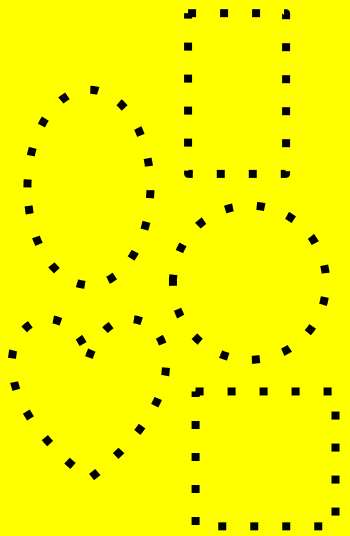
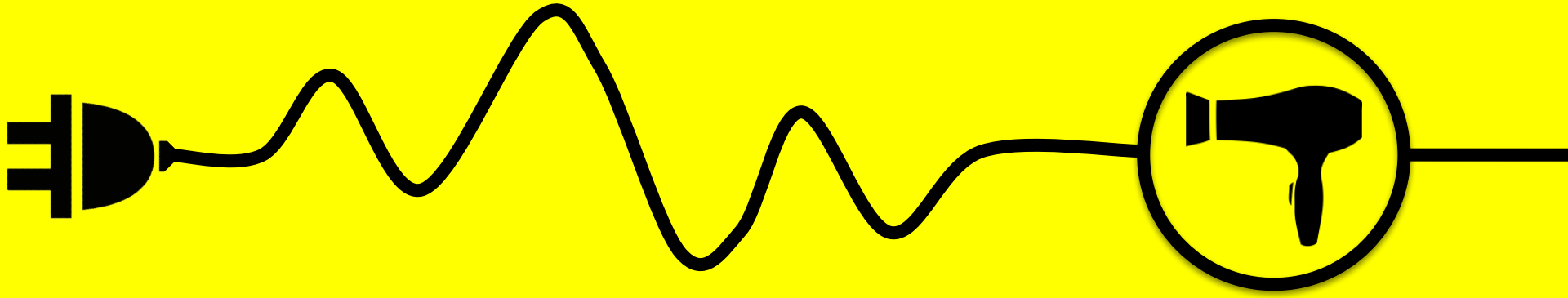
Automated Face Shape Detection & Hair Style Recommender



Marnie Boyer 12.08.2017

Purpose:

The $20B hair care industry has the opportunity to evolve and differentiate to meet the needs of today's high-tech, on-the-move women. Hair salons that appeal to these high-earning women must satisfy them by offering a differentiating level of service. With this project, I will attempt to address this challenge by developing a **hairstyle recommendation system** that identifies the user's face shape and **recommends** the most flattering hair style.

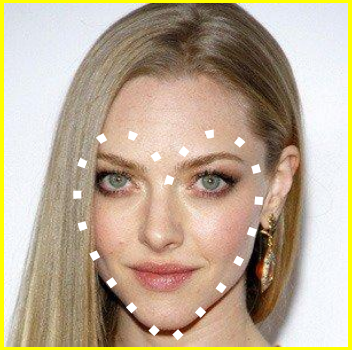


Women spend on average $55,000 in their lifetime on their hair. Each week, they spend over 2 hours on styling and caring for their hair.

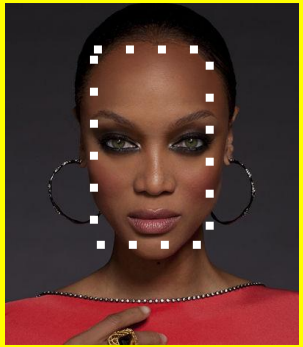
Source: https://us.lookfantastic.com/blog/uncategorised/the-hair-habits-of-american-women/

There are five main face shapes often cited on websites and in style magazines. These shapes can be used to find the most flattering hair styles.

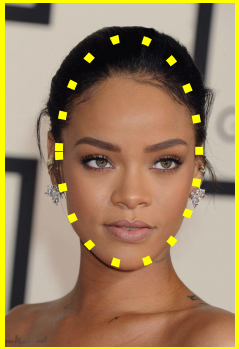
Heart



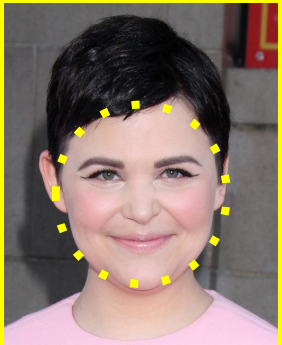
Long



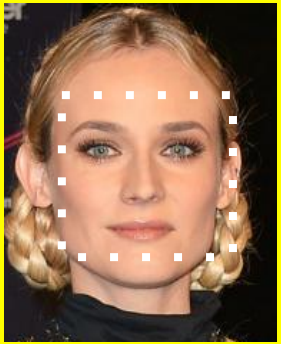
Oval



Round



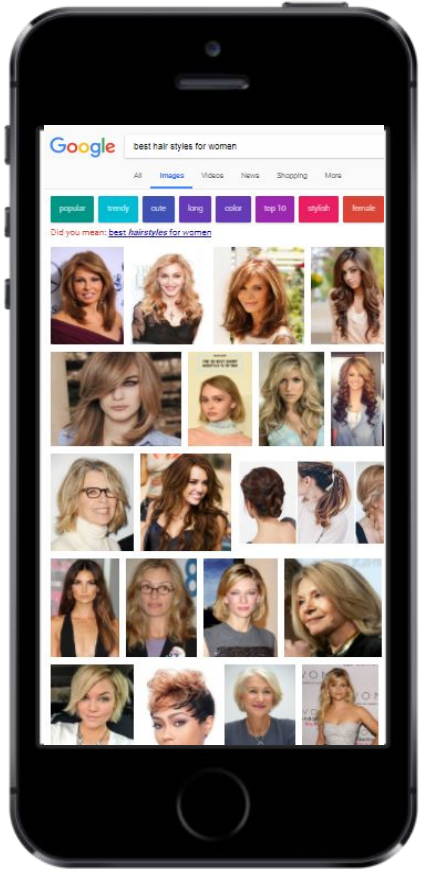
Square



Meet Jacquelyn

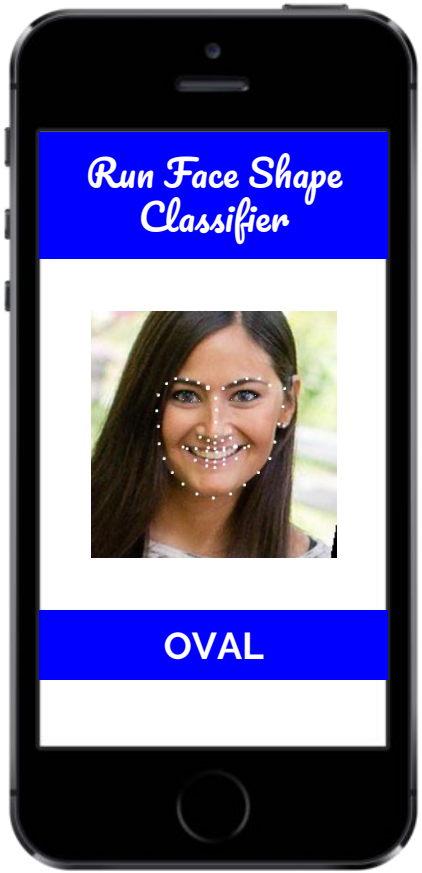
She's a new mom and successful journalist. Her company has purchased a table at this year's USO Gala. With the rare opportunity to have a date night with her husband, Nick, Jacquelyn wants to look her best.

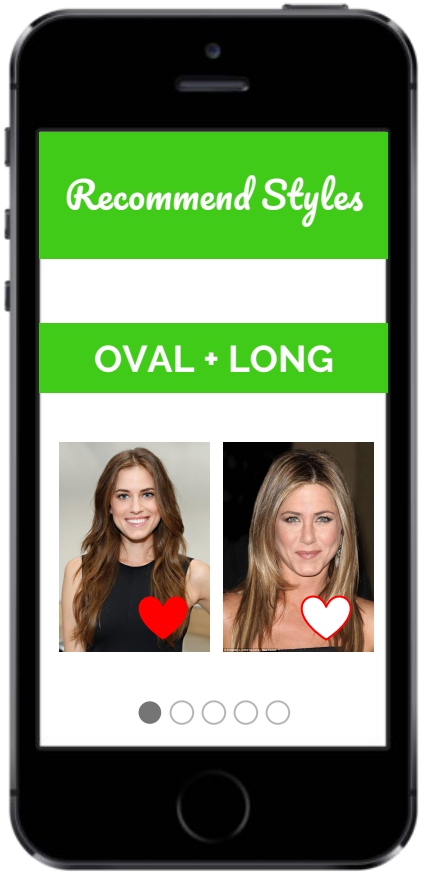
She makes an appointment with a salon on her mobile phone and starts searching online for flattering styles - in between diaper changes and deadlines!



Confronted with way too many choices, Jacquelyn decides to try the *What's Her Face* App.

What's Her Face

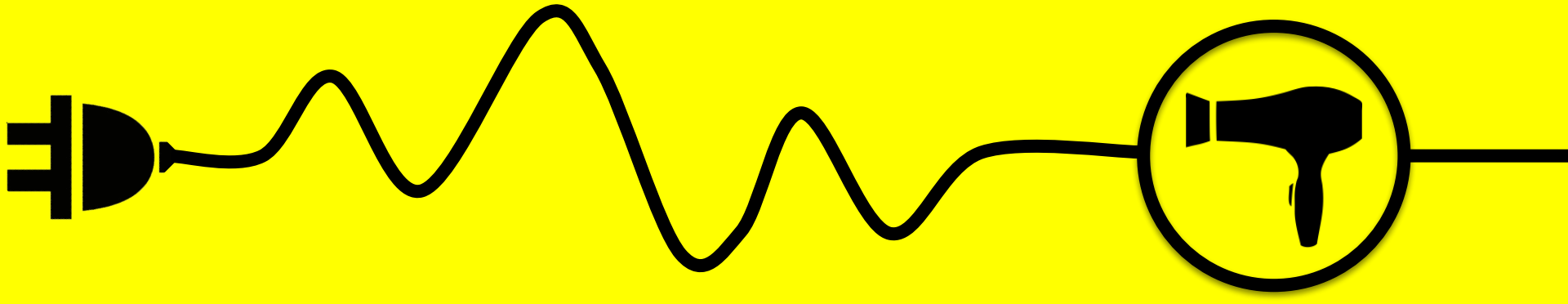




Jacqueline decides these **beachy waves** will be perfect for the night ❤️

Modeling Pipeline:

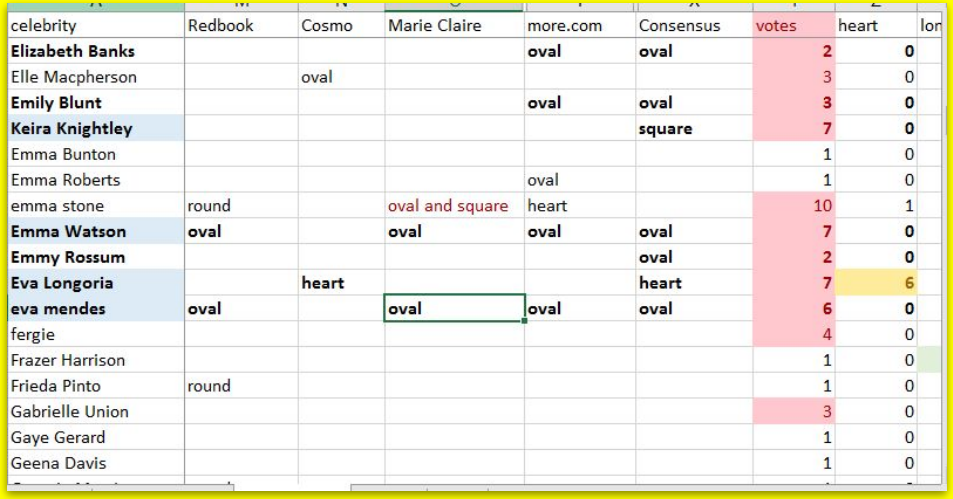
Collect Classified Image Samples → Feature Extraction and Generation → Split into Train/Test Datasets → Run models (MLP, KNN, RF, GB, LDA) → Develop Recommendation system



Dataset Collection

In order to develop a set of images labeled with the correct face shape, I turned to the experts in the fashion and style industry.

- ➔ **Reviewed 22 websites**
- ➔ **Identified 234 celebrities**



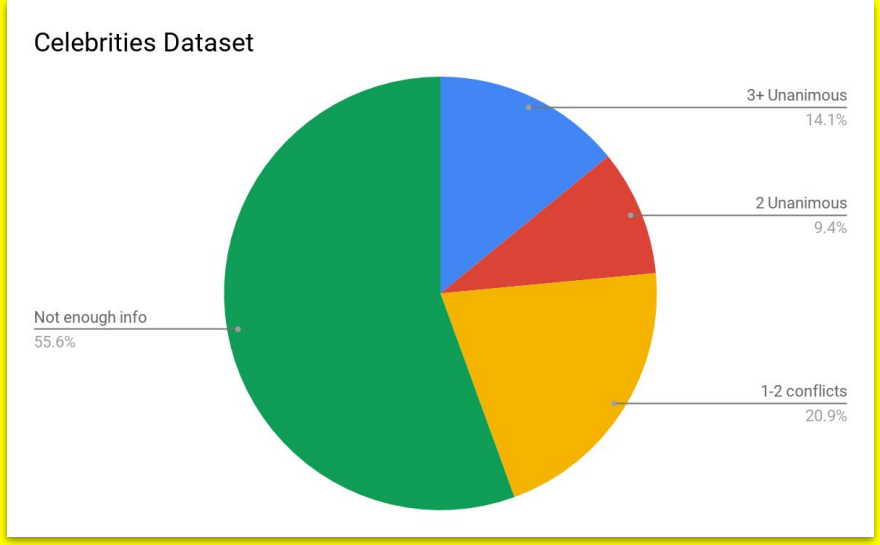
celebrity	Redbook	Cosmo	Marie Claire	more.com	Consensus	votes	heart	lon
Elizabeth Banks				**oval**	**oval**	**2**	**0**	
Elle Macpherson		oval				3	0	
Emily Blunt				**oval**	**oval**	**3**	**0**	
Keira Knightley					**square**	**7**	**0**	
Emma Bunton						1	0	
Emma Roberts				oval		1	0	
emma stone	round		oval and square	heart		10	1	
Emma Watson	**oval**		**oval**	**oval**	**oval**	**7**	**0**	
Emmy Rossum					**oval**	**2**	**0**	
Eva Longoria		**heart**			**heart**	**7**	**6**	
eva mendes	**oval**		**oval**	**oval**	**oval**	**6**	**0**	
fergie						4	0	
Frazer Harrison						1	0	
Frieda Pinto	round					1	0	
Gabrielle Union						3	0	
Gaye Gerard						1	0	
Geena Davis						1	0	

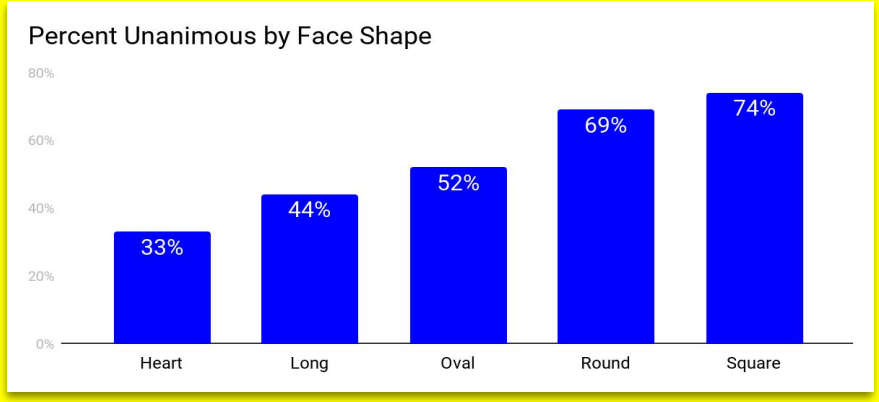
Dataset Validation

The classification of face shape is subjective. This project attempts to develop an approach to developing a method by which objective classifications can occur.

33 celebrities had a unanimous classification from 3+ sites (65 from 2+). 49 celebrities had one or two conflicting classifications but had strong consensus towards a face shape with which I could use to classify.

Square faced celebrities were the most agreed upon by the experts,





Collect Images:

Scrape Google Images to collect 100 images of each celebrity. Visually inspect to select appropriate images. Organize into folders by shape.

Processing Images

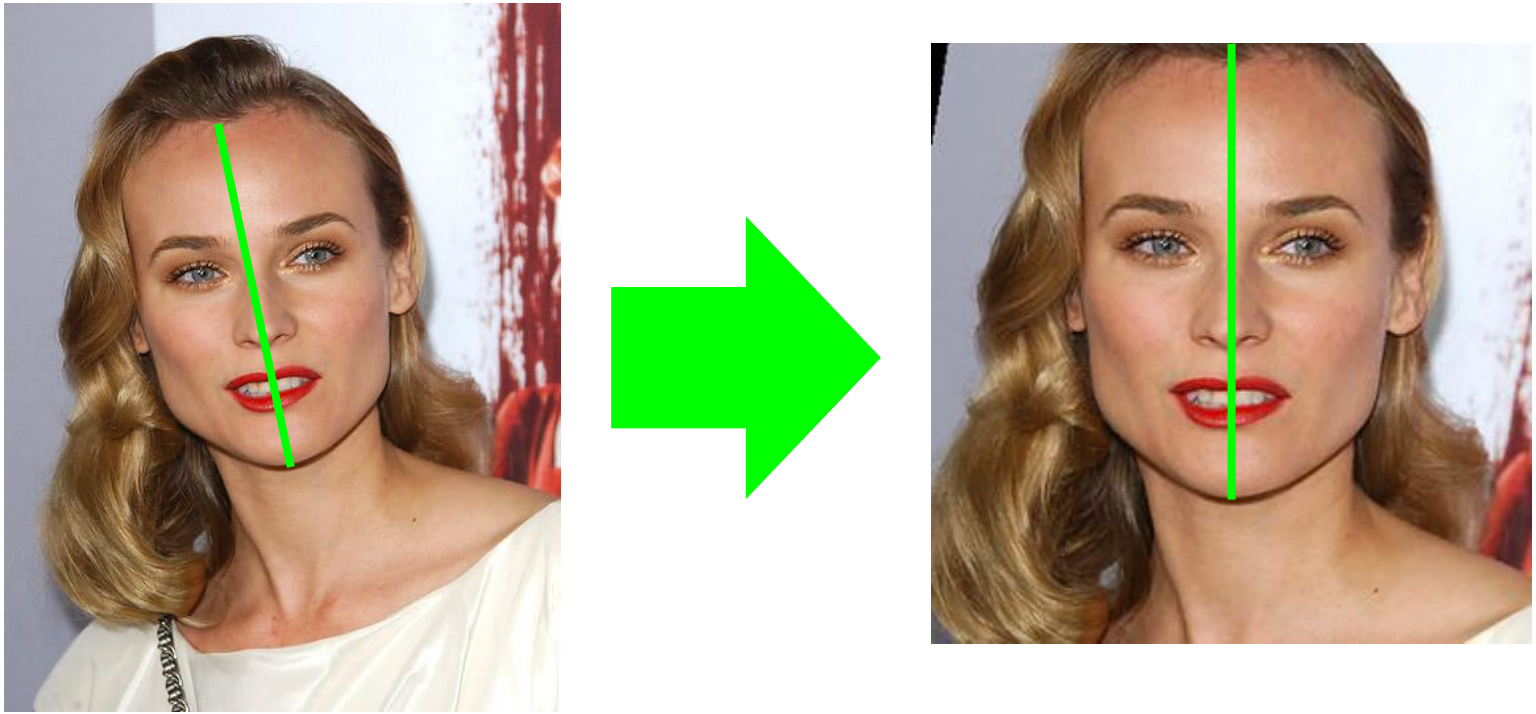
Identify facial features using the `face_recognition` package (dlib)

Rotate, align and crop images

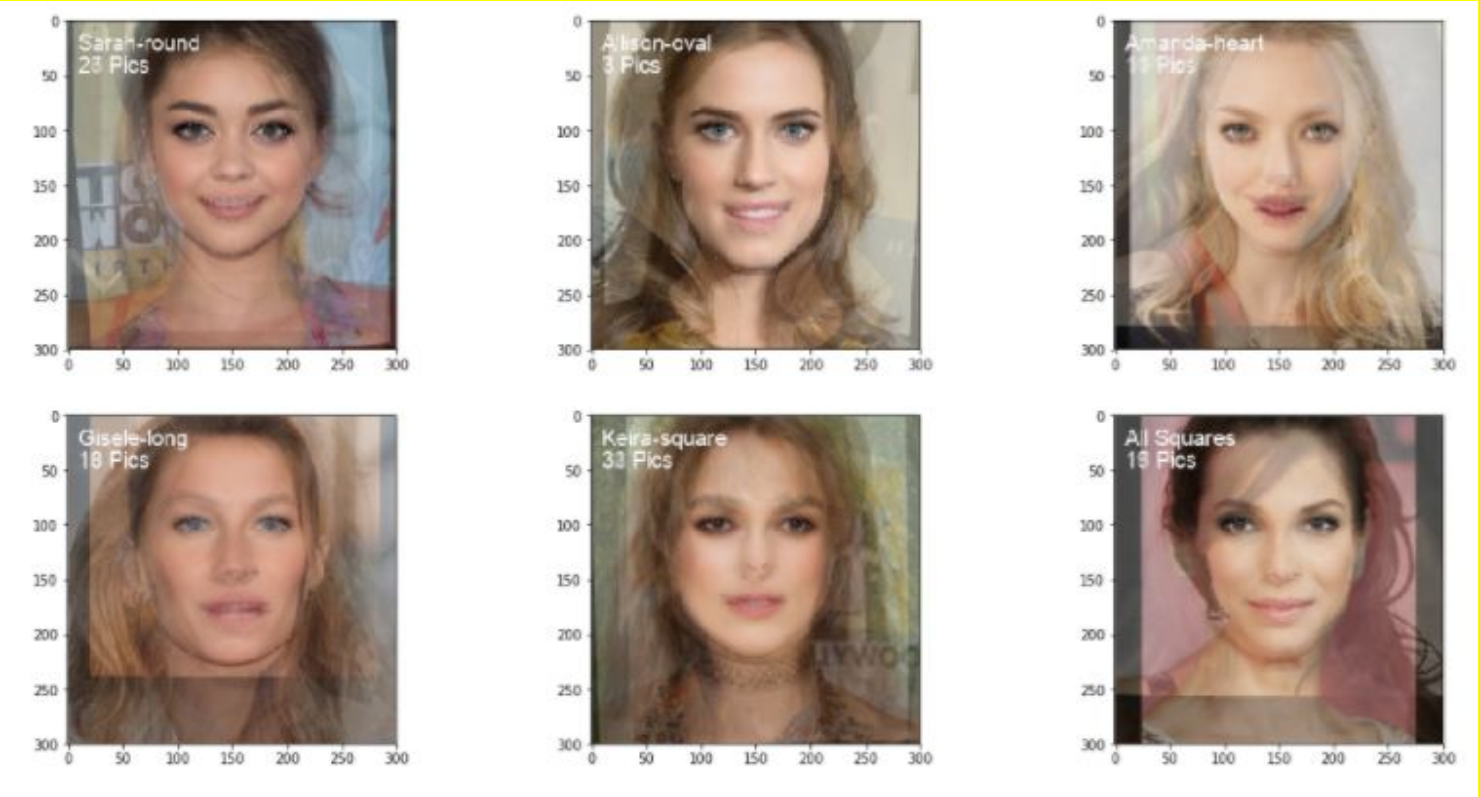
Generate features - points, angles, distances, and ratios

Execute process on image folders to develop dataframe.

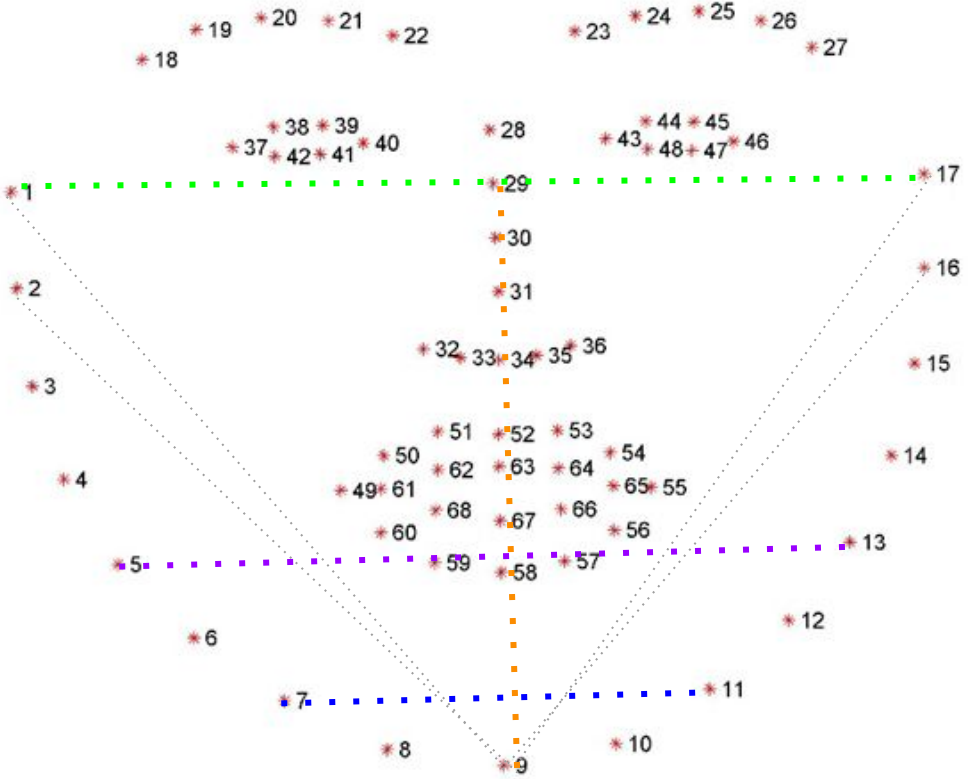
Rotate, Crop and Align



Alignment of Images:



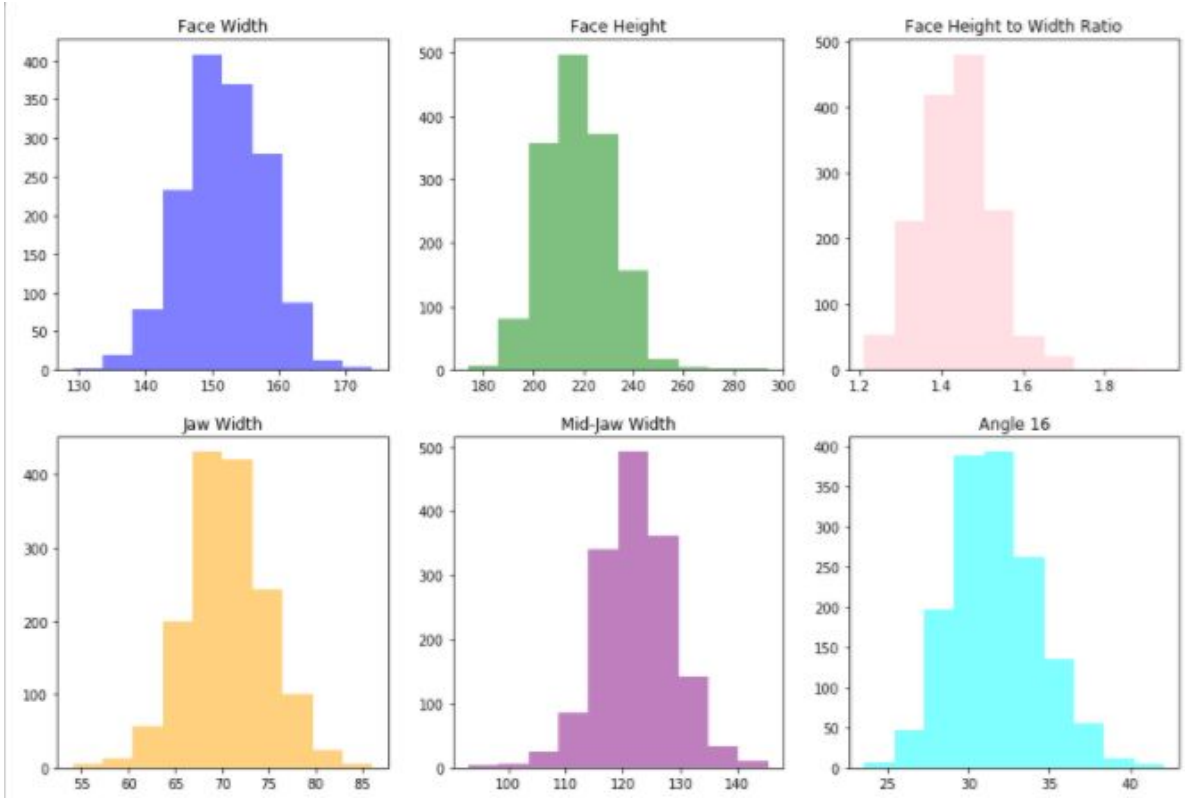
Feature Generation



Features:

- 68 Facial Landmarks
- Angles between point 9 and all the lower facial points (1-8, 10-17)
- **Face Width:** Distance between 1 & 17
- **Height:** 2X Distance between 9 & 29
- **Height** to **Width** Ratio
- **Jaw Width:** Distance between 7 & 11
- **Jaw Width** to **Face Width** Ratio
- **Mid-Jaw Width:** Distance between 5 & 13
- **Mid-Jaw width** to **Jaw Width** Ratio

Visualizing the feature set



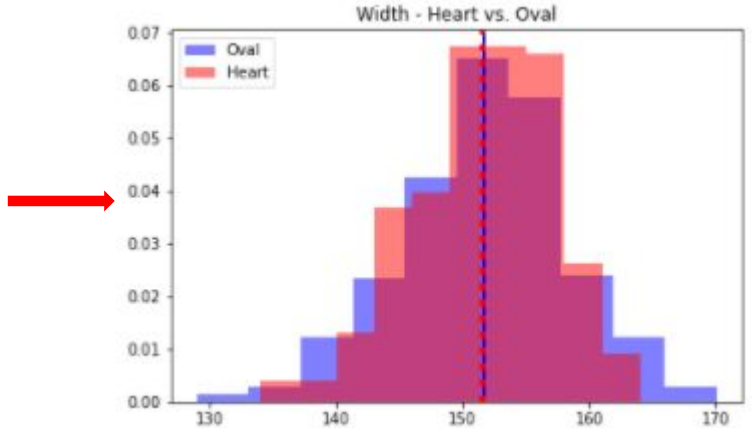
Based on these histograms, the features appear to be normally distributed.

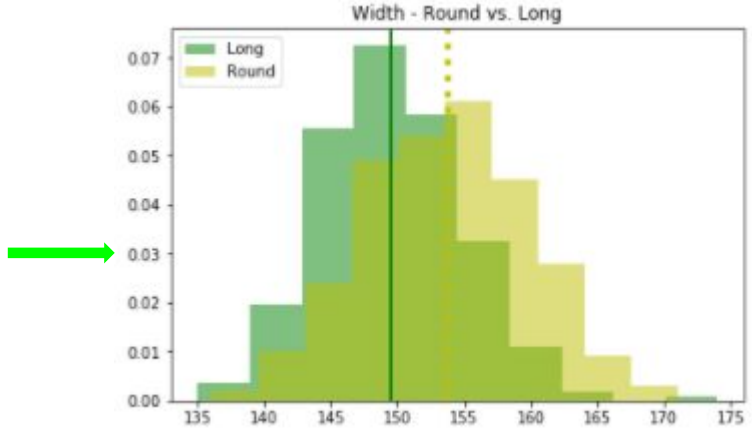
Next, I will compare the features by face shapes.

Face Width T-tests

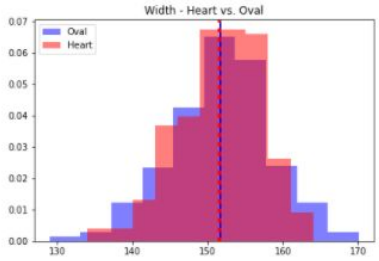
Face Width is the distance from ear-to-ear.

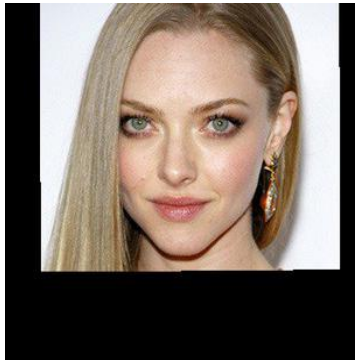
Shape 1	Shape 2	p-value
Heart	Long	0.00003
Heart	Oval	0.68089
Heart	Round	0.00001
Heart	Square	0.09246
Long	Oval	0.00000
Long	Round	0.00000
Long	Square	0.01561
Oval	Round	0.00005
Oval	Square	0.03163
Round	Long	0.00000
Round	Oval	0.00005
Round	Square	0.00000

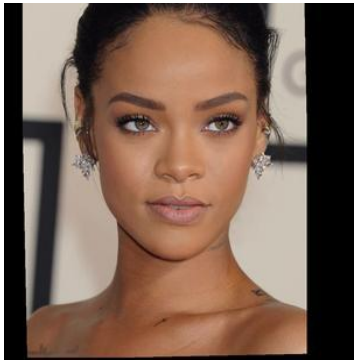


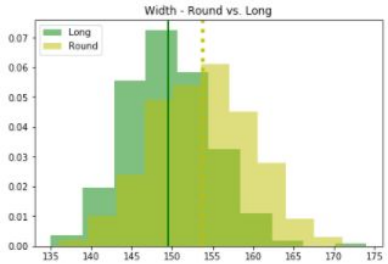


Face Width Comparison





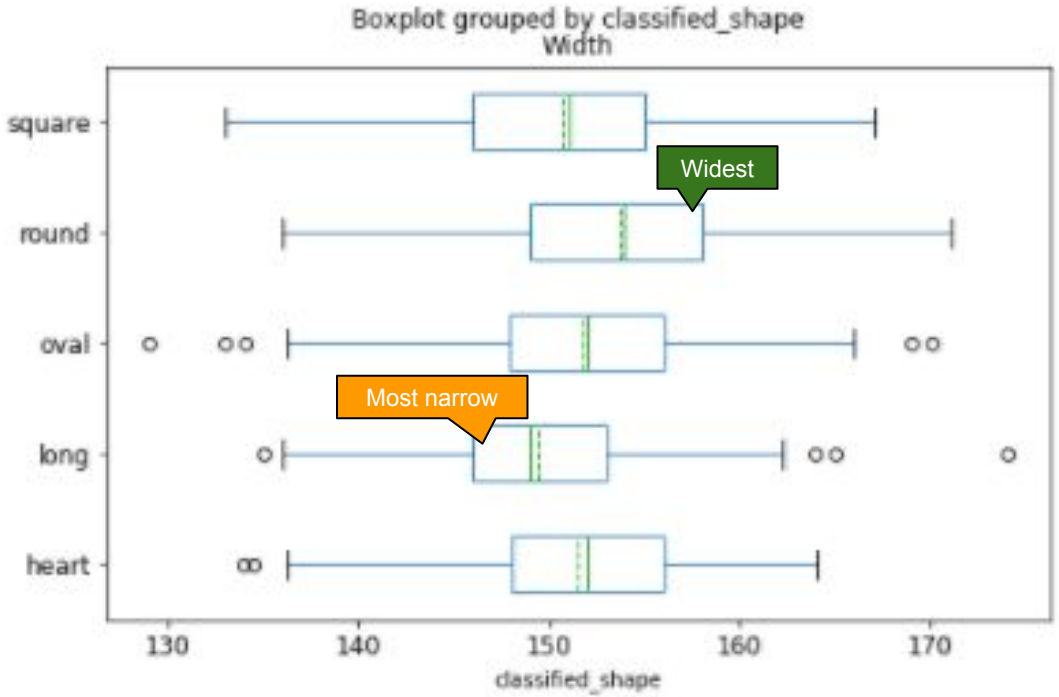




In the top graph (p >= 0.05), you can see how close the means are for oval- and heart-shaped faces' width and the distributions overlap significantly. Based on the sample images, you can see that these faces' widths are similar.

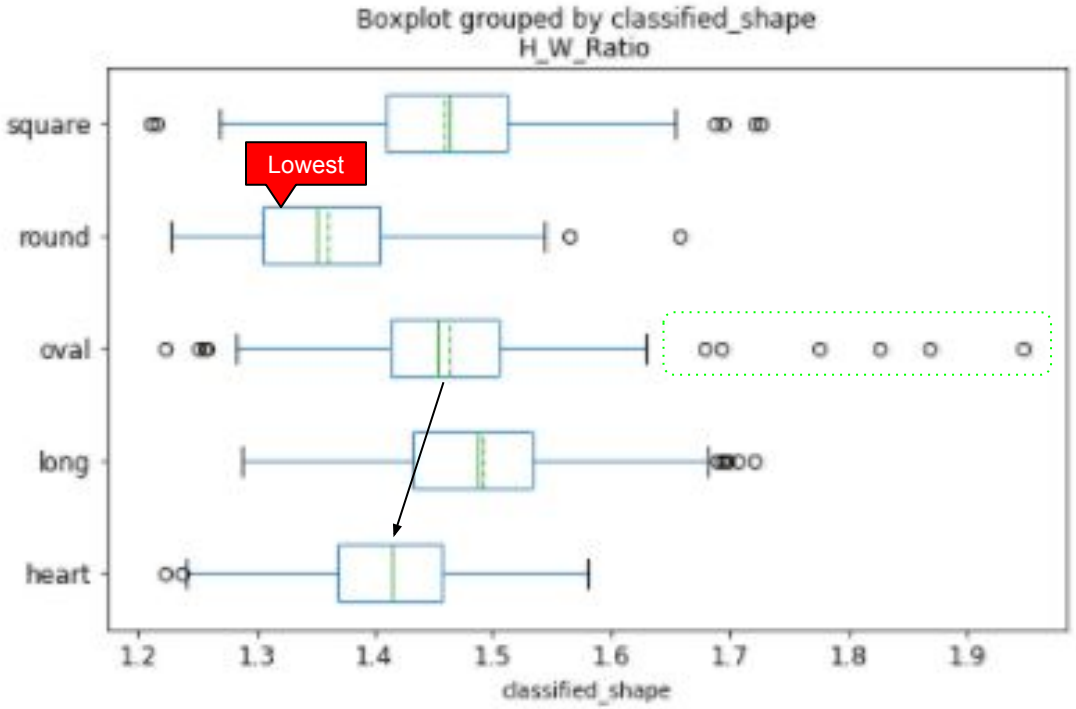
The width for long and round faces are significantly different. The mean for round faces is higher and the entire distribution is shifted towards wider face dimensions. The two sample images further reinforce the difference.

Box Plot: Face Width



This box plot illustrates the median (solid line), mean (dotted), quartiles and range of the facial widths by facial shape. As expected, round faces have the largest facial width median, mean and max. Long faces are characterized by having the most narrow face. Just like the histogram demonstrated, heart-& oval-shaped faces are very similar.

Box Plot: Height to Width Ratio

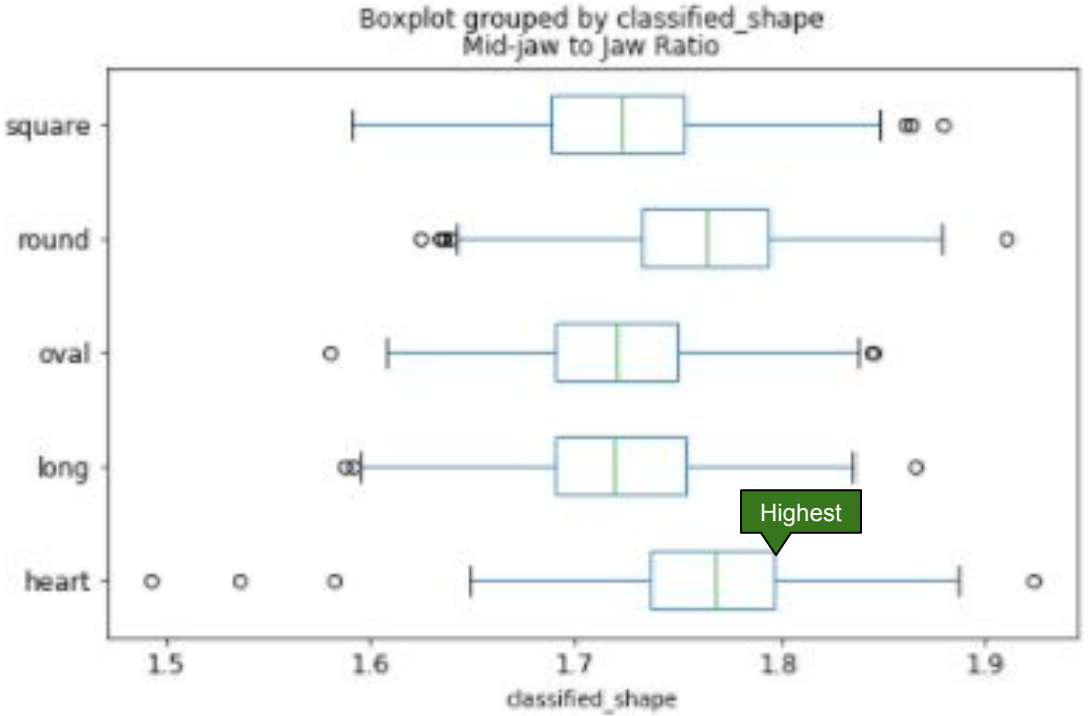


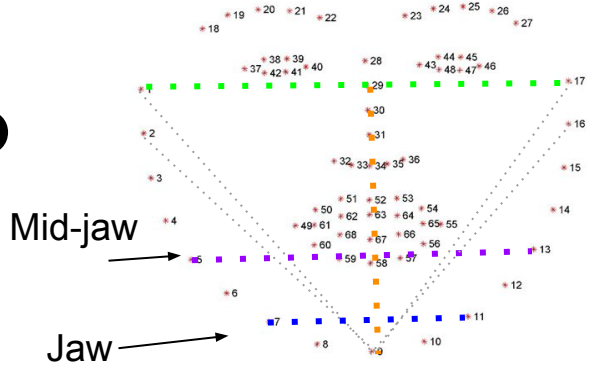
As expected, round faces have the lowest height to width ratio (closest to 1:1).

For width, the heart and oval were very similar, but they differ more for the height-to-width ratio.

Oval-shaped faces have a higher height-to-width ratio than heart (i.e., ovals are longer than hearts).

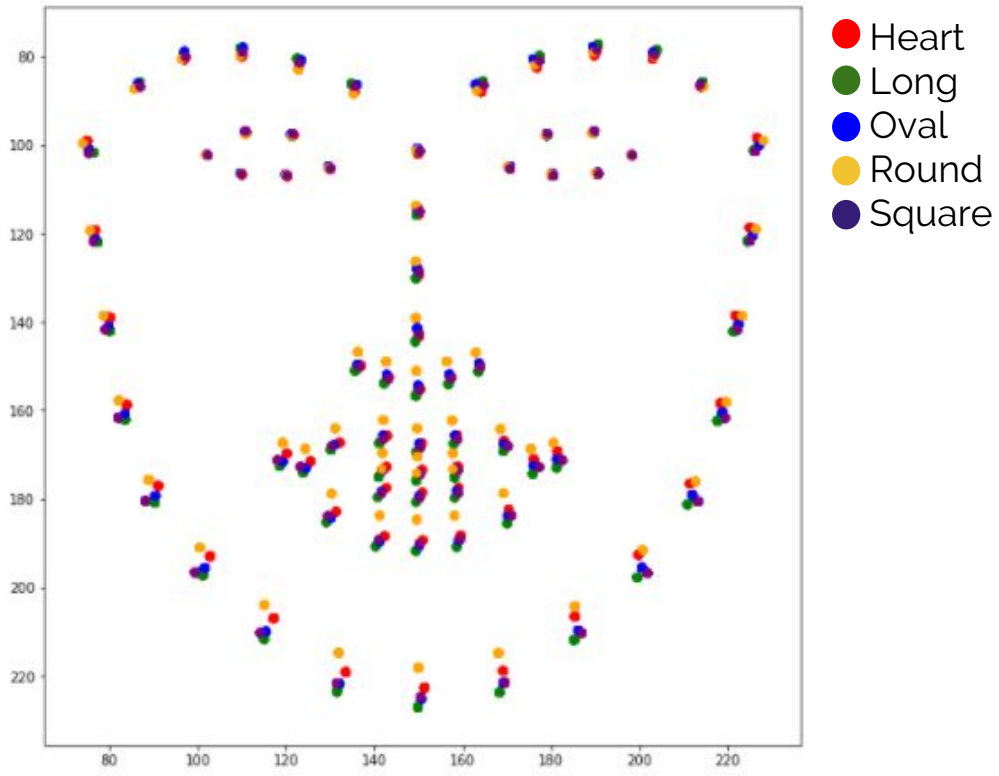
Box Plot: Mid-Jaw to Jaw Ratio





This ratio quantifies the extent of the narrowing between the mid-jaw and jaw. Heart-shaped faces, have the highest ratio which aligns with the expectation. Once again, you can see that heart and oval differ.

Average of Each Face Shape



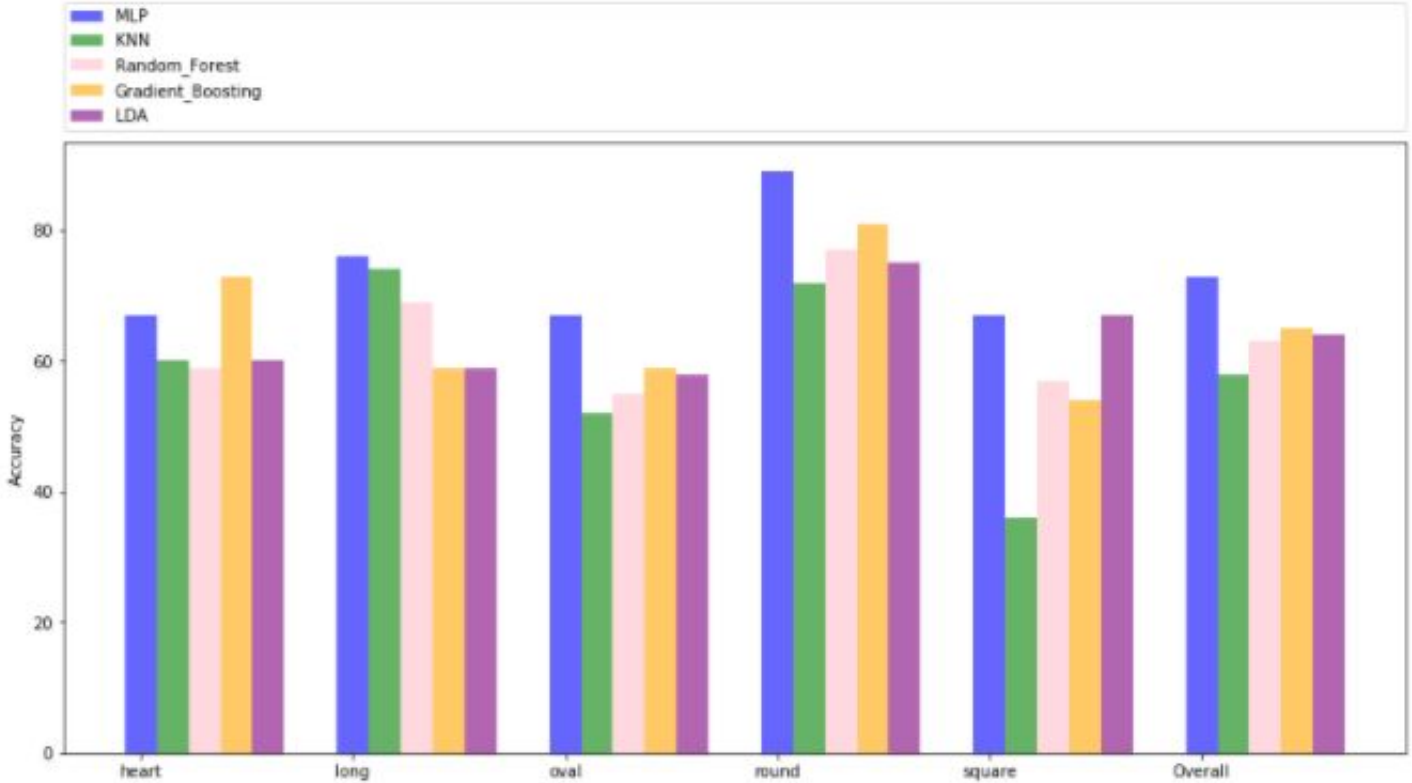
This graph maps the coordinates of the average of each face shape. The dots all overlap at the eyes because the make_face_df2 function locks the eyes to a standard position. Below the eyes, the face landmarks differ. Round faces (orange) are much shorter. Long faces (green) are appropriately at the lowest point on the graph. The narrow chin of the heart-shape face (red) is also distinguishable here.

Model Comparisons

I constructed a dataset for the 1500+ images that contains the 68 coordinates for facial landmarks, the calculated lengths and ratios and the classified shape.

I attempted several machine learning models to find the best predictor of face shape.

Model Comparison



I tested the recall for each of the models for each of the face shapes. The MLP neural network performs the best overall as well as for 4 out of the 5 face shapes.

KNN performs the weakest, especially for the square face shape.

MLP Confusion Matrix (test images)

classified_shape	heart	long	oval	round	square	All
heart	49	4	12	7	1	73
long	2	44	6	2	4	58
oval	12	8	62	6	4	92
round	4	1	1	70	3	79
square	3	7	11	3	48	72
All	70	64	92	88	60	374

The model performed well and had the highest errors where you might expect - distinguishing heart and oval which had some similar features.

Recommender System

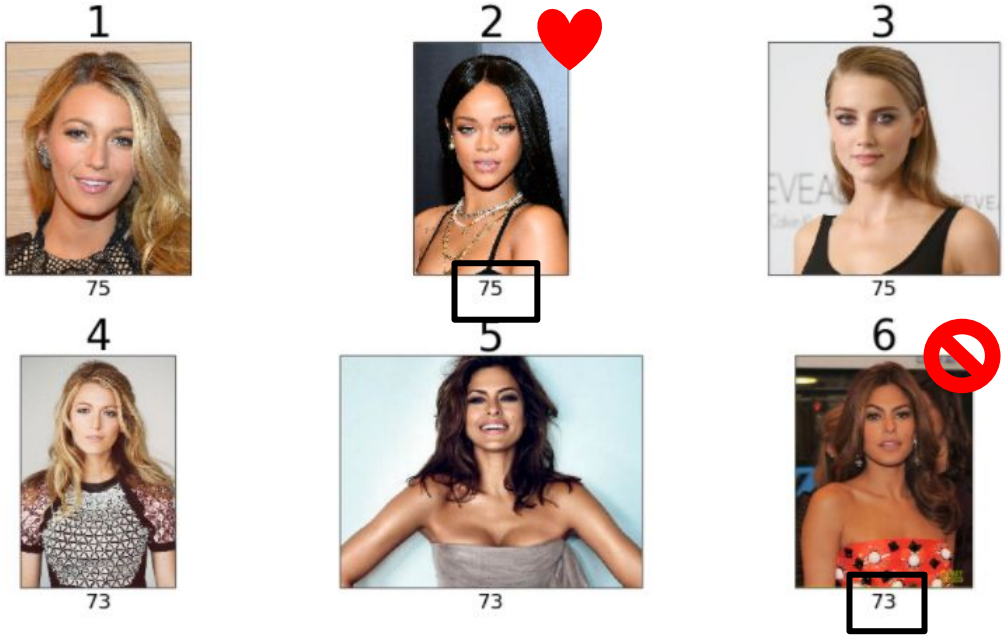
The recommender system returns 6 images of hair styles recommended for their face shape. The original selection is based on a random number score. However, each time they use the system, the user can provide feedback that indicates their top and bottom preference. This preference iterates back into the score by adding or removing points from the score. If the user liked the style, this will increase the priority of the style for the next user and the opposite is true for the user's least favorite style. This is a rudimentary system but utilized as a basic concept.

Recommendation Example

```
run_recommender(test_shape[0])
```

```
What is your name? marnie
Hello, marnie.
Would you like to see up-dos? (Y/N)n
Is your hair short (shoulder-length shorter) or long?long
Long
oval
```

The user inputs her hair length. Then 6 recommended styles are displayed. User then selects their most and least favorite.
If the user were to re-run the recommender with the same inputs (long hair, oval face shape), the scores would iterate up and down based on the first run and new images would be displayed.



Recommendation Example

Again, 6 recommended styles are displayed. The favorite selected in the last iteration has been promoted to first position in the rank and the score increased by 5 points.

The least favorite dropped off and a new style is displayed.

What people are saying about *What's Her Face?*

That's such a cool idea, I would definitely try that!

Susan, Washington, DC

OMG - A salon would totally buy this!

Jayme, Maryland

I always need ideas for my hair. What else can you make it do?

Nancy (my mom), Florida

Code and images available at:

https://github.com/marnieboyer/ThinkFul-Capstone-3-Final