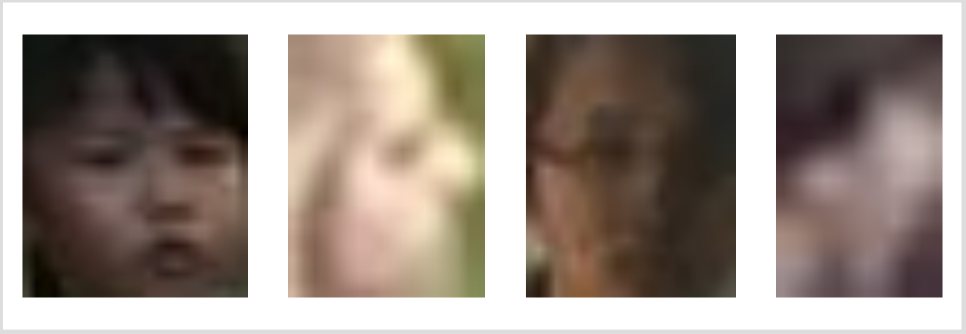
Images	13000
ID	1680
Detection method	MTCNN
Problem	Verification
Protocol	Image Restricted Configuration: pairs and synthetically downsampled to (7x7, 14x14, 28x28, 56x56) LR

7x7 14x14 28x28 56x56 112x112

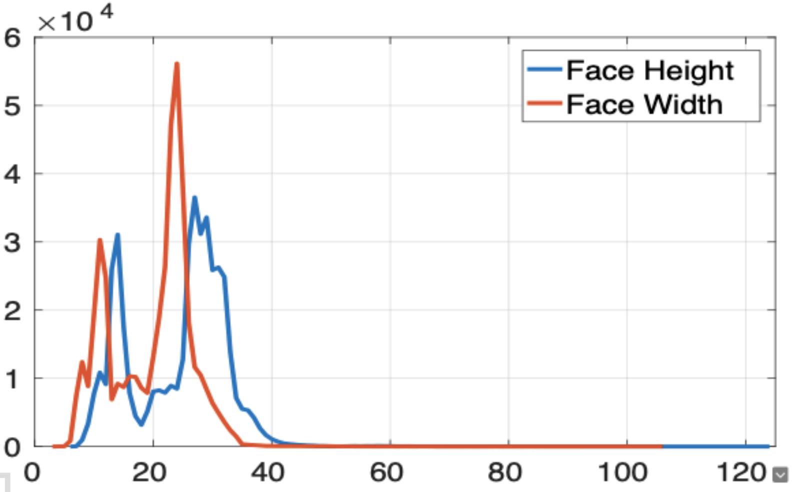
Downsampled LFW [4]

QMUL-SurvFace

Images	463507
ID	15573
Detection method	-
Problem	Verification
Protocol	Image Restricted Configuration



QMUL-SurvFace[5] examples



Scale distributions

SCface

Gallery

Images	4160
ID	130
Detection method	MTCNN
Problem	Identification
Protocol	- Day (5 cameras) / night (3 cameras) - Distance: 1, 2, 3

SCface[6] Camera 1

Night

Day

Distance 1 Distance 2 Distance 3

Softmax-based Loss Functions

$$L = -\log \frac{\exp(f(\theta_{y_i}, m))}{\exp(f(\theta_{y_i}, m)) + \sum_{j\neq y_i}^{n} \exp(s\cos\theta_j)}$$

SphereFace [7] $$f(\theta_j, m) = \begin{cases} s\cos(m\theta_j) & j = y_i \\ s\cos(\theta_j) & j \neq y_i \end{cases}$$

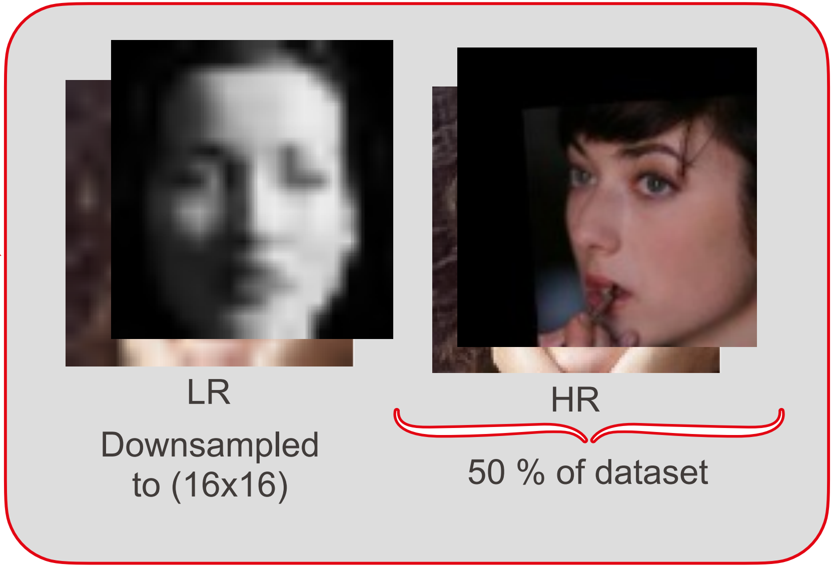
CosFace [8] $$f(\theta_j, m) = \begin{cases} s(\cos\theta_j - m) & j = y_i \\ s\cos(\theta_j) & j \neq y_i \end{cases}$$

ArcFace [9] $$f(\theta_j, m) = \begin{cases} s\cos(\theta_j + m) & j = y_i \\ s\cos(\theta_j) & j \neq y_i \end{cases}$$

Idea:
Constant margin

Adapting HRFR techniques : Training Settings

Backbone	ResNet50
Data Loader	Cross Resolution Batch Training [10]
Optimizer	SGD
Epochs	18
Training dataset	CASIA-WebFace [11]
Images in training dataset	494414
Classes in training dataset	10575

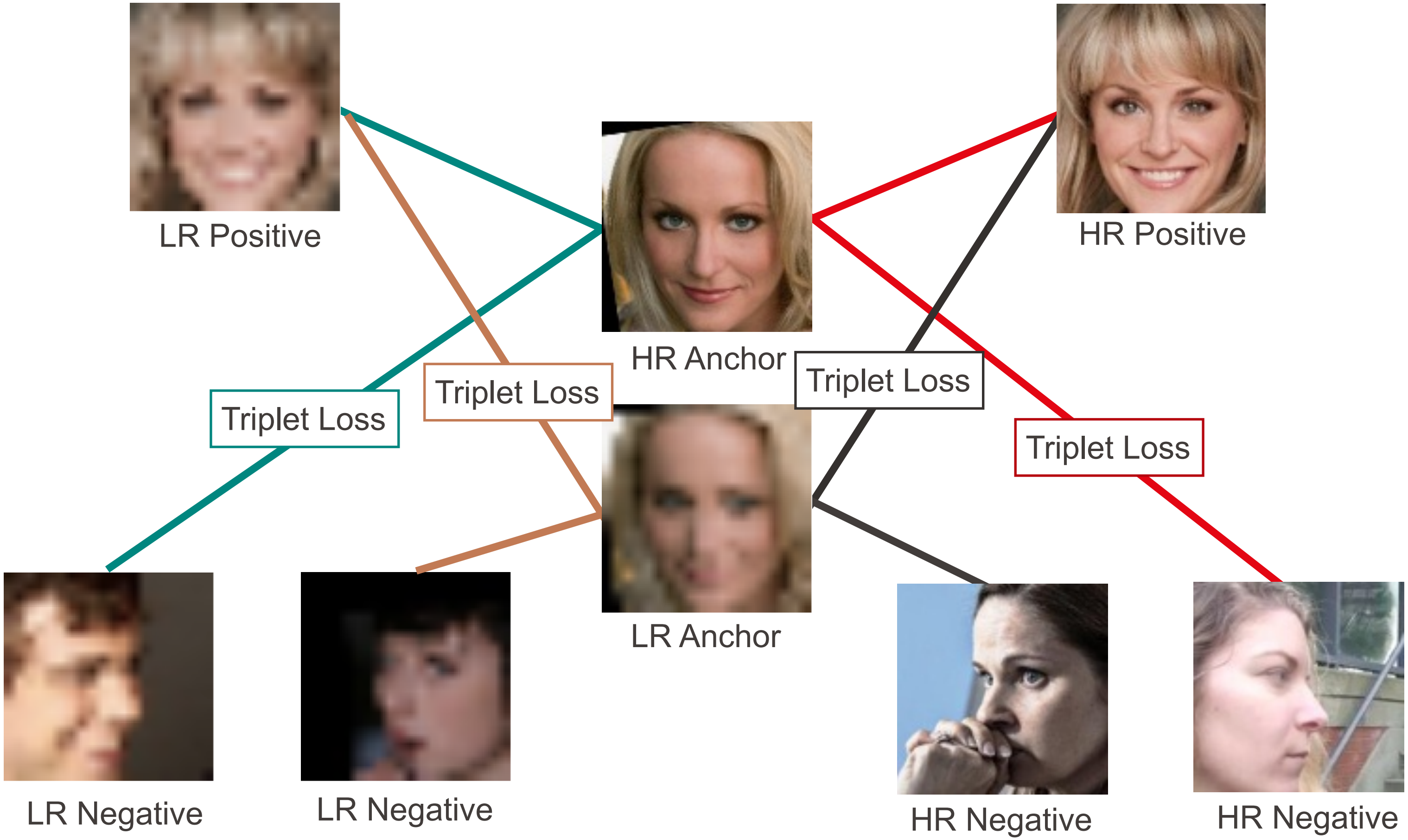


Training dataset

Softmax-based Loss Functions and their performance

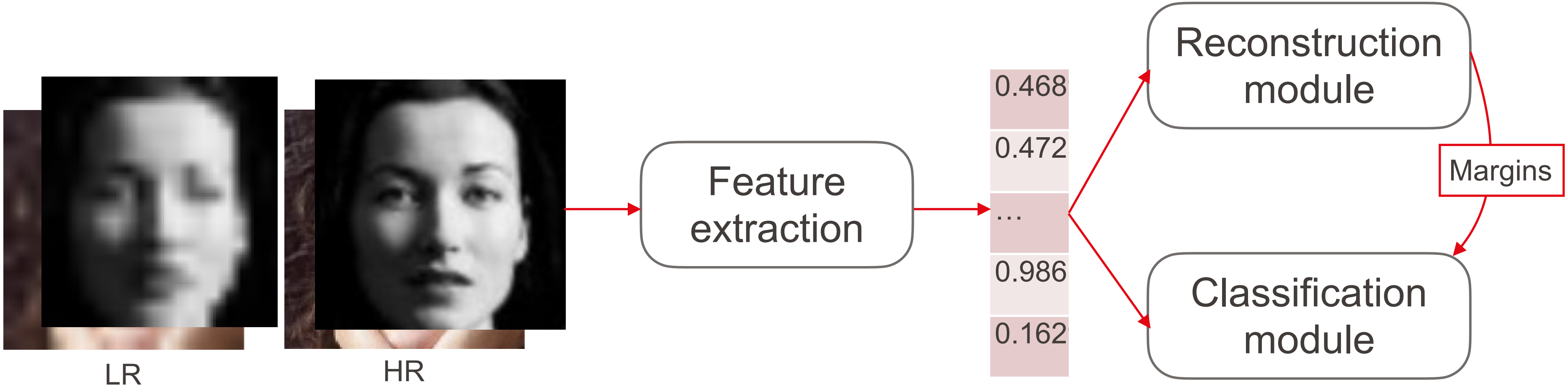
	CosFace	*SphereFace*	ArcFace
LFW (112x112)	**0.979**	0.9641	0.9773
LFW (56x56	**0.9801**	0.9625	0.97399
LFW (28x28)	**0.9721**	0.9025	0.96933
LFW (14 x 14)	**0.9266**	0.7155	0.9189
LFW (7x 7)	**0.7543**	0.5926	0.74666
QMUL-SurvFace	**0.6411**	0.5953	0.6303
SCface dist 1	0.6873	0.1253	**0.7349**
SCface dist 2	0.9336	0.3487	**0.95679**
SCface dist 3	0.9229	0.5654	**0.9322**

Finetuning: Octuplet Loss



[11]

DeriveNet

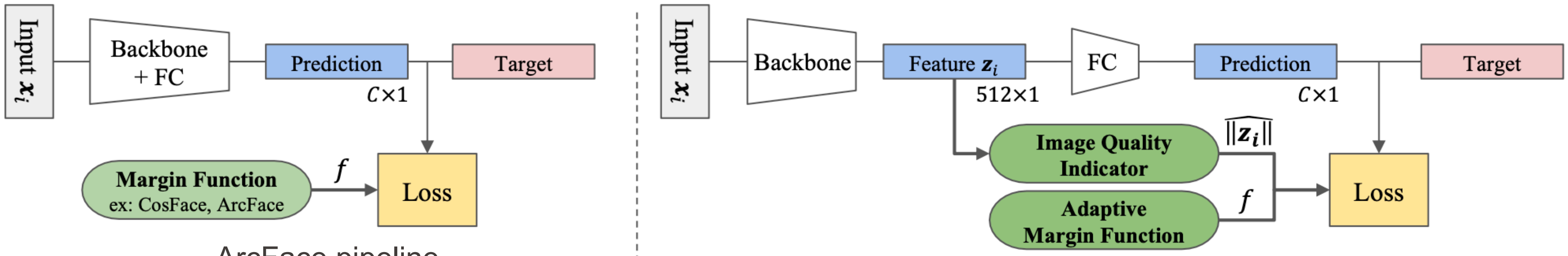


[12]

Finetuning for LRFR

	Octuplet Loss	*DeriveNet*
LFW (112x112)	0.9208	**0.9878**
LFW (56x56	0.9211	**0.9873**
LFW (28x28)	0.9135	**0.9471**
LFW (14 x 14)	**0.8616**	0.7103
LFW (7x 7)	**0.7375**	0.5708
QMUL-SurvFace	**0.6602**	0.56184
SCface dist 1	**0.5095**	0.346
SCface dist 2	0.6296	**0.8302**
SCface dist 3	0.4175	**0.9583**

Cross Resolution Loss Functions: AdaFace



ArcFace pipeline

AdaFace [13] pipeline

<u>Idea</u>:
Adaptive margin function depends on the norm of input image

Proposed method 1

Case 1

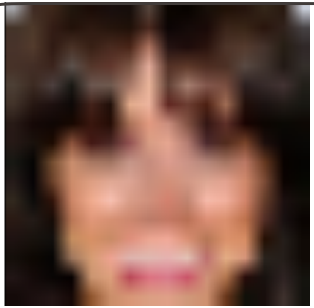
Original

margin

0.35

ArcFace

Case 2



Downsampled
to 16x16

margin

0.5

ArcFace

Idea:
Adaptive margin function depends on downsampling of image

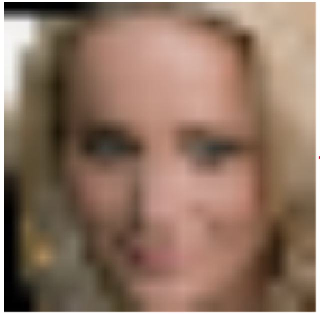
Image Quality

HR image

Laplacian

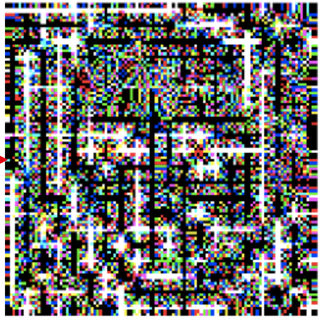
$\text{mean}(\|x\|_2^2)$

15.721



LR image

Laplacian



$\text{mean}(\|x\|_2^2)$

2.317

Proposed method 2

$\rightarrow \|\text{Laplacian}\|_2^2 \rightarrow mean \rightarrow \underset{\text{margin}}{} \frac{1}{mean} \rightarrow$ ArcFace

margin

$$\frac{1}{mean}$$

Idea:
Adaptive margin function depends on mean discriminative laplacian

Experiments: LFW

	AdaFace	*Appr. 1*	*Appr. 2*
112x112	**0.9906**	0.977	0.9623
56x56	**0.9869**	0.974	0.9645
28x28	0.9685	**0.969**	0.9584
14x14	0.6321	**0.9236**	0.9138
7x7	0.5653	0.7685	**0.7905**

QMUL-SurvFace

	AdaFace	*Appr. 1*	*Appr. 2*
mean accuracy	0.5324	0.6281	**0.7125**
std	0.04875	0.02956	0.0265

SCface

	AdaFace	*Appr. 1*	*Appr. 2*
Dist 1 Day	0.50634	**0.7539**	0.7492
Dist 2 Day	**0.96913**	0.9506	0.9182
Dist 3 Day	**0.99691**	0.9491	0.8104

Results

	CosFace	*SphereFace*	*ArcFace*	*Octuplet Loss*	*DeriveNet*	*AdaFace*	*Approach 1*	*Approach 2*
LFW (112x112)	0.979	0.9641	0.9773	0.9208	0.9878	**0.9906**	0.977	0.9623
LFW (56x56	0.9801	0.9625	0.97399	0.9211	**0.9873**	0.9869	0.974	0.9645
LFW (28x28)	**0.9721**	0.9025	0.96933	0.9135	0.9471	0.9685	0.969	0.9584
LFW (14 x 14)	**0.9266**	0.7155	0.9189	0.8616	0.7103	0.6321	0.9236	0.9138
LFW (7x 7)	0.7543	0.5926	0.74666	0.7375	0.5708	0.5653	0.7685	**0.7905**
QMUL-SurvFace	0.6411	0.5953	0.6303	0.6602	0.5618	0.5324	0.6281	**0.7125**
SCface dist 1	0.6873	0.1253	0.7349	0.5095	0.346	0.50634	**0.7539**	0.7492
SCface dist 2	0.9336	0.3487	0.95679	0.6296	0.8302	**0.96913**	0.9506	0.9182
SCface dist 3	0.9229	0.5654	0.9322	0.4175	0.9583	**0.99691**	0.9491	0.8104

Conclusion

- Studied the state-of-the-art deep learning-based LRFR methods
- Implemented the deep learning FR pipeline based on the state-of-the-art implementation
- Investigated LRFR datasets: LFW, QMUL-SurvFace, SCface; and set up evaluation protocols
- Implemented FR methods: CosFace, SphereFace, ArcFace; and adapted them to LRFR using Cross Resolution Batch Training
- Implemented LRFR finetuning methods: OctupletLos, DeriveNet
- Proposed 2 methods for LRFR that obtained better performance on low-resolution faces when compared to AdaFace
- Compared the performance of implemented methods

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Thank you!

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