Eigenfaces & PCA

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Executive Summary

1. PCA
2. Intro to Facial Recognition
3. Eigenfaces
4. Results
5. Other Methods & Applications
6. Summary

1
PCA

PCA Review

What is PCA ?

Dimensionality reduction tool

Good for clustering & predictive analysis

Similar to Factor Analysis

Invented by Karl Pearson in 1901

How does PCA work?

Performed on a square symmetric matrix such as a covariance matrix

Based on orthogonal projections

Requires centering

Uses eigenvalue decomposition

Each subsequent principal component maximizes the proportion of remaining variance explained

Connecting PCA and SVD

- PCA is equivalent to finding eigenvalues of a covariance matrix
- Covariance(A) = $A^TA=\Sigma$
- SVD of A = $U\Sigma V^T$
- Then U is an orthogonal projection, known as the left singular values.
- U will be our eigenfaces (coming soon!)
- We have now avoided the need to calculate the covariance matrix

SVD MAKES PCA FASTER

(SOMETIMES)

2

Intro to Facial Recognition

> This recognition problem is made difficult by the great variability in head rotation and tilt, lighting intensity and angle, facial expression, aging, etc.

— Woody Bledsoe, Father of Facial Recognition, 1966

What is Facial Recognition?

- Facial Recognition is a category of biometric software that maps an individual's facial features mathematically and stores the data as a 'faceprint'.

Applications of Facial Recognition

Iphone

The latest Iphone X, released in 2017, uses facial recognition “Face ID” that allows your face to be your password.

Android

Android phones introduced the “Trusted Face” feature in 2014 with the release of Android Lollipop.

Snapchat

Snapchat uses facial recognition to allow its users to have cool filters on their face (dog ears filter).

Surveillance

Private intelligence agencies were using facial recognition in their surveillance as early as 1964.

Instagram

Copying Snapchat, Instagram started using facial recognition to also allow their users to have cool filters on their face.

Digital Cameras

Many digital cameras can recognize human faces that allow for clearer and better portrait photos.

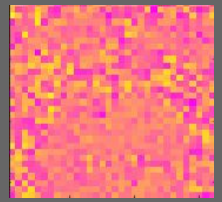
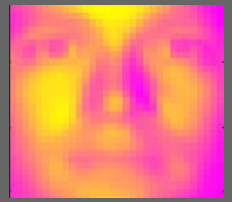
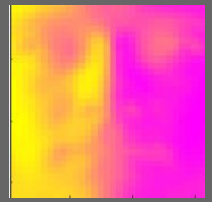
3

Eigenfaces

Background Information

We used Extended Yale Face Database B

- 32x32 Data file
- This contains faces and their labels
- 38 individuals
- 9 poses
- 64 different illuminations per individual.
- The eigenfaces are the PCs of this dataset

$= C_1$  $+ C_2$  $+ C_3$  $+ \ldots$

Any Face in Training Set (vector)

Eigenface 1 (vector)

Eigenface 2 (vector)

Eigenface 3 (vector)

Where $C_1, C\text{---}_2, \ldots, C_n$ are constants

Eigenfaces

What

Eigenfaces are eigenvectors used to help computers perform facial recognition. Eigenfaces form a basis for the set of all training images.

Why

There is a need for low dimensional representation for faces. Eigenfaces decrease required computation time for facial recognition.

How

Eigenvectors are derived from the covariance matrix of the probability distribution over the high-dimensional vector space of face images.

Steps to find the Eigenfaces

Step 1: To create a set of eigenfaces one must first prepare a training set of face images.

Step 2: Centering (subtracting the mean).

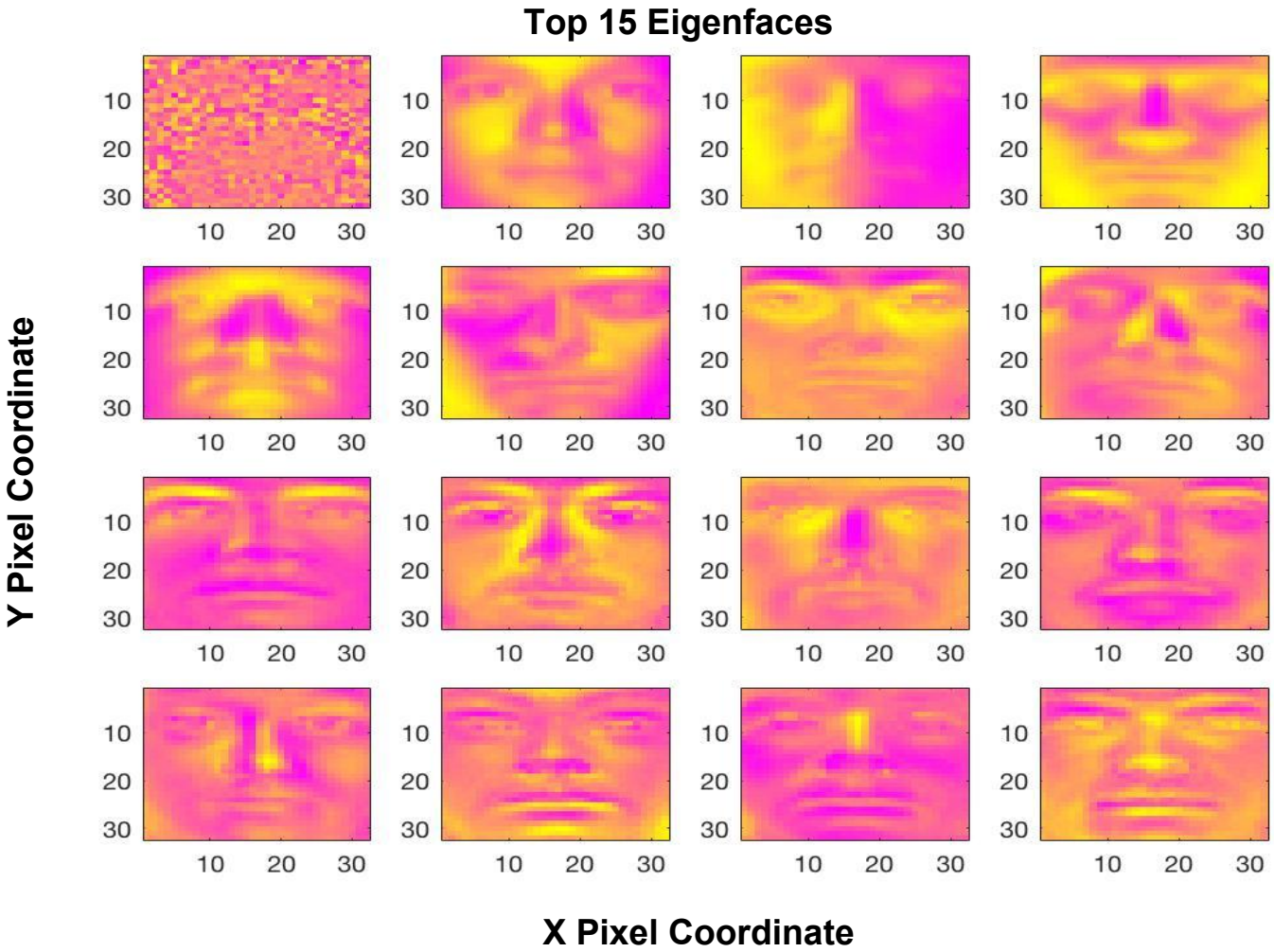
Step 3: Calculate the eigenvectors and eigenvalues of the covariance matrix.

Step 4: Choose the principal components. Sort the eigenvalues in descending order and arrange eigenvectors accordingly. The number of principal components k is determined arbitrarily by setting a threshold ε on the total variance. Total variance {\displaystyle v=n\cdot (\lambda _{1}+\lambda _{2}+...+\lambda _{n})}, n = number of data images by

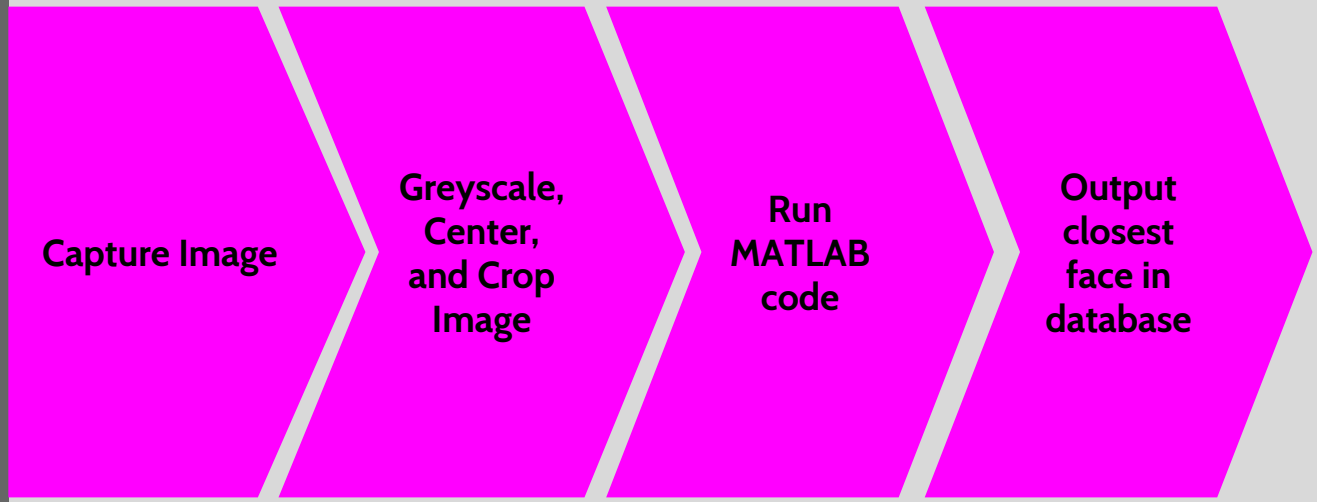
Step 5: k is the smallest number satisfies :{\displaystyle {\frac {n(\lambda _{1}+\lambda _{2}+...+\lambda _{k})}{v}}>\epsilon }

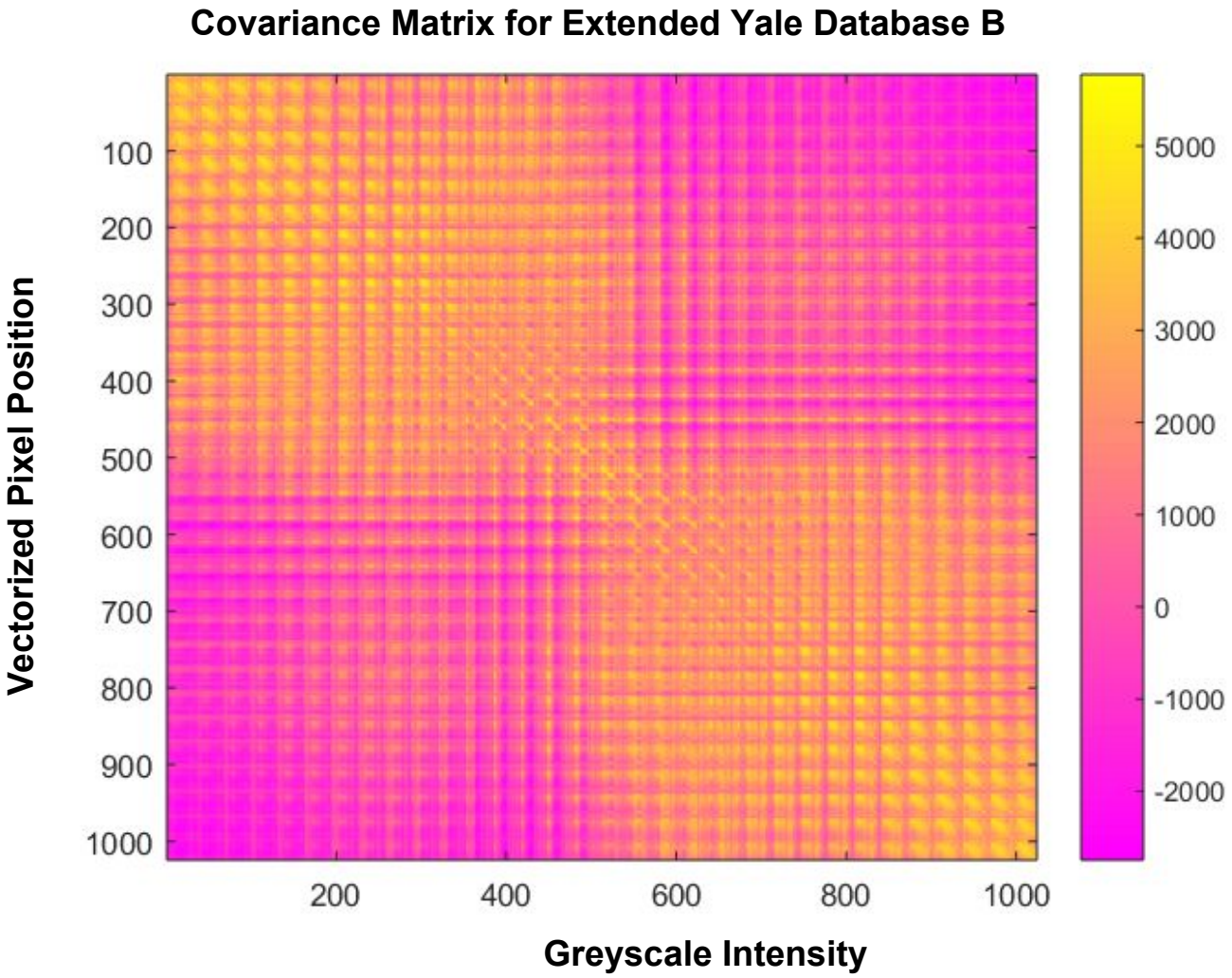
4

Results


Top 15 Eigenfaces
Y Pixel Coordinate
X Pixel Coordinate
10
20
30

Our process


Capture Image
Greyscale, Center, and Crop Image
Run MATLAB code
Output closest face in database


Covariance Matrix for Extended Yale Database B
Vectorized Pixel Position
100
200
300
400
500
600
700
800
900
1000
200
400
600
800
1000
Greyscale Intensity
5000
4000
3000
2000
1000
0
-1000
-2000

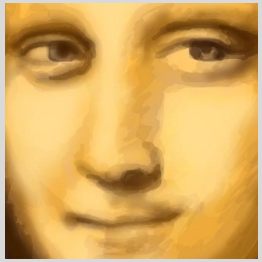
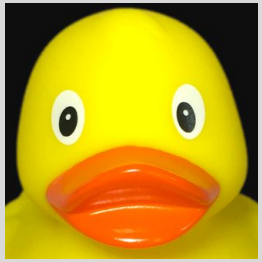
1.33 Seconds

for computing eigenfaces with a covariance matrix

1.86 Seconds

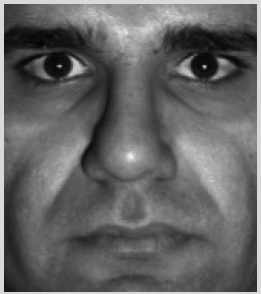
for computing eigenfaces with singular value decomposition

Guess Who?

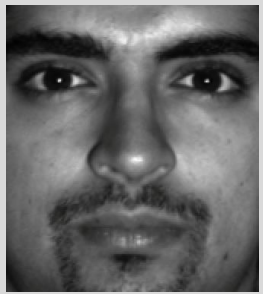



Error: 1364

Error: 1041

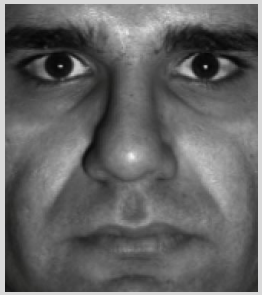


Error: 809



Error: 1101

Error: 1874



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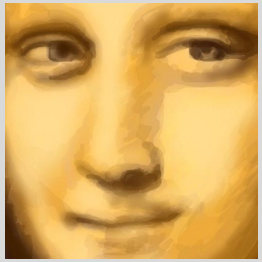
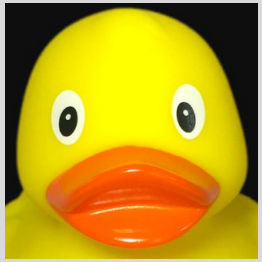

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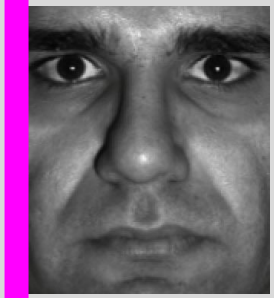

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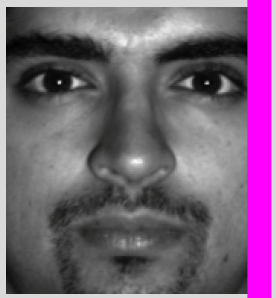

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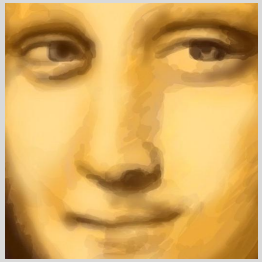
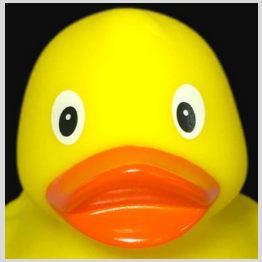

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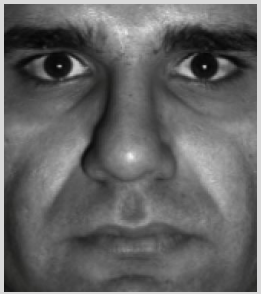

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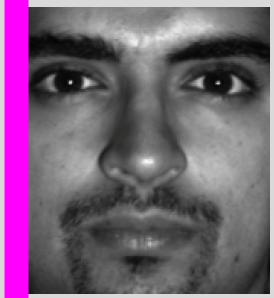

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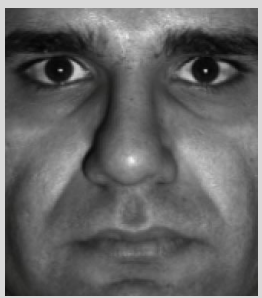


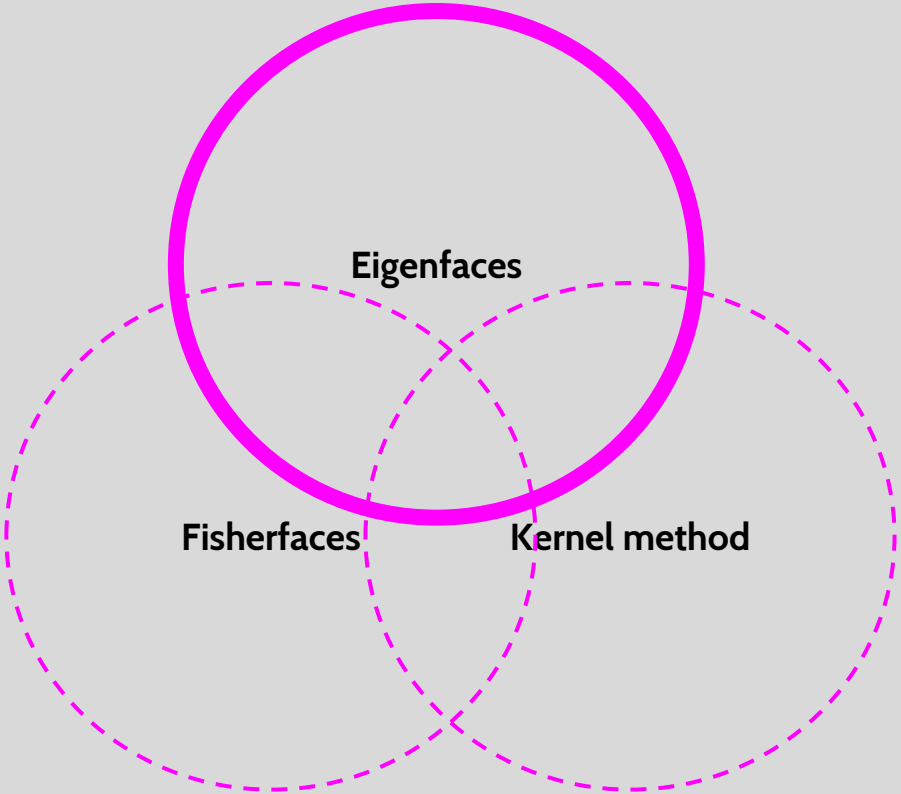
Limitations

- Faces must be very well centered and adjusted for accurate results
- Small training set
- Need more data to set error bounds e1, and e2
- Not much racial diversity in the training set

5

Other Methods & Applications

Methods for Facial Recognition



6

Summary

Final Summary

- SVD improves PCA
- Facial Recognition has many applications
- Eigenfaces form a basis for a set of faces
- Eigenface algorithm can find closest face
- Eigenfaces, Fisherfaces, and Kernel method all do facial recognition

“

One is never alone with a rubber duck.

- Douglas Adams

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1

Transition headline

“

Quotations are commonly printed as a means of inspiration and to invoke philosophical thoughts from the reader.

This is a slide title

- Here you have a list of items
- And some text
- But remember not to overload your slides with content

Your audience will listen to you or read the content, but won’t do both.

BIG CONCEPT

Bring the attention of your audience over a key concept using icons or illustrations

You can also split your content

White

Is the color of milk and fresh snow, the color produced by the combination of all the colors of the visible spectrum.

Black

Is the color of coal, ebony, and of outer space. It is the darkest color, the result of the absence of or complete absorption of light.

In two or three columns

Yellow

Is the color of gold, butter and ripe lemons. In the spectrum of visible light, yellow is found between green and orange.

Blue

Is the colour of the clear sky and the deep sea. It is located between violet and green on the optical spectrum.

Red

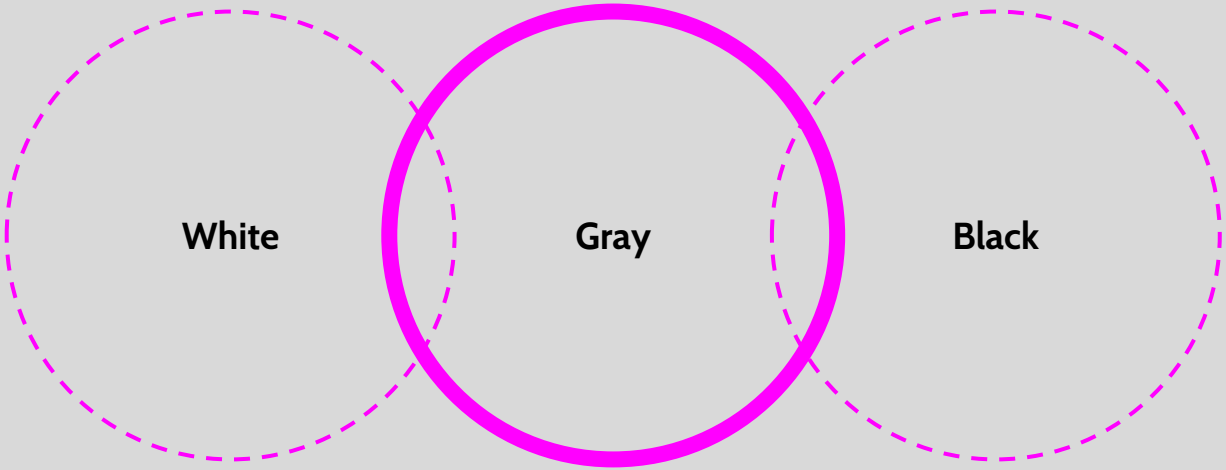
Is the color of blood, and because of this it has historically been associated with sacrifice, danger and courage.

A picture is worth a thousand words

A complex idea can be conveyed with just a single still image, namely making it possible to absorb large amounts of data quickly.

Want big impact?
Use big image.

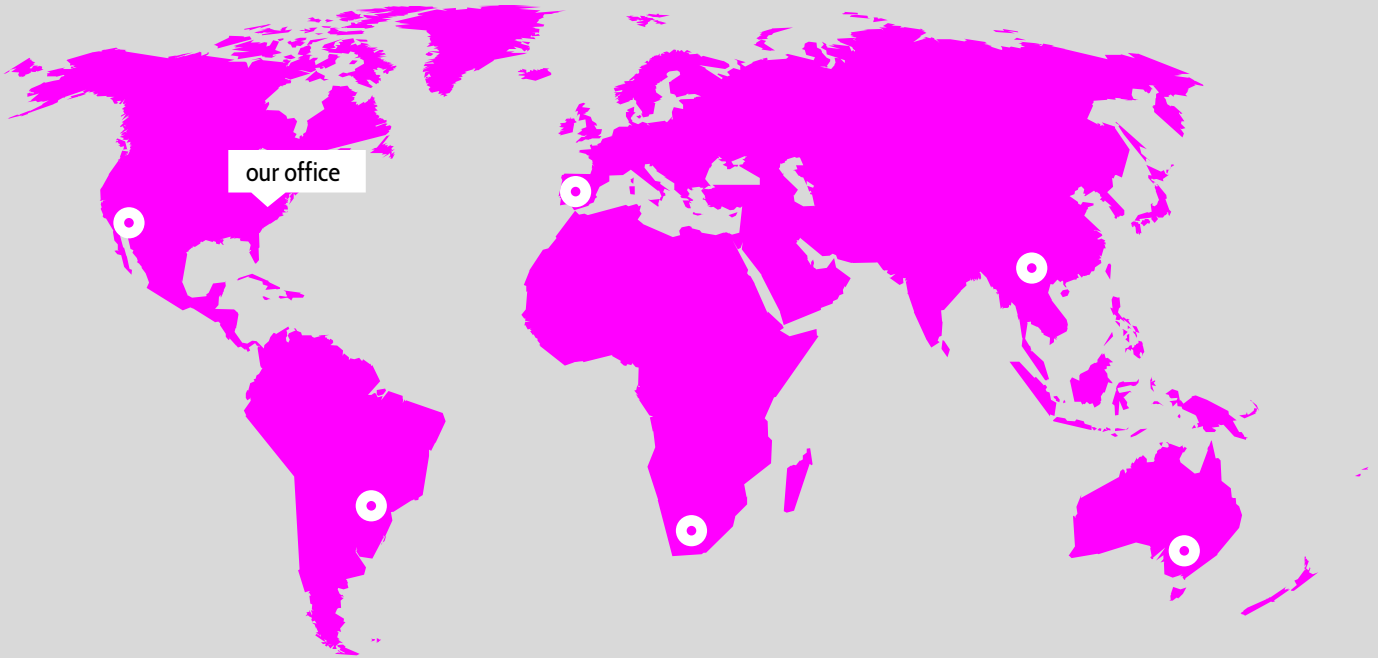
Use charts to explain your ideas



And tables to compare data

	A	B	C
Yellow	10	20	7
Blue	30	15	10
Orange	5	24	16

Maps



89,526,124

Whoa! That’s a big number, aren’t you proud?

89,526,124$

That's a lot of money

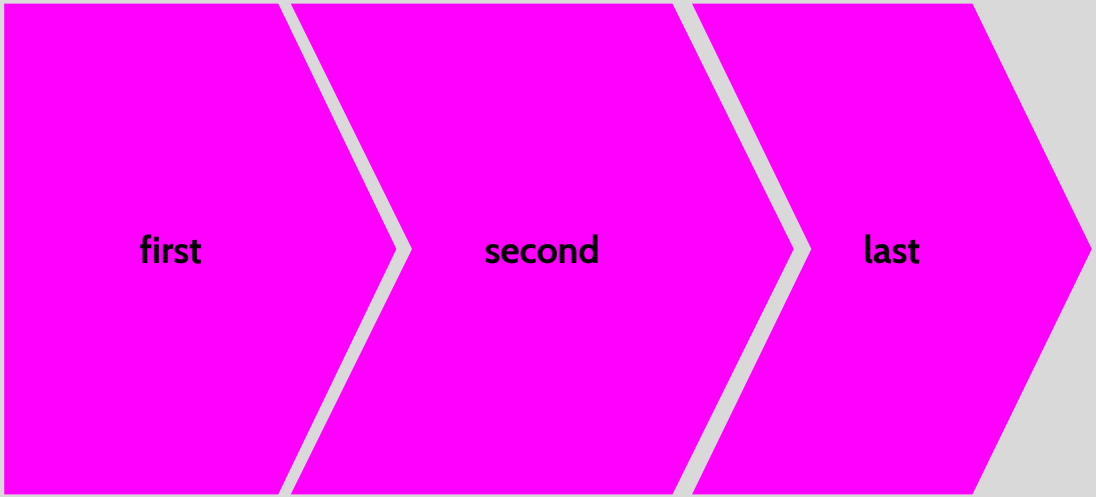
185,244 users

And a lot of users

100%

Total success!

Our process is easy



Let’s review some concepts

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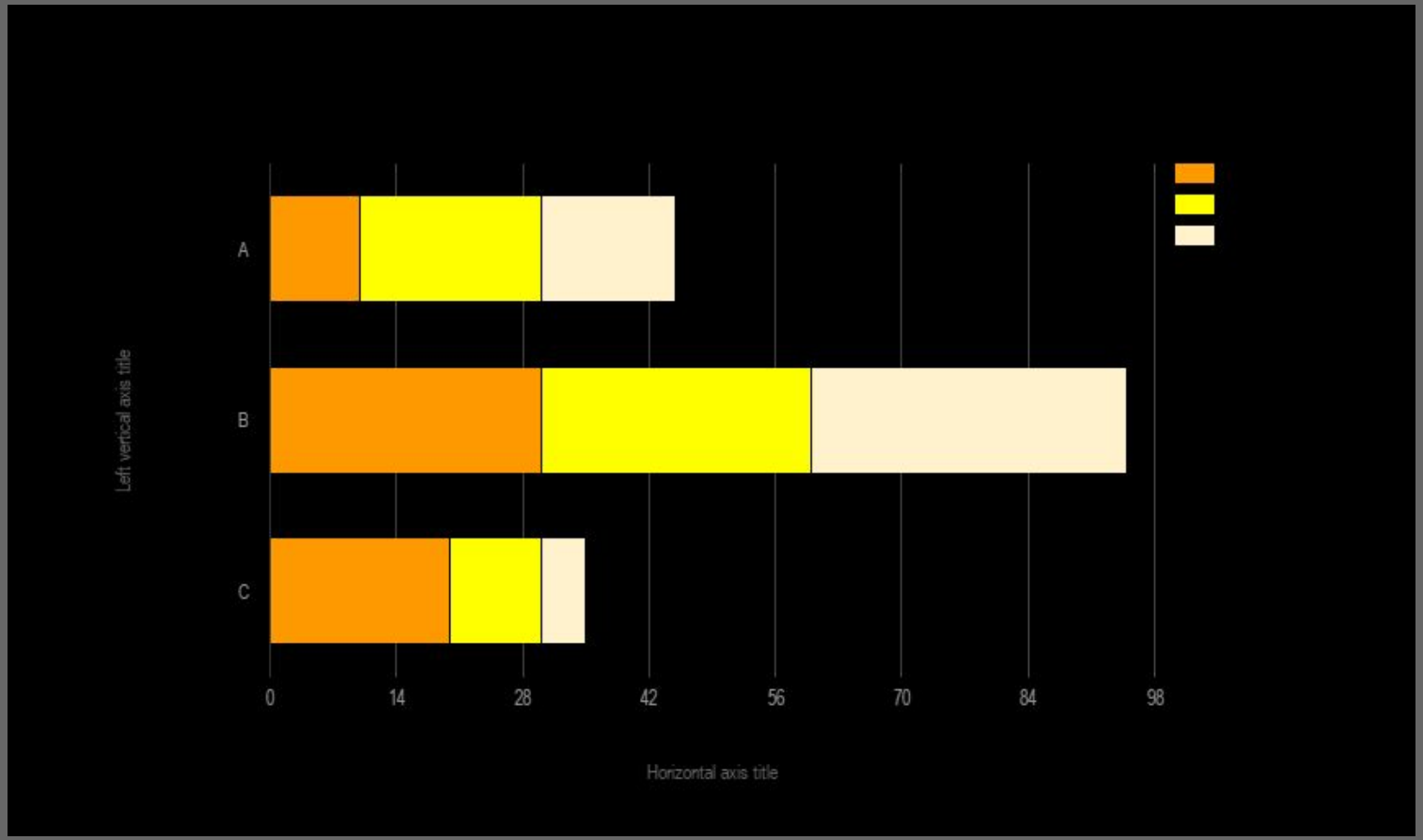

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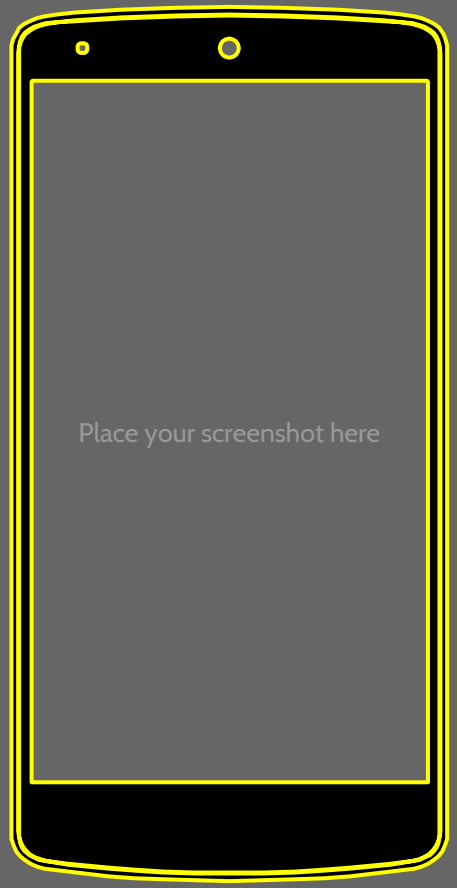

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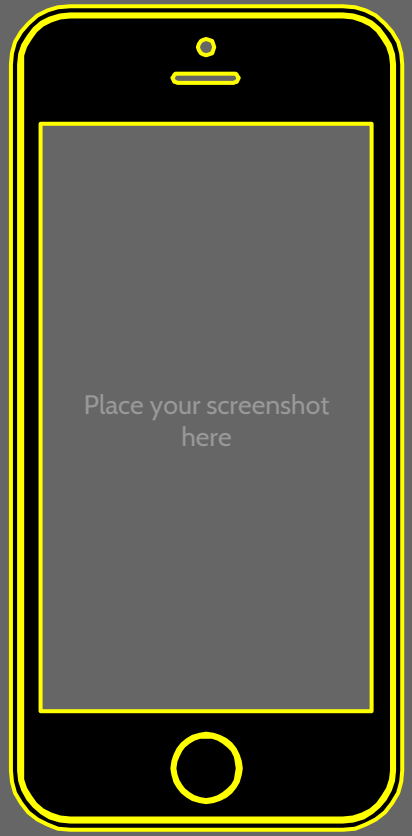

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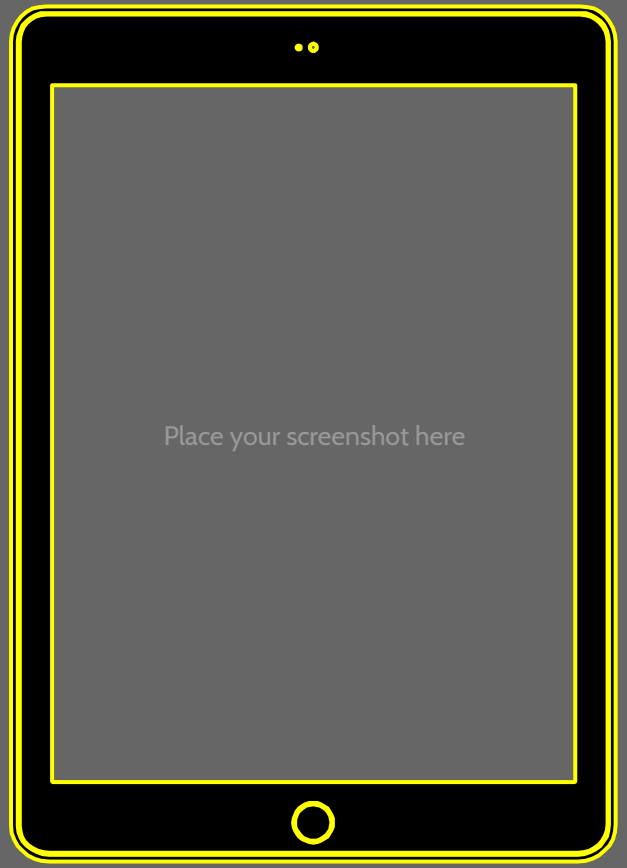

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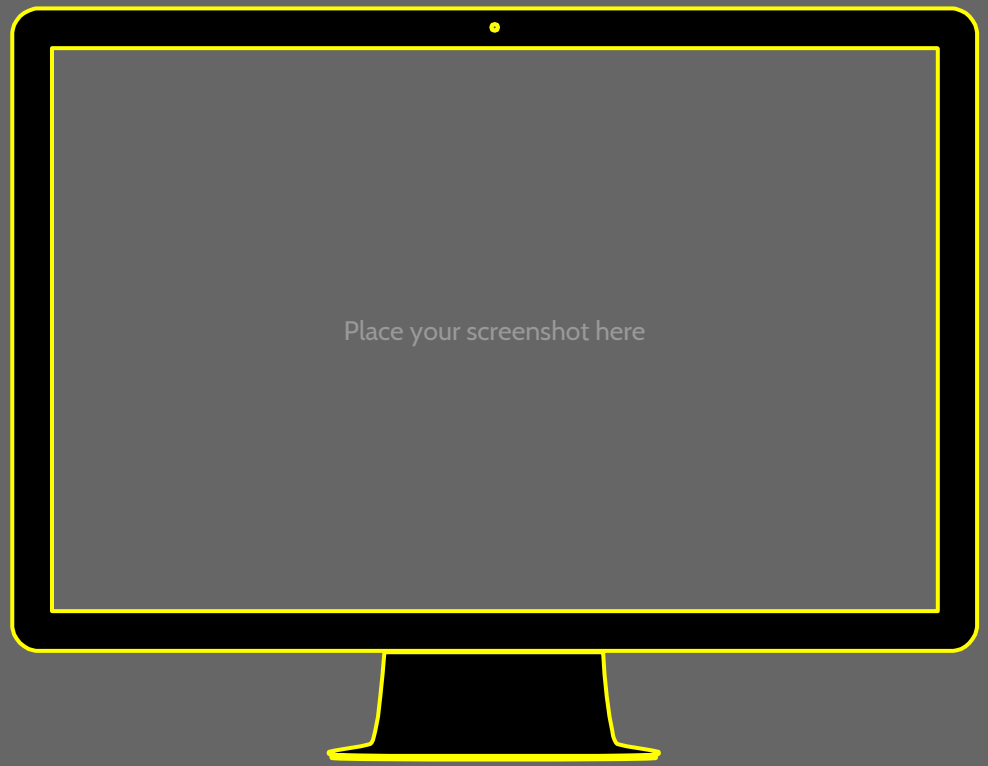

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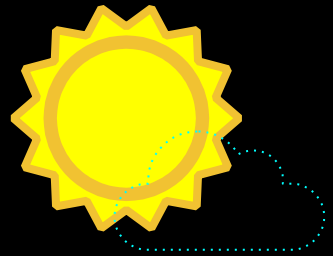

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