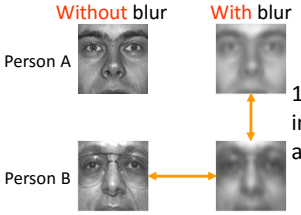
TOSHIBA
Leading Innovation

Facial Deblur Inference to Improve Recognition of Blurred Faces

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1. Purpose

Deblurring facial images to recognize faces degraded by blur



2. Appearance of an individual changes drastically

***Removing* blur from facial appearances**

2. Background

PSF (*Point Spread Function*) is required for deblurring

Degradation process

Blurred image $\mathbf{g} = \mathbf{Hf} + \mathbf{n}$ Noise

PSF Original sharp image

For example, the different PSFs are applied...



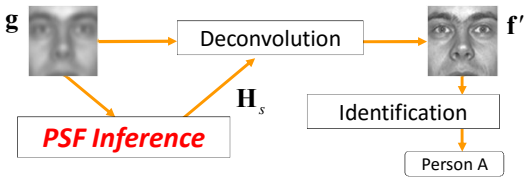
Existing methods (Hu & Haan, Yitzhaky & Kopeika, ...)

- Using the smoothness of intensity changes around edges
- Difficult to distinguish between blurred edges and smooth surfaces

3. Overview

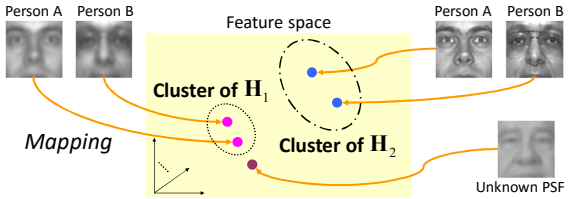
i. Detect facial region
ii. Infer PSF from blurred face
iii. Deconvolve using inferred PSF and Farsiu et al.'s BTV regularization
iv. Identify

Main contribution



To accurately infer PSFs...

Constructing a feature space that is sensitive to the appearance variations of different blurs but insensitive to the difference between individuals



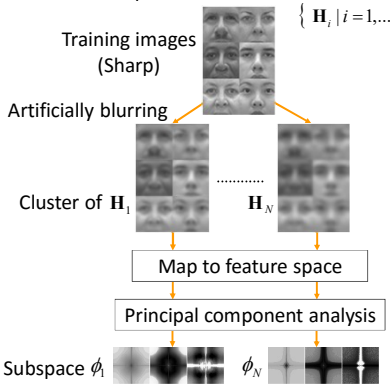
Blurred faces degraded by the same PSF are similar to one another and form a cluster

I. Learn the variation in appearances caused by blur from clusters
II. Recognize PSF by finding the closest cluster

4. PSF Inference

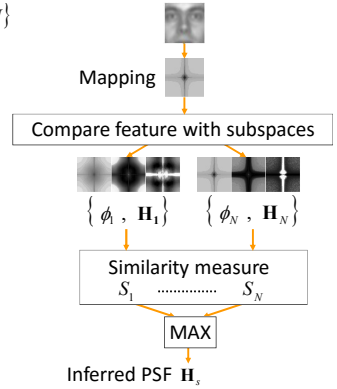
I. Learning

Assume a representative fixed set of PSFs $\{\mathbf{H}_i \mid i = 1,\ldots,N\}$



II. Recognition

Given a face with unknown PSF



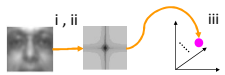
Mapping Procedure

Frequency domain amplitude

High frequency amplitudes for blurred images become smaller than those for sharp images

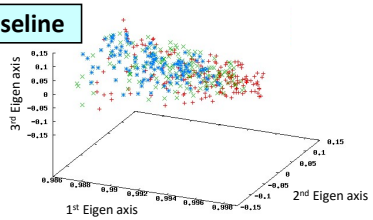
To emphasize discriminative high frequency:

i. 2D Fourier Transform
ii. Take logarithms
iii. Vectorize



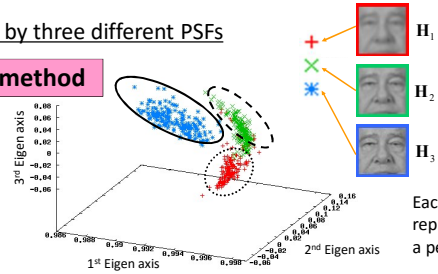
Visualizing feature spaces containing images blurred by three different PSFs

Baseline



Simply vectorizing does not generalize well to clearly separate blurred images

Our method



Each point represents a person

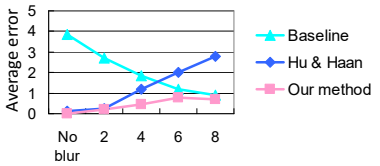
Our *frequency magnitude*-based feature space gives clusters that are much better separated

5. Results

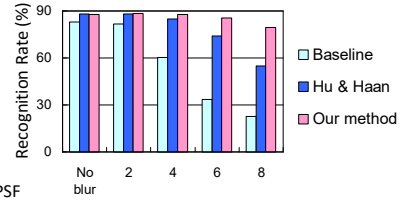
Artificially blurred database (FERET)

Focus blur

PSF inference accuracy



Identification performance



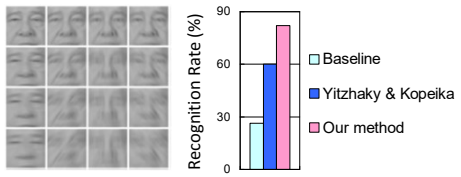
Standard deviation of Gaussian PSF



Our method is significantly better than existing methods, especially in the presence of large blur

Motion blur

Identification performance



Real blurred database (FRGC1.0a)

Focus blur

Exp 4
Controlled indoor still vs. uncontrolled still

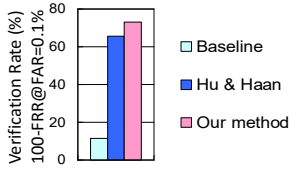
Target image Query image



Real blur

Focal length is adjusted to the background

Identification performance



Our method is effective at deblurring real images to improve face recognition

Blur is removed



Faces deblurred using our method



Faces with real blur