face-landmark-detection

May 6, 2023

Importing the data from Kaggle

[1]:
```
! pip install -q kaggle
from google.colab import files
files.upload()
! mkdir ~/.kaggle
! cp kaggle.json ~/.kaggle/
! chmod 600 ~/.kaggle/kaggle.json
```

```
<IPython.core.display.HTML object>
```

```
Saving kaggle.json to kaggle.json
```

[2]:
```
!kaggle datasets download -d drgilermo/face-images-with-marked-landmark-points
```

```
Downloading face-images-with-marked-landmark-points.zip to /content
100% 105M/105M [00:05<00:00, 23.8MB/s]
100% 105M/105M [00:05<00:00, 18.5MB/s]
```

[3]:
```
!unzip face-images-with-marked-landmark-points.zip
```

```
Archive:  face-images-with-marked-landmark-points.zip
  inflating: face_images.npz
  inflating: facial_keypoints.csv
```

Importing Dependencies

[4]:
```
import numpy as np
import pandas as pd
import keras
import cv2 as cv
import xgboost as xgb
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor
from keras.layers import Conv2D, MaxPool2D, GlobalAveragePooling2D, Dense,␣
 ↪Dropout, Input
from keras.models import Sequential, Model
from sklearn.metrics import mean_absolute_error
```

Loading the images

[5]:
```
images = np.load('/content/face_images.npz')
faces = images.get(images.files[0])
faces=np.moveaxis(faces,-1,0)
faces=faces.reshape(faces.shape[0],faces.shape[1],faces.shape[1],1)
```

[6]:
```
print(f"shape of the faces {faces.shape}")
```

```
shape of the faces (7049, 96, 96, 1)
```

[7]:
```
df = pd.read_csv('/content/facial_keypoints.csv')
```

[8]:
```
df.head()
```

[8]:

	left_eye_center_x	left_eye_center_y	right_eye_center_x	right_eye_center_y	left_eye_inner_corner_x	left_eye_inner_corner_y	left_eye_outer_corner_x	left_eye_outer_corner_y	right_eye_inner_corner_x	right_eye_inner_corner_y	…	nose_tip_x	nose_tip_y	mouth_left_corner_x	mouth_left_corner_y	mouth_right_corner_x	mouth_right_corner_y
0	66.033564	39.002274	30.227008	36.421678	59.582075	39.647423	73.130346	39.969997	36.356571	37.389402	…	44.420571	57.066803	61.195308	79.970165	28.614496	77.388992
1	64.332936	34.970077	29.949277	33.448715	58.856170	35.274349	70.722723	36.187166	36.034723	34.361532	…	48.206298	55.660936	56.421447	76.352000	35.122383	76.047660
2	65.057053	34.909642	30.903789	34.909642	59.412000	36.320968	70.984421	36.320968	37.678105	36.320968	…	47.557263	53.538947	60.822947	73.014316	33.726316	72.732000
3	65.225739	37.261774	32.023096	37.261774	60.003339	39.127179	72.314713	38.380967	37.618643	38.754115	…	51.885078	54.166539	65.598887	72.703722	37.245496	74.195478
4	66.725301	39.621261	32.244810	38.042032	58.565890	39.621261	72.515926	39.884466	36.982380	39.094852	…	43.299534	64.889521	60.671411			

```
4            77.523239            31.191755            76.997301

   mouth_center_top_lip_x  mouth_center_top_lip_y  mouth_center_bottom_lip_x  \
0               43.312602               72.935459                  43.130707
1               46.684596               70.266553                  45.467915
2               47.274947               70.191789                  47.274947
3               50.303165               70.091687                  51.561183
4               44.962748               73.707387                  44.227141

   mouth_center_bottom_lip_y
0                  84.485774
1                  85.480170
2                  78.659368
3                  78.268383
4                  86.871166

[5 rows x 30 columns]
```

[9]:
```
df.corr()
```

[9]:
```
                           left_eye_center_x  left_eye_center_y  \
left_eye_center_x                   1.000000           0.029908
left_eye_center_y                   0.029908           1.000000
right_eye_center_x                  0.274459           0.259012
right_eye_center_y                 -0.154728           0.346331
left_eye_inner_corner_x             0.856572           0.065749
left_eye_inner_corner_y             0.022211           0.926728
left_eye_outer_corner_x             0.879976          -0.013411
left_eye_outer_corner_y             0.062128           0.956066
right_eye_inner_corner_x            0.308649           0.101996
right_eye_inner_corner_y           -0.104698           0.537101
right_eye_outer_corner_x           -0.065016           0.152378
right_eye_outer_corner_y           -0.075857           0.229097
left_eyebrow_inner_end_x            0.631805           0.082724
left_eyebrow_inner_end_y           -0.128193           0.609392
left_eyebrow_outer_end_x            0.796638           0.057346
left_eyebrow_outer_end_y           -0.071141           0.760461
right_eyebrow_inner_end_x           0.268463           0.225890
right_eyebrow_inner_end_y          -0.201853           0.342458
right_eyebrow_outer_end_x          -0.137146           0.194586
right_eyebrow_outer_end_y          -0.190548           0.070824
nose_tip_x                          0.457468          -0.166891
nose_tip_y                          0.192274           0.333053
mouth_left_corner_x                 0.422891          -0.340755
mouth_left_corner_y                 0.284087           0.480924
mouth_right_corner_x               -0.008382          -0.392434
mouth_right_corner_y                0.202842           0.219366
```

mouth_center_top_lip_x	0.260753	-0.425576
mouth_center_top_lip_y	0.151302	0.251472
mouth_center_bottom_lip_x	0.374314	-0.379980
mouth_center_bottom_lip_y	0.265655	0.130062

	right_eye_center_x	right_eye_center_y	\
left_eye_center_x	0.274459	-0.154728	
left_eye_center_y	0.259012	0.346331	
right_eye_center_x	1.000000	0.067621	
right_eye_center_y	0.067621	1.000000	
left_eye_inner_corner_x	0.294550	-0.149295	
left_eye_inner_corner_y	0.127367	0.531960	
left_eye_outer_corner_x	-0.024408	-0.144389	
left_eye_outer_corner_y	0.060942	0.221829	
right_eye_inner_corner_x	0.817895	0.055758	
right_eye_inner_corner_y	0.090214	0.923050	
right_eye_outer_corner_x	0.861858	0.078540	
right_eye_outer_corner_y	0.062292	0.954285	
left_eyebrow_inner_end_x	0.301658	-0.262560	
left_eyebrow_inner_end_y	0.138773	0.366292	
left_eyebrow_outer_end_x	-0.063364	-0.240284	
left_eyebrow_outer_end_y	0.083405	0.093072	
right_eyebrow_inner_end_x	0.572767	-0.121474	
right_eyebrow_inner_end_y	0.137839	0.600844	
right_eyebrow_outer_end_x	0.776246	-0.015320	
right_eyebrow_outer_end_y	0.084007	0.751725	
nose_tip_x	0.402189	0.182866	
nose_tip_y	0.024502	0.329233	
mouth_left_corner_x	0.061124	0.312434	
mouth_left_corner_y	-0.172144	0.098019	
mouth_right_corner_x	0.424439	0.257956	
mouth_right_corner_y	-0.215123	0.397645	
mouth_center_top_lip_x	0.308889	0.294145	
mouth_center_top_lip_y	-0.109026	0.198499	
mouth_center_bottom_lip_x	0.319541	0.344010	
mouth_center_bottom_lip_y	-0.251105	0.044597	

	left_eye_inner_corner_x	left_eye_inner_corner_y	\
left_eye_center_x	0.856572	0.022211	
left_eye_center_y	0.065749	0.926728	
right_eye_center_x	0.294550	0.127367	
right_eye_center_y	-0.149295	0.531960	
left_eye_inner_corner_x	1.000000	-0.021444	
left_eye_inner_corner_y	-0.021444	1.000000	
left_eye_outer_corner_x	0.653318	0.010531	
left_eye_outer_corner_y	0.080430	0.869743	
right_eye_inner_corner_x	0.267661	0.150281	

right_eye_inner_corner_y	-0.172852	0.710354
right_eye_outer_corner_x	0.248756	0.104186
right_eye_outer_corner_y	-0.106544	0.371340
left_eyebrow_inner_end_x	0.750635	-0.011428
left_eyebrow_inner_end_y	-0.152820	0.677130
left_eyebrow_outer_end_x	0.622702	0.035147
left_eyebrow_outer_end_y	-0.021592	0.681814
right_eyebrow_inner_end_x	0.372169	0.180705
right_eyebrow_inner_end_y	-0.258597	0.489169
right_eyebrow_outer_end_x	0.112094	0.130958
right_eyebrow_outer_end_y	-0.204863	0.208522
nose_tip_x	0.387317	-0.091006
nose_tip_y	-0.054712	0.426897
mouth_left_corner_x	0.287427	-0.211855
mouth_left_corner_y	0.156495	0.493657
mouth_right_corner_x	0.145968	-0.335989
mouth_right_corner_y	0.046439	0.327081
mouth_center_top_lip_x	0.322217	-0.315929
mouth_center_top_lip_y	-0.083635	0.387311
mouth_center_bottom_lip_x	0.242669	-0.367069
mouth_center_bottom_lip_y	0.303769	0.308555

	left_eye_outer_corner_x	left_eye_outer_corner_y \
left_eye_center_x	0.879976	0.062128
left_eye_center_y	-0.013411	0.956066
right_eye_center_x	-0.024408	0.060942
right_eye_center_y	-0.144389	0.221829
left_eye_inner_corner_x	0.653318	0.080430
left_eye_inner_corner_y	0.010531	0.869743
left_eye_outer_corner_x	1.000000	0.054156
left_eye_outer_corner_y	0.054156	1.000000
right_eye_inner_corner_x	0.316254	0.050529
right_eye_inner_corner_y	-0.094245	0.373183
right_eye_outer_corner_x	-0.350353	0.090892
right_eye_outer_corner_y	-0.077623	0.060410
left_eyebrow_inner_end_x	0.468184	0.109101
left_eyebrow_inner_end_y	-0.140902	0.522014
left_eyebrow_outer_end_x	0.868225	0.139029
left_eyebrow_outer_end_y	-0.097167	0.802413
right_eyebrow_inner_end_x	0.229020	0.232601
right_eyebrow_inner_end_y	-0.200114	0.188524
right_eyebrow_outer_end_x	-0.336098	0.164726
right_eyebrow_outer_end_y	-0.213001	-0.069495
nose_tip_x	0.179189	-0.176047
nose_tip_y	0.165361	0.222928
mouth_left_corner_x	0.507755	-0.392594
mouth_left_corner_y	0.325291	0.506364

```
mouth_right_corner_x                  -0.136411                -0.462165
mouth_right_corner_y                   0.263466                 0.183239
mouth_center_top_lip_x                 0.229154                -0.494482
mouth_center_top_lip_y                 0.292129                 0.216060
mouth_center_bottom_lip_x              0.176392                -0.561581
mouth_center_bottom_lip_y              0.332880                 0.329316

                        right_eye_inner_corner_x  right_eye_inner_corner_y  \
left_eye_center_x                       0.308649                -0.104698
left_eye_center_y                       0.101996                 0.537101
right_eye_center_x                      0.817895                 0.090214
right_eye_center_y                      0.055758                 0.923050
left_eye_inner_corner_x                 0.267661                -0.172852
left_eye_inner_corner_y                 0.150281                 0.710354
left_eye_outer_corner_x                 0.316254                -0.094245
left_eye_outer_corner_y                 0.050529                 0.373183
right_eye_inner_corner_x                1.000000                 0.124023
right_eye_inner_corner_y                0.124023                 1.000000
right_eye_outer_corner_x                0.543188                 0.054442
right_eye_outer_corner_y                0.074985                 0.861327
left_eyebrow_inner_end_x                0.346247                -0.243664
left_eyebrow_inner_end_y                0.137977                 0.515579
left_eyebrow_outer_end_x                0.189012                -0.183551
left_eyebrow_outer_end_y                0.034023                 0.237008
right_eyebrow_inner_end_x               0.657995                -0.046338
right_eyebrow_inner_end_y               0.125718                 0.672297
right_eyebrow_outer_end_x               0.521745                -0.003771
right_eyebrow_outer_end_y               0.068031                 0.673633
nose_tip_x                              0.377931                 0.053212
nose_tip_y                              0.118548                 0.356647
mouth_left_corner_x                     0.262597                 0.237858
mouth_left_corner_y                    -0.054888                 0.225398
mouth_right_corner_x                    0.262056                 0.108121
mouth_right_corner_y                   -0.094748                 0.449346
mouth_center_top_lip_x                  0.369890                 0.176403
mouth_center_top_lip_y                  0.109785                 0.354693
mouth_center_bottom_lip_x               0.309453                 0.203002
mouth_center_bottom_lip_y              -0.230177                 0.164086

                        …  nose_tip_x  nose_tip_y  mouth_left_corner_x  \
left_eye_center_x       …    0.457468    0.192274             0.422891
left_eye_center_y       …   -0.166891    0.333053            -0.340755
right_eye_center_x      …    0.402189    0.024502             0.061124
right_eye_center_y      …    0.182866    0.329233             0.312434
left_eye_inner_corner_x …    0.387317   -0.054712             0.287427
left_eye_inner_corner_y …   -0.091006    0.426897            -0.211855
left_eye_outer_corner_x …    0.179189    0.165361             0.507755
```

left_eye_outer_corner_y	…	-0.176047	0.222928	-0.392594
right_eye_inner_corner_x	…	0.377931	0.118548	0.262597
right_eye_inner_corner_y	…	0.053212	0.356647	0.237858
right_eye_outer_corner_x	…	0.156996	-0.133285	-0.177957
right_eye_outer_corner_y	…	0.171852	0.118600	0.454774
left_eyebrow_inner_end_x	…	0.554900	-0.087723	0.104528
left_eyebrow_inner_end_y	…	-0.007749	0.477947	-0.218913
left_eyebrow_outer_end_x	…	0.103122	0.130824	0.320783
left_eyebrow_outer_end_y	…	-0.161689	0.196461	-0.438723
right_eyebrow_inner_end_x	…	0.516089	0.126098	-0.059611
right_eyebrow_inner_end_y	…	-0.057668	0.422549	0.060252
right_eyebrow_outer_end_x	…	0.046404	-0.134561	-0.302128
right_eyebrow_outer_end_y	…	0.187261	0.112216	0.374869
nose_tip_x	…	1.000000	0.070132	0.339788
nose_tip_y	…	0.070132	1.000000	0.035640
mouth_left_corner_x	…	0.339788	0.035640	1.000000
mouth_left_corner_y	…	-0.099397	0.442267	-0.153760
mouth_right_corner_x	…	0.308948	-0.177473	0.257016
mouth_right_corner_y	…	0.040560	0.415741	0.156002
mouth_center_top_lip_x	…	0.703506	-0.060059	0.722451
mouth_center_top_lip_y	…	-0.010470	0.733981	0.119111
mouth_center_bottom_lip_x	…	0.845545	0.064277	0.737955
mouth_center_bottom_lip_y	…	-0.010041	0.138304	0.051944

	mouth_left_corner_y	mouth_right_corner_x	\
left_eye_center_x	0.284087	-0.008382	
left_eye_center_y	0.480924	-0.392434	
right_eye_center_x	-0.172144	0.424439	
right_eye_center_y	0.098019	0.257956	
left_eye_inner_corner_x	0.156495	0.145968	
left_eye_inner_corner_y	0.493657	-0.335989	
left_eye_outer_corner_x	0.325291	-0.136411	
left_eye_outer_corner_y	0.506364	-0.462165	
right_eye_inner_corner_x	-0.054888	0.262056	
right_eye_inner_corner_y	0.225398	0.108121	
right_eye_outer_corner_x	-0.262503	0.468401	
right_eye_outer_corner_y	0.031565	0.364246	
left_eyebrow_inner_end_x	0.037376	0.017408	
left_eyebrow_inner_end_y	0.276619	-0.170956	
left_eyebrow_outer_end_x	0.389780	-0.240134	
left_eyebrow_outer_end_y	0.386743	-0.385602	
right_eyebrow_inner_end_x	0.139671	0.024607	
right_eyebrow_inner_end_y	0.099020	0.117008	
right_eyebrow_outer_end_x	-0.245991	0.315302	
right_eyebrow_outer_end_y	-0.066545	0.351068	
nose_tip_x	-0.099397	0.308948	
nose_tip_y	0.442267	-0.177473	

mouth_left_corner_x	-0.153760	0.257016
mouth_left_corner_y	1.000000	-0.231965
mouth_right_corner_x	-0.231965	1.000000
mouth_right_corner_y	0.845165	0.047169
mouth_center_top_lip_x	-0.237070	0.706419
mouth_center_top_lip_y	0.726913	-0.182543
mouth_center_bottom_lip_x	-0.278776	0.727747
mouth_center_bottom_lip_y	0.724428	-0.183575

	mouth_right_corner_y	mouth_center_top_lip_x	\
left_eye_center_x	0.202842	0.260753	
left_eye_center_y	0.219366	-0.425576	
right_eye_center_x	-0.215123	0.308889	
right_eye_center_y	0.397645	0.294145	
left_eye_inner_corner_x	0.046439	0.322217	
left_eye_inner_corner_y	0.327081	-0.315929	
left_eye_outer_corner_x	0.263466	0.229154	
left_eye_outer_corner_y	0.183239	-0.494482	
right_eye_inner_corner_x	-0.094748	0.369890	
right_eye_inner_corner_y	0.449346	0.176403	
right_eye_outer_corner_x	-0.323196	0.179465	
right_eye_outer_corner_y	0.398740	0.451419	
left_eyebrow_inner_end_x	-0.124903	0.266158	
left_eyebrow_inner_end_y	0.202403	-0.183568	
left_eyebrow_outer_end_x	0.264717	0.058748	
left_eyebrow_outer_end_y	0.100390	-0.448908	
right_eyebrow_inner_end_x	-0.035666	0.191600	
right_eyebrow_inner_end_y	0.244345	0.058862	
right_eyebrow_outer_end_x	-0.383826	-0.001356	
right_eyebrow_outer_end_y	0.276684	0.426359	
nose_tip_x	0.040560	0.703506	
nose_tip_y	0.415741	-0.060059	
mouth_left_corner_x	0.156002	0.722451	
mouth_left_corner_y	0.845165	-0.237070	
mouth_right_corner_x	0.047169	0.706419	
mouth_right_corner_y	1.000000	0.114100	
mouth_center_top_lip_x	0.114100	1.000000	
mouth_center_top_lip_y	0.741801	-0.021879	
mouth_center_bottom_lip_x	0.119912	0.975837	
mouth_center_bottom_lip_y	0.681152	-0.077797	

	mouth_center_top_lip_y	mouth_center_bottom_lip_x	\
left_eye_center_x	0.151302	0.374314	
left_eye_center_y	0.251472	-0.379980	
right_eye_center_x	-0.109026	0.319541	
right_eye_center_y	0.198499	0.344010	
left_eye_inner_corner_x	-0.083635	0.242669	

left_eye_inner_corner_y	0.387311	-0.367069
left_eye_outer_corner_x	0.292129	0.176392
left_eye_outer_corner_y	0.216060	-0.561581
right_eye_inner_corner_x	0.109785	0.309453
right_eye_inner_corner_y	0.354693	0.203002
right_eye_outer_corner_x	-0.327911	0.140704
right_eye_outer_corner_y	0.139957	0.504343
left_eyebrow_inner_end_x	-0.114208	0.178256
left_eyebrow_inner_end_y	0.414661	-0.219322
left_eyebrow_outer_end_x	0.243773	0.020986
left_eyebrow_outer_end_y	0.159086	-0.493071
right_eyebrow_inner_end_x	0.081940	0.093641
right_eyebrow_inner_end_y	0.371001	0.076888
right_eyebrow_outer_end_x	-0.271817	-0.042747
right_eyebrow_outer_end_y	0.085133	0.477362
nose_tip_x	-0.010470	0.845545
nose_tip_y	0.733981	0.064277
mouth_left_corner_x	0.119111	0.737955
mouth_left_corner_y	0.726913	-0.278776
mouth_right_corner_x	-0.182543	0.727747
mouth_right_corner_y	0.741801	0.119912
mouth_center_top_lip_x	-0.021879	0.975837
mouth_center_top_lip_y	1.000000	-0.047274
mouth_center_bottom_lip_x	-0.047274	1.000000
mouth_center_bottom_lip_y	0.410089	-0.034845

	mouth_center_bottom_lip_y
left_eye_center_x	0.265655
left_eye_center_y	0.130062
right_eye_center_x	-0.251105
right_eye_center_y	0.044597
left_eye_inner_corner_x	0.303769
left_eye_inner_corner_y	0.308555
left_eye_outer_corner_x	0.332880
left_eye_outer_corner_y	0.329316
right_eye_inner_corner_x	-0.230177
right_eye_inner_corner_y	0.164086
right_eye_outer_corner_x	-0.277736
right_eye_outer_corner_y	0.090795
left_eyebrow_inner_end_x	0.079219
left_eyebrow_inner_end_y	0.103497
left_eyebrow_outer_end_x	0.419651
left_eyebrow_outer_end_y	0.234645
right_eyebrow_inner_end_x	-0.016916
right_eyebrow_inner_end_y	-0.019619
right_eyebrow_outer_end_x	-0.368392
right_eyebrow_outer_end_y	0.018289

```
nose_tip_x                    -0.010041
nose_tip_y                     0.138304
mouth_left_corner_x            0.051944
mouth_left_corner_y            0.724428
mouth_right_corner_x          -0.183575
mouth_right_corner_y           0.681152
mouth_center_top_lip_x        -0.077797
mouth_center_top_lip_y         0.410089
mouth_center_bottom_lip_x     -0.034845
mouth_center_bottom_lip_y      1.000000

[30 rows x 30 columns]
```

[10]:
```
df.isnull().sum()
```

[10]:
```
left_eye_center_x             10
left_eye_center_y             10
right_eye_center_x            13
right_eye_center_y            13
left_eye_inner_corner_x     4778
left_eye_inner_corner_y     4778
left_eye_outer_corner_x     4782
left_eye_outer_corner_y     4782
right_eye_inner_corner_x    4781
right_eye_inner_corner_y    4781
right_eye_outer_corner_x    4781
right_eye_outer_corner_y    4781
left_eyebrow_inner_end_x    4779
left_eyebrow_inner_end_y    4779
left_eyebrow_outer_end_x    4824
left_eyebrow_outer_end_y    4824
right_eyebrow_inner_end_x   4779
right_eyebrow_inner_end_y   4779
right_eyebrow_outer_end_x   4813
right_eyebrow_outer_end_y   4813
nose_tip_x                     0
nose_tip_y                     0
mouth_left_corner_x         4780
mouth_left_corner_y         4780
mouth_right_corner_x        4779
mouth_right_corner_y        4779
mouth_center_top_lip_x      4774
mouth_center_top_lip_y      4774
mouth_center_bottom_lip_x     33
mouth_center_bottom_lip_y     33
dtype: int64
```

[11]:
```
def missing_values(df, column):    # handling the missing values with mean
  df[column] = df[column].fillna(df[column].mean())
```

[12]:
```
for i in df.columns:
  missing_values(df, i)
```

[13]:
```
df.isnull().sum()
```

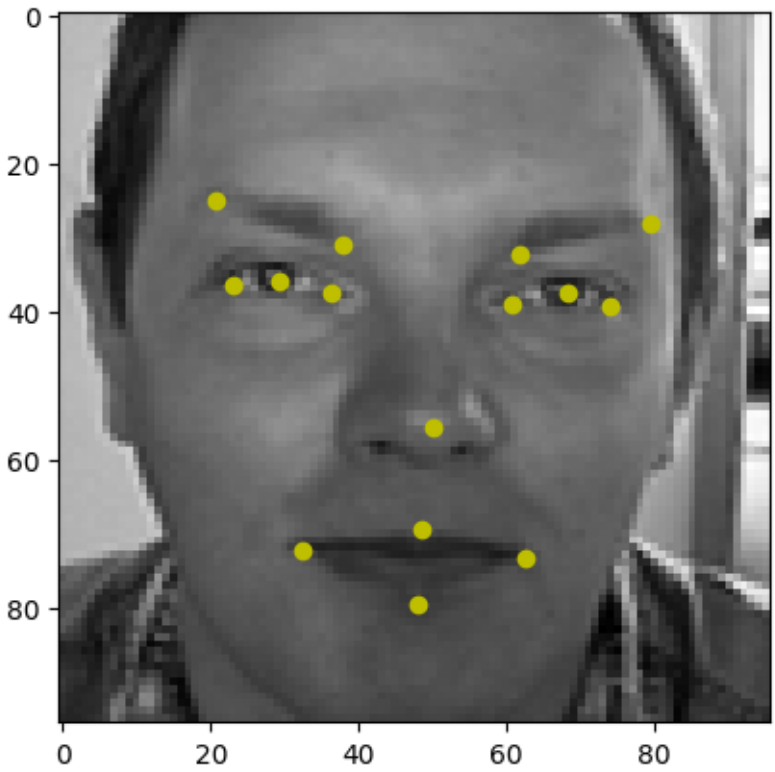
[13]:
```
left_eye_center_x            0
left_eye_center_y            0
right_eye_center_x           0
right_eye_center_y           0
left_eye_inner_corner_x      0
left_eye_inner_corner_y      0
left_eye_outer_corner_x      0
left_eye_outer_corner_y      0
right_eye_inner_corner_x     0
right_eye_inner_corner_y     0
right_eye_outer_corner_x     0
right_eye_outer_corner_y     0
left_eyebrow_inner_end_x     0
left_eyebrow_inner_end_y     0
left_eyebrow_outer_end_x     0
left_eyebrow_outer_end_y     0
right_eyebrow_inner_end_x    0
right_eyebrow_inner_end_y    0
right_eyebrow_outer_end_x    0
right_eyebrow_outer_end_y    0
nose_tip_x                   0
nose_tip_y                   0
mouth_left_corner_x          0
mouth_left_corner_y          0
mouth_right_corner_x         0
mouth_right_corner_y         0
mouth_center_top_lip_x       0
mouth_center_top_lip_y       0
mouth_center_bottom_lip_x    0
mouth_center_bottom_lip_y    0
dtype: int64
```

[14]:
```
face_points = []     # appending the landmarks into face_points list
for i in range(df.shape[0]):
  face_points.append(list(df.iloc[i,:]))
```

[15]:
```
face_points = np.array(face_points)    #converting the face points into numpy␣
 ↪array
```

[16]:
```
plt.figure(figsize=(10,5))
for i in range(25):
  plt.subplot(5,5,i+1)
  plt.imshow(faces[i], cmap='gray')
  plt.axis("off")
plt.show()
```

[17]:
```
def plot_points(img_number):
  points = list(df.iloc[img_number,:])
  plt.imshow(faces[img_number], cmap='gray')
  for i in range(0, len(points), 2):
    plt.scatter(points[i:i+2][0], points[i:i+2][1], c='y')
  plt.show()
plot_points(799)
```



[18]:
```
faces = faces/255      # normalising the faces
```

[19]:
```
x_train, x_test, y_train, y_test = train_test_split(faces, face_points,␣
 ↪test_size = 0.2, random_state=44)
```

[20]:
```
print(f"the shape of x_train is {x_train.shape}")
print(f"the shape of y_train is {y_train.shape}")
print(f"the shape of x_test is {x_test.shape}")
print(f"the shape of y_test is {y_test.shape}")
```

```
the shape of x_train is (5639, 96, 96, 1)
the shape of y_train is (5639, 30)
the shape of x_test is (1410, 96, 96, 1)
the shape of y_test is (1410, 30)
```

CNN Model

[21]:
```
model = Sequential()

model.add(Conv2D(32, (3,3), input_shape=(96,96,1), activation="relu",␣
 ↪padding="same"))
model.add(MaxPool2D(2,2))
model.add(Dropout(0.1))
```

```
model.add(Conv2D(64, (3,3), activation="relu",padding="same"))
model.add(MaxPool2D(2,2))
model.add(Dropout(0.2))
model.add(Conv2D(128, (3,3), activation="relu", padding="same"))
model.add(MaxPool2D(2,2))
model.add(Dropout(0.3))
model.add(Conv2D(256, (3,3), activation="relu", padding="same"))
model.add(MaxPool2D(2,2))
model.add(Dropout(0.3))
model.add(GlobalAveragePooling2D())
model.add(Dense(128, activation="relu"))
model.add(Dense(30, activation="leaky_relu"))
```

[22]:
```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 96, 96, 32)        320

 max_pooling2d (MaxPooling2D  (None, 48, 48, 32)       0
 )

 dropout (Dropout)           (None, 48, 48, 32)        0

 conv2d_1 (Conv2D)           (None, 48, 48, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 24, 24, 64)       0
 2D)

 dropout_1 (Dropout)         (None, 24, 24, 64)        0

 conv2d_2 (Conv2D)           (None, 24, 24, 128)       73856

 max_pooling2d_2 (MaxPooling  (None, 12, 12, 128)      0
 2D)

 dropout_2 (Dropout)         (None, 12, 12, 128)       0

 conv2d_3 (Conv2D)           (None, 12, 12, 256)       295168

 max_pooling2d_3 (MaxPooling  (None, 6, 6, 256)        0
 2D)

 dropout_3 (Dropout)         (None, 6, 6, 256)         0
```

```
 global_average_pooling2d (G  (None, 256)              0
 lobalAveragePooling2D)

 dense (Dense)               (None, 128)              32896

 dense_1 (Dense)             (None, 30)               3870

=================================================================
Total params: 424,606
Trainable params: 424,606
Non-trainable params: 0
_________________________________________________________________
```

[23]:
```
model.compile(optimizer="adam", loss="mse", metrics=['mae'])
```

[24]:
```
history = model.fit(x_train, y_train, validation_data=(x_test, y_test),␣
↪epochs=100)
```

```
Epoch 1/100
177/177 [==============================] - 15s 25ms/step - loss: 247.6686 - mae:
8.0113 - val_loss: 83.7798 - val_mae: 8.1261
Epoch 2/100
177/177 [==============================] - 3s 17ms/step - loss: 10.6864 - mae:
2.1842 - val_loss: 113.7821 - val_mae: 9.6577
Epoch 3/100
177/177 [==============================] - 3s 16ms/step - loss: 9.2263 - mae:
1.9392 - val_loss: 110.1818 - val_mae: 9.4742
Epoch 4/100
177/177 [==============================] - 3s 16ms/step - loss: 9.3054 - mae:
1.9498 - val_loss: 98.8887 - val_mae: 8.9893
Epoch 5/100
177/177 [==============================] - 3s 16ms/step - loss: 9.6848 - mae:
2.0189 - val_loss: 103.1080 - val_mae: 9.1244
Epoch 6/100
177/177 [==============================] - 3s 16ms/step - loss: 8.8998 - mae:
1.8674 - val_loss: 159.7516 - val_mae: 11.5458
Epoch 7/100
177/177 [==============================] - 3s 17ms/step - loss: 9.4427 - mae:
1.9738 - val_loss: 111.6284 - val_mae: 9.5531
Epoch 8/100
177/177 [==============================] - 3s 17ms/step - loss: 9.4034 - mae:
1.9845 - val_loss: 97.8728 - val_mae: 8.9150
Epoch 9/100
177/177 [==============================] - 3s 16ms/step - loss: 9.5542 - mae:
1.9968 - val_loss: 133.2152 - val_mae: 10.4973
Epoch 10/100
177/177 [==============================] - 3s 16ms/step - loss: 9.3016 - mae:
1.9448 - val_loss: 100.8673 - val_mae: 9.1203
```

```
Epoch 11/100
177/177 [==============================] - 3s 17ms/step - loss: 9.5358 - mae:
1.9911 - val_loss: 89.7404 - val_mae: 8.5451
Epoch 12/100
177/177 [==============================] - 3s 16ms/step - loss: 9.2227 - mae:
1.9397 - val_loss: 106.7844 - val_mae: 9.3419
Epoch 13/100
177/177 [==============================] - 3s 16ms/step - loss: 8.8619 - mae:
1.8504 - val_loss: 102.1288 - val_mae: 9.1179
Epoch 14/100
177/177 [==============================] - 3s 16ms/step - loss: 9.2572 - mae:
1.9336 - val_loss: 106.6310 - val_mae: 9.3546
Epoch 15/100
177/177 [==============================] - 3s 17ms/step - loss: 9.3389 - mae:
1.9620 - val_loss: 82.9103 - val_mae: 8.1393
Epoch 16/100
177/177 [==============================] - 3s 17ms/step - loss: 9.1877 - mae:
1.9333 - val_loss: 90.3143 - val_mae: 8.5493
Epoch 17/100
177/177 [==============================] - 3s 16ms/step - loss: 9.1932 - mae:
1.9149 - val_loss: 114.8879 - val_mae: 9.7004
Epoch 18/100
177/177 [==============================] - 3s 16ms/step - loss: 9.1223 - mae:
1.9126 - val_loss: 84.8320 - val_mae: 8.2596
Epoch 19/100
177/177 [==============================] - 3s 17ms/step - loss: 9.2219 - mae:
1.9320 - val_loss: 103.1709 - val_mae: 9.1269
Epoch 20/100
177/177 [==============================] - 3s 16ms/step - loss: 8.8229 - mae:
1.8510 - val_loss: 101.4413 - val_mae: 9.1014
Epoch 21/100
177/177 [==============================] - 3s 17ms/step - loss: 8.6790 - mae:
1.8219 - val_loss: 65.5756 - val_mae: 7.2342
Epoch 22/100
177/177 [==============================] - 3s 17ms/step - loss: 9.1055 - mae:
1.9128 - val_loss: 79.3852 - val_mae: 7.9963
Epoch 23/100
177/177 [==============================] - 3s 17ms/step - loss: 8.9796 - mae:
1.8918 - val_loss: 77.5703 - val_mae: 7.9403
Epoch 24/100
177/177 [==============================] - 3s 17ms/step - loss: 8.7981 - mae:
1.8426 - val_loss: 73.4912 - val_mae: 7.6473
Epoch 25/100
177/177 [==============================] - 3s 17ms/step - loss: 8.8405 - mae:
1.8562 - val_loss: 95.9177 - val_mae: 8.8139
Epoch 26/100
177/177 [==============================] - 3s 17ms/step - loss: 8.7959 - mae:
1.8459 - val_loss: 101.8479 - val_mae: 9.1248
```

```
Epoch 27/100
177/177 [==============================] - 3s 17ms/step - loss: 8.9323 - mae:
1.8700 - val_loss: 53.6439 - val_mae: 6.5124
Epoch 28/100
177/177 [==============================] - 3s 17ms/step - loss: 8.7616 - mae:
1.8328 - val_loss: 67.9234 - val_mae: 7.3416
Epoch 29/100
177/177 [==============================] - 3s 16ms/step - loss: 9.0021 - mae:
1.8954 - val_loss: 97.4173 - val_mae: 8.8958
Epoch 30/100
177/177 [==============================] - 3s 16ms/step - loss: 8.9739 - mae:
1.8845 - val_loss: 74.2736 - val_mae: 7.6851
Epoch 31/100
177/177 [==============================] - 3s 17ms/step - loss: 8.7079 - mae:
1.8233 - val_loss: 37.1465 - val_mae: 5.2425
Epoch 32/100
177/177 [==============================] - 3s 17ms/step - loss: 8.8279 - mae:
1.8487 - val_loss: 52.3115 - val_mae: 6.3940
Epoch 33/100
177/177 [==============================] - 3s 16ms/step - loss: 8.7103 - mae:
1.8222 - val_loss: 69.0528 - val_mae: 7.4193
Epoch 34/100
177/177 [==============================] - 3s 17ms/step - loss: 8.7592 - mae:
1.8341 - val_loss: 82.6843 - val_mae: 8.1918
Epoch 35/100
177/177 [==============================] - 3s 17ms/step - loss: 8.5312 - mae:
1.7767 - val_loss: 69.9608 - val_mae: 7.4930
Epoch 36/100
177/177 [==============================] - 3s 17ms/step - loss: 8.5891 - mae:
1.8035 - val_loss: 61.9837 - val_mae: 7.0418
Epoch 37/100
177/177 [==============================] - 3s 16ms/step - loss: 8.7157 - mae:
1.8235 - val_loss: 78.1996 - val_mae: 7.9179
Epoch 38/100
177/177 [==============================] - 3s 17ms/step - loss: 8.7549 - mae:
1.8291 - val_loss: 66.0679 - val_mae: 7.2954
Epoch 39/100
177/177 [==============================] - 3s 16ms/step - loss: 8.7454 - mae:
1.8421 - val_loss: 65.0089 - val_mae: 7.1298
Epoch 40/100
177/177 [==============================] - 3s 17ms/step - loss: 8.7682 - mae:
1.8444 - val_loss: 61.1667 - val_mae: 6.9679
Epoch 41/100
177/177 [==============================] - 3s 16ms/step - loss: 8.4494 - mae:
1.7594 - val_loss: 54.8232 - val_mae: 6.5255
Epoch 42/100
177/177 [==============================] - 3s 16ms/step - loss: 9.3137 - mae:
1.9588 - val_loss: 44.4323 - val_mae: 5.8153
```

```
Epoch 43/100
177/177 [==============================] - 3s 16ms/step - loss: 8.9189 - mae:
1.8762 - val_loss: 54.5603 - val_mae: 6.5240
Epoch 44/100
177/177 [==============================] - 3s 17ms/step - loss: 8.6738 - mae:
1.8216 - val_loss: 72.8856 - val_mae: 7.6386
Epoch 45/100
177/177 [==============================] - 3s 16ms/step - loss: 8.5333 - mae:
1.7914 - val_loss: 62.3959 - val_mae: 6.9697
Epoch 46/100
177/177 [==============================] - 3s 16ms/step - loss: 8.7475 - mae:
1.8180 - val_loss: 47.0339 - val_mae: 6.0760
Epoch 47/100
177/177 [==============================] - 3s 17ms/step - loss: 8.5913 - mae:
1.8032 - val_loss: 47.9425 - val_mae: 6.1126
Epoch 48/100
177/177 [==============================] - 3s 16ms/step - loss: 8.4712 - mae:
1.7779 - val_loss: 56.3800 - val_mae: 6.6307
Epoch 49/100
177/177 [==============================] - 3s 17ms/step - loss: 8.4064 - mae:
1.7641 - val_loss: 53.0067 - val_mae: 6.4272
Epoch 50/100
177/177 [==============================] - 3s 16ms/step - loss: 8.4607 - mae:
1.7763 - val_loss: 63.2502 - val_mae: 7.0850
Epoch 51/100
177/177 [==============================] - 3s 17ms/step - loss: 8.5722 - mae:
1.8009 - val_loss: 52.5184 - val_mae: 6.4305
Epoch 52/100
177/177 [==============================] - 3s 16ms/step - loss: 8.3858 - mae:
1.7621 - val_loss: 53.6307 - val_mae: 6.5158
Epoch 53/100
177/177 [==============================] - 3s 17ms/step - loss: 8.2413 - mae:
1.7310 - val_loss: 53.4798 - val_mae: 6.4642
Epoch 54/100
177/177 [==============================] - 3s 16ms/step - loss: 8.5102 - mae:
1.7841 - val_loss: 44.5038 - val_mae: 5.8885
Epoch 55/100
177/177 [==============================] - 3s 16ms/step - loss: 8.6417 - mae:
1.8303 - val_loss: 52.5037 - val_mae: 6.4289
Epoch 56/100
177/177 [==============================] - 3s 16ms/step - loss: 8.4937 - mae:
1.7833 - val_loss: 52.7772 - val_mae: 6.4411
Epoch 57/100
177/177 [==============================] - 3s 17ms/step - loss: 8.2668 - mae:
1.7316 - val_loss: 32.1862 - val_mae: 4.8185
Epoch 58/100
177/177 [==============================] - 3s 16ms/step - loss: 8.7145 - mae:
1.8418 - val_loss: 26.5276 - val_mae: 4.3258
```

```
Epoch 59/100
177/177 [==============================] - 3s 16ms/step - loss: 8.2396 - mae:
1.7212 - val_loss: 35.2654 - val_mae: 5.1483
Epoch 60/100
177/177 [==============================] - 3s 16ms/step - loss: 8.4176 - mae:
1.7674 - val_loss: 43.3570 - val_mae: 5.7617
Epoch 61/100
177/177 [==============================] - 3s 17ms/step - loss: 8.5178 - mae:
1.7926 - val_loss: 42.6054 - val_mae: 5.7153
Epoch 62/100
177/177 [==============================] - 3s 16ms/step - loss: 8.3288 - mae:
1.7395 - val_loss: 33.5896 - val_mae: 5.0125
Epoch 63/100
177/177 [==============================] - 3s 16ms/step - loss: 8.1065 - mae:
1.6984 - val_loss: 20.0270 - val_mae: 3.5657
Epoch 64/100
177/177 [==============================] - 3s 16ms/step - loss: 8.3581 - mae:
1.7635 - val_loss: 22.6849 - val_mae: 3.9956
Epoch 65/100
177/177 [==============================] - 3s 16ms/step - loss: 8.0364 - mae:
1.6897 - val_loss: 26.7727 - val_mae: 4.3404
Epoch 66/100
177/177 [==============================] - 3s 16ms/step - loss: 8.1213 - mae:
1.7080 - val_loss: 21.6563 - val_mae: 3.8046
Epoch 67/100
177/177 [==============================] - 3s 15ms/step - loss: 8.2241 - mae:
1.7429 - val_loss: 16.0141 - val_mae: 3.2331
Epoch 68/100
177/177 [==============================] - 3s 16ms/step - loss: 8.0199 - mae:
1.6879 - val_loss: 42.4361 - val_mae: 5.7043
Epoch 69/100
177/177 [==============================] - 3s 15ms/step - loss: 8.3339 - mae:
1.7552 - val_loss: 23.3266 - val_mae: 4.0400
Epoch 70/100
177/177 [==============================] - 3s 17ms/step - loss: 8.1687 - mae:
1.7268 - val_loss: 16.2006 - val_mae: 3.2437
Epoch 71/100
177/177 [==============================] - 3s 16ms/step - loss: 8.1271 - mae:
1.7238 - val_loss: 15.0111 - val_mae: 2.9976
Epoch 72/100
177/177 [==============================] - 3s 16ms/step - loss: 8.0443 - mae:
1.7159 - val_loss: 12.3291 - val_mae: 2.6578
Epoch 73/100
177/177 [==============================] - 3s 16ms/step - loss: 8.0654 - mae:
1.7158 - val_loss: 24.9140 - val_mae: 4.2030
Epoch 74/100
177/177 [==============================] - 3s 17ms/step - loss: 8.0045 - mae:
1.7041 - val_loss: 16.1755 - val_mae: 3.2555
```

```
Epoch 75/100
177/177 [==============================] - 3s 15ms/step - loss: 7.8202 - mae:
1.6691 - val_loss: 20.4917 - val_mae: 3.7420
Epoch 76/100
177/177 [==============================] - 3s 15ms/step - loss: 8.0126 - mae:
1.7227 - val_loss: 19.7065 - val_mae: 3.6758
Epoch 77/100
177/177 [==============================] - 3s 15ms/step - loss: 7.8310 - mae:
1.6813 - val_loss: 15.4774 - val_mae: 3.1098
Epoch 78/100
177/177 [==============================] - 3s 17ms/step - loss: 7.7742 - mae:
1.6670 - val_loss: 16.0787 - val_mae: 3.1778
Epoch 79/100
177/177 [==============================] - 3s 17ms/step - loss: 7.8609 - mae:
1.6908 - val_loss: 21.0233 - val_mae: 3.7739
Epoch 80/100
177/177 [==============================] - 3s 15ms/step - loss: 7.8045 - mae:
1.6851 - val_loss: 17.0281 - val_mae: 3.3428
Epoch 81/100
177/177 [==============================] - 3s 15ms/step - loss: 7.8090 - mae:
1.7006 - val_loss: 13.2803 - val_mae: 2.8194
Epoch 82/100
177/177 [==============================] - 3s 16ms/step - loss: 8.0213 - mae:
1.7467 - val_loss: 11.8131 - val_mae: 2.6356
Epoch 83/100
177/177 [==============================] - 3s 17ms/step - loss: 7.7927 - mae:
1.7003 - val_loss: 12.2382 - val_mae: 2.6739
Epoch 84/100
177/177 [==============================] - 3s 16ms/step - loss: 7.6791 - mae:
1.6584 - val_loss: 15.3685 - val_mae: 3.1307
Epoch 85/100
177/177 [==============================] - 3s 16ms/step - loss: 7.6913 - mae:
1.6834 - val_loss: 16.1119 - val_mae: 3.2295
Epoch 86/100
177/177 [==============================] - 3s 15ms/step - loss: 7.5466 - mae:
1.6398 - val_loss: 10.7598 - val_mae: 2.4090
Epoch 87/100
177/177 [==============================] - 3s 16ms/step - loss: 7.6180 - mae:
1.6670 - val_loss: 13.5462 - val_mae: 2.8233
Epoch 88/100
177/177 [==============================] - 3s 15ms/step - loss: 7.7813 - mae:
1.7066 - val_loss: 18.1851 - val_mae: 3.5273
Epoch 89/100
177/177 [==============================] - 3s 15ms/step - loss: 7.6687 - mae:
1.6926 - val_loss: 18.3210 - val_mae: 3.5165
Epoch 90/100
177/177 [==============================] - 3s 16ms/step - loss: 7.7163 - mae:
1.6930 - val_loss: 13.8138 - val_mae: 2.9126
```

```
Epoch 91/100
177/177 [==============================] - 3s 17ms/step - loss: 7.3981 - mae:
1.6206 - val_loss: 8.9744 - val_mae: 2.1093
Epoch 92/100
177/177 [==============================] - 3s 17ms/step - loss: 7.5680 - mae:
1.6752 - val_loss: 19.7709 - val_mae: 3.6264
Epoch 93/100
177/177 [==============================] - 3s 15ms/step - loss: 7.6256 - mae:
1.6861 - val_loss: 13.3184 - val_mae: 2.8322
Epoch 94/100
177/177 [==============================] - 3s 16ms/step - loss: 7.3932 - mae:
1.6445 - val_loss: 10.0174 - val_mae: 2.2282
Epoch 95/100
177/177 [==============================] - 3s 17ms/step - loss: 7.3429 - mae:
1.6242 - val_loss: 11.8309 - val_mae: 2.6271
Epoch 96/100
177/177 [==============================] - 3s 16ms/step - loss: 7.5236 - mae:
1.6728 - val_loss: 12.2052 - val_mae: 2.6475
Epoch 97/100
177/177 [==============================] - 3s 16ms/step - loss: 7.4714 - mae:
1.6601 - val_loss: 7.3549 - val_mae: 1.6120
Epoch 98/100
177/177 [==============================] - 3s 16ms/step - loss: 7.4413 - mae:
1.6529 - val_loss: 8.3854 - val_mae: 1.9461
Epoch 99/100
177/177 [==============================] - 3s 16ms/step - loss: 7.4853 - mae:
1.6658 - val_loss: 11.0050 - val_mae: 2.4938
Epoch 100/100
177/177 [==============================] - 3s 17ms/step - loss: 7.2580 - mae:
1.6183 - val_loss: 11.8805 - val_mae: 2.6062
```

[25]:
```
y_pred = model.predict(x_test)
```

```
45/45 [==============================] - 0s 4ms/step
```

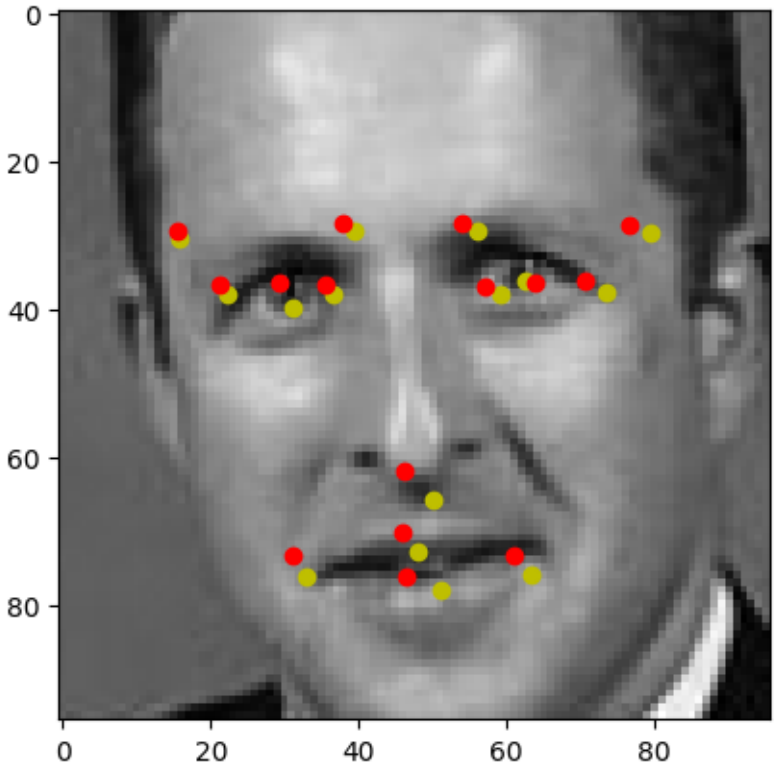
[26]:
```
print(f"mean absolute error of the model is {mean_absolute_error(y_pred,␣
↪y_test)}")
```

```
mean absolute error of the model is 2.606207433861229
```

[27]:
```
def plot_points(img_number):
  plt.imshow(x_test[img_number], cmap='gray')
  predicted_points = model.predict(x_test[img_number].reshape(1, 96, 96, 1))
  predicted_points = predicted_points[0]
  original_points = y_test[img_number]
  for i in range(0, 30, 2):
    plt.scatter(original_points[i:i+2][0], original_points[i:i+2][1], c='y')  ␣
↪ #original
```

```
    plt.scatter(predicted_points[i:i+2][0], predicted_points[i:i+2][1], c='r') ␣
  ↪ #predicted
   plt.show()
plot_points(555)
```

```
1/1 [==============================] - 0s 139ms/step
```



CNN Model as Feature Extractor + Random Forest for Regression

[29]:
```
features_model = Model(inputs = [model.input], outputs = [model.
  ↪get_layer("global_average_pooling2d").output])
#creating a model with above CNN model upto GlobalAveragePooling2D layer output
```

[30]:
```
train_features = features_model.predict(x_train)    # predicting the features on␣
  ↪x_train
```

```
177/177 [==============================] - 1s 3ms/step
```

[31]:
```
rf_reg = RandomForestRegressor()
```

[32]:
```
rf_reg.fit(train_features, y_train)  # fitting random forest on train_features␣
  ↪and y_train
```

[32]:
```
RandomForestRegressor()
```

[33]:
```
test_features = features_model.predict(x_test)  # predicting the test features
```

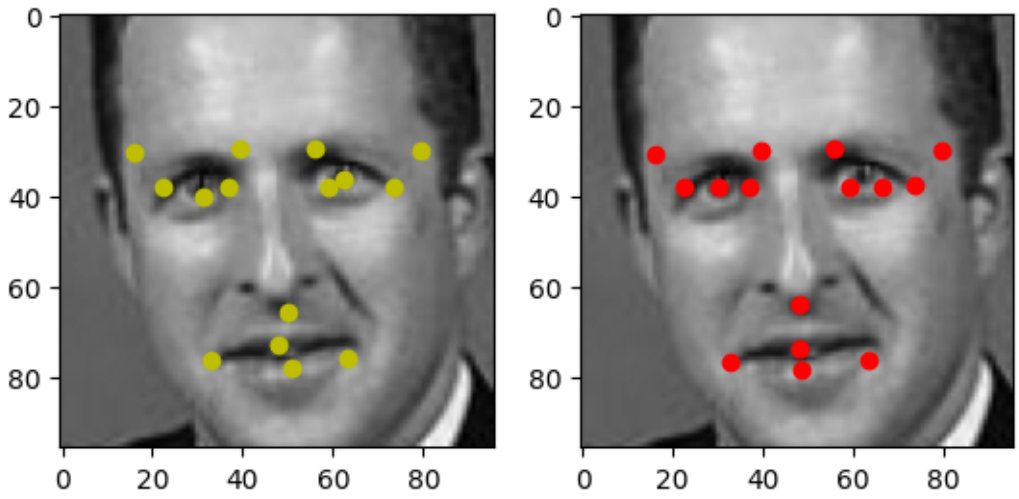
```
45/45 [==============================] - 0s 3ms/step
```

[34]:
```
output_points = rf_reg.predict(test_features)   # predicting the output features
```

[35]:
```
print(f"the mean abosulute error for random forest regressor is␣
 ↪{mean_absolute_error(output_points, y_test)}")
```

```
the mean abosulute error for random forest regressor is 1.2129046985875478
```

[36]:
```
def plot_output(img_number):
  predicted_points = output_points[img_number]
  original_points = y_test[img_number]
  plt.subplot(1,2,1)
  plt.imshow(x_test[img_number], cmap='gray')
  for i in range(0, 30, 2):
    plt.scatter(original_points[i:i+2][0], original_points[i:i+2][1], c='y')
  plt.subplot(1,2,2)
  plt.imshow(x_test[img_number], cmap='gray')
  for i in range(0, 30, 2):
    plt.scatter(predicted_points[i:i+2][0], predicted_points[i:i+2][1], c='r')
plt.show()
plot_output(555)
```



XGBoost as the Regressor

[37]:
```
xgb_reg = xgb.XGBRegressor()
```

[38]:
```
xgb_reg.fit(train_features, y_train)  # training xgboost on train features
```

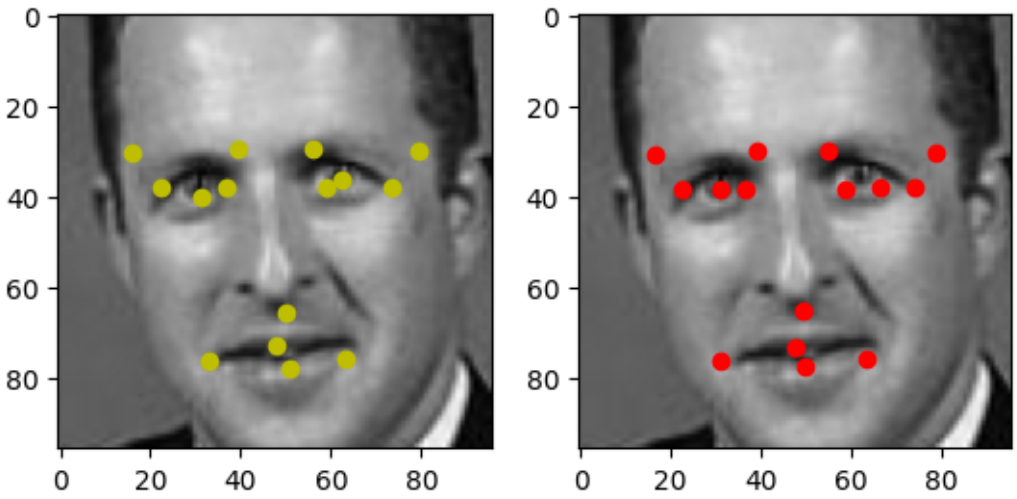
[38]:
```
XGBRegressor(base_score=None, booster=None, callbacks=None,
             colsample_bylevel=None, colsample_bynode=None,
             colsample_bytree=None, early_stopping_rounds=None,
             enable_categorical=False, eval_metric=None, feature_types=None,
             gamma=None, gpu_id=None, grow_policy=None, importance_type=None,
             interaction_constraints=None, learning_rate=None, max_bin=None,
             max_cat_threshold=None, max_cat_to_onehot=None,
             max_delta_step=None, max_depth=None, max_leaves=None,
             min_child_weight=None, missing=nan, monotone_constraints=None,
             n_estimators=100, n_jobs=None, num_parallel_tree=None,
             predictor=None, random_state=None, …)
```

[40]:
```
y_pred_xgb = xgb_reg.predict(test_features)
```

[41]:
```
print(f"the mean abosulute error for xgboost regressor is␣
 ↪{mean_absolute_error(y_pred_xgb, y_test)}")
```

```
the mean abosulute error for xgboost regressor is 1.331619245343443
```

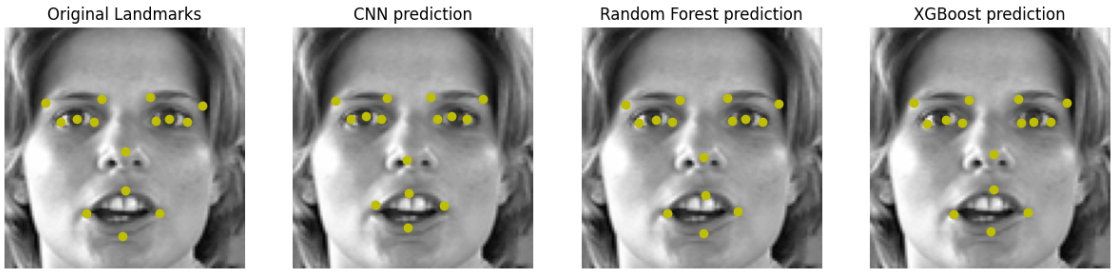
[42]:
```
def plot_output(img_number):
  predicted_points = y_pred_xgb[img_number]
  original_points = y_test[img_number]
  plt.subplot(1,2,1)
  plt.imshow(x_test[img_number], cmap='gray')
  for i in range(0, 30, 2):
    plt.scatter(original_points[i:i+2][0], original_points[i:i+2][1], c='y')  ␣
 ↪# original
  plt.subplot(1,2,2)
  plt.imshow(x_test[img_number], cmap='gray')
  for i in range(0, 30, 2):
    plt.scatter(predicted_points[i:i+2][0], predicted_points[i:i+2][1], c='r') ␣
 ↪ # predicted
plt.show()
plot_output(555)
```



Comparing the 3 Models

[56]:
```
def compare(img_number):    # plotting the comparisons
  y_pred_cnn = y_pred[img_number]
  y_pred_rf = output_points[img_number]
  y_pred_Xgb = y_pred_xgb[img_number]
  y_original = y_test[img_number]

  plt.figure(figsize=(15,10))
  plt.subplot(1, 4, 1)
  plt.imshow(x_test[img_number], cmap='gray')
  plt.title("Original Landmarks")
  plt.axis("off")
  plt.imshow(x_test[img_number], cmap='gray')
  for i in range(0, 30, 2):
    plt.scatter(y_original[i:i+2][0], y_original[i:i+2][1], c='y')

  plt.subplot(1, 4, 2)
  plt.imshow(x_test[img_number], cmap='gray')
  plt.title("CNN prediction")
  plt.axis("off")
  for i in range(0, 30, 2):
    plt.scatter(y_pred_cnn[i:i+2][0], y_pred_cnn[i:i+2][1], c='y')

  plt.subplot(1, 4, 3)
  plt.imshow(x_test[img_number], cmap='gray')
  plt.title("Random Forest prediction")
  plt.axis("off")
  for i in range(0, 30, 2):
    plt.scatter(y_pred_rf[i:i+2][0], y_pred_rf[i:i+2][1], c='y')
```

```
  plt.subplot(1, 4, 4)
  plt.imshow(x_test[img_number], cmap='gray')
  plt.title("XGBoost prediction")
  plt.axis("off")
  for i in range(0, 30, 2):
    plt.scatter(y_pred_Xgb[i:i+2][0], y_pred_Xgb[i:i+2][1], c='y')
  plt.show()

compare(23)
```



[ ]: