Facial Recognition with Principal Component Analysis

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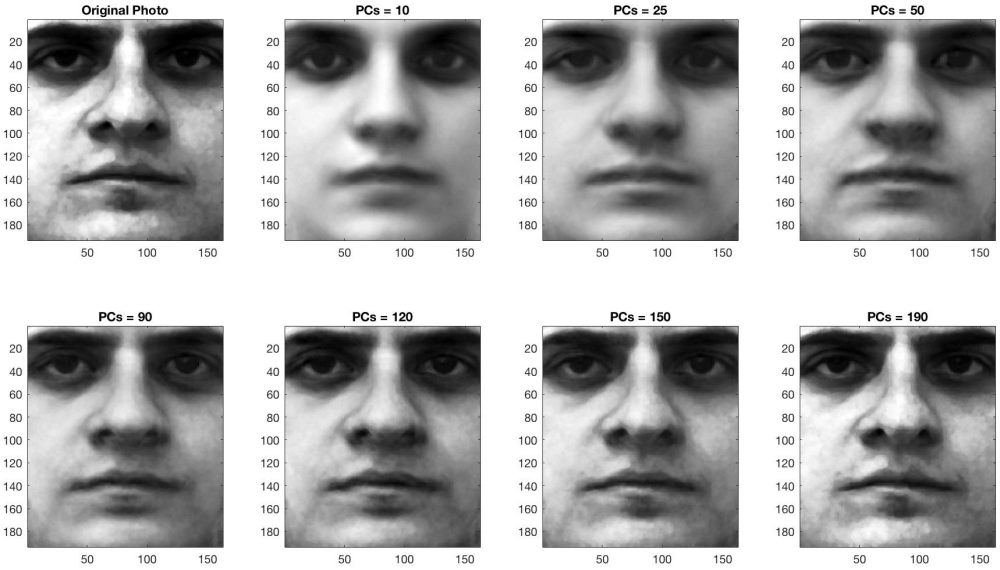
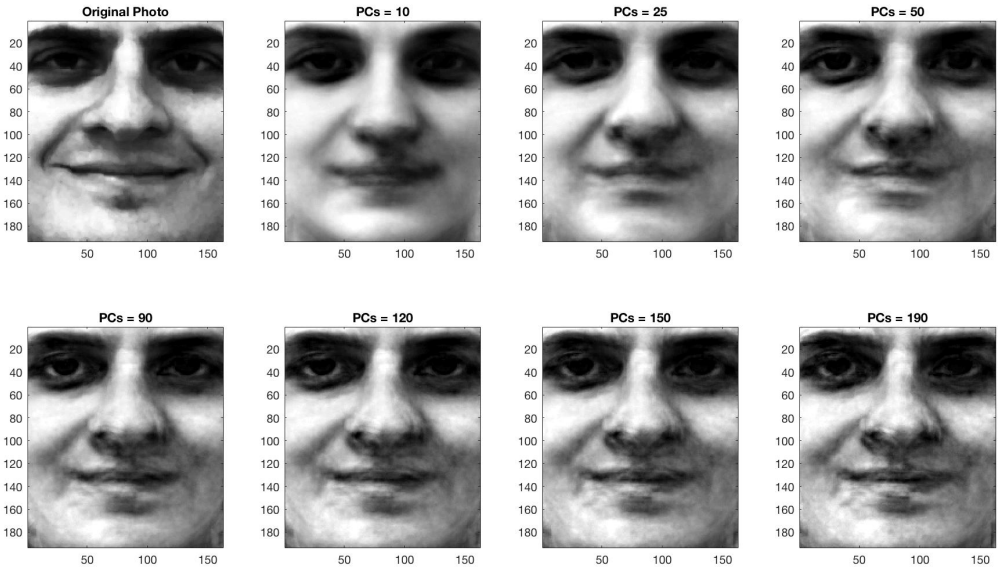
(a) Compute the principal components (PCs) using first 190 individuals' neutral expression image

According to the paper, for each face photo, we reshaped the matrix from a two-dimensional M by N array to a vector of dimension M*N by 1. Then we stack 190 training photos together. We could get a matrix M*N by 190 and we computed the average face. Then we can get a matrix which represented the difference between each training face photo and the average face, denoted as A. We tried to find the eigenvectors of AA^T. However, M*N is big. To reduce the computation time, we first computed the eigenvectors of A^TA, denoted as V. Then eigenfaces are the columns of A*V which are the principal components (PCs).

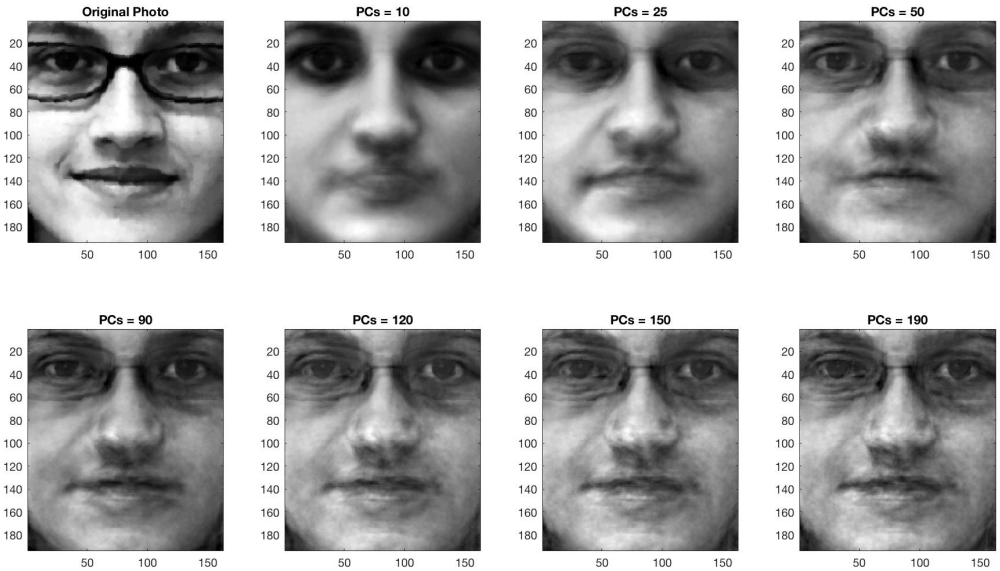
(b) Reconstruct one of 190 individuals' neutral expression image using different number of PCs



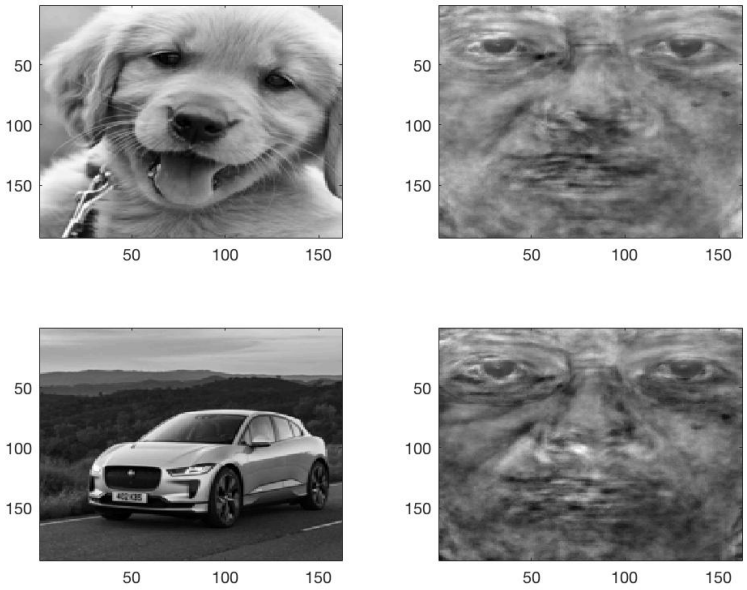
(c) Reconstruct one of 190 individuals' smiling expression image using different number of PCs



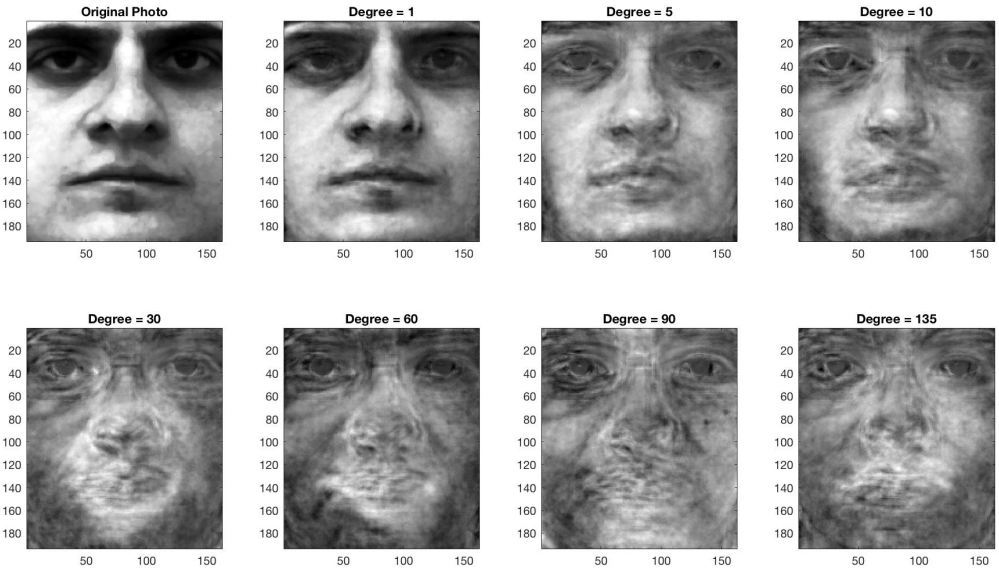
(d) Reconstruct one of the other 10 individuals' neutral expression image using different number of PCs



(e) Use other non-human image (e.g., car image, resize and crop to the same size), and try to reconstruct it using all PCs.



(f) Rotate one of 190 individuals' neutral expression image with different degrees and try to reconstruct it using all PCs



Matlab Code:

```
%% read image
filepath1='./frontalimages_spatiallynormalized_cropped_equalized_part1/';
filepath2='./frontalimages_spatiallynormalized_cropped_equalized_part2/';
f=mat2gray(imread([filepath1 num2str(1) 'a' '.jpg']));
[m,n] = size(f);
neutralMatrix = zeros(m*n,200);
for i=1:100
%    f=mat2gray(imread([filepath1 num2str(i) 'a' '.jpg']));
   f=imread([filepath1 num2str(i) 'a' '.jpg']);
   f = f(:);
   neutralMatrix(:,i) = f;
end
for i=1:100
%    f=mat2gray(imread([filepath2 num2str(i+100) 'a' '.jpg']));
   f=imread([filepath2 num2str(i+100) 'a' '.jpg']);
   f = f(:);
   neutralMatrix(:,i+100) = f;
end

smileMatrix = zeros(m*n,200);
% smileMatrix = zeros(200,m*n);
for i=1:100
   f=imread([filepath1 num2str(i) 'b' '.jpg']);
   f = f(:);
   smileMatrix(:,i) = f;
end
for i=1:100
   f=imread([filepath2 num2str(i+100) 'b' '.jpg']);
   f = f(:);
   smileMatrix(:,i+100) = f;
end



%%
trainNeutral = neutralMatrix(:,1:190);
Psi = sum(trainNeutral,2)/190;
fai = trainNeutral - repmat(Psi,[1,length(trainNeutral(1,:))]);
C = fai'*fai;
[U,lam] = eig(double(C));
Ueig = fai *U;

%% reconstruction training neutral face
num = 1;
pic = fai(:,num);
pca_num = [10,25,50,90,120,150,190]; % number of PCA
figure;
subplot(2, 4, 1)
f=imread([filepath1 num2str(1) 'a' '.jpg']);
imagesc(f)
title('Original Photo')
colormap('gray');
for j = 1:length(pca_num)
    recpic = 0;
    for i=191-pca_num(j) : 190
```

```
        U = Ueig(:,i)./sqrt(sum(Ueig(:,i).*Ueig(:,i)));
        recpic = recpic + U'*pic*U;
    end
    recpic = recpic + Psi;
    subplot(2, 4, j+1)
    imagesc(reshape(Ueig_1(:, end-i+1), m, n));
    title(['PCs = ',num2str(pca_num(j))])
    imagesc(reshape(recpic,[m,n]))
    title(['PCs = ',num2str(pca_num(j))])
    colormap('gray');
end


%% reconstruction smiling face
num = 1;
pic = smileMatrix(:,num)-Psi;
figure;
subplot(2,4,1)
f=imread([filepath1 num2str(1) 'b' '.jpg']);
imagesc(f)
title('Original Photo')
colormap('gray');
for j = 1:length(pca_num)
    recpic = 0;
    for i=191-pca_num(j) : 190
        U = Ueig(:,i)./sqrt(sum(Ueig(:,i).*Ueig(:,i)));
        recpic = recpic + U'*pic*U;
    end
    recpic = recpic + Psi;
    subplot(2,4,j+1)
    imagesc(reshape(uint8(recpic),[m,n]))
    title(['PCs = ',num2str(pca_num(j))])
    colormap('gray');
end




%% reconstruction nontraining neutral face
num = 195;
pic = neutralMatrix(:,num)-Psi;
figure;
subplot(2,4,1)
f=imread([filepath2 num2str(195) 'a' '.jpg']);
imagesc(f)
title('Original Photo')
colormap('gray');
for j = 1:length(pca_num)
    recpic = 0;
    for i=191-pca_num(j) : 190
        U = Ueig(:,i)./sqrt(sum(Ueig(:,i).*Ueig(:,i)));
        recpic = recpic + U'*pic*U;
    end
    recpic = recpic + Psi;
    subplot(2,4,j+1)
    imagesc(reshape(recpic,[m,n]));hold on
    title(['PCs = ',num2str(pca_num(j))])
```

```
end



%% reconstruction non human face
Dog=rgb2gray(imread('dog.jpeg'));
Dog=Dog(:,480:size(Dog,2)-480);
dog = imresize(Dog,[m n]);
pic = double(reshape(dog,[m*n,1]))-Psi;
recpic = 0;
for i=1:190
     U = Ueig(:,i)./sqrt(sum(Ueig(:,i).*Ueig(:,i)));
     recpic = recpic + U'*pic*U;
end
recpic = recpic + Psi;
figure;
subplot(2,2,1)
imagesc(dog)
subplot(2,2,2)
imagesc(reshape(recpic,[m,n]))
colormap('gray');

Car=rgb2gray(imread('car.jpg'));
car = imresize(Car,[m n]);
pic = double(reshape(car,[m*n,1]))-Psi;
recpic = 0;
for i=1:190 % number of PCA
     U = Ueig(:,i)./sqrt(sum(Ueig(:,i).*Ueig(:,i)));
     recpic = recpic + U'*pic*U;
end
recpic = recpic + Psi;
subplot(2,2,3)
imagesc(car)
subplot(2,2,4)
imagesc(reshape(recpic,[m,n]))
colormap('gray');


%% reconstruction rotated neutral face
num = 1;
angle = [1,5,10,30,60,90,135];
img = imread([filepath1 num2str(num) 'a' '.jpg']);
figure;
subplot(2,4,1)
imagesc(img)
title('Original Photo')
colormap('gray');
for j = 1:length(angle)
    pic = imresize(imrotate(img,angle(j)),[m,n]);
    pic = double(reshape(pic,[m*n,1]))-Psi;
    recpic = 0;
    for i=1:190
        U = Ueig(:,i)./sqrt(sum(Ueig(:,i).*Ueig(:,i)));
        recpic = recpic + U'*pic*U;
    end
    recpic = recpic + Psi;
    subplot(2,4,j+1)
```

```
    imagesc(reshape(recpic,[m,n]))
    colormap('gray');
    title(['Degree = ',num2str(angle(j))])
end
```