Face Image Quality Enhancement Study for Face Recognition

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Introduction

- The problem of face recognition in low quality photos has not been well-studied so far.
- Explore the face recognition performance on low quality photos
- Try to improve the accuracy in dealing with low quality face images

- Assemble a large database with low quality photos
- Examine the performance of face recognition algorithms for three different quality sets
- Using state-of-the-art facial image enhancement approaches, we explore the face recognition performance for the enhanced face images.

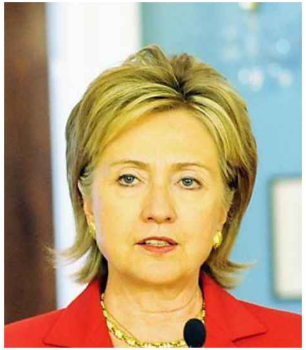
Database

- Real world images can simultaneously have multiple quality attributes, e.g,
  - having pose variation, low illumination and a large expression variation at the same image, which makes the problem very hard.
- We use a database of unconstrained face images and performed cross quality face recognition.
  - IJB-A dataset.
    - contains 500 celebrities of the world.
    - 21,230 images in total
- Focus on studying the affect of face image quality enhancement for improved face recognition with different image qualities.

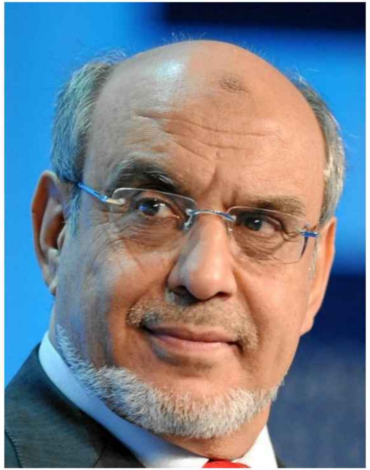
- Divide the database into three different quality sets
    - High Quality:
        - score of each image >= 60
    - Middle Quality:
        - score of each image between [30,60)
    - Low Quality:
        - score of each image < 30

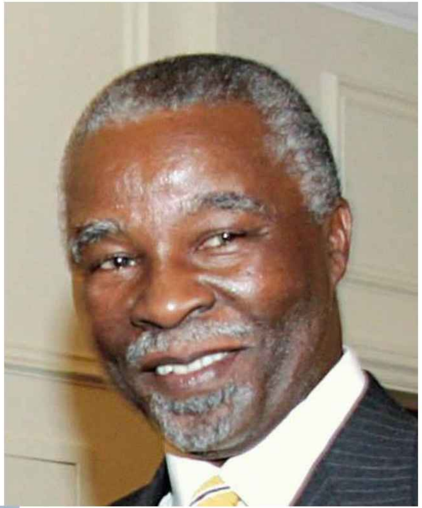
- High Quality: 1,543 images



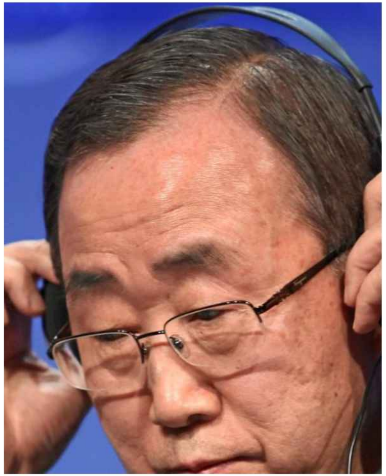


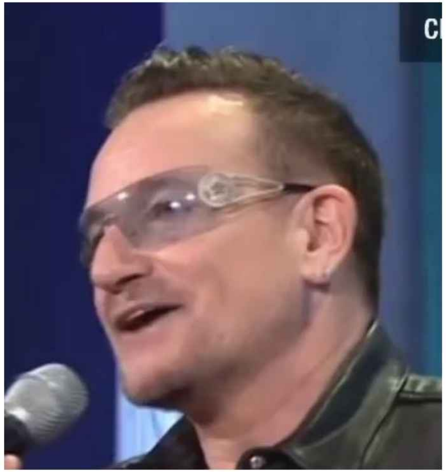

- Middle Quality: 13,491 images





- Low Quality: 6,196 images



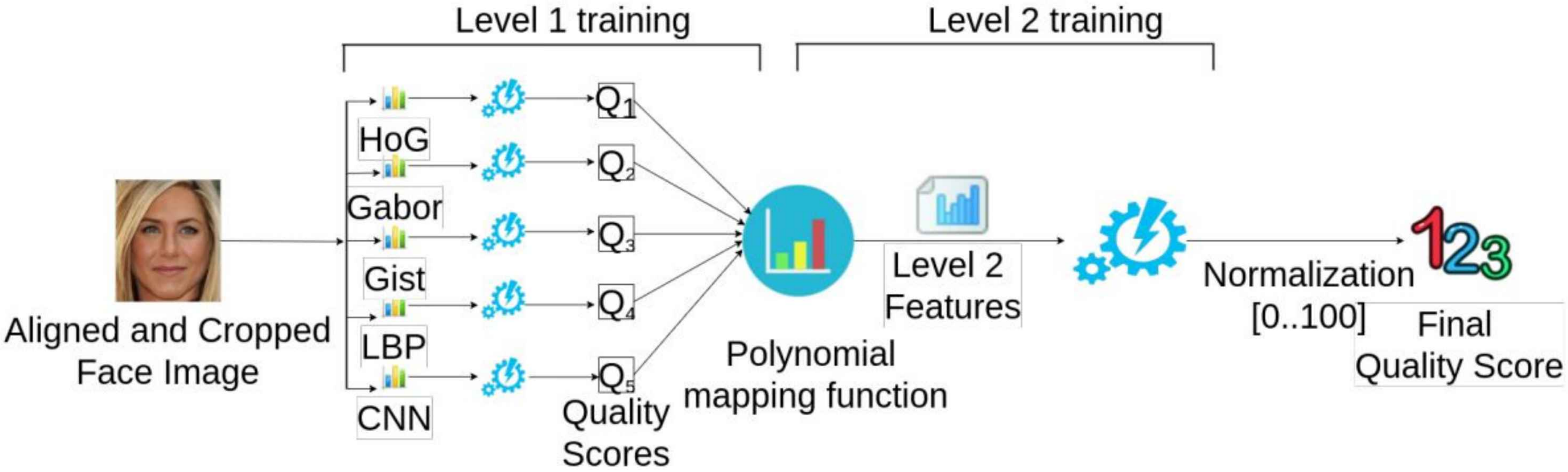


Quality Score

- A learning of rank based quality assessment approach is used.
- The face image quality framework uses two level training process to train a RankSVM.
  - First, five different face recognition features are extracted
    - HoG, Gabor, Gist, LBP and CNN
  - Then, construct new features from the output of the first level prediction using a 5th degree polynomial kernel mapping function.
  - The result of the second level prediction is normalized and rounded off and considered as the quality score.

J. Chen, Y. Deng, G. Bai, and G. Su, “Face image quality assessment based on learning to rank,” IEEE Signal Processing Letters, vol. 22, no. 1, pp. 90–94, Jan 2015.

Two level learning method to calculate the face image quality.



Quality Enhancement

- There are various causes that can affect the quality of a face images, such as:
  - pose variation
  - uneven or too high or too low illumination
  - image resolution
  - occlusion
  - motion blur etc.
- We tried to enhance the quality of the low and middle quality image sets by applying different image quality enhancement methods.
- For our study, we focused on three enhancement methods:
  - 1) pose correction,
  - 2) correcting motion blur and
  - 3) normalizing illumination variation.

(1) Pose estimation and correction

- We chose the frontalization technique proposed by Hassner et al. [*] for pose correction.
  - a face is first detected using an off-the-shelf face detector,
  - and then cropped and rescaled to a standard coordinate system.
  - Then facial feature points are localized and used to align the photo with a textured, 3D model of a generic, reference face.
- A rendered, frontal view of this face provides a reference coordinate system.
- The initial frontalized face is obtained by back-projecting the appearance of the query photo to the reference coordinate system using the 3D surface as a proxy.
- Then the final result is produced by borrowing appearances from corresponding symmetric sides of the face wherever facial features are poorly visible due to the query's pose.

T. Hassner, S. Harel, E. Paz, and R. Enbar, "Effective face frontalization in unconstrained images," in The IEEE Conference on Computer Vision and Pattern Recognition (CVPR), June 2015.

Good and Bad

- **Good :** Experiment 34
- Use frontal_sym images (sysmetric frontalization)
- Threshold: mean of high quality.

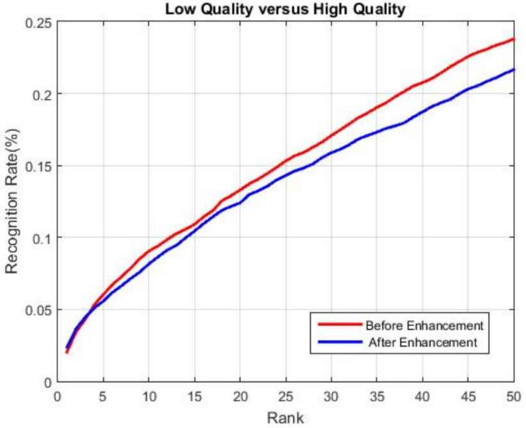
(a) (b) (c)

- **Bad : ignore**

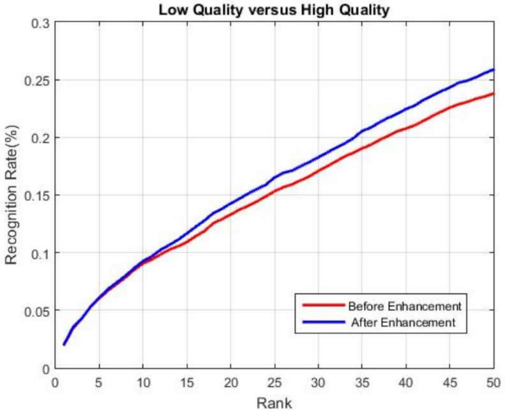
  Experiment 33、35、36.

Low vs High

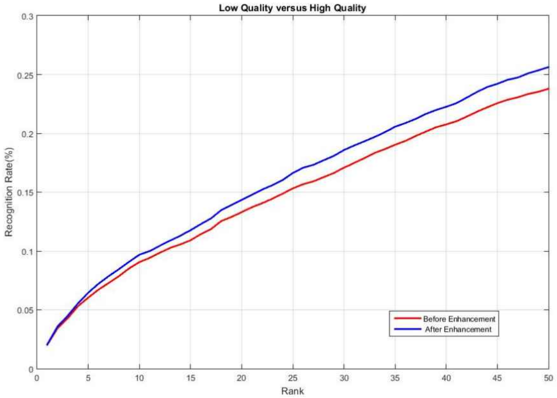
[33] frontalization_using rgb



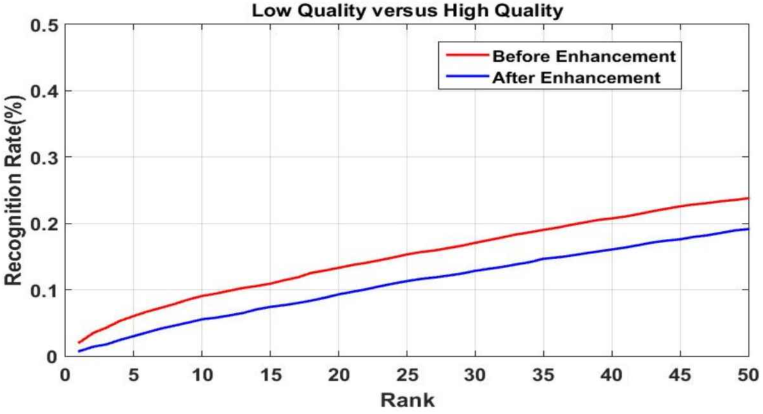
[34] frontalization_using highmean_rgb



[35] frontalization_using xyz angles

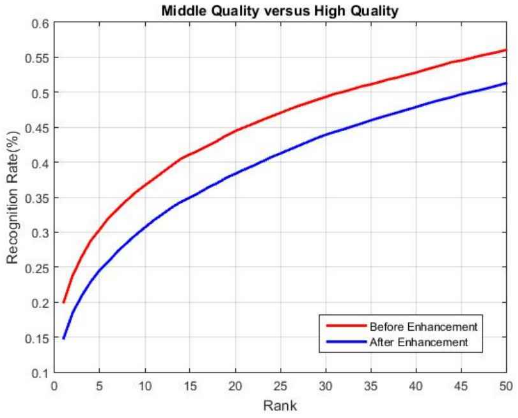


[36] front_rgb_xyz_all

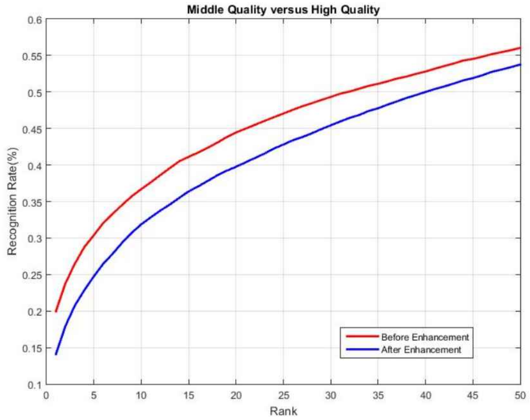


Middle vs High

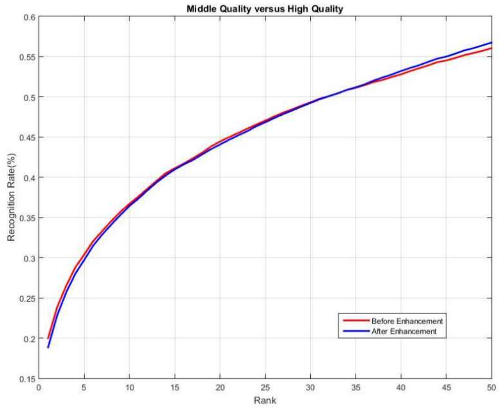
[33] frontalization_using rgb



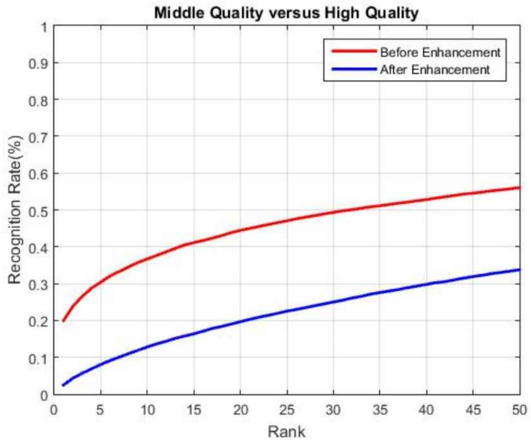
[34] frontalization_using highmean_rgb



[35] frontalization_using xyz angles



[36] front_rgb_xyz_all



Experiment Description

33 frontalization_using rgb

- Use frontal_raw images
- Use original images
- Angles of x,y,z >30 degree
- Use all faces to do face recognition

34 frontalization_using highmean_rgb

- Use frontal_sym images
- Use original images
- Find images the x,y,z values of which are > mean of high quality.
- Use all faces to do face recognition

35 frontalization_using xyz angles

- Use frontal_sym images
- Use original images
- Thresholds: |x|=25 degree, |y|=15 degree, |z|=45 degree
- Use enhanced faces to do face recognition

36 front_rgb_xyz_all

- Use frontal_sym images
- Use original images
- Thresholds: |x|=25 degree, |y|=15 degree, |z|=45 degree
- Use all faces to do face recognition

(2) Blur measure and deblurring

- Use two types of measures separately.
  - First one was measuring the edge density
    - to measures the average magnitude of the gradient over the face of a person.
  - The second approach was to measure the sharpness.
    - apply a low-pass filter to the face image and then the average value of the pixels of the image is considered as the sharpness measure

(a) (b) (c) (d)

E. P. Krotkov, Active computer vision by cooperative focus and stereo. Springer Science & Business Media, 2012.
K. Nasrollahi and T. B. Moeslund, Face Quality Assessment System in Video Sequences. Berlin, Heidelberg: Springer Berlin Heidelberg, 2008, pp. 10–18. [Online]. Available: http://dx.doi.org/10. 1007/978-3-540-89991-4 2

Good and Bad

- **Good :** Experiment 12
- Measurement: focus
- Threshold: mean of high quality
- Method: after frontalization;

- **Bad：ignore**

Experiment 13、14、15

Experiment Description

[12] deblur_using frontalized images

- Threshold: focus measure < mean of high quality.
- Using frontalized faces to do deblurring
- Besides, unfrontalized faces, if < threshold, also do deblurring
- Use all images to do face recognition.

[13] deblur_using front_enhanced_matching

- Also use frontalized faces and unfrontalized faces to do deblurring.
- Use enhanced images to do face recognition.
- Use equal number of subjects of middle and low images to do face recognition(n=461).

[14] deblur_sharpness_new

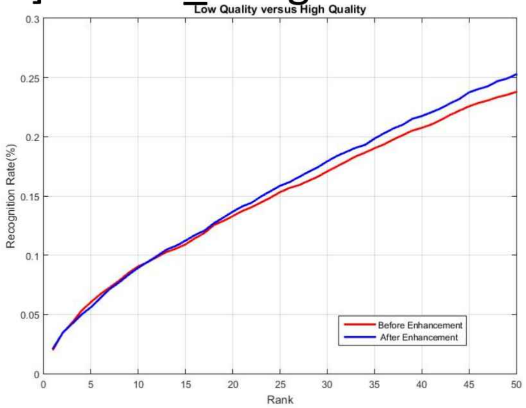
- Find images the sharpness values of which are < mean of high quality.
- Using frontalized faces to do deblurring
- Besides, unfrontalized faces, if < threshold, also do deblurring
- Use enhanced images to do face recognition

[15] deblur_rgb_sharpness_new_all

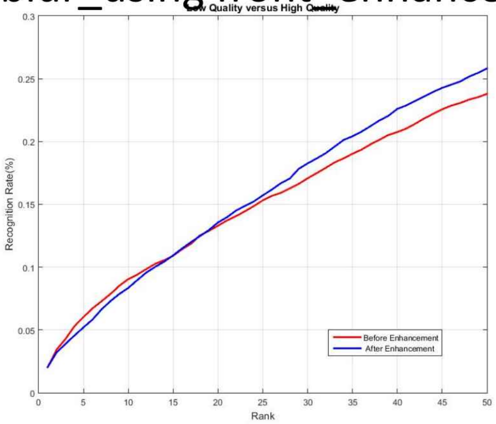
- Find images the sharpness values of which are < mean of high quality.
- Using frontalized faces to do deblurring
- Besides, unfrontalized faces, if < threshold, also do deblurring
- Use all images to do face recognition

Low vs High

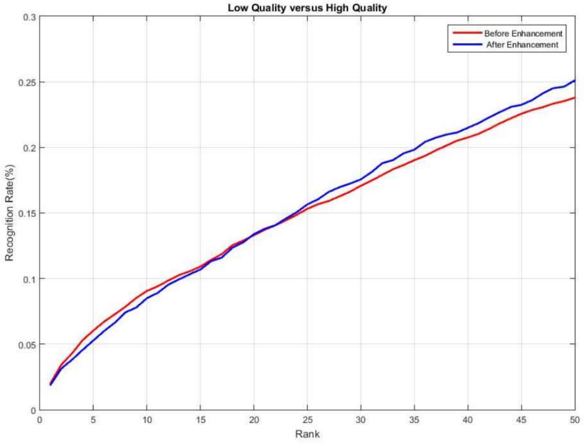
[12] deblur_using frontalized images



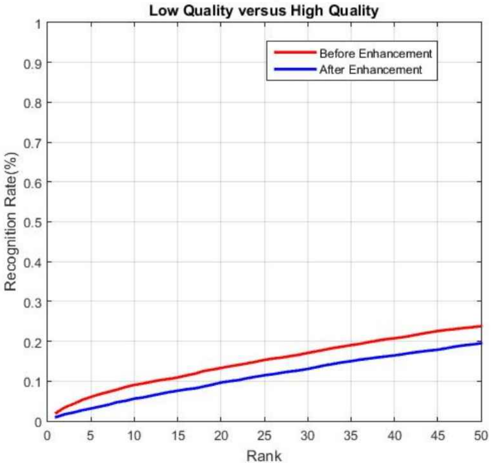
[13] deblur_using front_enhanced_matching



[14] deblur_sharpness_new

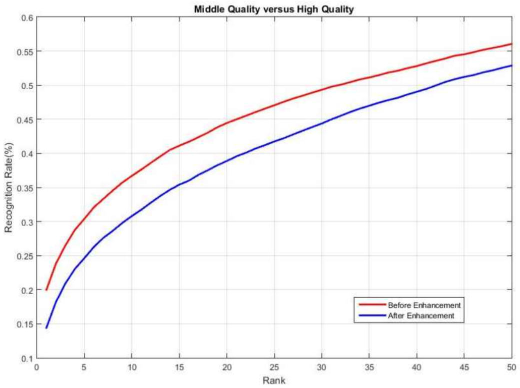


[15] deblur_rgb_sharpness_new_all

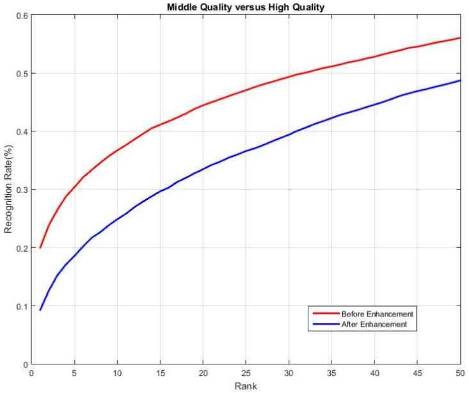


Middle vs High

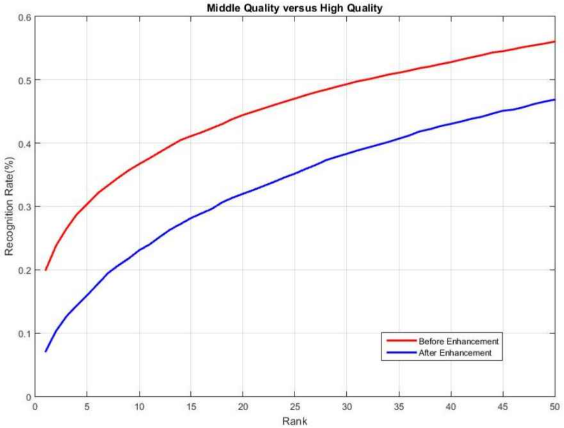
[12] deblur_using frontalized images



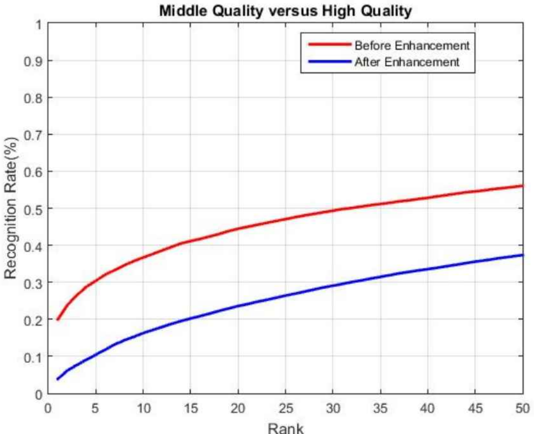
[13] deblur_using front_enhanced_matching



[14] deblur_sharpness_new



[15] deblur_rgb_sharpness_new_all



(3) Illumination measure and photometric normalization

- Photometric normalization methods
  - uses the Weber's law, which concludes that stimuli are perceived not in absolute terms, but in relative terms.
  - Given a face image, for each pixel we compute the ratio between two terms:
    - one is the relative intensity difference of the current pixel against its neighbors;
    - the other is the intensity of the current pixel.
  - The obtained ratio is called "Weber-face".
  - Weber-face can extract the local salient patterns very well from the input image, and it is an illumination insensitive representation.

Good and Bad

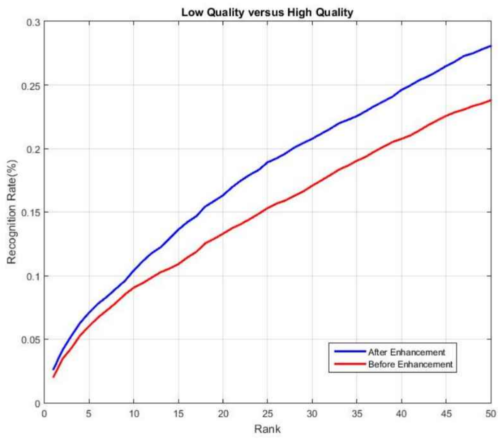
- **Good :** Experiment 21
- Use cropped faces to do normalization
- All faces normalized(high,mid,low)
- **Bad:ignore**

Experiment 22、23、25.

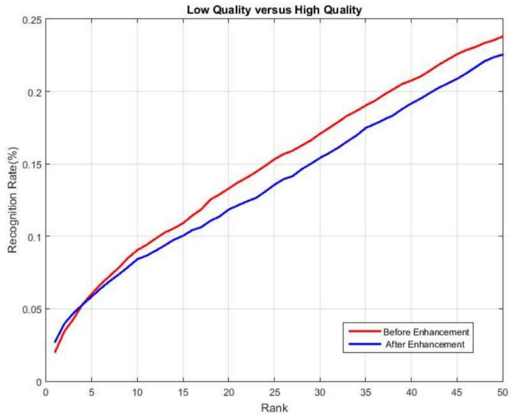
Experiment 23: the result is pretty good, but it just use enhanced images to do face recognition.

Low vs High

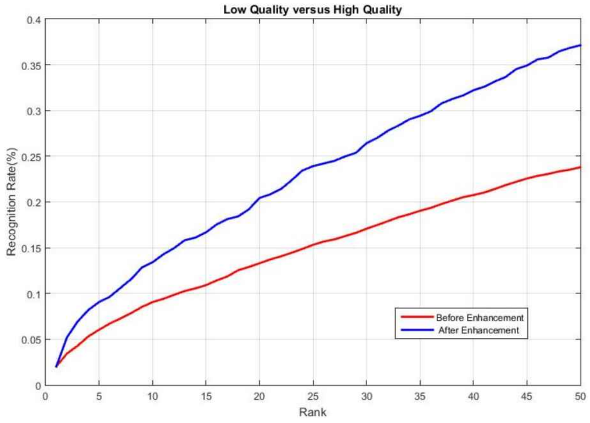
[21] photo_using QA



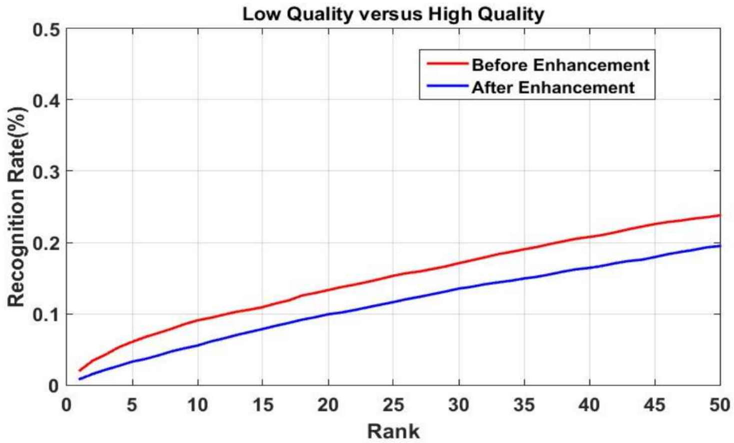
[22] photometric_rgb_ faces



[23] photo_rgb_illum_measure

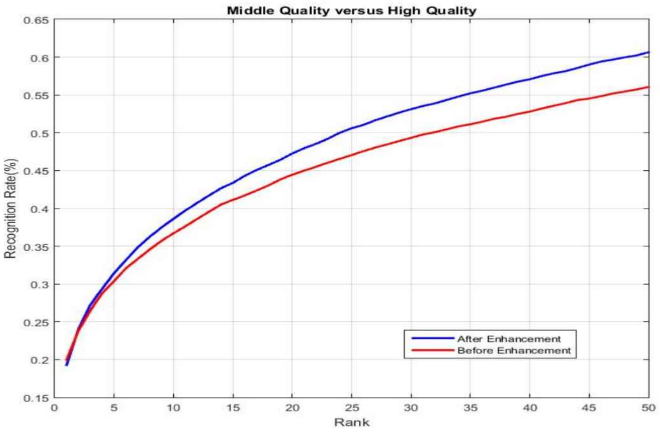


[25] photo_rgb_measure_all_h

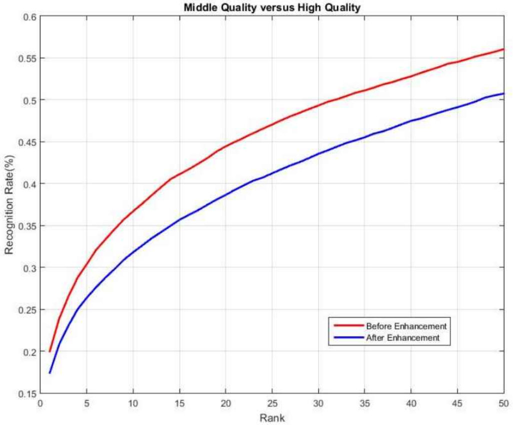


Middle vs High

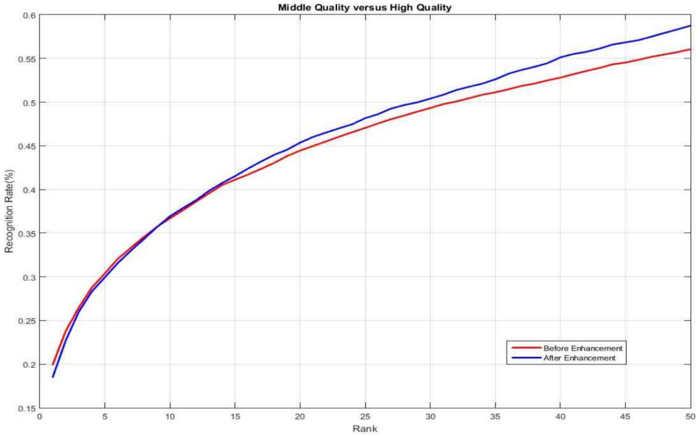
[21] photo_using QA



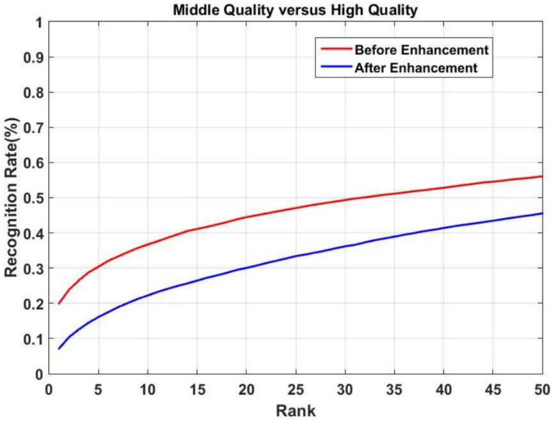
[22] photometric_rgb_ faces



[23] photo_rgb_illum_measure



[25] photo_rgb_measure_all_h



Experiment Description

[21] photo_using QA

- Use cropped faces to do normalization
- All faces normalized(high,mid,low)

[22] photometric_rgb_ faces

- Use original images to do
- All faces normalized

[23] photo_rgb_illum_measure

- Use illumination measure
- Use original images
- Find images the measure values of which are
  < mean of high quality.
- Use enhanced faces to do normalization

[25] photo_rgb_measure_all_h

- Use illumination measure
- Use original images
- Find images the measure values of which are
  < mean of high quality.
- Use all faces to do normalization