```
"A:\College\Portfolio\Data Mining and Machine Learning 1\Final Project\Code\venv\Scripts\python.exe" "A:/College/Portfolio/Data Mining and Machine Learning 1/Final Project/Code/HAM10000_Data_Processing_and_CNN.py"
2022-04-28 23:33:22.575987: W tensorflow/stream_executor/platform/default/dso_loader.cc:64] Could not load dynamic library 'cudart64_110.dll'; dlerror: cudart64_110.dll not found
2022-04-28 23:33:22.576533: I tensorflow/stream_executor/cuda/cudart_stub.cc:29] Ignore above cudart dlerror if you do not have a GPU set up on your machine.
Data\HAM10000
lesion_id            0
image_id             0
dx                   0
dx_type              0
age                 57
sex                  0
localization         0
Path                 0
Cell_Type            0
Cell_Type_id_Cat     0
dtype: int64

 *****Exploring the data frame

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10015 entries, 0 to 10014
Data columns (total 10 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   lesion_id         10015 non-null  object
 1   image_id          10015 non-null  object
 2   dx                10015 non-null  object
 3   dx_type           10015 non-null  object
 4   age               9958 non-null   float64
 5   sex               10015 non-null  object
 6   localization      10015 non-null  object
 7   Path              10015 non-null  object
```

```
32  8   Cell_Type         10015 non-null  object
33  9   Cell_Type_id_Cat  10015 non-null  int8
34 dtypes: float64(1), int8(1), object(8)
35 memory usage: 714.1+ KB
36
37  ***DataFrame Info
38  None
39
40  ***DataFrame Nulls
41  lesion_id            0
42 image_id             0
43 dx                   0
44 dx_type              0
45 age                 57
46 sex                  0
47 localization         0
48 Path                 0
49 Cell_Type            0
50 Cell_Type_id_Cat     0
51 dtype: int64
52 ['dx', 'dx_type', 'age', 'sex', 'localization', '
   Cell_Type', 'Cell_Type_id_Cat']
53
54 *** dx ***
55  nv       6705
56 mel      1113
57 bkl      1099
58 bcc       514
59 akiec     327
60 vasc      142
61 df        115
62 Name: dx, dtype: int64
63
64 *** dx_type ***
65  histo        5340
66 follow_up    3704
67 consensus     902
68 confocal       69
69 Name: dx_type, dtype: int64
70
71 *** age ***
```

```
 72  45.000000    1299
 73 50.000000    1187
 74 55.000000    1009
 75 40.000000     985
 76 60.000000     803
 77 70.000000     756
 78 35.000000     753
 79 65.000000     731
 80 75.000000     618
 81 30.000000     464
 82 80.000000     404
 83 85.000000     290
 84 25.000000     247
 85 20.000000     169
 86 5.000000       86
 87 15.000000      77
 88 51.863828      57
 89 10.000000      41
 90 0.000000       39
 91 Name: age, dtype: int64
 92
 93 *** sex ***
 94  male       5406
 95 female     4552
 96 unknown      57
 97 Name: sex, dtype: int64
 98
 99 *** localization ***
100  back               2192
101 lower extremity    2077
102 trunk              1404
103 upper extremity    1118
104 abdomen            1022
105 face                745
106 chest               407
107 foot                319
108 unknown             234
109 neck                168
110 scalp               128
111 hand                 90
112 ear                  56
```

```
genital              48
acral                 7
Name: localization, dtype: int64

*** Cell_Type ***
 Melanocytic Nevi                  6705
Melanoma                           1113
Benign Keratosis-Like Lesions      1099
Basal Cell Carcinoma                514
Actinic Keratoses                   327
Vascular Lesions                    142
Dermatofibroma                      115
Name: Cell_Type, dtype: int64

*** Cell_Type_id_Cat ***
 4    6705
5    1113
2    1099
1     514
0     327
6     142
3     115
Name: Cell_Type_id_Cat, dtype: int64
(75, 100, 3)    10015
Name: Image, dtype: int64
     lesion_id      image_id   dx dx_type   age
    sex localization
                                                Path
                          Cell_Type  Cell_Type_id_Cat
                                                Image
0  HAM_0000118  ISIC_0027419  bkl   histo  80.0
    male        scalp  Data\HAM10000\
    HAM10000_images_part_1\ISIC_0027...  Benign
    Keratosis-Like Lesions                  2  [[[190,
    153, 194], [192, 154, 196], [191, 153,...
1  HAM_0000118  ISIC_0025030  bkl   histo  80.0
    male        scalp  Data\HAM10000\
    HAM10000_images_part_1\ISIC_0025...  Benign
    Keratosis-Like Lesions                  2  [[[23, 13
    , 22], [24, 14, 24], [25, 14, 28], [3...
2  HAM_0002730  ISIC_0026769  bkl   histo  80.0
```

```
141 male        scalp  Data\HAM10000\
    HAM10000_images_part_1\ISIC_0026...  Benign
    Keratosis-Like Lesions                  2  [[[185,
    127, 137], [189, 133, 147], [194, 136,...
142 3  HAM_0002730  ISIC_0025661  bkl   histo  80.0
    male        scalp  Data\HAM10000\
    HAM10000_images_part_1\ISIC_0025...  Benign
    Keratosis-Like Lesions                  2  [[[24, 11
    , 17], [26, 13, 22], [38, 21, 32], [5...
143 4  HAM_0001466  ISIC_0031633  bkl   histo  75.0
    male          ear  Data\HAM10000\
    HAM10000_images_part_2\ISIC_0031...  Benign
    Keratosis-Like Lesions                  2  [[[134,
    90, 113], [147, 102, 125], [159, 115, ...
144 0    [[[190, 153, 194], [192, 154, 196], [191, 153
    ,...
145 1    [[[23, 13, 22], [24, 14, 24], [25, 14, 28], [3
    ...
146 2    [[[185, 127, 137], [189, 133, 147], [194, 136
    ,...
147 3    [[[24, 11, 17], [26, 13, 22], [38, 21, 32], [5
    ...
148 4    [[[134, 90, 113], [147, 102, 125], [159, 115
    , ...
149 Name: Image, dtype: object
150 0    2
151 1    2
152 2    2
153 3    2
154 4    2
155 Name: Cell_Type_id_Cat, dtype: int8
156 Shape of dataset: (10015,)
157 Shape of X_train: (7525,)
158 Shape of X_test: (1002,)
159 Shape of X_val: (1488,)
160 2022-04-28 23:37:10.878033: W tensorflow/
    stream_executor/platform/default/dso_loader.cc:64]
    Could not load dynamic library 'cudart64_110.dll';
    dlerror: cudart64_110.dll not found
161 2022-04-28 23:37:10.878484: W tensorflow/
    stream_executor/platform/default/dso_loader.cc:64]
```

```
161 Could not load dynamic library 'cublas64_11.dll';
    dlerror: cublas64_11.dll not found
162 2022-04-28 23:37:10.878925: W tensorflow/
    stream_executor/platform/default/dso_loader.cc:64]
    Could not load dynamic library 'cublasLt64_11.dll';
    dlerror: cublasLt64_11.dll not found
163 2022-04-28 23:37:10.879364: W tensorflow/
    stream_executor/platform/default/dso_loader.cc:64]
    Could not load dynamic library 'cufft64_10.dll';
    dlerror: cufft64_10.dll not found
164 2022-04-28 23:37:10.879794: W tensorflow/
    stream_executor/platform/default/dso_loader.cc:64]
    Could not load dynamic library 'curand64_10.dll';
    dlerror: curand64_10.dll not found
165 2022-04-28 23:37:10.880226: W tensorflow/
    stream_executor/platform/default/dso_loader.cc:64]
    Could not load dynamic library 'cusolver64_11.dll';
    dlerror: cusolver64_11.dll not found
166 2022-04-28 23:37:10.880664: W tensorflow/
    stream_executor/platform/default/dso_loader.cc:64]
    Could not load dynamic library 'cusparse64_11.dll';
    dlerror: cusparse64_11.dll not found
167 2022-04-28 23:37:10.881405: W tensorflow/
    stream_executor/platform/default/dso_loader.cc:64]
    Could not load dynamic library 'cudnn64_8.dll';
    dlerror: cudnn64_8.dll not found
168 2022-04-28 23:37:10.881760: W tensorflow/core/
    common_runtime/gpu/gpu_device.cc:1850] Cannot dlopen
     some GPU libraries. Please make sure the missing
    libraries mentioned above are installed properly if
    you would like to use GPU. Follow the guide at https
    ://www.tensorflow.org/install/gpu for how to
    download and setup the required libraries for your
    platform.
169 Skipping registering GPU devices...
170 2022-04-28 23:37:10.921022: I tensorflow/core/
    platform/cpu_feature_guard.cc:151] This TensorFlow
    binary is optimized with oneAPI Deep Neural Network
    Library (oneDNN) to use the following CPU
    instructions in performance-critical operations:
    AVX AVX2
```

```
To enable them in other operations, rebuild TensorFlow with the appropriate compiler flags.
A:\College\Portfolio\Data Mining and Machine Learning 1\Final Project\Code\HAM10000_Data_Processing_and_CNN.py:252: UserWarning: `Model.fit_generator` is deprecated and will be removed in a future version. Please use `Model.fit`, which supports generators.
  history[i] = model[i].fit_generator(datagen.flow(X_train, y_train, batch_size=batch_size),

Epoch 14: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.

Epoch 18: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
CNN Model 1.1: Epochs=20, Train accuracy=0.83839, Validation accuracy=0.77083

Epoch 9: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.

Epoch 19: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
CNN Model 1.2: Epochs=20, Train accuracy=0.87023, Validation accuracy=0.76949

Epoch 20: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
CNN Model 1.3: Epochs=20, Train accuracy=0.83385, Validation accuracy=0.75806
A:\College\Portfolio\Data Mining and Machine Learning 1\Final Project\Code\HAM10000_Data_Processing_and_CNN.py:310: UserWarning: `Model.fit_generator` is deprecated and will be removed in a future version. Please use `Model.fit`, which supports generators.
  history[i] = model[i].fit_generator(datagen.flow(X_train, y_train, batch_size=batch_size),

Epoch 18: ReduceLROnPlateau reducing learning rate
```

```
190 to 0.0005000000237487257.
191 CNN Model 2.1: Epochs=20, Train accuracy=0.86301,
    Validation accuracy=0.77487
192
193 Epoch 15: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
194 CNN Model 2.2: Epochs=20, Train accuracy=0.83625,
    Validation accuracy=0.78360
195
196 Epoch 12: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
197
198 Epoch 19: ReduceLROnPlateau reducing learning rate
    to 0.00025000000118743628.
199 CNN Model 2.3: Epochs=20, Train accuracy=0.84602,
    Validation accuracy=0.78024
200 A:\College\Portfolio\Data Mining and Machine
    Learning 1\Final Project\Code\
    HAM10000_Data_Processing_and_CNN.py:367: UserWarning
    : `Model.fit_generator` is deprecated and will be
    removed in a future version. Please use `Model.fit
    `, which supports generators.
201   history[i] = model[i].fit_generator(datagen.flow(
    X_train, y_train, batch_size=batch_size),
202
203 Epoch 10: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
204
205 Epoch 19: ReduceLROnPlateau reducing learning rate
    to 0.00025000000118743628.
206 CNN 512N: Epochs=20, Train accuracy=0.86033,
    Validation accuracy=0.77621
207
208 Epoch 15: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
209 CNN 1024N: Epochs=20, Train accuracy=0.86247,
    Validation accuracy=0.78091
210 Model: "sequential_8"
211 _________________________________________________
    _____________
212  Layer (type)                 Output Shape
```

```
212                Param #
213 =================================================================
214  conv2d_42 (Conv2D)          (None, 75, 100, 64
    )       1792
215
216  batch_normalization (BatchN  (None, 75, 100, 64
    )      256
217  ormalization
    )
218
219  conv2d_43 (Conv2D)          (None, 75, 100, 64
    )       36928
220
221  batch_normalization_1 (Batc  (None, 75, 100, 64
    )      256
222  hNormalization
    )
223
224  max_pooling2d_21 (MaxPoolin  (None, 37, 50, 64
    )       0
225  g2D
    )
226
227  conv2d_44 (Conv2D)          (None, 37, 50, 128
    )       73856
228
229  batch_normalization_2 (Batc  (None, 37, 50, 128
    )      512
230  hNormalization
    )
231
232  conv2d_45 (Conv2D)          (None, 37, 50, 128
```

```
232 )        147584
233
234  batch_normalization_3 (Batc  (None, 37, 50, 128
    )       512
235  hNormalization
    )
236
237  max_pooling2d_22 (MaxPoolin  (None, 18, 25, 128
    )       0
238  g2D
    )
239
240  conv2d_46 (Conv2D)           (None, 18, 25, 256
    )        295168
241
242  batch_normalization_4 (Batc  (None, 18, 25, 256
    )       1024
243  hNormalization
    )
244
245  conv2d_47 (Conv2D)           (None, 18, 25, 256
    )        590080
246
247  batch_normalization_5 (Batc  (None, 18, 25, 256
    )       1024
248  hNormalization
    )
249
250  max_pooling2d_23 (MaxPoolin  (None, 9, 12, 256
    )        0
251  g2D
    )
```

```
252
253  flatten_8 (Flatten)         (None, 27648
    )             0
254
255  dense_16 (Dense)            (None, 512
    )               14156288
256
257  batch_normalization_6 (Batc  (None, 512
    )              2048
258  hNormalization
    )
259
260  dense_17 (Dense)            (None, 7
    )                 3591
261
262 =================================================================
    =============
263 Total params: 15,310,919
264 Trainable params: 15,308,103
265 Non-trainable params: 2,816
266 _________________________________________________________________
    _____________
267 A:\College\Portfolio\Data Mining and Machine
    Learning 1\Final Project\Code\
    HAM10000_Data_Processing_and_CNN.py:432: UserWarning
    : `Model.fit_generator` is deprecated and will be
    removed in a future version. Please use `Model.fit
    `, which supports generators.
268   history[0] = model.fit_generator(datagen.flow(
    X_train, y_train, batch_size=batch_size),
269 Epoch 1/25
270 150/150 [==============================] - 318s 2s/
    step - loss: 1.2947 - accuracy: 0.6292 - val_loss: 1
    .0946 - val_accuracy: 0.6707 - lr: 0.0010
271 Epoch 2/25
272 150/150 [==============================] - 318s 2s/
```

```
272 step - loss: 0.7872 - accuracy: 0.7128 - val_loss: 1
    .0535 - val_accuracy: 0.6680 - lr: 0.0010
273 Epoch 3/25
274 150/150 [==============================] - 316s 2s/
    step - loss: 0.7446 - accuracy: 0.7304 - val_loss: 0
    .7935 - val_accuracy: 0.7245 - lr: 0.0010
275 Epoch 4/25
276 150/150 [==============================] - 316s 2s/
    step - loss: 0.7020 - accuracy: 0.7429 - val_loss: 0
    .8726 - val_accuracy: 0.7137 - lr: 0.0010
277 Epoch 5/25
278 150/150 [==============================] - 315s 2s/
    step - loss: 0.6753 - accuracy: 0.7549 - val_loss: 0
    .9174 - val_accuracy: 0.7009 - lr: 0.0010
279 Epoch 6/25
280 150/150 [==============================] - 318s 2s/
    step - loss: 0.6394 - accuracy: 0.7596 - val_loss: 0
    .7683 - val_accuracy: 0.7386 - lr: 0.0010
281 Epoch 7/25
282 150/150 [==============================] - 317s 2s/
    step - loss: 0.6340 - accuracy: 0.7640 - val_loss: 0
    .7885 - val_accuracy: 0.7245 - lr: 0.0010
283 Epoch 8/25
284 150/150 [==============================] - 318s 2s/
    step - loss: 0.6217 - accuracy: 0.7743 - val_loss: 0
    .7132 - val_accuracy: 0.7392 - lr: 0.0010
285 Epoch 9/25
286 150/150 [==============================] - 315s 2s/
    step - loss: 0.6036 - accuracy: 0.7774 - val_loss: 0
    .7344 - val_accuracy: 0.7567 - lr: 0.0010
287 Epoch 10/25
288 150/150 [==============================] - 329s 2s/
    step - loss: 0.5824 - accuracy: 0.7834 - val_loss: 0
    .7029 - val_accuracy: 0.7440 - lr: 0.0010
289 Epoch 11/25
290 150/150 [==============================] - 334s 2s/
    step - loss: 0.5581 - accuracy: 0.7926 - val_loss: 0
    .7488 - val_accuracy: 0.7426 - lr: 0.0010
291 Epoch 12/25
292 150/150 [==============================] - ETA: 0s
     - loss: 0.5752 - accuracy: 0.7868
```

```
293 Epoch 12: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
294 150/150 [==============================] - 328s 2s/
    step - loss: 0.5752 - accuracy: 0.7868 - val_loss: 0
    .8882 - val_accuracy: 0.7198 - lr: 0.0010
295 Epoch 13/25
296 150/150 [==============================] - 319s 2s/
    step - loss: 0.4832 - accuracy: 0.8195 - val_loss: 0
    .6097 - val_accuracy: 0.7755 - lr: 5.0000e-04
297 Epoch 14/25
298 150/150 [==============================] - 316s 2s/
    step - loss: 0.4648 - accuracy: 0.8243 - val_loss: 0
    .6216 - val_accuracy: 0.7849 - lr: 5.0000e-04
299 Epoch 15/25
300 150/150 [==============================] - 317s 2s/
    step - loss: 0.4390 - accuracy: 0.8376 - val_loss: 0
    .7127 - val_accuracy: 0.7433 - lr: 5.0000e-04
301 Epoch 16/25
302 150/150 [==============================] - 316s 2s/
    step - loss: 0.4423 - accuracy: 0.8320 - val_loss: 0
    .6155 - val_accuracy: 0.7776 - lr: 5.0000e-04
303 Epoch 17/25
304 150/150 [==============================] - ETA: 0s
     - loss: 0.4282 - accuracy: 0.8407
305 Epoch 17: ReduceLROnPlateau reducing learning rate
    to 0.0002500000118743628.
306 150/150 [==============================] - 316s 2s/
    step - loss: 0.4282 - accuracy: 0.8407 - val_loss: 0
    .6525 - val_accuracy: 0.7836 - lr: 5.0000e-04
307 Epoch 18/25
308 150/150 [==============================] - 318s 2s/
    step - loss: 0.3690 - accuracy: 0.8602 - val_loss: 0
    .6095 - val_accuracy: 0.7776 - lr: 2.5000e-04
309 Epoch 19/25
310 150/150 [==============================] - 320s 2s/
    step - loss: 0.3456 - accuracy: 0.8704 - val_loss: 0
    .5875 - val_accuracy: 0.8044 - lr: 2.5000e-04
311 Epoch 20/25
312 150/150 [==============================] - 316s 2s/
    step - loss: 0.3400 - accuracy: 0.8756 - val_loss: 0
    .6249 - val_accuracy: 0.7802 - lr: 2.5000e-04
```

```
313 Epoch 21/25
314 150/150 [==============================] - 315s 2s/
    step - loss: 0.3194 - accuracy: 0.8825 - val_loss: 0
    .6198 - val_accuracy: 0.7836 - lr: 2.5000e-04
315 Epoch 22/25
316 150/150 [==============================] - ETA: 0s
     - loss: 0.3294 - accuracy: 0.8736
317 Epoch 22: ReduceLROnPlateau reducing learning rate
    to 0.00012500000593718141.
318 150/150 [==============================] - 316s 2s/
    step - loss: 0.3294 - accuracy: 0.8736 - val_loss: 0
    .6154 - val_accuracy: 0.7883 - lr: 2.5000e-04
319 Epoch 23/25
320 150/150 [==============================] - 316s 2s/
    step - loss: 0.2769 - accuracy: 0.9002 - val_loss: 0
    .5718 - val_accuracy: 0.8017 - lr: 1.2500e-04
321 Epoch 24/25
322 150/150 [==============================] - 314s 2s/
    step - loss: 0.2631 - accuracy: 0.9030 - val_loss: 0
    .5942 - val_accuracy: 0.7863 - lr: 1.2500e-04
323 Epoch 25/25
324 150/150 [==============================] - ETA: 0s
     - loss: 0.2461 - accuracy: 0.9138
325 Epoch 25: ReduceLROnPlateau reducing learning rate
    to 6.25000029685907e-05.
326 150/150 [==============================] - 314s 2s/
    step - loss: 0.2461 - accuracy: 0.9138 - val_loss: 0
    .5882 - val_accuracy: 0.7944 - lr: 1.2500e-04
327 32/32 [==============================] - 11s 334ms/
    step - loss: 0.6184 - accuracy: 0.7884
328 47/47 [==============================] - 16s 346ms/
    step - loss: 0.5882 - accuracy: 0.7944
329 Test Set Accuracy = 0.788423  ;  loss = 0.618439
330 Validation Set Accuracy = 0.794355  ;  loss_v = 0.
    588232
331 --- 45566.956988573074 seconds ---
332
333 Process finished with exit code 0
334
```