Faces-exercise

September 14, 2018

1 Least squares face-off

In the following lines, use your own integer to seed the random number generator.

```
In [1]: using Random
        Random.seed!(3383)   # CHANGE ME
        @show poses = shuffle(1:10)[1:5];
        @show subjects = shuffle(1:40)[1:20];
```

```
poses = (shuffle(1:10))[1:5] = [5, 7, 9, 4, 10]
subjects = (shuffle(1:40))[1:20] = [4, 33, 22, 8, 16, 20, 36, 14, 39, 40, 37, 26, 3, 31, 27, 2
```

The following block will read in images for all the selected poses and subjects. You may need to change the directory in the argument to `imread`. Use `pwd()` to see Julia's working directory, and `cd` to change it.

```
In [2]: using PyPlot, LinearAlgebra
        npo = length(poses);
        nsub = length(subjects);
        A = zeros(112*92,npo*nsub);
        j = 1
        for (i1,s) in enumerate(subjects)
          for (i2,p) in enumerate(poses)
                X = imread("../attfaces/s$s/$p.png")
                A[:,j] = vec(X)
                j += 1
          end
        end
        @show size(A)
```

```
size(A) = (10304, 100)
```

```
Out[2]: (10304, 100)
```

Each column of `A` is a vectorized 112×92 array of pixel gray levels. Here is a little function that makes it easy to reshape and plot any such image vector.

```
In [3]: showface(x) = imshow(reshape(x,112,92),cmap="gray")
        subplot(121), showface(A[:,1]);
        subplot(122), showface(A[:,2]);
```

- Use the following block to find and plot the "average face" from the dataset.

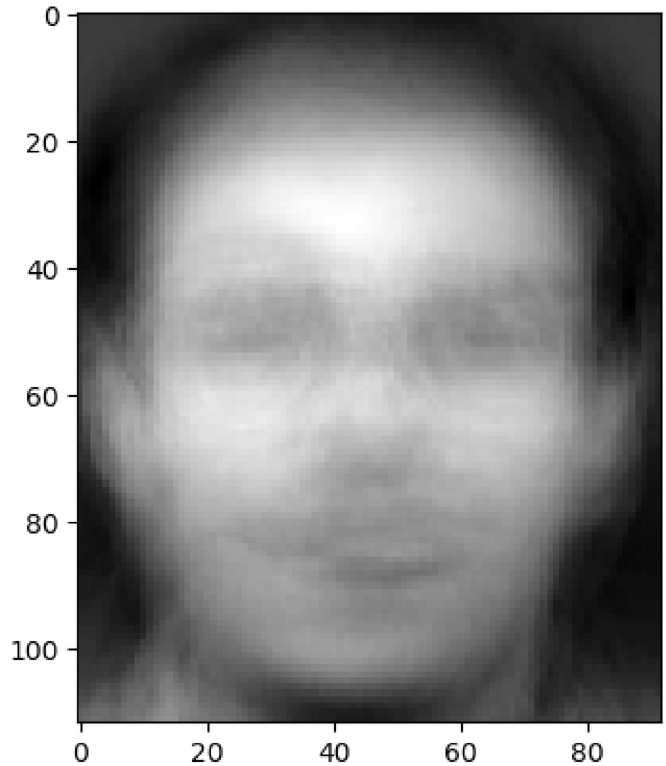
1.1 SVD

The left singular vectors of A are known in the literature as "eigenfaces". One can compress the dataset if the singular values decay rapidly enough.

- In the following block, compute a **thin** SVD of A and make a `semilogy` plot of the singular values.

The first singular value really stands out. Let's look at the leading eigenface.

```
In [12]: showface(-U[:,1]);
```



This is essentially the average face again. (You may have to change the sign of the vector to see it properly.)

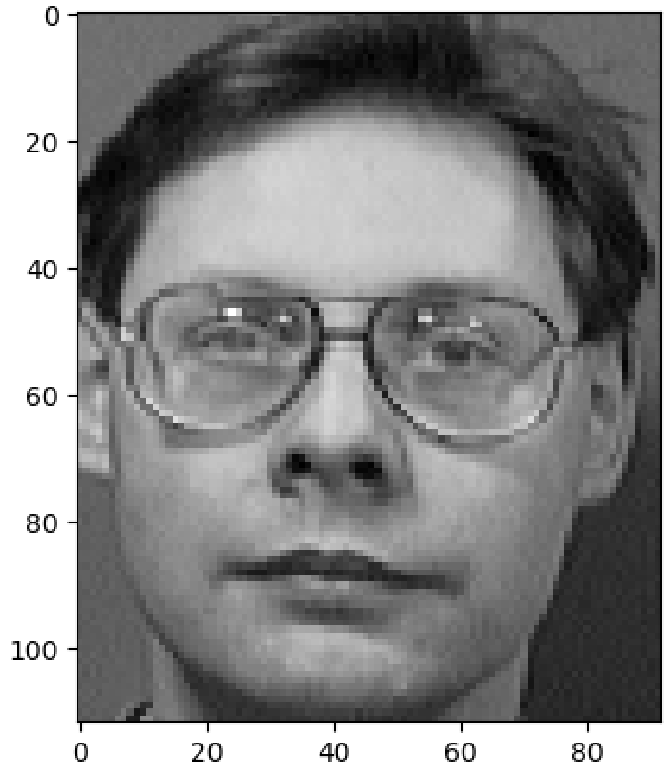
- In the following block, plot the next 3 eigenfaces side by side. They should be roughly facelike.

1.2 Least squares approximation

Here is a *very* primitive facial recognition algorithm. Given a new image, find its least-squares approximation using the data set. Take a norm of all coefficients that belong to one subject at a time. The subject with the largest norm is the identity.

Let's import an image from one of the unused poses of a selected subject.

```
In [8]: p = setdiff(1:10,poses)[1]   # new pose
        B = imread("../attfaces/s$(subjects[1])/$p.png")
        b = vec(B);
        showface(b);
```



- In the following block, solve the least squares problem $Ax \approx b$ for x. On one graph, plot the coefficients in x corresponding to the selected subject in one color, and the rest of the coefficients in another color.

- In the following block, take the 1-norm of the coefficient subvector corresponding to each of the 20 subjects. Does the algorithm get the ID right?

- Using only the columns of A corresponding to the correct subject, plot the linear combination that best approximates the "new" face b. (In other words, the projection of b onto the space spanned by those columns.)