1. Introduction

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- Results From CUHK Database
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- CNN Implementation
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Progress

Progress Presentation

- Images of CUHK database are processed.
- HOG features are obtained.
- Face sketch recognition applied to selected 16 images and their sketches by using euclidean distance, chi square distance and cosine similarity.

After Progress Presentation

- Images of AR database are processed.
- HOG features are obtained from all images of CUHK and AR datasets.
- Euclidean distance, chi square distance and cosine similarity is applied to perform face sketch recognition.
- CNN implemented.

HOG Implementation

Photograph (200 x 250)

Preprocessed and
Resized Image
(128 x 128)

HOG Feature
Vector

Distance
Metrics

Result

ChiSq
Cosine Sim
Euclidean

Sketch (200 x 250)

Resized Sketch
(128 x 128)

HOG Feature
Vector

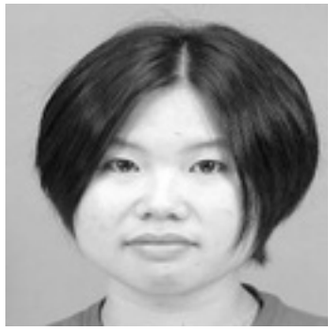
Image Preprocessing

All images of CUHK and AR datasets are preprocessed.

Original images are 200 x 250, both photos and sketches.
They are resized to 128 x 128.

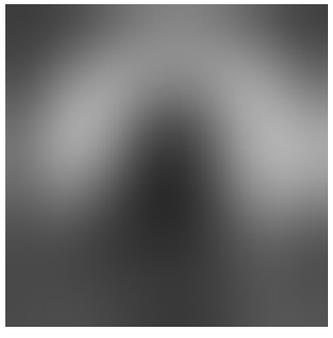
Photos are;

- 1 - Grayscaled
- 2 - Inversed (255 - Grayscaled image)
- 3 - Blurred Inversed image using GaussianBlur function with sigmaX = 15, kernelSize = 61,61
- 4 - Blurred image and Grayscaled image are divided (DODGING). This process lightens the image.
- Sketch-like photos are obtained.



1

2



3

4

AR Database

AR Database has 53 female images and 70 male images. 123 in total.

Data were in the RAW format at the first place.

ImageMagick is used to convert them into .JPEG file.

```
convert -depth 8 -interlace plane -size 768x576 rgb:theimage.raw thenewimage.jpeg
```

AR Database

Obtained images are noisier than the images in CUHK Database.

Initial Results

HOG features of sketch-like photographs and sketches are obtained and their euclidean distance, cosine similarity and chi square distance values are obtained.

	Female	Male
EUCLIDEAN DISTANCE	1/53	0/70
COSINE SIMILARITY	1/53	0/70
CHI SQUARE DISTANCE	4/53	0/70

Results Obtained by Zooming the Image (Male Images)

I started my tests using male images because their accuracy rates were lower than females.

To increase the accuracy rate images are zoomed. Following table shows the results obtained from male images of AR Database by zooming.

	Photo 1.31 Zoom - Normal Sketch	Photo 1.31 Zoom - Sketch 1.31 Zoom	Photo 1.41 Zoom - Sketch 1.41 Zoom	Photo 1.5 Zoom - Sketch 1.5 Zoom	Photo 1.5 Zoom - Normal Sketch
EUCLIDEAN DISTANCE	2/70	0/70	2/70	2/70	6/70
COSINE SIMILARITY	2/70	1/70	1/70	1/70	6/70
CHI SQUARE DISTANCE	5/70	1/70	1/70	1/70	13/70

Observation1: Increasing the zoom rate has a positive effect.
Observation2: Changing the sketch image has a negative effect.

Zoomed Images

Default

1.31 Zoom

1.41 Zoom

1.46 Zoom

1.5 Zoom

Results Obtained by Zooming and Denoising the Image (Male Images)

	Denoised Photo + Normal Sketch	Photo 1.46 Zoom + Denoising - Normal Sketch	Photo 1.46 Zoom + Denoising- Normal Sketch	Photo 1.46 Zoom + Denoising- Sketch 1.46 Zoom	Photo 1.5 Zoom + Denoise- Normal Sketch
EUCLIDEAN DISTANCE	0/70	6/70	3/70	0/70	5/70
COSINE SIMILARITY	0/70	5/70	4/70	0/70	6/70
CHI SQUARE DISTANCE	0/70	7/70	6/70	0/70	9/70

Observation1: Increasing the zoom rate has a positive effect.
Observation2: Changing the sketch image has a negative effect.
Observation3: Denoising has a negative effect.

Denoised Images

Male 1.5 Zoom Photograph

Female 1.5 Zoom Photograph

Male 1.5 Zoom Sketch

Female 1.5 Zoom Photograph

+ Denoising

+ Denoising

+ Denoising

+ Denoising

Results of Female Images

In female images, 1.5 Zoomed version of the images are used because of the results obtained from male images. Also, impact of the denoising is also observed.

	Normal Photo + Normal Sketch	Photo 1.5 Zoom - Sketch 1.5 Zoom	Photo 1.5 Zoom - Normal Sketch	Photo 1.5 Zoom + Denoise- Normal Sketch	Photo 1.5 Zoom + Denoise - Sketch 1.5 Zoom	Denoised Photo - Normal Sketch
EUCLIDEAN DISTANCE	1/53	1/53	5/53	8/53	1/53	1/53
COSINE SIMILARITY	1/53	2/53	7/53	11/53	1/53	1/53
CHI SQUARE DISTANCE	4/53	3/53	10/53	9/53	3/53	3/53

Final Results of AR Database

	Female	Male
EUCLIDEAN DISTANCE	8/53 (15%)	6/70 (8.5%)
COSINE SIMILARITY	11/53 (20%)	6/70 (8.5%)
CHI SQUARE DISTANCE	9/53 (17%)	13/70 (18.5%)

CUHK Database

CUHK Database has 54 female images and 134 male images.
188 in total.






Results

	Female	Male
EUCLIDEAN DISTANCE	51/54 (94%)	35/134 (26%)
COSINE SIMILARITY	53/54 (98%)	92/134 (68.6%)
CHI SQUARE DISTANCE	54/54 (100%)	114/134 (85%)

Results

Effect of denoising is also observed for CUHK Database. It has a negative impact on results.

	Female	Male
EUCLIDEAN DISTANCE	50/54 (92.6%) **(-1.4%)**	48/134 (35.8%) **(+9.8%)**
COSINE SIMILARITY	47/54 (87%) **(-11%)**	88/134 (65.6%) **(-3%)**
CHI SQUARE DISTANCE	48/54 (88.9%) **(-11.1%)**	101/134 (75.4%) **(-9.6%)**

Comparison with the Reference Paper

CUHK	Female - Paper	Female - My Approach	Male - Paper	Male - My Approach
EUCLIDEAN DISTANCE	97.06%	94%	81.48%	26%
COSINE SIMILARITY	100%	98%	88.89%	68.6%
CHI SQUARE DISTANCE	100%	100%	85.19%	85.07%

Robust Face Sketch Recognition Using Locality Sensitive Histograms, Hanhoon PARK, IEICE TRANS. INF. & SYST., 02.2019

Comparison with the Reference Paper

AR	Female - Paper	Female - My Approach	Male - Paper	Male - My Approach
EUCLIDEAN DISTANCE	96.23%	15%	91.43%	8.5%
COSINE SIMILARITY	100%	20%	94.29%	8.5%
CHI SQUARE DISTANCE	100%	17%	91.43%	18.5%

Robust Face Sketch Recognition Using Locality Sensitive Histograms, Hanhoon PARK, IEICE TRANS. INF. & SYST., 02.2019

CNN Implementation

First Model - Implemented Using AR Dataset

Layer (type)		Output Shape	Param #	
conv2d_1 (Conv2D)	(3,3)	(None, 126, 126, 64)	640	ReLu
conv2d_2 (Conv2D)	(3,3)	(None, 124, 124, 32)	18464	ReLu
flatten_1 (Flatten)		(None, 492032)	0	
dense_1 (Dense)		(None, 123)	60520059	Softmax

Starting from first epoch, result didn't change.

```
Epoch 500/500
492/492 [==============================] - 46s 94ms/step - loss: 0.0161 - acc: 0.0203 - val_loss: 0.0160 - val_acc:
0.0163
```

Second Model - Regularized and Dropout Added LeNet5 with Augmented Images

Test Set

About 70% of the test set included into train set.

70/123 of AR

100/188 of CUHK

Train Set

Regularized and Dropout Added LeNet5 with Augmented Images

Train set includes 2405 images in total. Test set includes 141 images in total.

```
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 126, 126, 6)       60
_________________________________________________________________
average_pooling2d_1 (Average (None, 63, 63, 6)         0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 61, 61, 16)        880
_________________________________________________________________
average_pooling2d_2 (Average (None, 30, 30, 16)        0
_________________________________________________________________
dropout_1 (Dropout)          (None, 30, 30, 16)        0
_________________________________________________________________
flatten_1 (Flatten)          (None, 14400)             0
_________________________________________________________________
dense_1 (Dense)              (None, 120)               1728120
_________________________________________________________________
dense_2 (Dense)              (None, 100)               12100
_________________________________________________________________
dense_3 (Dense)              (None, 311)               31411
=================================================================
Total params: 1,772,571
Trainable params: 1,772,571
Non-trainable params: 0
_________________________________________________________________
```

In [18]:

Epochs

Epoch 1/150
2405/2405 [==============================] - 17s 7ms/step - loss: 1.1149 - acc: 0.8586 - val_loss: 15.9860 - **val_acc: 0.0071**

Epoch 10/150
2405/2405 [==============================] - 35s 15ms/step - loss: 1.1470 - acc: 0.8516 - val_loss: 16.1950 - **val_acc: 0.0000e+00**

Epoch 30/150
2405/2405 [==============================] - 42s 18ms/step - loss: 1.1115 - acc: 0.8574 - val_loss: 16.0630 - **val_acc: 0.0071**

Epoch 44/150
2405/2405 [==============================] - 41s 17ms/step - loss: 1.1123 - acc: 0.8553 - val_loss: 15.4913 - **val_acc: 0.0426**

Epoch 57/150
2405/2405 [==============================] - 36s 15ms/step - loss: 1.0867 - acc: 0.8582 - val_loss: 14.7975 - **val_acc: 0.0851**

Epoch 85/150
2405/2405 [==============================] - 35s 15ms/step - loss: 1.1337 - acc: 0.8482 - val_loss: 14.2238 - **val_acc: 0.1206**

Epoch 91/150
2405/2405 [==============================] - 35s 15ms/step - loss: 1.0699 - acc: 0.8603 - val_loss: 14.5636 - **val_acc: 0.0993**

Epoch 92/150
2405/2405 [==============================] - 35s 15ms/step - loss: 1.0873 - acc: 0.8553 - val_loss: 14.1063 - **val_acc: 0.1277**

Epoch 112/150
2405/2405 [==============================] - 35s 15ms/step - loss: 1.0723 - acc: 0.8599 - val_loss: 15.2494 - **val_acc: 0.0567**

Epoch 150/150
2405/2405 [==============================] - 41s 17ms/step - loss: 1.0640 - acc: 0.8599 - val_loss: 15.5882 - **val_acc: 0.0355**

Regularized and Dropout Added LeNet5 with Augmented Images

12.77% (with 86.07% in train set) accomplished. 200 epoch. Model is trained using a trained model with 50 epochs.

Maximum accuracy obtained from a train set is 86.11% but it has lower test set accuracy. (4.26 in test)

Third Model - Regularized and Dropout Added LeNet5 with Augmented Images MaxPooling used instead of AveragePooling

```
Epoch 1/150
2405/2405 [==============================] - 34s 14ms/step - loss: 0.9951 - acc: 0.8694 - val_loss: 15.8706 - val_acc: 0.0213

Epoch 10/150
2405/2405 [==============================] - 31s 13ms/step - loss: 1.0230 - acc: 0.8603 - val_loss: 15.5211 - val_acc: 0.0426

Epoch 21/150
2405/2405 [==============================] - 44s 18ms/step - loss: 1.0980 - acc: 0.8432 - val_loss: 14.2181 - val_acc: 0.1206

Epoch 24/150
2405/2405 [==============================] - 43s 18ms/step - loss: 1.0901 - acc: 0.8570 - val_loss: 16.2089 - val_acc: 0.0000e+00

Epoch 80/150
2405/2405 [==============================] - 38s 16ms/step - loss: 1.0362 - acc: 0.8578 - val_loss: 15.6125 - val_acc: 0.0355

Epoch 120/150
2405/2405 [==============================] - 38s 16ms/step - loss: 1.0218 - acc: 0.8636 - val_loss: 16.1621 - val_acc: 0.0000e+00

Epoch 127/150
2405/2405 [==============================] - 40s 17ms/step - loss: 1.0347 - acc: 0.8574 - val_loss: 14.9112 - val_acc: 0.0780

Epoch 150/150
2405/2405 [==============================] - 31s 13ms/step - loss: 0.9981 - acc: 0.8640 - val_loss: 15.6878 - val_acc: 0.0284
```

12.06%, 200 epoch

Third Model - Regularized and Dropout Added LeNet5 with Augmented Images MaxPooling used instead of AveragePooling

12.06% (with 84.32% in train set) accomplished. 200 epoch. Model is trained using a trained model with 50 epochs.

Maximum accuracy obtained from a train set is 86.94% but it has lower test set accuracy. (2.13% in test)

LeNet - Regularization + Dropout

LeNet - Regularization + Dropout + MaxPooling

Train: 86.11%

Train: 84.32%

Test: 12.77%

Test: 12.06%

I also have several failed experiments. One of them is (without augmentation)

```
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_21 (Conv2D)           (None, 126, 126, 6)       60
_________________________________________________________________
average_pooling2d_1 (Average (None, 63, 63, 6)         0
_________________________________________________________________
dropout_4 (Dropout)          (None, 63, 63, 6)         0
_________________________________________________________________
conv2d_22 (Conv2D)           (None, 61, 61, 16)        880
_________________________________________________________________
average_pooling2d_2 (Average (None, 30, 30, 16)        0
_________________________________________________________________
dropout_5 (Dropout)          (None, 30, 30, 16)        0
_________________________________________________________________
conv2d_23 (Conv2D)           (None, 28, 28, 32)        4640
_________________________________________________________________
average_pooling2d_3 (Average (None, 14, 14, 32)        0
_________________________________________________________________
dropout_6 (Dropout)          (None, 14, 14, 32)        0
_________________________________________________________________
conv2d_24 (Conv2D)           (None, 12, 12, 64)        18496
_________________________________________________________________
average_pooling2d_4 (Average (None, 6, 6, 64)          0
_________________________________________________________________
flatten_2 (Flatten)          (None, 2304)              0
_________________________________________________________________
dense_5 (Dense)              (None, 500)               1152500
_________________________________________________________________
dense_6 (Dense)              (None, 311)               155811
=================================================================
Total params: 1,332,387
Trainable params: 1,332,387
Non-trainable params: 0
_________________________________________________________________
```

Never above 0% for 50 epochs.

Original LeNet (without augmentation)

```
Epoch 14/50
2405/2405 [==============================] - 16s 7ms/step - loss: 2.2157 - acc: 0.4599 - val_loss: 15.1267 - val_acc:
0.0426
```

This was the best results among 50 epochs. The last 10 epochs are

```
Epoch 41/50
2405/2405 [==============================] - 27s 11ms/step - loss: 0.6595 - acc: 0.8832 - val_loss: 16.0980 - val_acc:
0.0000e+00
Epoch 42/50
2405/2405 [==============================] - 30s 12ms/step - loss: 0.6584 - acc: 0.8832 - val_loss: 16.1181 - val_acc:
0.0000e+00
Epoch 43/50
2405/2405 [==============================] - 27s 11ms/step - loss: 0.6543 - acc: 0.8832 - val_loss: 16.1122 - val_acc:
0.0000e+00
Epoch 44/50
2405/2405 [==============================] - 31s 13ms/step - loss: 0.6549 - acc: 0.8832 - val_loss: 16.0783 - val_acc:
0.0000e+00
Epoch 45/50
2405/2405 [==============================] - 28s 12ms/step - loss: 0.6576 - acc: 0.8840 - val_loss: 16.0431 - val_acc:
0.0000e+00
Epoch 46/50
2405/2405 [==============================] - 28s 12ms/step - loss: 0.6562 - acc: 0.8836 - val_loss: 16.0319 - val_acc:
0.0000e+00
Epoch 47/50
2405/2405 [==============================] - 30s 13ms/step - loss: 0.6552 - acc: 0.8836 - val_loss: 16.0387 - val_acc:
0.0000e+00
Epoch 48/50
2405/2405 [==============================] - 26s 11ms/step - loss: 0.6543 - acc: 0.8836 - val_loss: 16.0710 - val_acc:
0.0000e+00
Epoch 49/50
2405/2405 [==============================] - 32s 13ms/step - loss: 0.6552 - acc: 0.8832 - val_loss: 16.0048 - val_acc:
0.0071
Epoch 50/50
2405/2405 [==============================] - 27s 11ms/step - loss: 0.6538 - acc: 0.8832 - val_loss: 16.0155 - val_acc:
0.0000e+00
```

Thank you!