```
"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"
2022-04-26 04:51:32.583861: W tensorflow/stream_executor/platform/default/dso_loader.cc:64] Could not load dynamic library 'cudart64_110.dll'; dlerror: cudart64_110.dll not found
2022-04-26 04:51:32.584189: 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
```

```
 8   Cell_Type         10015 non-null  object
 9   Cell_Type_id_Cat  10015 non-null  int8
dtypes: float64(1), int8(1), object(8)
memory usage: 714.1+ KB

 ***DataFrame Info
 None

 ***DataFrame Nulls
 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
['dx', 'dx_type', 'age', 'sex', 'localization', '
  Cell_Type', 'Cell_Type_id_Cat']

*** dx ***
 nv       6705
mel      1113
bkl      1099
bcc       514
akiec     327
vasc      142
df        115
Name: dx, dtype: int64

*** dx_type ***
 histo        5340
follow_up    3704
consensus     902
confocal       69
Name: dx_type, dtype: int64

*** 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 2022-04-26 04:52:41.422295: 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 2022-04-26 04:52:41.422736: 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 2022-04-26 04:52:41.423158: 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 2022-04-26 04:52:41.423587: 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 2022-04-26 04:52:41.424009: 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 2022-04-26 04:52:41.424430: 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 2022-04-26 04:52:41.424858: 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 2022-04-26 04:52:41.425283: 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 2022-04-26 04:52:41.425584: 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 2022-04-26 04:52:41.426574: 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
```

```
171 To enable them in other operations, rebuild
    TensorFlow with the appropriate compiler flags.
172 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.
173   history[i] = model[i].fit_generator(datagen.flow(
    X_train, y_train, batch_size=batch_size),
174
175 Epoch 11: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
176
177 Epoch 16: ReduceLROnPlateau reducing learning rate
    to 0.0002500000118743628.
178
179 Epoch 20: ReduceLROnPlateau reducing learning rate
    to 0.0001250000059371814.
180 CNN Model 1.1: Epochs=20, Train accuracy=0.82528,
    Validation accuracy=0.76882
181
182 Epoch 14: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
183 CNN Model 1.2: Epochs=20, Train accuracy=0.87064,
    Validation accuracy=0.77621
184
185 Epoch 12: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
186
187 Epoch 15: ReduceLROnPlateau reducing learning rate
    to 0.0002500000118743628.
188 CNN Model 1.3: Epochs=20, Train accuracy=0.85753,
    Validation accuracy=0.77890
189 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.
190   history[i] = model[i].fit_generator(datagen.flow(
```

```
190 X_train, y_train, batch_size=batch_size),
191
192 Epoch 19: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
193 CNN Model 2.1: Epochs=20, Train accuracy=0.83706,
    Validation accuracy=0.78898
194
195 Epoch 10: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
196
197 Epoch 17: ReduceLROnPlateau reducing learning rate
    to 0.0002500000118743628.
198 CNN Model 2.2: Epochs=20, Train accuracy=0.84990,
    Validation accuracy=0.78293
199
200 Epoch 19: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
201 CNN Model 2.3: Epochs=20, Train accuracy=0.82328,
    Validation accuracy=0.77688
202 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.
203   history[i] = model[i].fit_generator(datagen.flow(
    X_train, y_train, batch_size=batch_size),
204
205 Epoch 9: ReduceLROnPlateau reducing learning rate to
     0.0005000000237487257.
206
207 Epoch 16: ReduceLROnPlateau reducing learning rate
    to 0.0002500000118743628.
208
209 Epoch 19: ReduceLROnPlateau reducing learning rate
    to 0.0001250000059371814.
210 CNN 512N: Epochs=20, Train accuracy=0.86635,
    Validation accuracy=0.77151
211
212 Epoch 16: ReduceLROnPlateau reducing learning rate
    to 0.0005000000237487257.
```

```
213 CNN 1024N: Epochs=20, Train accuracy=0.86288,
    Validation accuracy=0.77151
214 Model: "sequential_8"
215 _________________________________________________
    _____________
216  Layer (type)                Output Shape
                  Param #
217 =================================================
    =============
218  conv2d_42 (Conv2D)          (None, 75, 100, 64
    )       1792
219
220  batch_normalization (BatchN  (None, 75, 100, 64
    )      256
221  ormalization
    )
222
223  conv2d_43 (Conv2D)          (None, 75, 100, 64
    )       36928
224
225  batch_normalization_1 (Batc  (None, 75, 100, 64
    )      256
226  hNormalization
    )
227
228  max_pooling2d_21 (MaxPoolin  (None, 37, 50, 64
    )       0
229  g2D
    )
230
231  conv2d_44 (Conv2D)          (None, 37, 50, 128
    )       73856
232
233  batch_normalization_2 (Batc  (None, 37, 50, 128
```

```
)       512
 hNormalization
)

 conv2d_45 (Conv2D)          (None, 37, 50, 128
)       147584

 batch_normalization_3 (Batc  (None, 37, 50, 128
)       512
 hNormalization
)

 max_pooling2d_22 (MaxPoolin  (None, 18, 25, 128
)       0
 g2D
)


 conv2d_46 (Conv2D)          (None, 18, 25, 256
)       295168

 batch_normalization_4 (Batc  (None, 18, 25, 256
)       1024
 hNormalization
)

 conv2d_47 (Conv2D)          (None, 18, 25, 256
)       590080

 batch_normalization_5 (Batc  (None, 18, 25, 256
)       1024
 hNormalization
)
```

```
253
254  max_pooling2d_23 (MaxPoolin  (None, 9, 12, 256
    )       0
255  g2D
    )

256

257  flatten_8 (Flatten)         (None, 27648
    )             0
258

259  dense_16 (Dense)            (None, 512
    )               14156288
260

261  batch_normalization_6 (Batc  (None, 512
    )              2048
262  hNormalization
    )
263

264  dense_17 (Dense)            (None, 7
    )                 3591
265

266 =================================================================
    =============
267 Total params: 15,310,919
268 Trainable params: 15,308,103
269 Non-trainable params: 2,816
270 _________________________________________________________________
    _____________
271 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.
272   history[0] = model.fit_generator(datagen.flow(
    X_train, y_train, batch_size=batch_size),
```

```
Epoch 1/25
150/150 [==============================] - 315s 2s/
    step - loss: 1.3096 - accuracy: 0.6318 - val_loss: 1
    .5317 - val_accuracy: 0.6647 - lr: 0.0010
Epoch 2/25
150/150 [==============================] - 313s 2s/
    step - loss: 0.7993 - accuracy: 0.7113 - val_loss: 1
    .1467 - val_accuracy: 0.6828 - lr: 0.0010
Epoch 3/25
150/150 [==============================] - 313s 2s/
    step - loss: 0.7228 - accuracy: 0.7320 - val_loss: 1
    .0456 - val_accuracy: 0.6257 - lr: 0.0010
Epoch 4/25
150/150 [==============================] - 313s 2s/
    step - loss: 0.6982 - accuracy: 0.7417 - val_loss: 0
    .7460 - val_accuracy: 0.7446 - lr: 0.0010
Epoch 5/25
150/150 [==============================] - 311s 2s/
    step - loss: 0.6738 - accuracy: 0.7473 - val_loss: 1
    .0026 - val_accuracy: 0.6599 - lr: 0.0010
Epoch 6/25
150/150 [==============================] - 311s 2s/
    step - loss: 0.6637 - accuracy: 0.7564 - val_loss: 0
    .7700 - val_accuracy: 0.7325 - lr: 0.0010
Epoch 7/25
150/150 [==============================] - 313s 2s/
    step - loss: 0.6222 - accuracy: 0.7722 - val_loss: 0
    .6871 - val_accuracy: 0.7460 - lr: 0.0010
Epoch 8/25
150/150 [==============================] - 311s 2s/
    step - loss: 0.6071 - accuracy: 0.7731 - val_loss: 0
    .7480 - val_accuracy: 0.7413 - lr: 0.0010
Epoch 9/25
150/150 [==============================] - 312s 2s/
    step - loss: 0.6037 - accuracy: 0.7785 - val_loss: 0
    .7539 - val_accuracy: 0.7352 - lr: 0.0010
Epoch 10/25
150/150 [==============================] - ETA: 0s
     - loss: 0.5978 - accuracy: 0.7785
Epoch 10: ReduceLROnPlateau reducing learning rate
    to 0.00050000000237487257.
```

```
294 150/150 [==============================] - 314s 2s/
    step - loss: 0.5978 - accuracy: 0.7785 - val_loss: 0
    .9286 - val_accuracy: 0.7050 - lr: 0.0010
295 Epoch 11/25
296 150/150 [==============================] - 314s 2s/
    step - loss: 0.5225 - accuracy: 0.8080 - val_loss: 0
    .6363 - val_accuracy: 0.7628 - lr: 5.0000e-04
297 Epoch 12/25
298 150/150 [==============================] - 313s 2s/
    step - loss: 0.4871 - accuracy: 0.8153 - val_loss: 0
    .6272 - val_accuracy: 0.7728 - lr: 5.0000e-04
299 Epoch 13/25
300 150/150 [==============================] - 311s 2s/
    step - loss: 0.4924 - accuracy: 0.8108 - val_loss: 0
    .6528 - val_accuracy: 0.7728 - lr: 5.0000e-04
301 Epoch 14/25
302 150/150 [==============================] - 312s 2s/
    step - loss: 0.4720 - accuracy: 0.8197 - val_loss: 0
    .6392 - val_accuracy: 0.7446 - lr: 5.0000e-04
303 Epoch 15/25
304 150/150 [==============================] - ETA: 0s
     - loss: 0.4646 - accuracy: 0.8197
305 Epoch 15: ReduceLROnPlateau reducing learning rate
    to 0.00025000000118743628.
306 150/150 [==============================] - 311s 2s/
    step - loss: 0.4646 - accuracy: 0.8197 - val_loss: 0
    .6618 - val_accuracy: 0.7540 - lr: 5.0000e-04
307 Epoch 16/25
308 150/150 [==============================] - 313s 2s/
    step - loss: 0.4012 - accuracy: 0.8503 - val_loss: 0
    .5920 - val_accuracy: 0.7897 - lr: 2.5000e-04
309 Epoch 17/25
310 150/150 [==============================] - 312s 2s/
    step - loss: 0.3896 - accuracy: 0.8542 - val_loss: 0
    .5903 - val_accuracy: 0.7897 - lr: 2.5000e-04
311 Epoch 18/25
312 150/150 [==============================] - 311s 2s/
    step - loss: 0.3742 - accuracy: 0.8563 - val_loss: 0
    .6138 - val_accuracy: 0.7856 - lr: 2.5000e-04
313 Epoch 19/25
314 150/150 [==============================] - ETA: 0s
```

```
314  - loss: 0.3688 - accuracy: 0.8653
315 Epoch 19: ReduceLROnPlateau reducing learning rate
    to 0.00012500000059371814.
316 150/150 [==============================] - 311s 2s/
    step - loss: 0.3688 - accuracy: 0.8653 - val_loss: 0
    .6397 - val_accuracy: 0.7782 - lr: 2.5000e-04
317 Epoch 20/25
318 150/150 [==============================] - 311s 2s/
    step - loss: 0.3218 - accuracy: 0.8808 - val_loss: 0
    .5936 - val_accuracy: 0.7950 - lr: 1.2500e-04
319 Epoch 21/25
320 150/150 [==============================] - 313s 2s/
    step - loss: 0.3115 - accuracy: 0.8843 - val_loss: 0
    .5747 - val_accuracy: 0.7897 - lr: 1.2500e-04
321 Epoch 22/25
322 150/150 [==============================] - 311s 2s/
    step - loss: 0.3033 - accuracy: 0.8847 - val_loss: 0
    .6052 - val_accuracy: 0.7863 - lr: 1.2500e-04
323 Epoch 23/25
324 150/150 [==============================] - 311s 2s/
    step - loss: 0.2896 - accuracy: 0.8940 - val_loss: 0
    .5982 - val_accuracy: 0.7964 - lr: 1.2500e-04
325 Epoch 24/25
326 150/150 [==============================] - 312s 2s/
    step - loss: 0.2775 - accuracy: 0.8981 - val_loss: 0
    .6153 - val_accuracy: 0.7944 - lr: 1.2500e-04
327 Epoch 25/25
328 150/150 [==============================] - 311s 2s/
    step - loss: 0.2690 - accuracy: 0.9006 - val_loss: 0
    .6402 - val_accuracy: 0.7802 - lr: 1.2500e-04
329 32/32 [==============================] - 11s 338ms/
    step - loss: 0.6834 - accuracy: 0.7715
330 47/47 [==============================] - 16s 343ms/
    step - loss: 0.6402 - accuracy: 0.7802
331 Test Set Accuracy = 0.771457  ;  loss = 0.683417
332 Validation Set Accuracy = 0.780242  ;  loss_v = 0.
    640185
333 --- 44652.560040950775 seconds ---
334
335 Process finished with exit code 0
336
```