

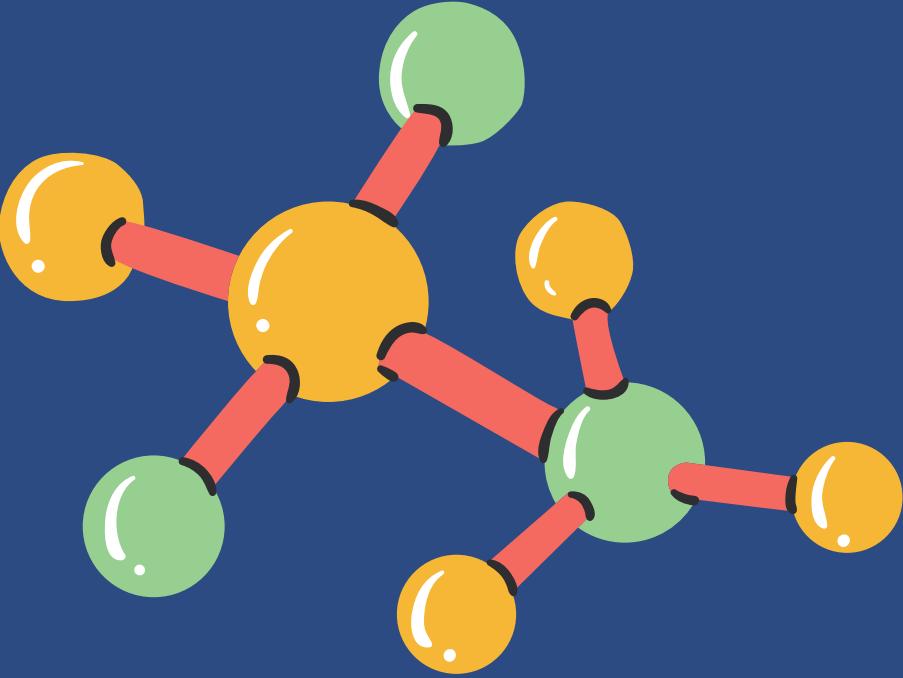


SPECHIO PROJECT - 10

ML Model for Facial Feature Extraction

TEAM - 33

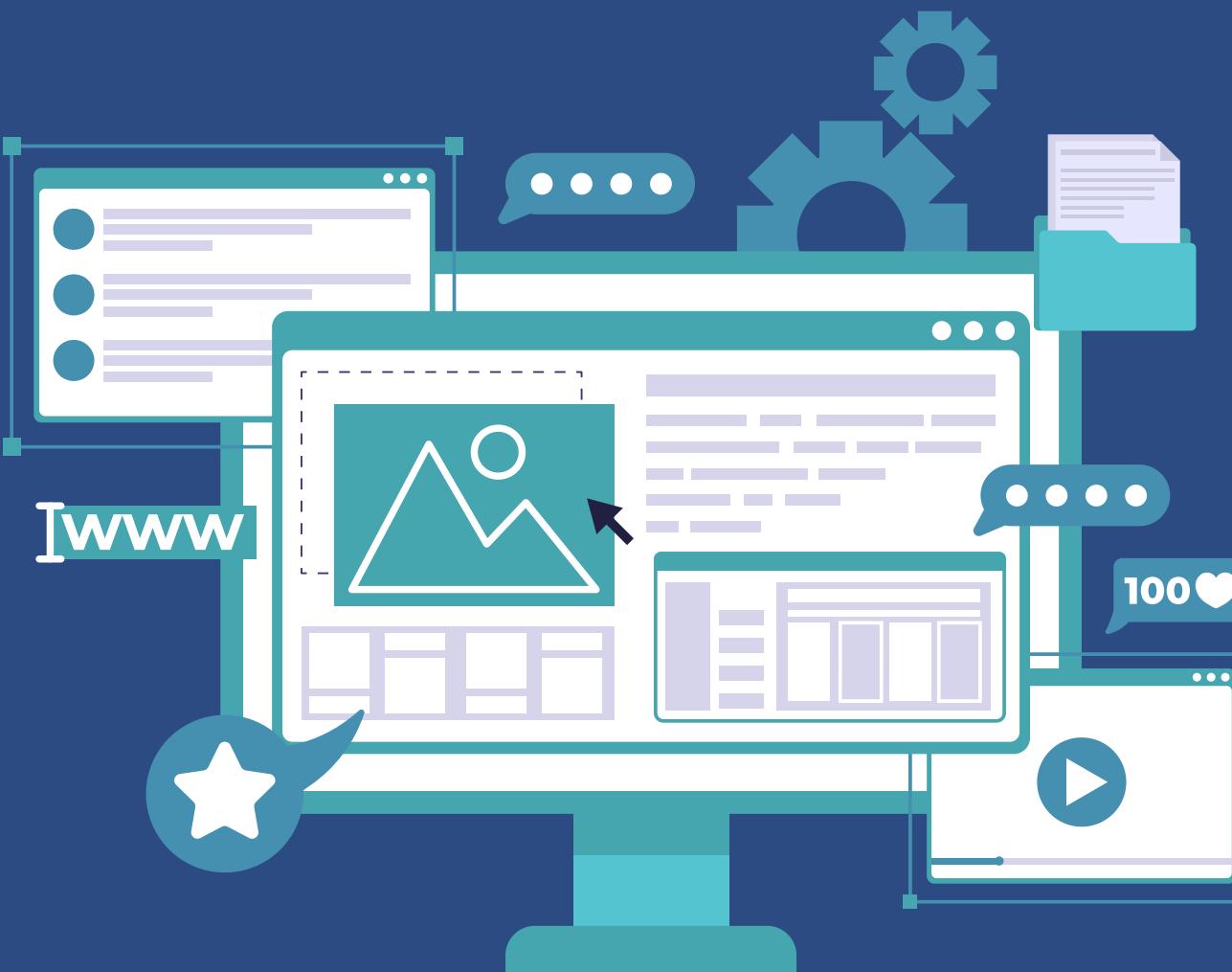
AMAN RAJ MOHTA



Outline

- Introduction
- Dataset
- Features
- Model
- Limitations
- API

python



Introduction

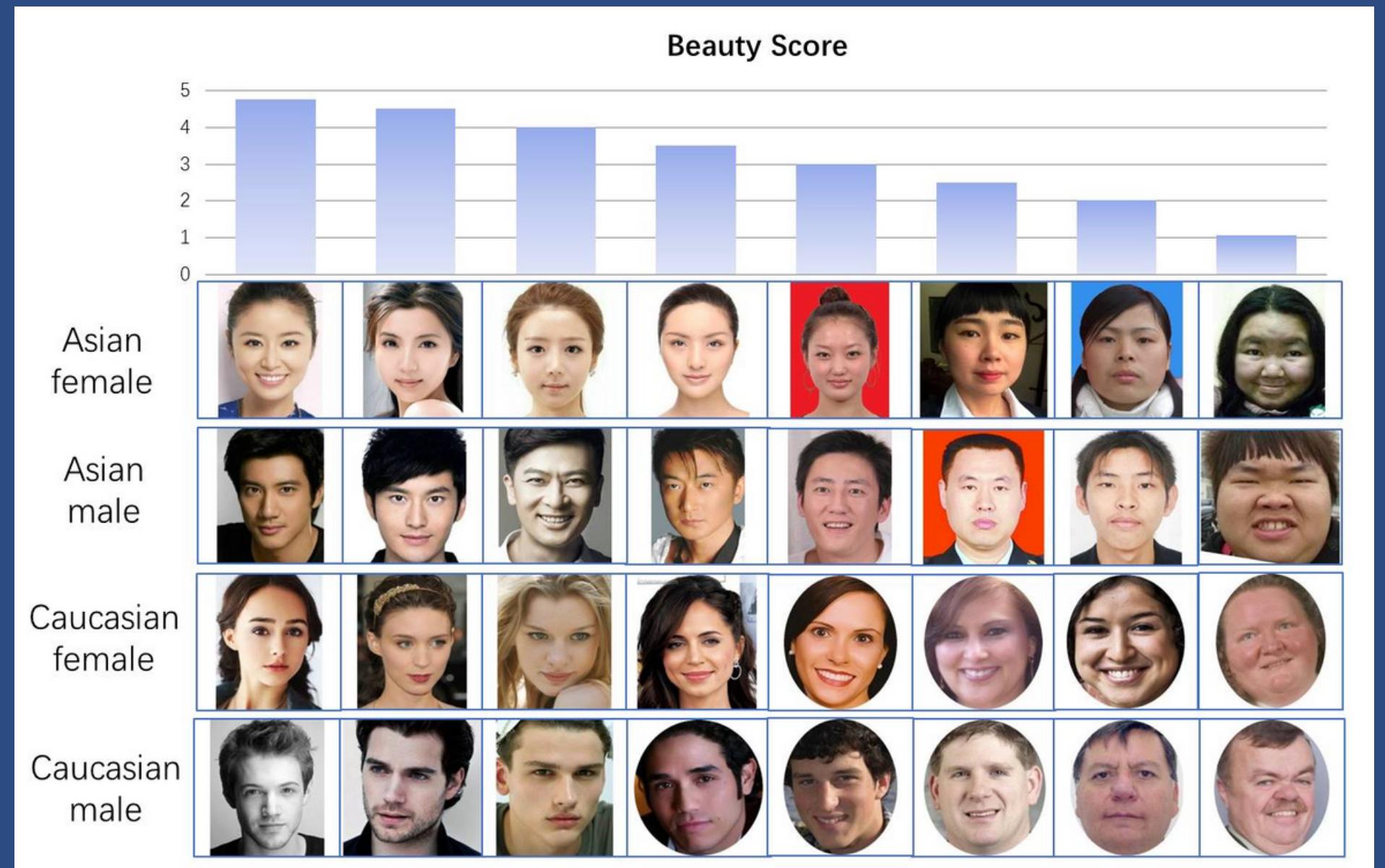
Facial feature extraction is the process of extracting face components features like eyes, nose, mouth, etc from human face images. Facial feature extraction is very much important for the initialisation of processing techniques like face tracking, facial expression recognition or face recognition.



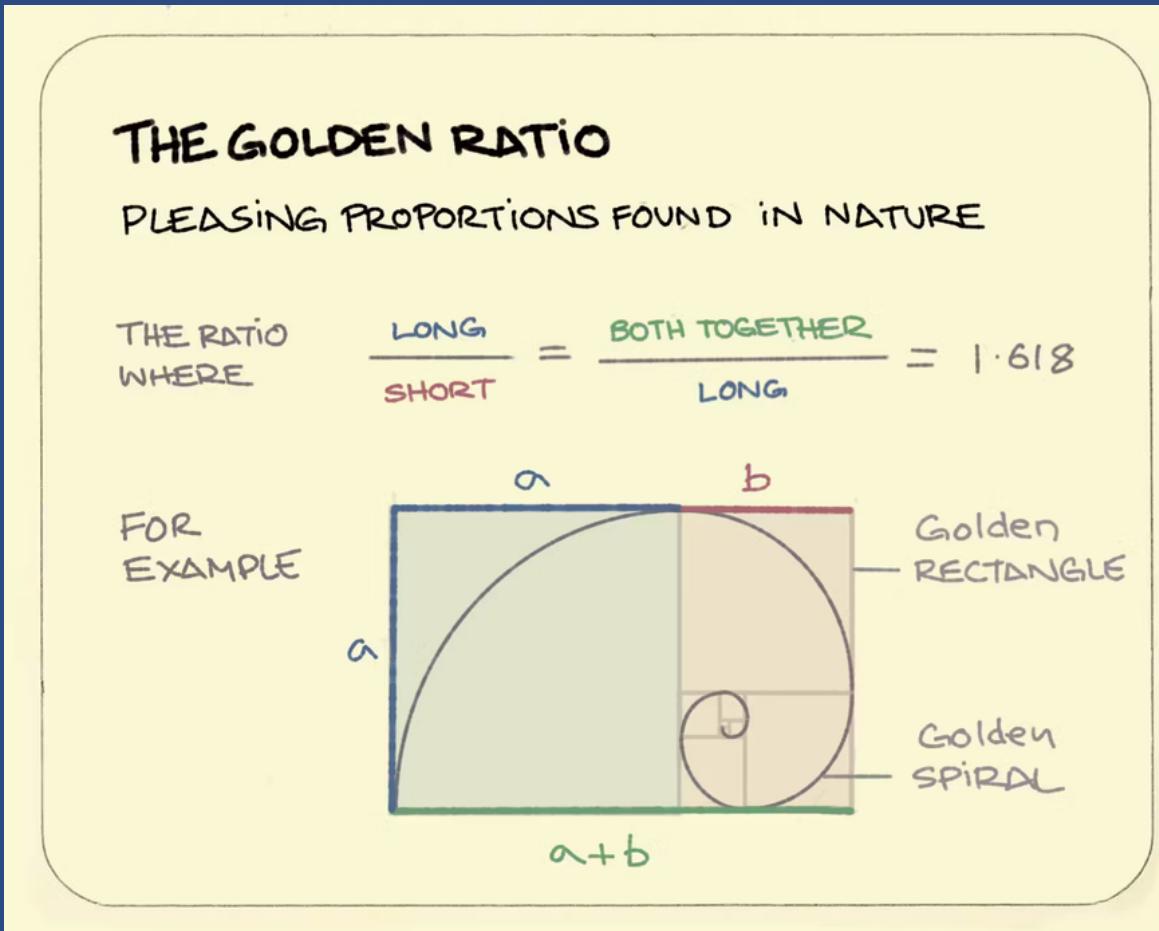
Dataset

SCUTFBP-550 v2

- 2000 Asian Male and Female.
- 750 Caucasian Male and Female.
- Images labelled with beauty score [1-5] by 60 volunteers.
- Dataset link- <https://github.com/HCIILAB/SCUT-FBP5500-Database-Release>



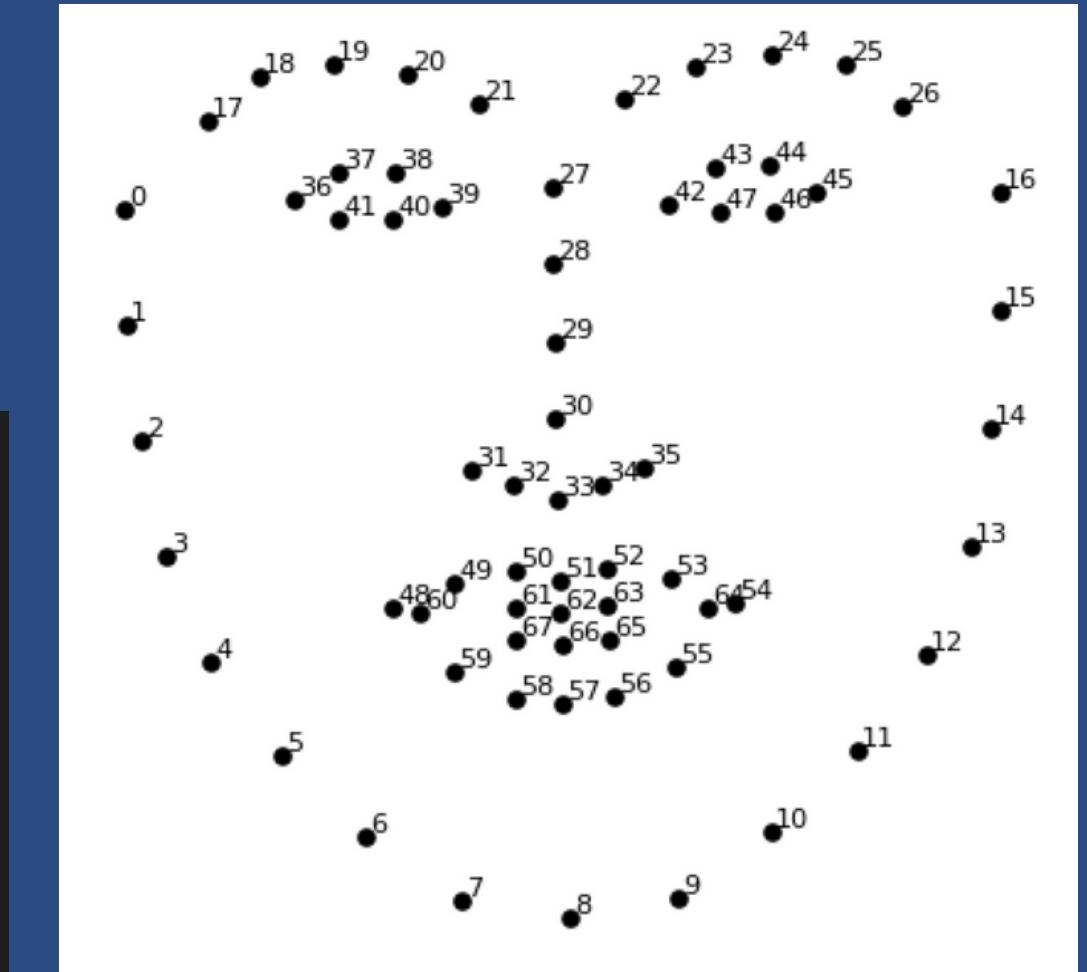
Features



Aesthetic Ratios in Nature

Golden Ratios

```
# Calculate the golden ratios
ratio1 = under_eyes / interocular
ratio2 = under_eyes / nose_width
ratio3 = mouth_width / interocular
ratio4 = upper_lip_jaw/interocular
ratio5 = upper_lip_jaw / nose_width
ratio6 = interocular / lip_height
ratio7 = nose_width / interocular
ratio8 = nose_width / upper_lip_height
ratio9 = interocular/nose_mouth_height
ratio10 = eyebrows_nose / nose_jaw
ratio11 = interocular / nose_width
```



DLIB Facial Landmarks

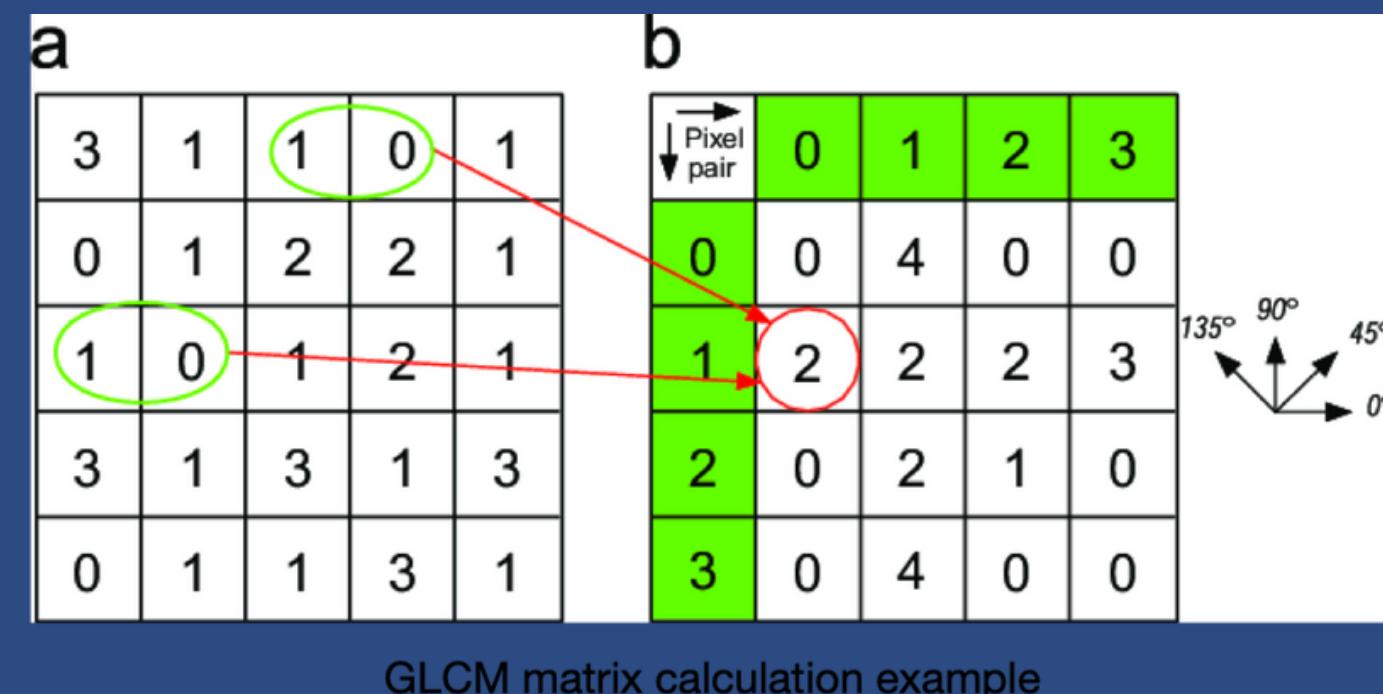
Symmetric Ratios

```
# Calculate the symmetric ratios
lower_eyebrow_length = (np.linalg.norm(landmarks[17]-landmarks[21]))/(np.linalg.norm(landmarks[22]-landmarks[26]))
lower_lip_length = (np.linalg.norm(landmarks[48]-landmarks[57]))/(np.linalg.norm(landmarks[54]-landmarks[57]))
upper_eyebrow = upper_eyebrow_numerator/upper_eyebrow_denominator
upper_lip = (np.linalg.norm(landmarks[48]-landmarks[51]))/(np.linalg.norm(landmarks[51]-landmarks[55]))
nose = (np.linalg.norm(landmarks[31]-landmarks[33]))/(np.linalg.norm(landmarks[33]-landmarks[35]))
```

Features

GLCM or Gray Level Covariance Matrix is also known as the Gray Level Spatial Dependence Matrix, which learns about the texture of an image by calculating the frequency of pixel pairs with certain values in a spatial relationship that occurs in an image. In total 14 different Textural features are defined by Haralik. In my analysis I have used only FOUR as follows -

- **1. Energy**
- **2. Contrast**
- **3. Homogeneity**
- **4. Correlation**



$$\sum_{i,j} (i - \mu i)(j - \mu j)p(i, j)/\sigma_i\sigma_j$$

Correlation

$$\sum_{i,j} p(i, j)/(1 + |i - j|)$$

Homogeneity

$$\sum_{i,j} |i - j|^2 p(i, j)$$

Contrast

$$\sum_{i,j} p(i, j)^2$$

Energy

Features

Hu Moments (or rather **Hu moment invariants**) are a set of 7 numbers calculated using central moments that are invariant to image transformations. The first 6 moments have been proved to be invariant to translation, scale, and rotation, and reflection. While the 7th moment's sign changes for image reflection.

$$h_0 = \eta_{20} + \eta_{02},$$

$$h_1 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2,$$

$$h_2 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{02})^2,$$

$$h_3 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2,$$

$$h_4 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2],$$

$$h_5 = (\eta_{20} - 3\eta_{03})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2 + 4\eta_{11}(\eta_{30} + 3\eta_{12})(\eta_{21} + \eta_{03})],$$

$$h_6 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})]^2.$$

$$\mu_{00} = m_{00}$$

$$\mu_{10} = 0$$

$$\mu_{01} = 0$$

$$\mu_{11} = m_{11} - \bar{y}m_{10}$$

$$\mu_{20} = m_{20} - \bar{x}m_{10}$$

$$\mu_{02} = m_{02} - \bar{y}m_{01}$$

$$\mu_{30} = m_{30} - 3\bar{x}m_{20} + 2\bar{x}^2m_{10}$$

$$\mu_{03} = m_{03} - 3\bar{y}m_{02} + 2\bar{y}^2m_{01}$$

$$\mu_{21} = m_{21} - 2\bar{x}m_{11} - \bar{y}m_{20} + 2\bar{x}^2m_{01}$$

$$\mu_{12} = m_{12} - 2\bar{y}m_{11} - \bar{x}m_{02} + 2\bar{y}^2m_{10}.$$

Features

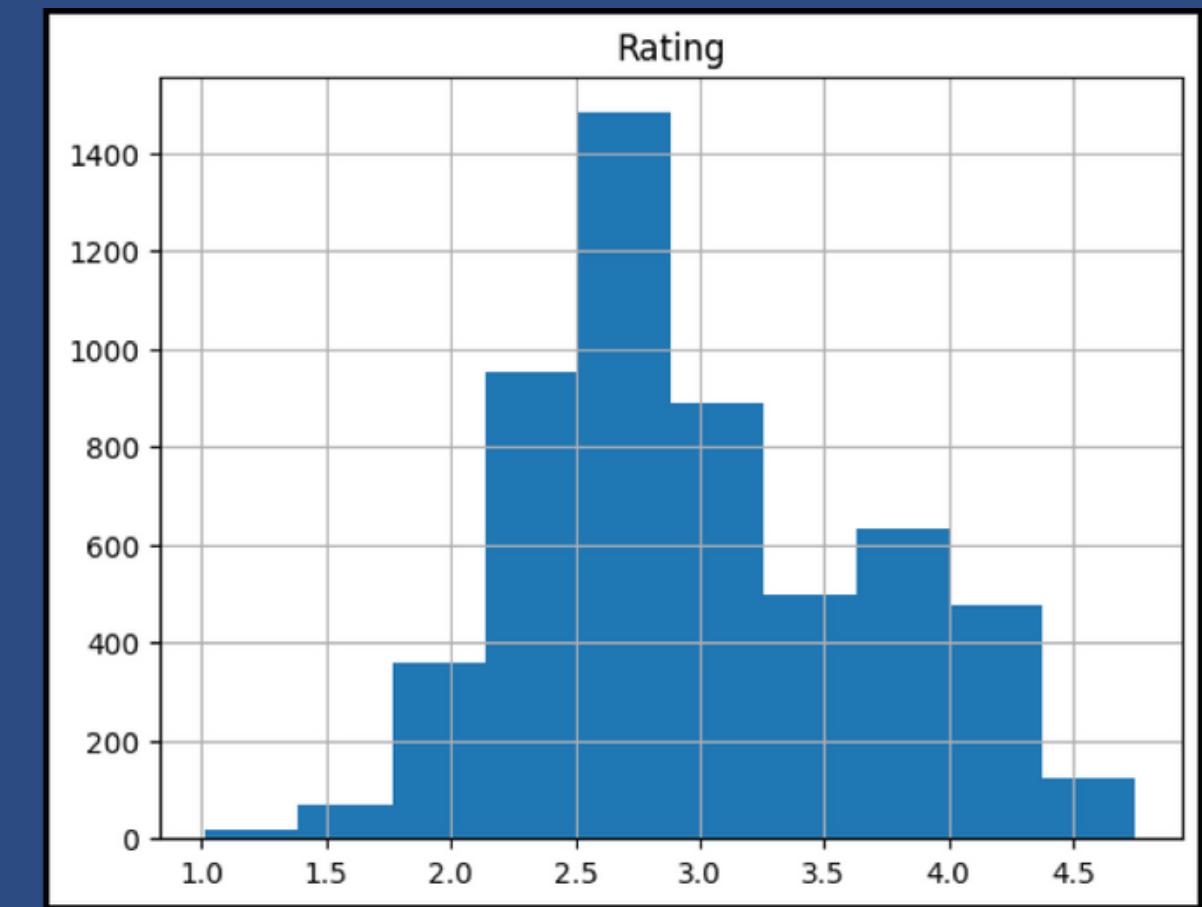
The entire feature set was stored in a CSV file. It contains a 5500 x 29 matrix. 27 features, 1 identifier column and 1 target variable.

| Image Name | UE/IO | UE/NW | MW/IO | ULJ/IO | ULJ/NW | IO/LH | NW/IO | NW/ULH | IO/NMH | EBN/NJ | IO/NW | LEL | LLL |
|------------|-------------|-------------|-------------|--------------|-------------|-------------|--------------|-------------|-------------|-------------|-------------|--------------|------------|
| AM218.jpg | 1.981239444 | 2.836753393 | 1.339131934 | 1.344276626 | 1.924745285 | 2.119258352 | 0.6984179341 | 2.810133117 | 3.296268286 | 1.369064035 | 1.431807448 | 0.8310511985 | 0.88466625 |
| AM1948.jpg | 1.833635288 | 2.929858494 | 1.270413898 | 1.030303416 | 1.64626152 | 3.002603037 | 0.6258443171 | 3.437585412 | 1.99482088 | 1.541129632 | 1.597841464 | 0.691924682 | 0.80986180 |
| AM1946.jpg | 1.933287729 | 2.395208597 | 1.465257404 | 1.564512905 | 1.938322322 | 1.566377931 | 0.8071479585 | 2.495685933 | 2.343096031 | 1.211412384 | 1.238930223 | 0.6722583807 | 0.81781900 |
| AM214.jpg | 1.882761394 | 2.3412752 | 1.431506843 | 1.531421505 | 1.904372589 | 2.315790707 | 0.8041606531 | 3.45998992 | 2.684210526 | 1.335611861 | 1.243532615 | 0.9497595246 | 1.0335663 |
| AM1939.jpg | 1.937527552 | 2.324811182 | 1.584222645 | 1.333694817 | 1.60028105 | 3.693108887 | 0.8334128668 | 4.915896433 | 3.17261756 | 1.518922984 | 1.199885483 | 0.8108720698 | 0.87455516 |
| AM215.jpg | 1.850899379 | 2.317093013 | 1.470470336 | 1.279877032 | 1.602244921 | 1.576377912 | 0.798802365 | 2.474347889 | 3.899743581 | 1.212526031 | 1.25187411 | 0.706830873 | 0.79394106 |
| AM217.jpg | 1.828327488 | 2.510010703 | 1.513668017 | 1.415510676 | 1.943277104 | 2.33428552 | 0.7284142199 | 3.211722829 | 3.606654622 | 1.094692291 | 1.372845248 | 1.306487163 | 1.2003754 |
| AM1947.jpg | 1.918848665 | 2.17129064 | 1.283559407 | 1.142864215 | 1.293218386 | 3.086794759 | 0.8837364421 | 4.648758856 | 2.5 | 1.432339972 | 1.131559085 | 0.9417939478 | 0.97955491 |
| AM213.jpg | 2.038552248 | 2.408576142 | 1.36592622 | 1.461538462 | 1.726826807 | 1.624207124 | 0.8463723494 | 2.702322107 | 3.058823529 | 1.32330357 | 1.181513078 | 0.9685395255 | 0.96079206 |
| AM1940.jpg | 2.018585161 | 2.467567403 | 1.436241331 | 1.040171321 | 1.271530622 | 3.659150247 | 0.818046615 | 4.838429975 | 2.89121359 | 1.532656047 | 1.222424226 | 0.8891639996 | 0.90181223 |
| AM1950.jpg | 1.957909289 | 2.787258032 | 1.404416496 | 1.319148936 | 1.877925852 | 2.607090922 | 0.7024499583 | 3.432751634 | 2.764705882 | 1.524415958 | 1.423588952 | 1.051709145 | 1.0945981 |
| AM1954.jpg | 2.057302117 | 2.660540923 | 1.357655284 | 1.208013297 | 1.562225006 | 2.522747192 | 0.7732646018 | 3.820256547 | 3.1144823 | 1.43880004 | 1.293218386 | 1.072801726 | 1.0580708 |
| AM1952.jpg | 1.967349299 | 2.645650465 | 1.292441198 | 0.9461761655 | 1.27239805 | 2.643412353 | 0.7436164849 | 3.582682855 | 3.229193755 | 1.470434072 | 1.344779225 | 0.7463132566 | 0.83189033 |
| AM1960.jpg | 1.888979664 | 2.756889239 | 1.222362506 | 1.217865411 | 1.777425194 | 1.738321506 | 0.6851851852 | 2.459843233 | 2.959181771 | 1.668938676 | 1.459459459 | 1.340154027 | 1.1597259 |
| AM1953.jpg | 1.882729851 | 2.791788466 | 1.253627675 | 1.183397892 | 1.754790569 | 2.268659164 | 0.6743812697 | 2.95149796 | 2.531184812 | 1.942834076 | 1.482840709 | 1.007072224 | 0.9151299 |
| AM1957.jpg | 1.975172895 | 2.694225224 | 1.267915608 | 1.365665265 | 1.862829231 | 1.708841388 | 0.7331135043 | 2.469373961 | 2.563262082 | 1.803620241 | 1.364045259 | 1.018493381 | |
| AM1951.jpg | 1.709195224 | 2.043457942 | 1.436586429 | 1.54616127 | 1.848539875 | 1.374797697 | 0.8364230012 | 2.238448321 | 6.112121129 | 1.310329594 | 1.195567313 | 1 | 1.0122190 |
| AM196.jpg | 1.874962052 | 2.595019116 | 1.445046813 | 1.343404587 | 1.859323275 | 2.018093233 | 0.7225234064 | 2.892729371 | 3.035030378 | 1.644322946 | 1.384038207 | 1.347072742 | 1.2929112 |
| AM1956.jpg | 1.893736549 | 2.543017651 | 1.340425532 | 1.192248998 | 1.601020083 | 2.473684211 | 0.7446808511 | 3.478327965 | 2.931779449 | 1.948933333 | 1.342857143 | 1.110016555 | 1.2041594 |
| AM1959.jpg | 1.977391418 | 2.513176952 | 1.233110022 | 1.148094159 | 1.45917685 | 2.462318765 | 0.7868094667 | 3.75815265 | 2.34919204 | 1.623032765 | 1.27095573 | 0.7941854183 | 0.82435059 |
| AM1955.jpg | 1.922929513 | 2.171389446 | 1.472361891 | 1.323479081 | 1.494484581 | 3.507944819 | 0.8855756008 | 4.921298414 | 1.954079882 | 1.132814797 | 1.129209069 | 0.7578719529 | 0.7338652 |
| AM1958.jpg | 1.849112512 | 2.513343745 | 1.339915544 | 1.207332285 | 1.641025641 | 2.206811576 | 0.735718111 | 3.006679044 | 2.52425872 | 1.347080173 | 1.359216234 | 1.076686559 | 1.0051591 |
| AM1783.jpg | 1.806765555 | 2.685226333 | 1.268438601 | 1.15315379 | 1.713824416 | 3.055802846 | 0.6728541031 | 3.914715826 | 3.438797393 | 1.614167582 | 1.48620629 | 1.017959533 | 0.98890342 |
| AM1961.jpg | 1.955577742 | 2.934090811 | 1.177487076 | 1.088846805 | 1.633673434 | 2.247747556 | 0.6665021186 | 2.853908965 | 2.994094482 | 2.007388267 | 1.500370325 | 0.9606773718 | 1.0289915 |
| AM1787.jpg | 1.898902491 | 2.783920723 | 1.22049851 | 1.319096651 | 1.933885768 | 1.786003616 | 0.6820964676 | 2.418041764 | 2.775718895 | 1.389451172 | 1.466068287 | 0.9877295966 | 1.035424 |
| AM1786.jpg | 1.914224821 | 2.185962609 | 1.56107764 | 1.19722529 | 1.36717991 | 2.230029979 | 0.8756896449 | 3.613010677 | 4.125903165 | 1.9364589 | 1.141957091 | 0.91972956 | 0.92902752 |

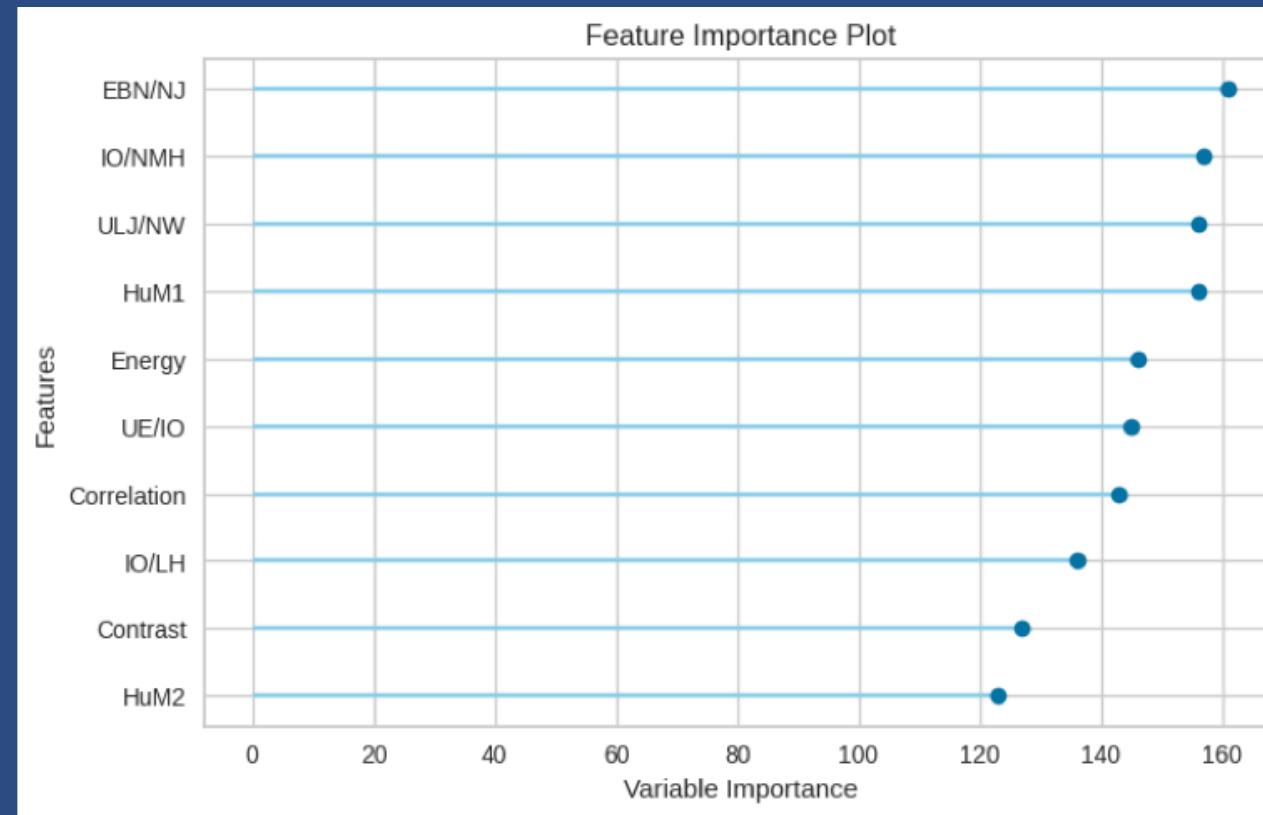
Model Regression

- None of the Ratings reach 5 or 1.
- The class distribution follows a normal distribution.
- Majority of the rating lie between 2.5 and 3.
- LightGBM Regressor was used for prediction.

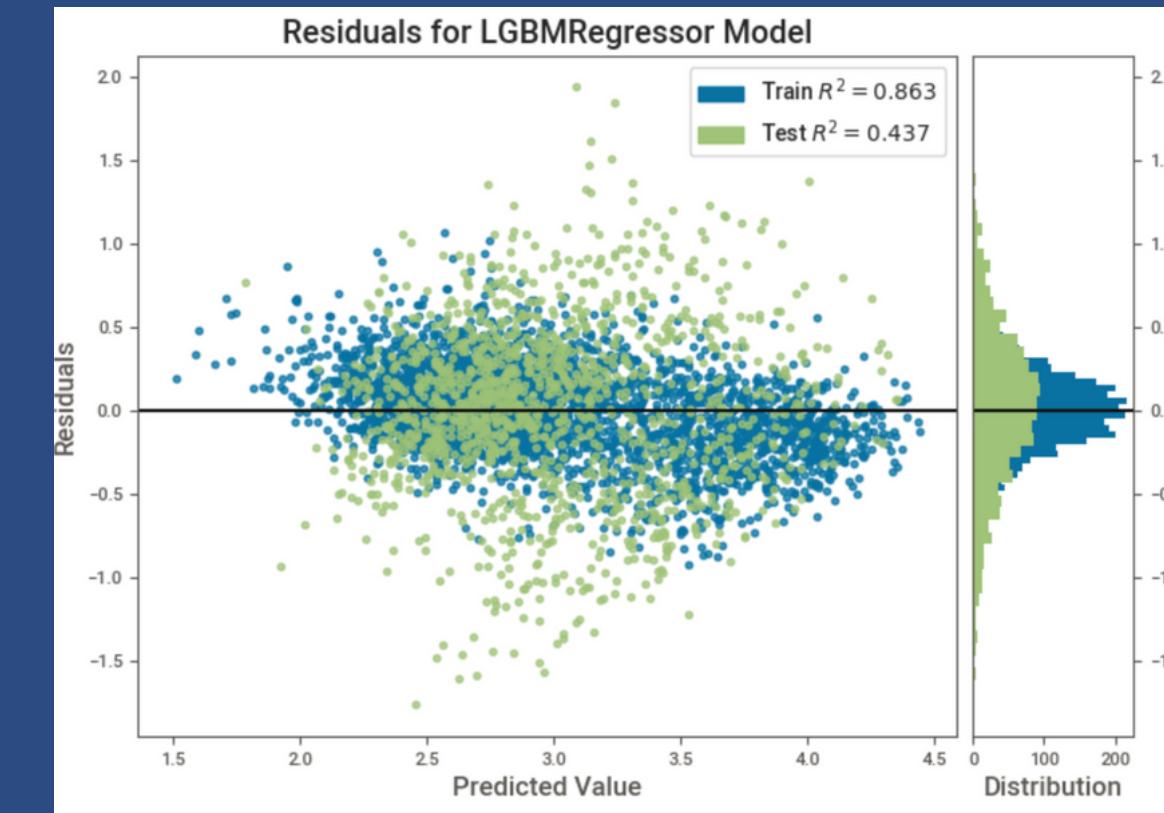
| Data | MAE | MSE | RMSE | R2 |
|-------|--------|--------|--------|--------|
| Train | 0.4022 | 0.2765 | 0.5256 | 0.4183 |
| Test | 0.3889 | 0.2521 | 0.5021 | 0.4355 |



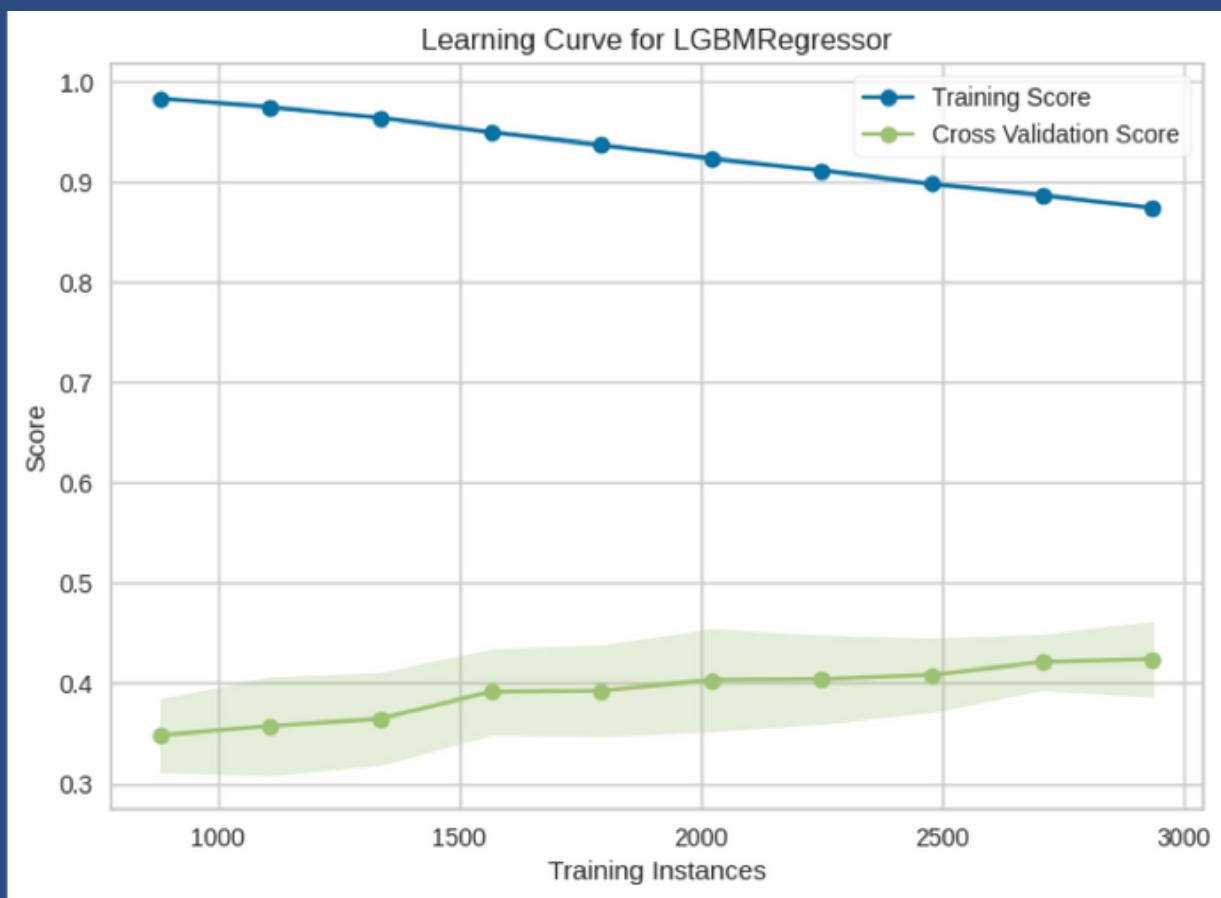
| Class Distribution | | | | | | |
|--|---------------|---------------|---------------|---------------|---------------|---------------|
| COMPARISON OF ALEXNET [41], RESNET-18 [42] AND RESNEXT-50 [43] IN MEASUREMENT OF PC, MAE AND RMSE BY 5-FOLD CROSS VALIDATION | | | | | | |
| PC | 1 | 2 | 3 | 4 | 5 | Average |
| AlexNet | 0.8667 | 0.8645 | 0.8615 | 0.8678 | 0.8566 | 0.8634 |
| ResNet-18 | 0.8847 | 0.8792 | 0.8929 | 0.8932 | 0.9004 | 0.89 |
| ResNeXt-50 | 0.8985 | 0.8932 | 0.9016 | 0.899 | 0.9064 | 0.8997 |
| MAE | 1 | 2 | 3 | 4 | 5 | Average |
| AlexNet | 0.2633 | 0.2605 | 0.2681 | 0.2609 | 0.2728 | 0.2651 |
| ResNet-18 | 0.248 | 0.2459 | 0.243 | 0.2383 | 0.2383 | 0.2419 |
| ResNeXt-50 | 0.2306 | 0.2285 | 0.226 | 0.2349 | 0.2258 | 0.2291 |
| RMSE | 1 | 2 | 3 | 4 | 5 | Average |
| AlexNet | 0.3408 | 0.3449 | 0.3538 | 0.3438 | 0.3576 | 0.3481 |
| ResNet-18 | 0.3258 | 0.3286 | 0.3184 | 0.3107 | 0.2994 | 0.3166 |
| ResNeXt-50 | 0.3025 | 0.3084 | 0.3016 | 0.3044 | 0.2918 | 0.3017 |



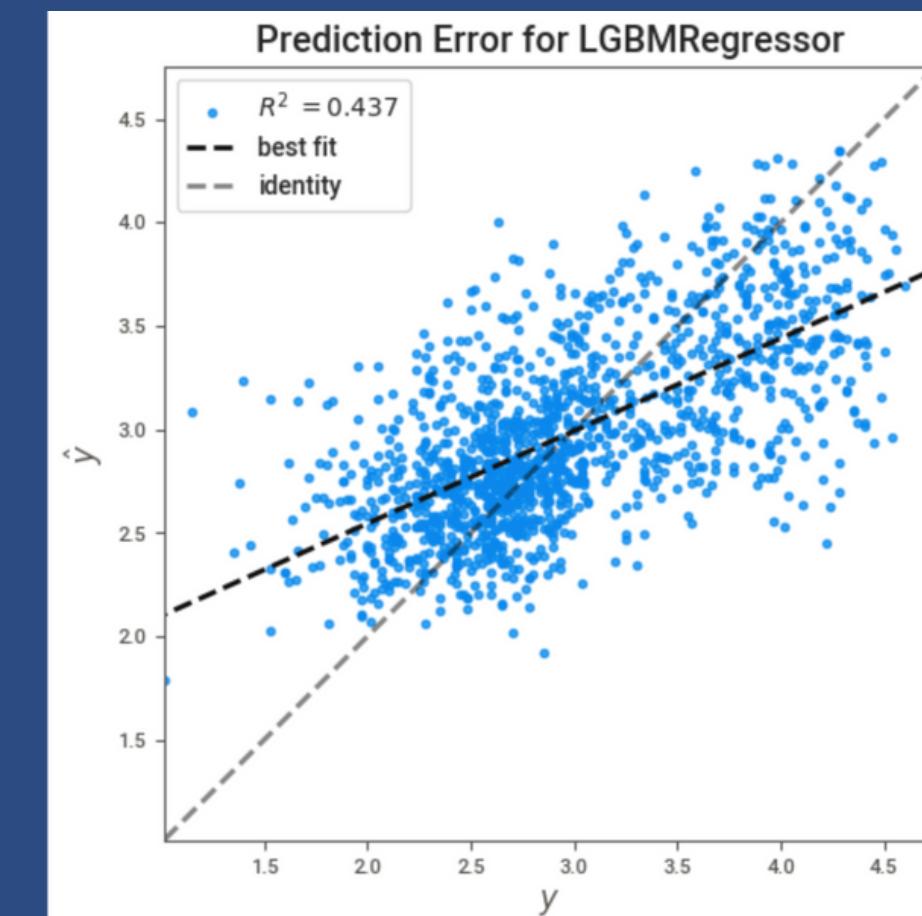
Best Features



Residuals for Train vs Validation set



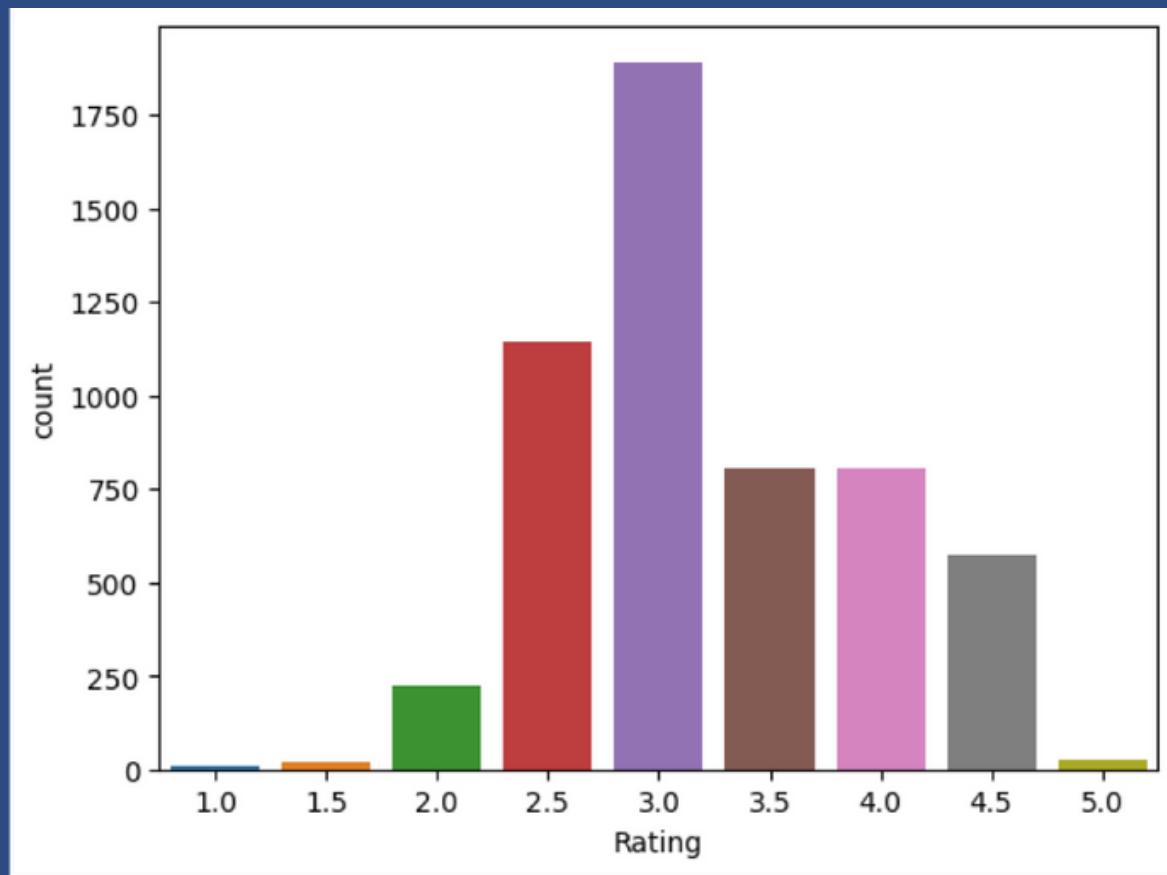
Learning Curves



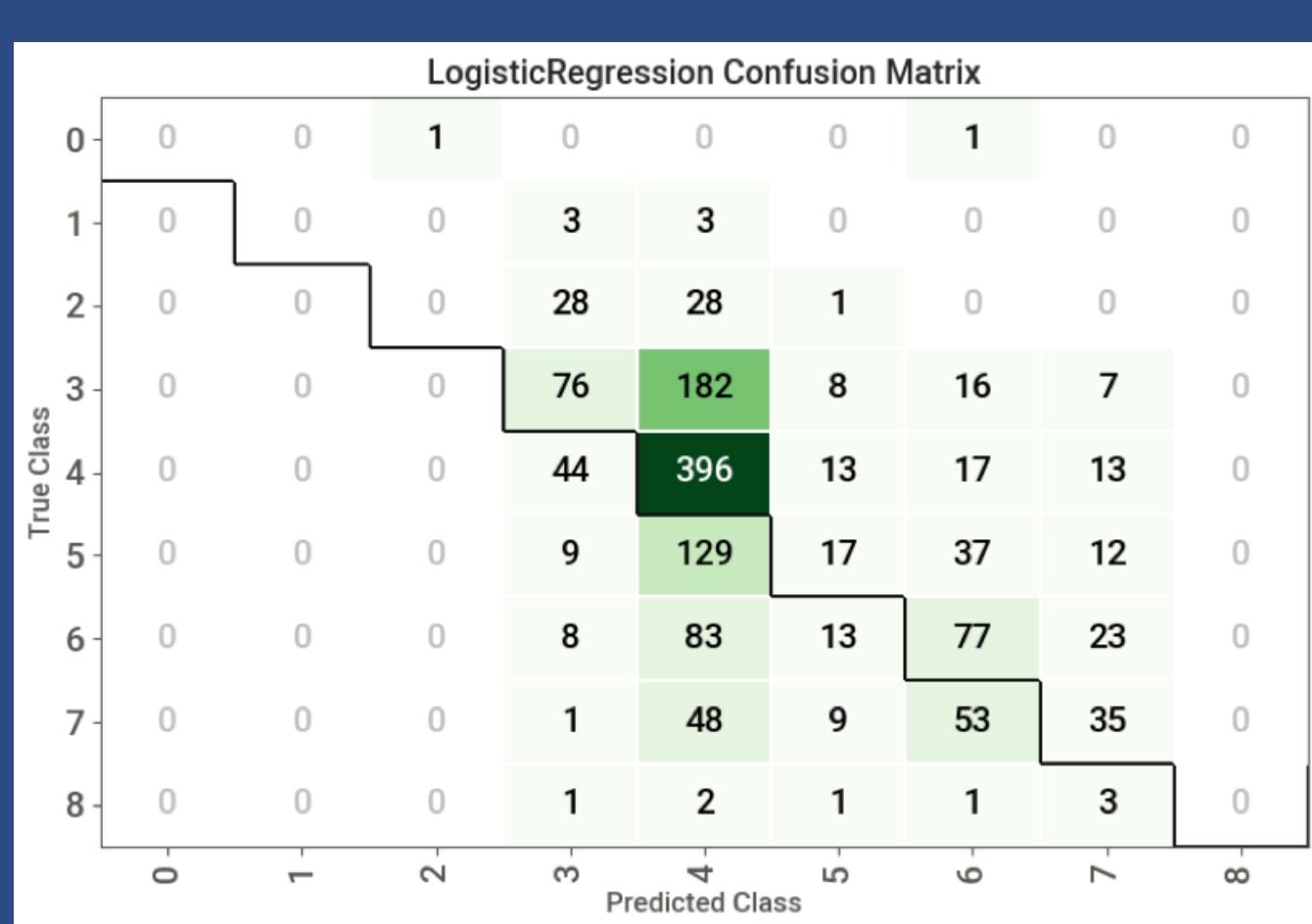
Prediction error on validation set

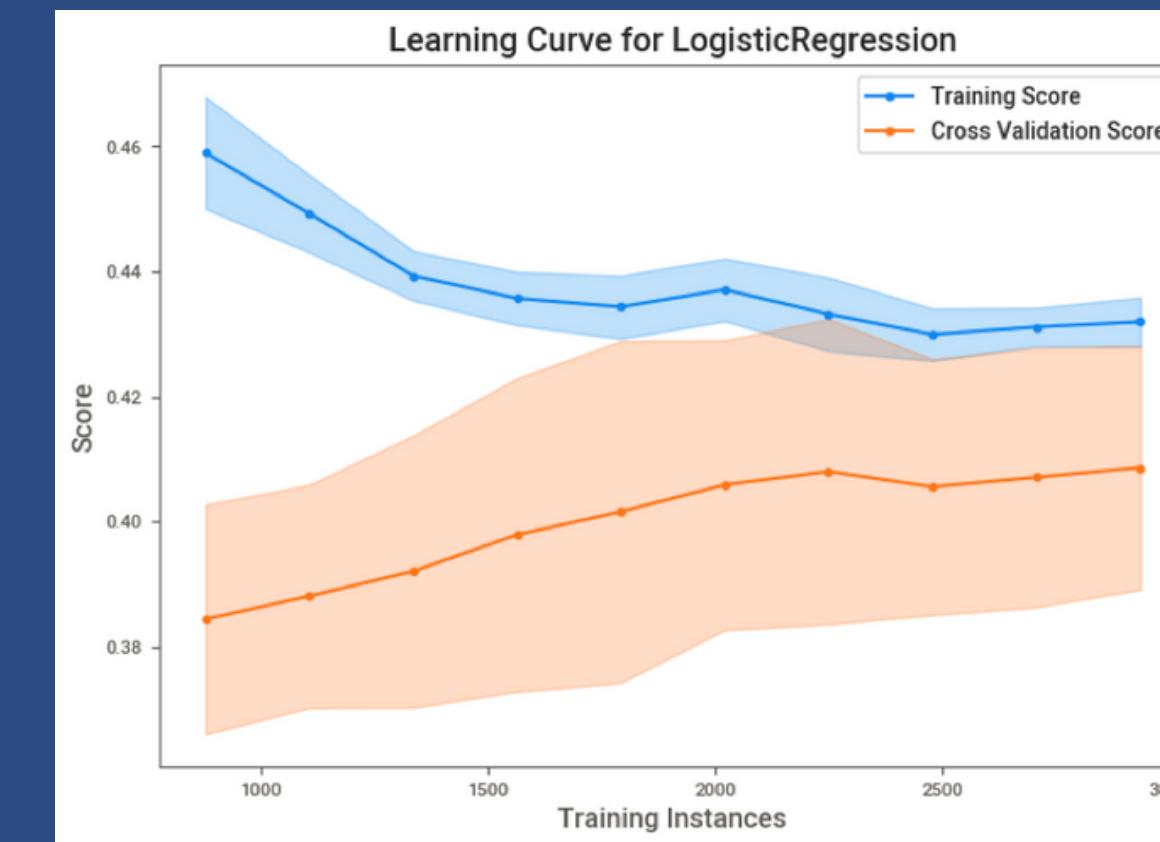
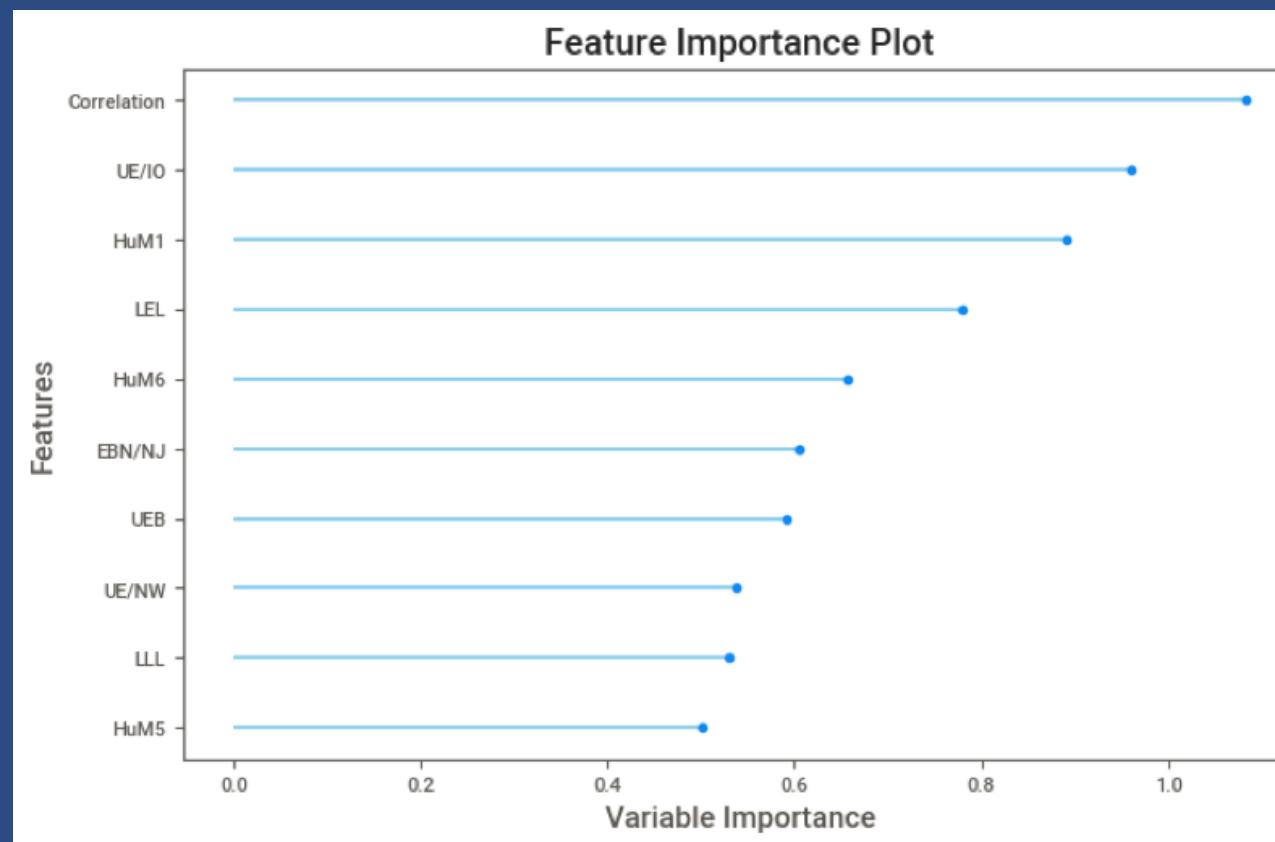
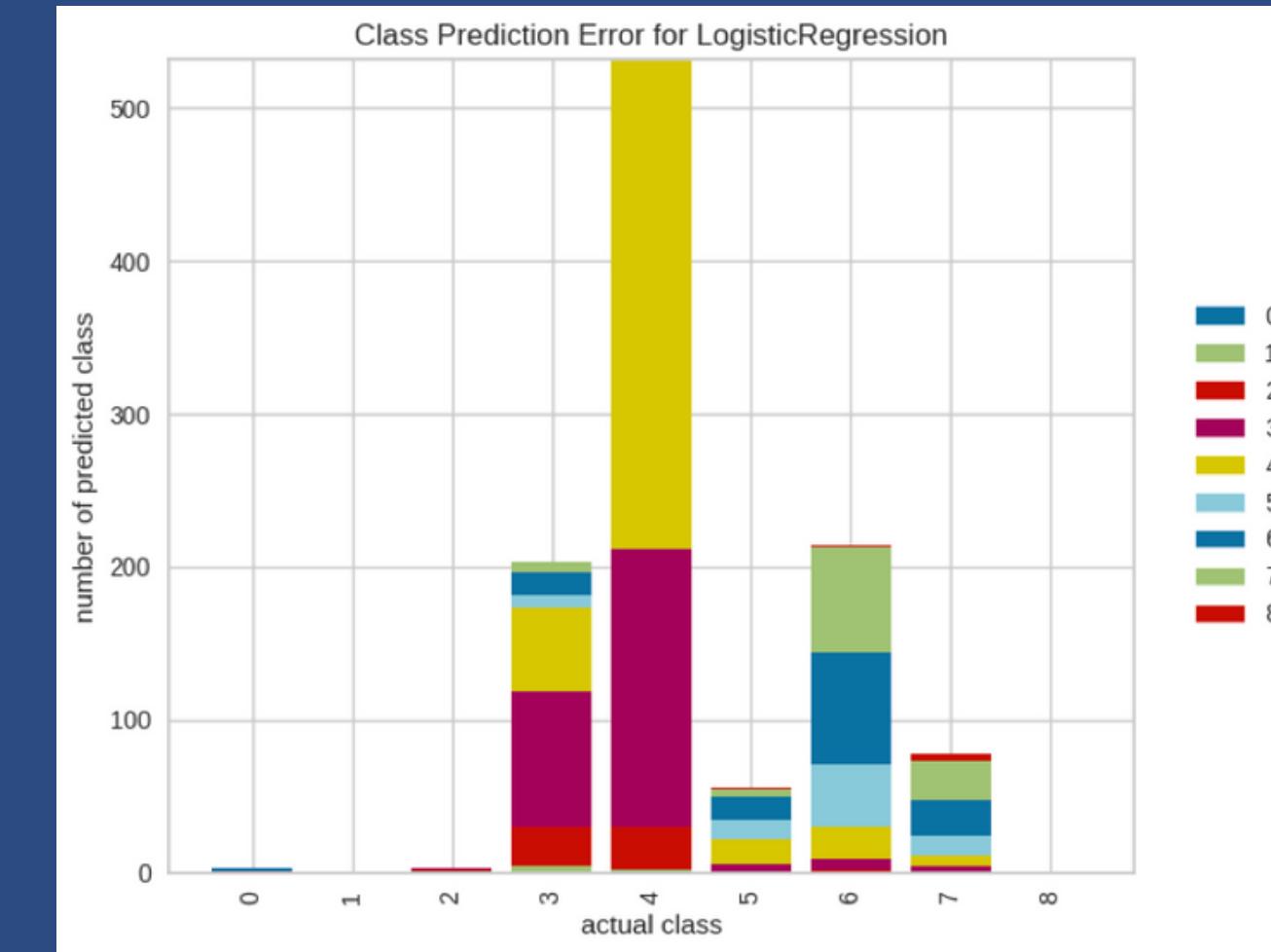
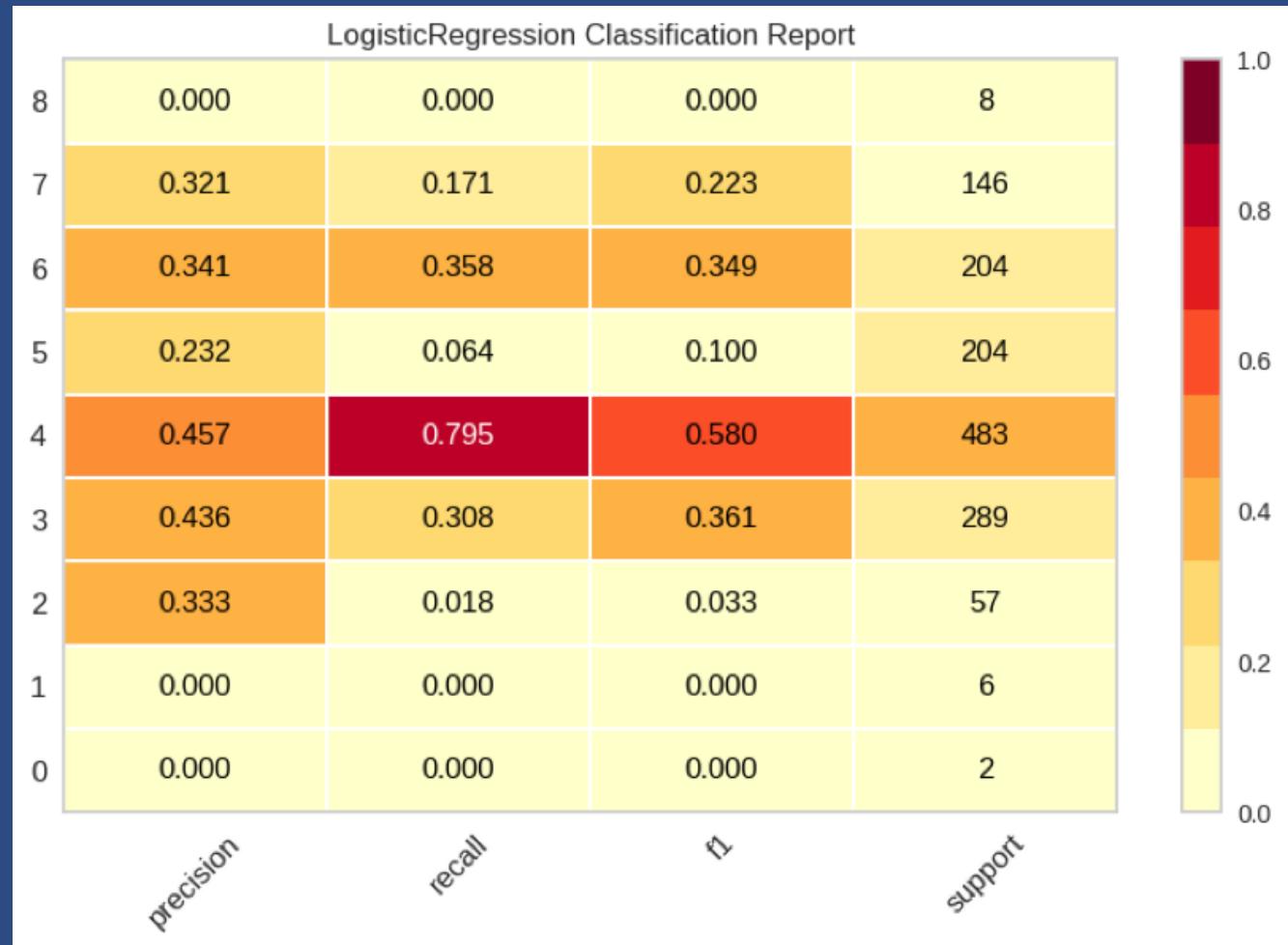
Model Classification

- The Rating were rounded off in intervals of 0.5.
- The class distribution follows a normal distribution.
- Majority of the rating is 3.
- LR Classifier was used for prediction.



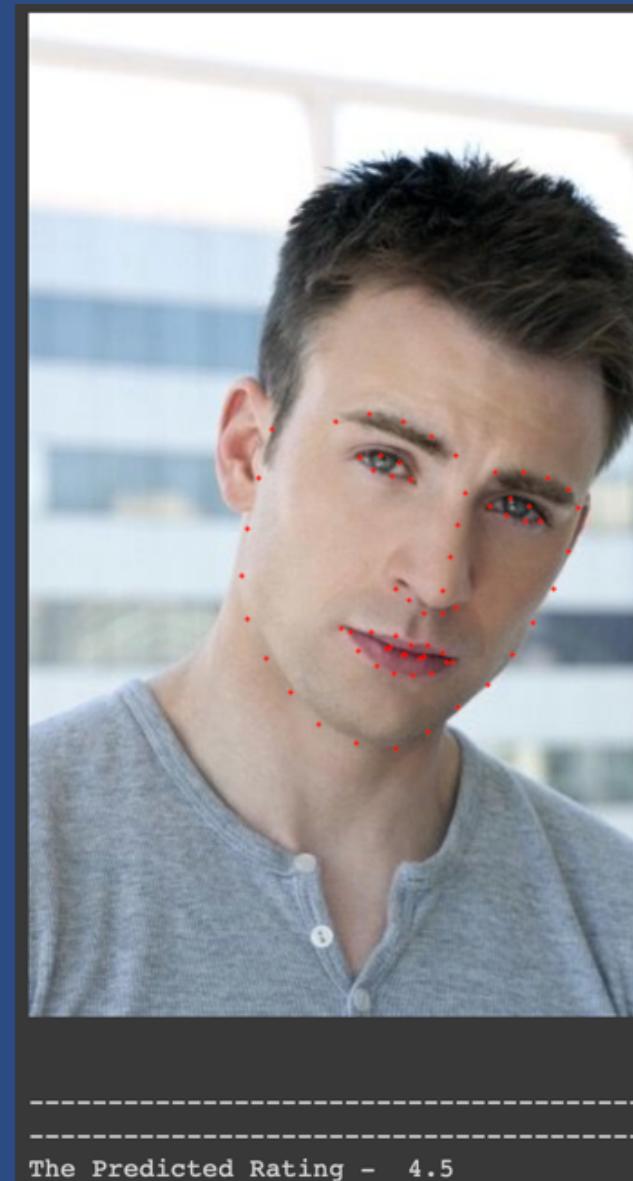
| Data | ACC | RECALL | RRECISION |
|-------|--------|--------|-----------|
| Train | 0.4188 | 0.4188 | 0.3757 |
| Test | 0.4022 | 0.4022 | 0.3750 |





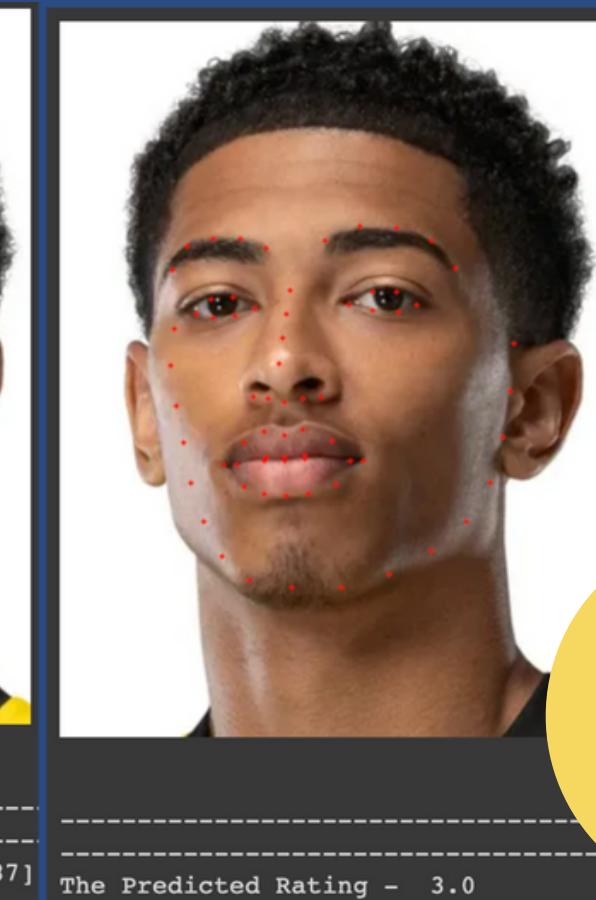
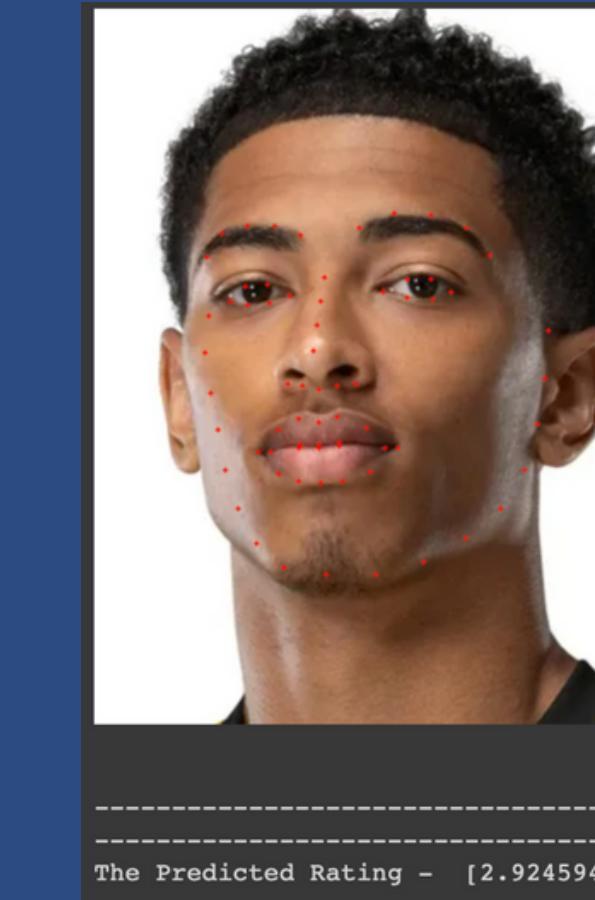
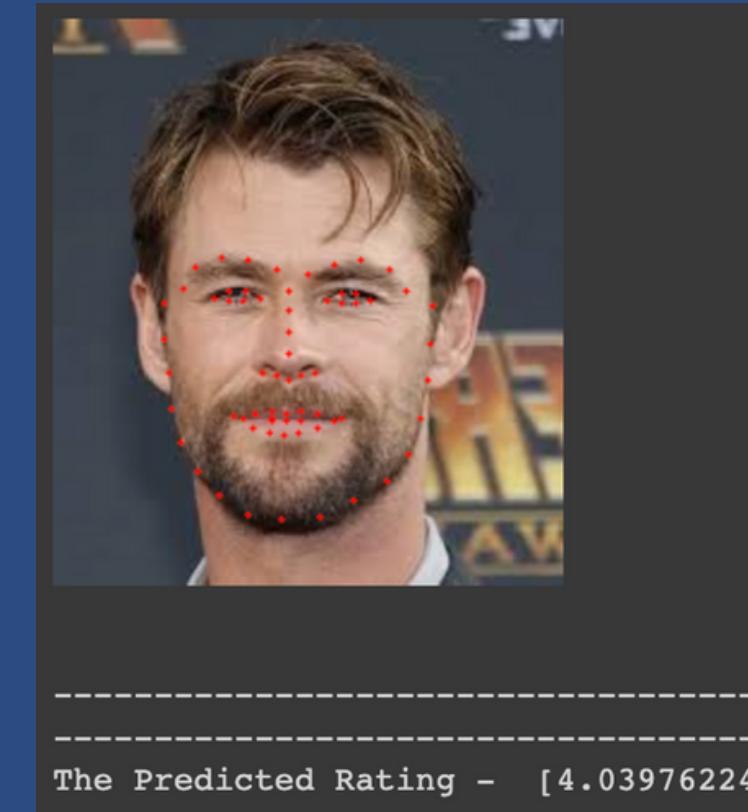
Limitations

1



1. Facial Hair
2. Female Bias
3. Fair Skin bias

2



3

Face Rating API

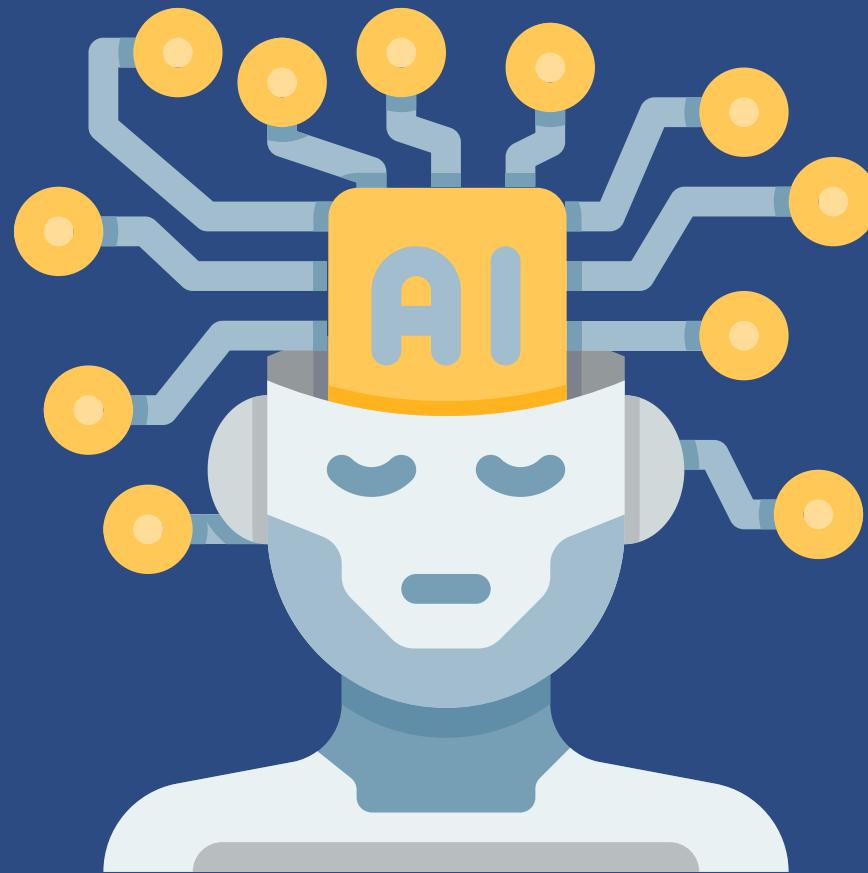


API

- Created using Flask API
 - LR Model (Classification)
- Integrated in the
Backenend
- HTML File created.



THANK YOU!!!



G DRIVE LINK - <https://drive.google.com/drive/folders/1s8dU1ftqWF-ZiUD2WLVR8zsFNZM2kwyy?usp=sharing>
GITHUB LINK - https://github.com/DarkMatter-404/Specchio_Project