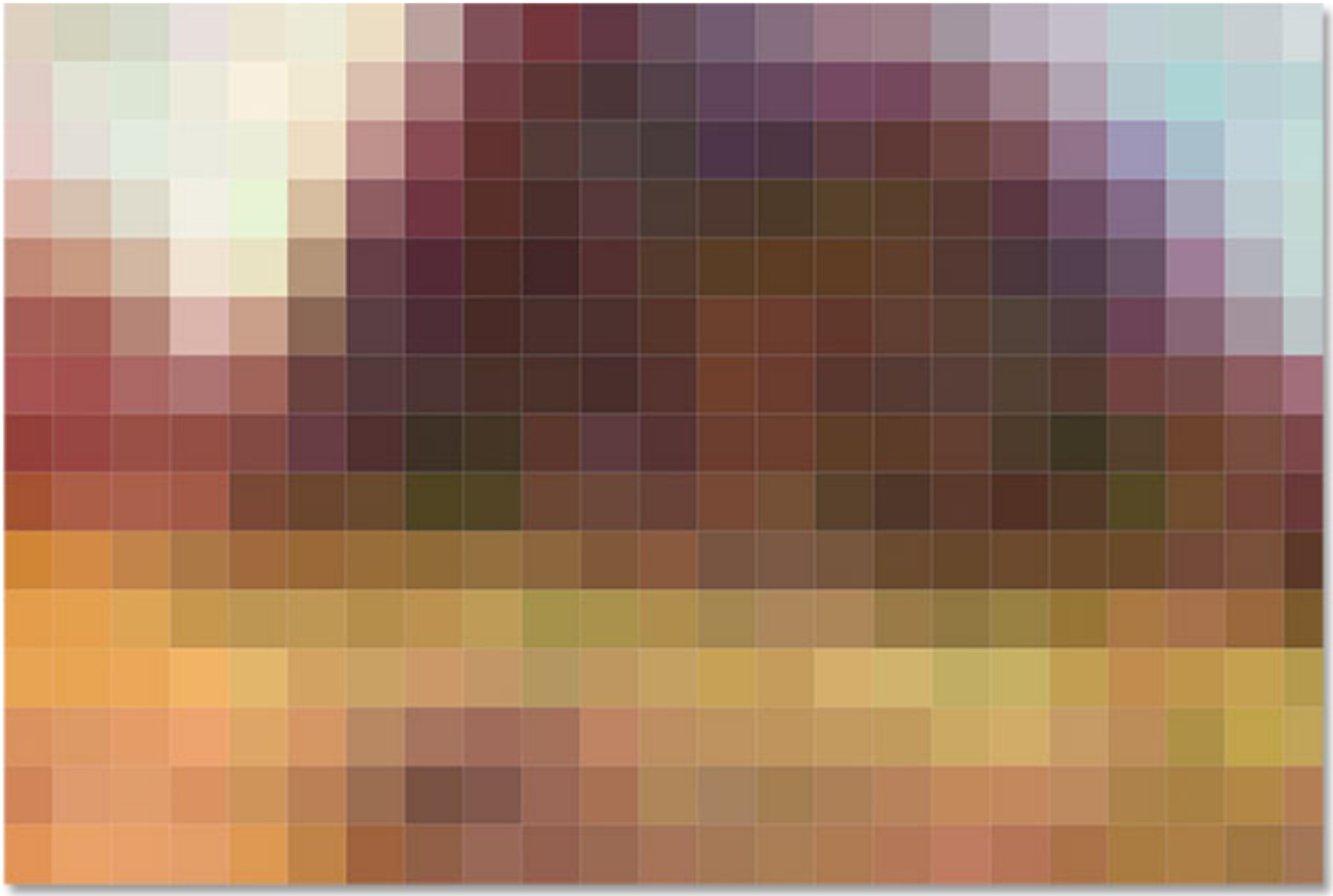
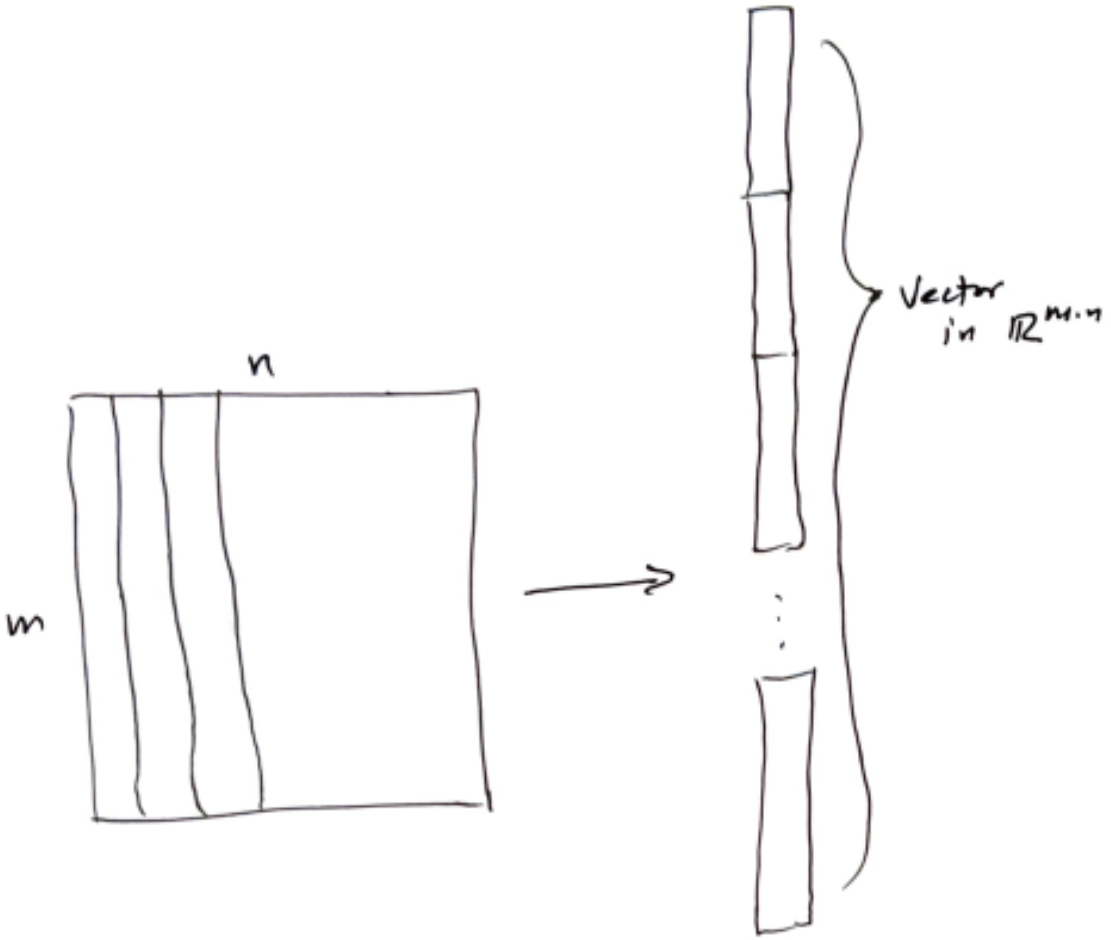
Photos to Linear Algebra



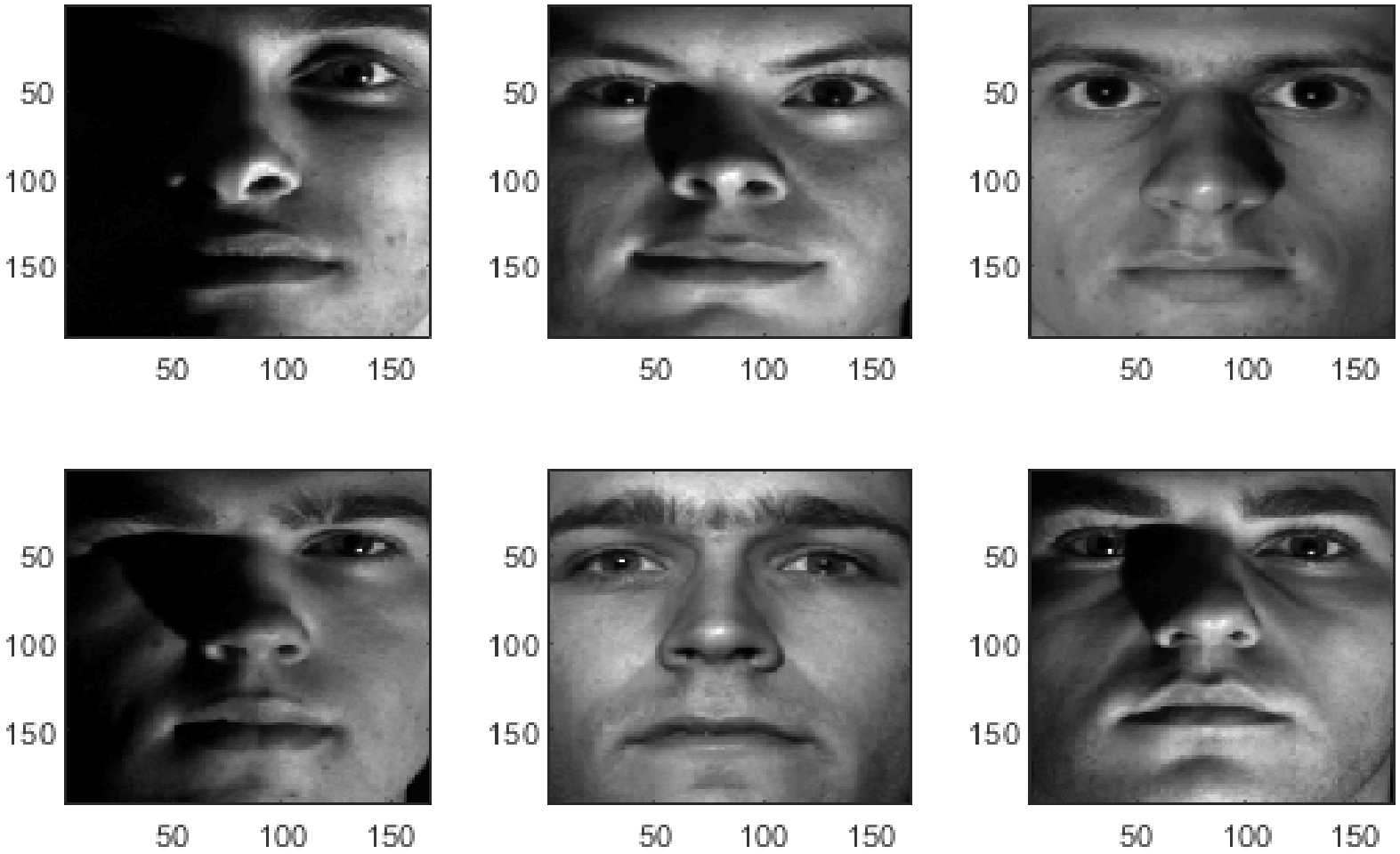
A close-up view of image pixels, each displaying a single color.

A photo can be re-constructed as a column vector by concatenating the columns:



The Data

The Yale Faces Database



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- X is 32256×2282

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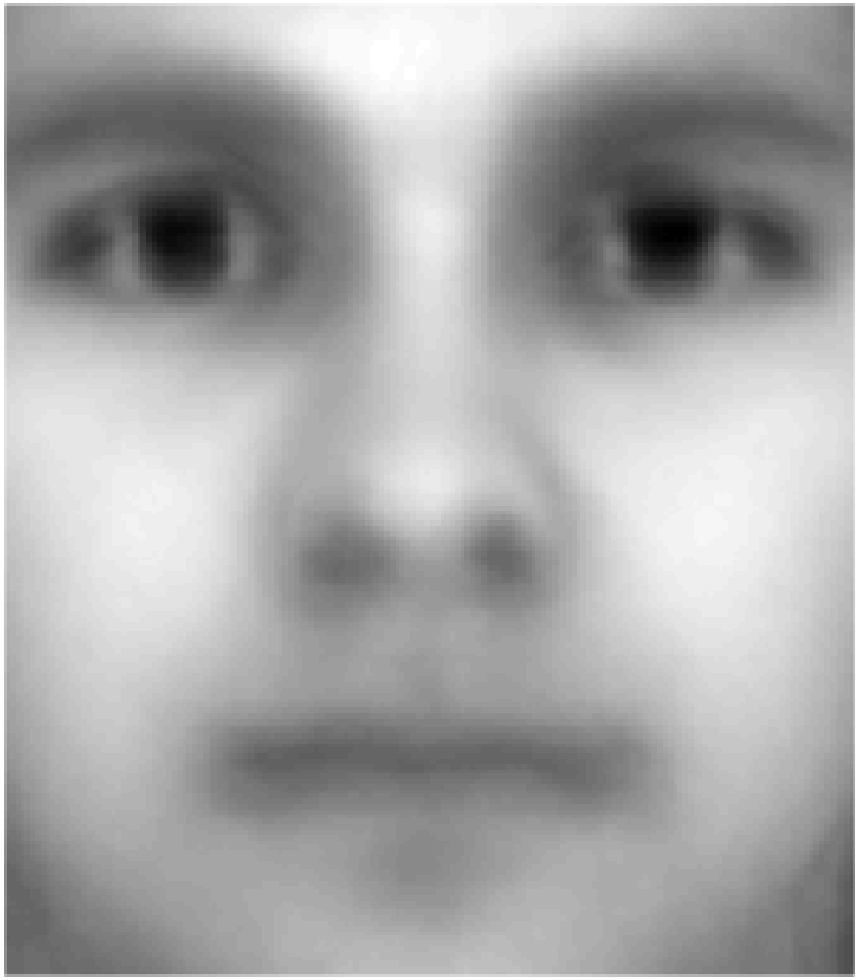
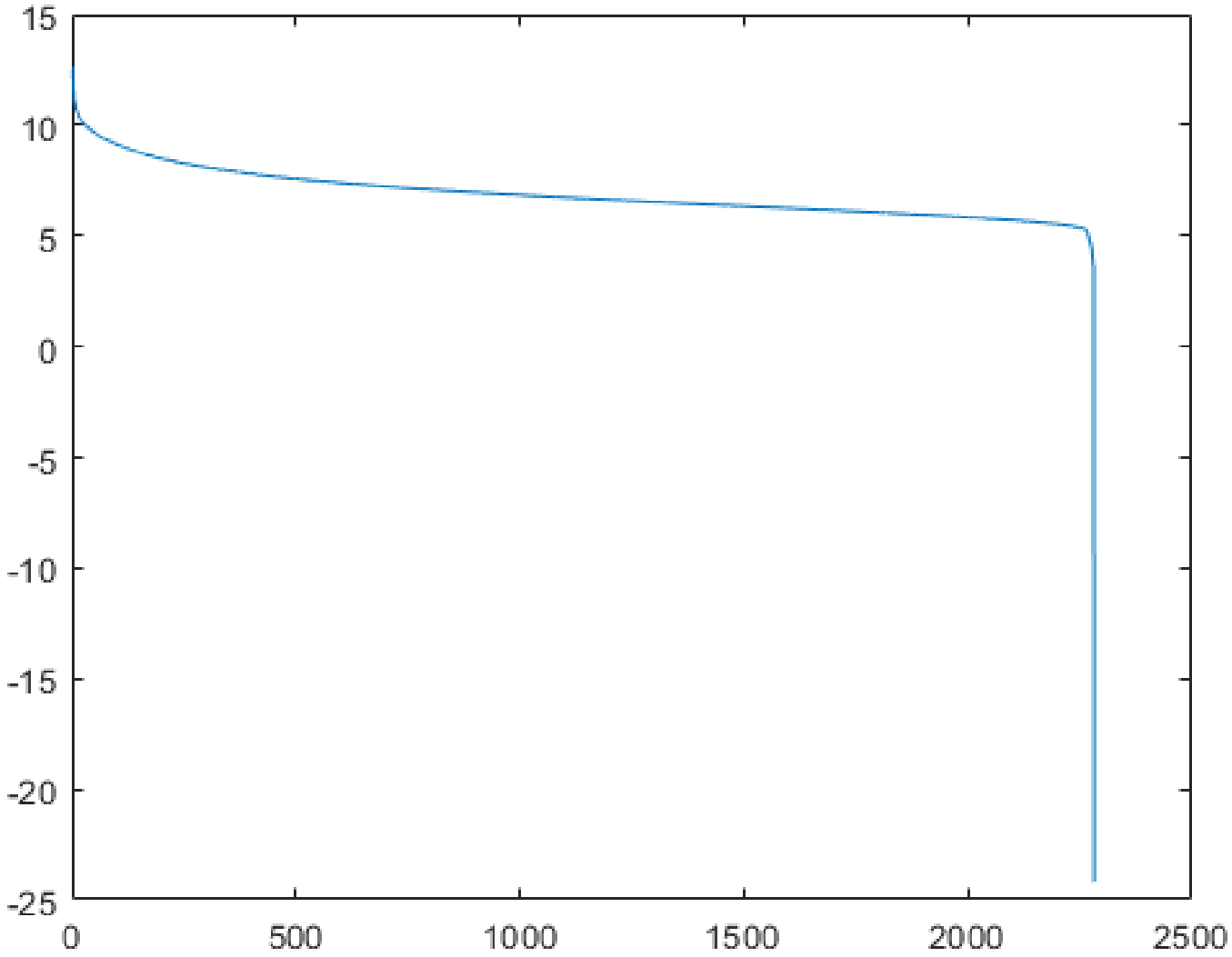
- What is the dimension of the space?
- Left singular vectors (in U) form a basis in $\mathbb{R}^{32256}$
- Every vector in $\mathbb{R}^{32256}$ can be visualized as a 192×168 image- What do these vectors look like?

The Mean



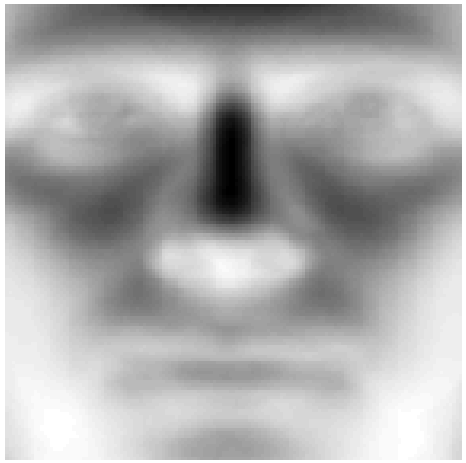
The Singular Values



Big drop at approx 2262.

First Four Eigenfaces

First Four Eigenfaces (Photo negative)



Experiment 1

Project the poses from Persons 2 and 7 into the plane formed by basis vectors 5 and 6.

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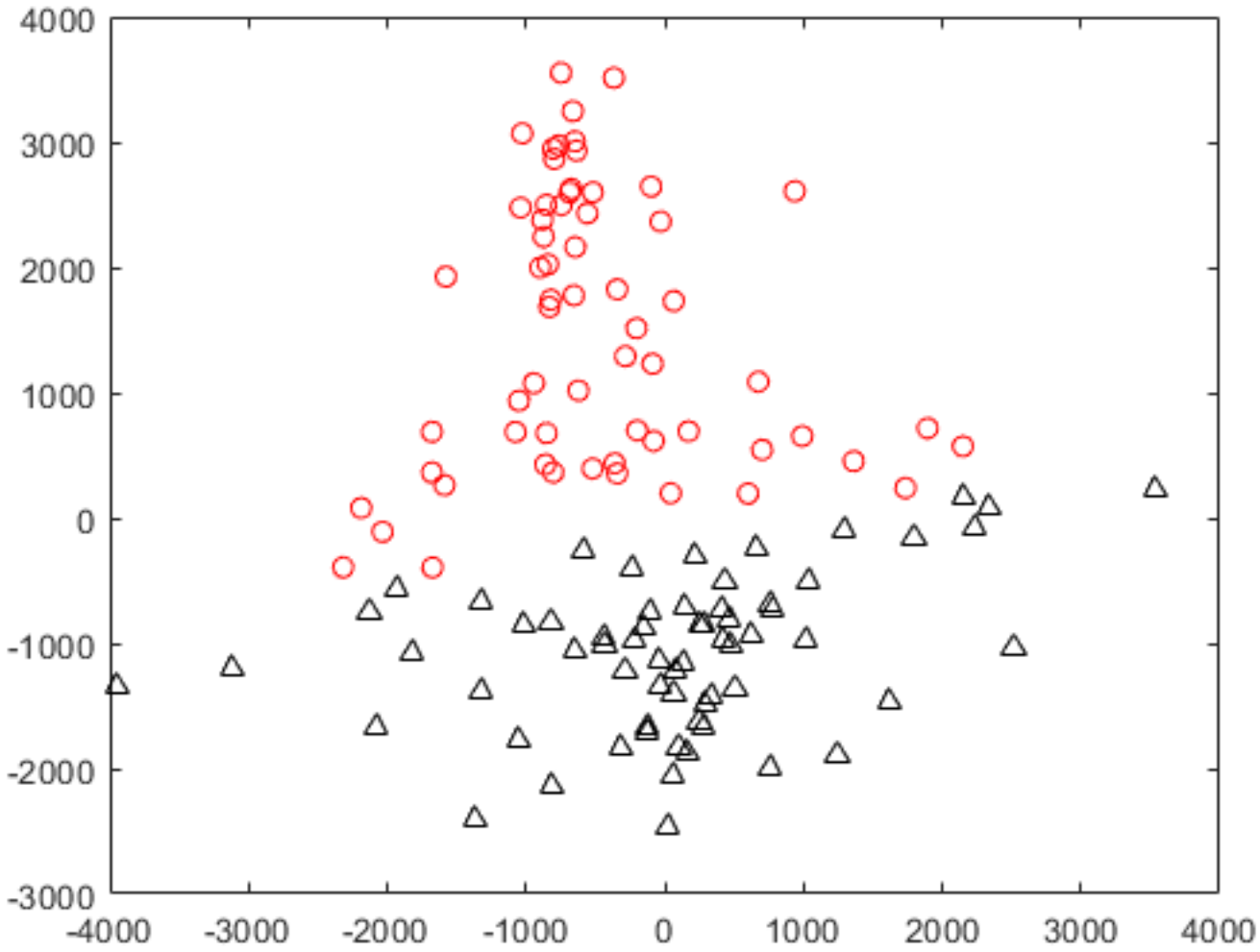
If Xf is the matrix of faces, 32256×128, then the matrix below is what size?

```
U1=U(:,5:6);
Coords=U1'*Xf;
```

Plot



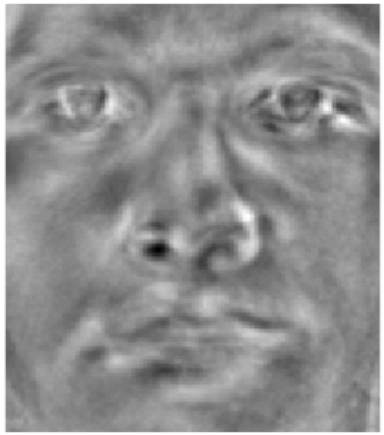
(Red circles = Person 2, Black triangles - Person 7)

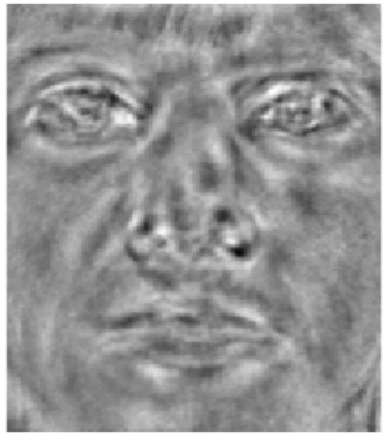
Person 2, 7 and Eigenface 5

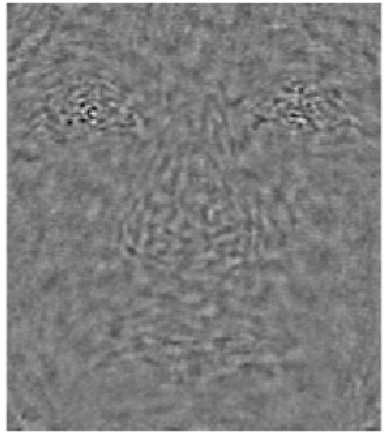
Can Person 38 be adequately represented by the basis constructed for the first 36 persons?

(See GIF animation)

Basis vectors: 100, 200, 500, 1000







Eigenfaces For Face Recognition

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Some large databases have used 100-200 basis vectors. Assume 100.

Photo in $\mathbb{R}^{32256}$ becomes a vector in $\mathbb{R}^{100}$.

To compare faces, compute the distance in 100-dimensional space. Closest face is the "winner".

"Eigenfaces" began in 1987 (Sirovich and Kirby). Turk and Pentland (1990s) extended the idea.

Modern face recognition methods use biometrics instead of actual photographic features, but this gives a good idea of where it all started.

Mystery face reconstruction!
(See the GIF animation)