Importing the labraries

```
In [28]: # Importing the libraries
import tensorflow as tf
import pandas as pd
import cv2
import warnings
import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pyplot as plt

warnings.filterwarnings("ignore")
from tqdm import tqdm
from tensorflow.keras.models import Sequential, Model
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.layers import Dense, Activation, Conv2D, MaxPooling2D, MaxPool2D, Flatten, Dropout, BatchNormalization
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint
from tensorflow.keras.utils import to_categorical
from imblearn.over_sampling import SMOTE
from tensorflow import keras
from IPython.display import clear_output
from sklearn.model_selection import train_test_split
from imblearn.under_sampling import RandomUnderSampler
from sklearn.preprocessing import LabelEncoder
from sklearn.metrics import confusion_matrix,ConfusionMatrixDisplay, accuracy_score,f1_score,classification_report
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.callbacks import ReduceLROnPlateau
```

Loading and Analysis of Data

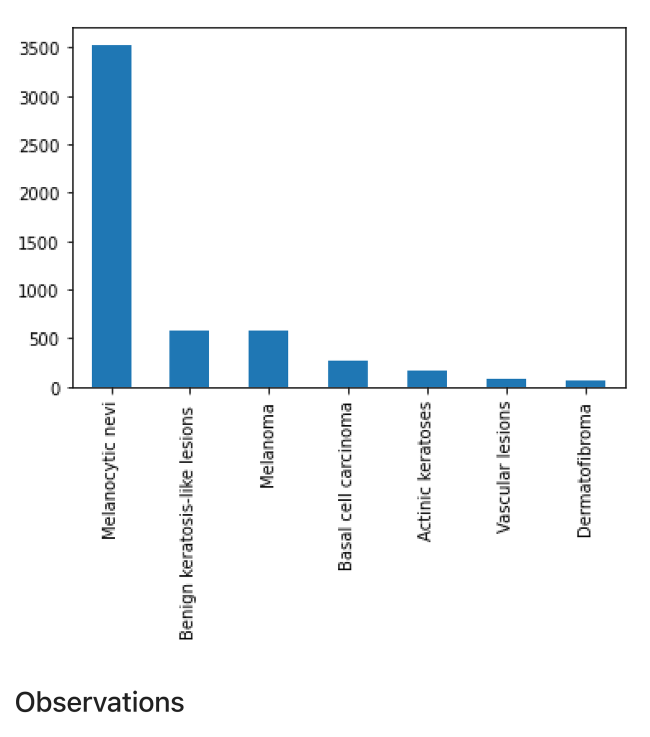
```
In [22]: df= pd.read_csv('skin_lesions.csv')
df
```

Out[22]:

	image_id	cell_type	is_benign	localization
0	ISIC_0025030	Benign keratosis-like lesions	1.0	scalp
1	ISIC_0025661	Benign keratosis-like lesions	1.0	scalp
2	ISIC_0027850	Benign keratosis-like lesions	1.0	ear
3	ISIC_0025837	Benign keratosis-like lesions	1.0	back
4	ISIC_0025209	Benign keratosis-like lesions	1.0	back
...	...	...	...	...
5365	ISIC_0030995	Melanocytic nevi	1.0	NaN
5366	ISIC_0028490	Benign keratosis-like lesions	1.0	NaN
5367	ISIC_0032722	Melanoma	1.0	NaN
5368	ISIC_0029038	Melanocytic nevi	1.0	NaN
5369	ISIC_0032603	Benign keratosis-like lesions	1.0	NaN

5370 rows × 4 columns

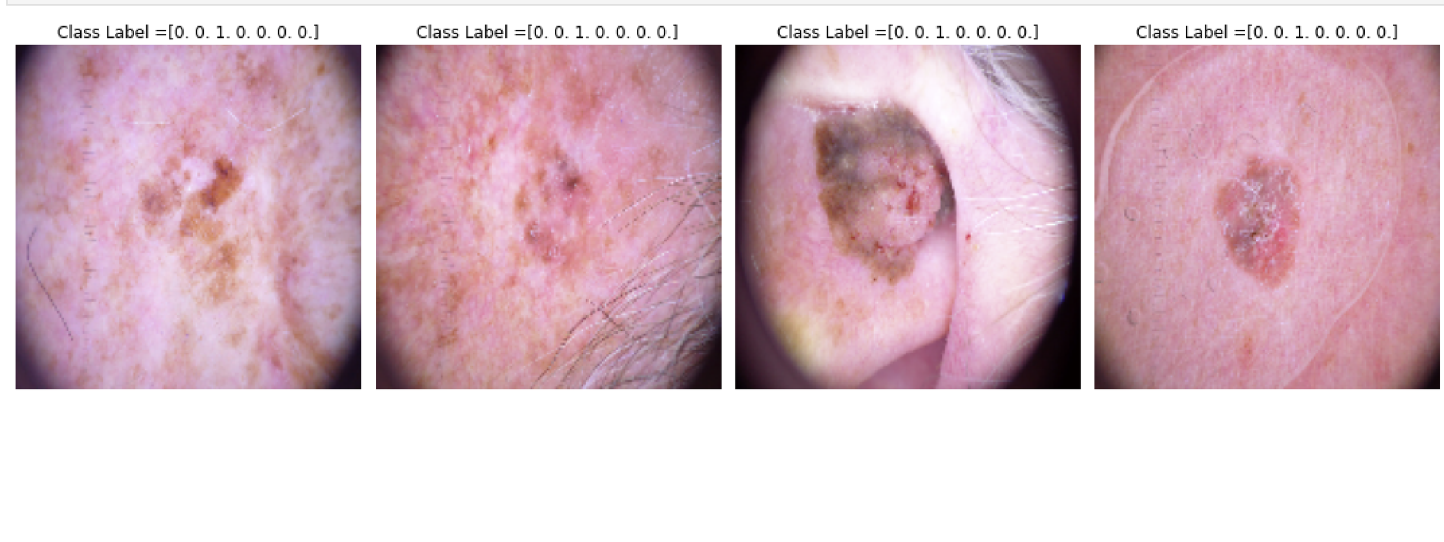
```
In [3]: # check for the missing values in the csv
df.isna().sum()

Out[3]: image_id        0
cell_type       150
is_benign       150
localization    150
dtype: int64

In [4]: # drop the rows with missing values
df = df.dropna()

In [5]: # again check for missing values
df.isna().sum()

Out[5]: image_id        0
cell_type       0
is_benign       0
localization    0
dtype: int64

In [6]: #check the class distribution
print(df["cell_type"].value_counts())
df["cell_type"].value_counts().plot.bar()

Melanocytic nevi                  3559
Benign keratosis-like lesions      580
Melanoma                           576
Basal cell carcinoma               288
Actinic keratoses                  169
Vascular lesions                    74
Dermatofibroma                      62
Name: cell_type, dtype: int64
Out[6]: <AxesSubplot:>
```

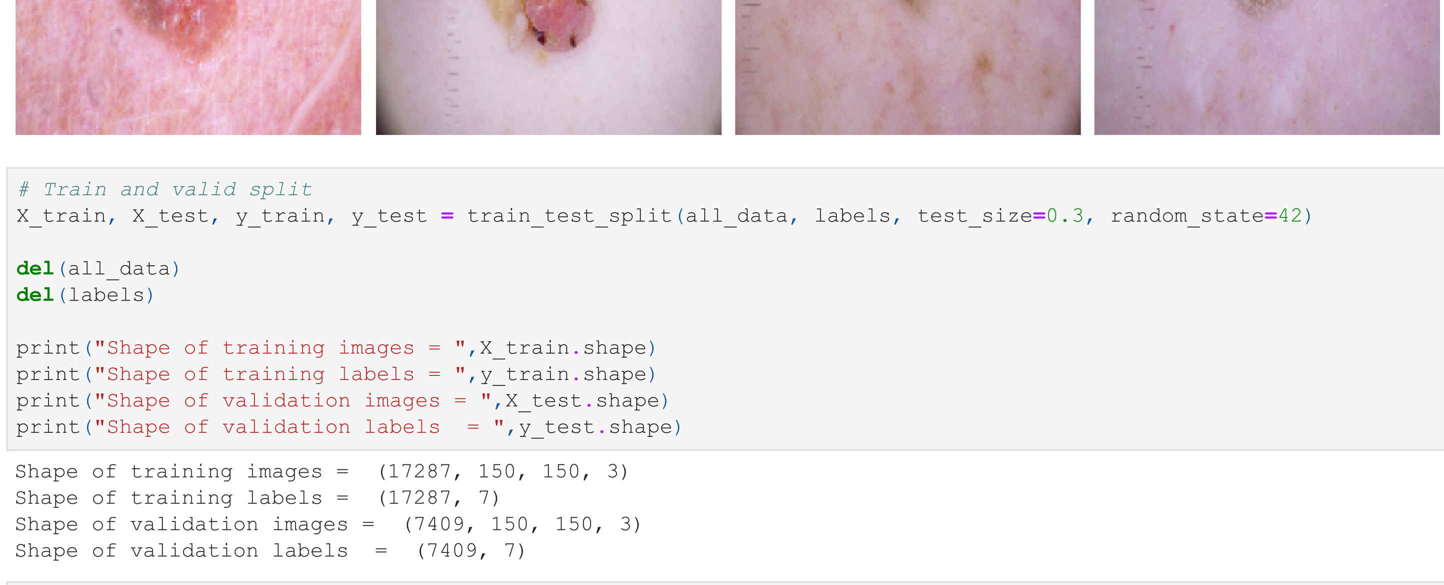


Observations

- The dataset is imbalanced.

```
In [7]: le = LabelEncoder()
df['cell_type'] = le.fit_transform(df['cell_type'])

In [8]: # There is no missing values
# now lets load the images

all_data=[]
labels=[]
for i in tqdm (range(len(df))):
    path="Users/priyank/Documents/Jupiter/Skinlesions/skin_lesions_images/"+df["image_id"][i]+".jpg"
    #print(path)
    img=cv2.imread(path)
    img=cv2.resize(img,(150,150))
    img=cv2.cvtColor(img,cv2.COLOR_BGR2RGB)
    img=img/255.0
    all_data.append(img)
    labels.append(df["cell_type"][i])

100%|██████████| 5257/5257 [00:18<00:00, 331.77it/s]

In [9]: all_data=np.array(all_data)
labels=np.array(labels)

In [10]: # Balancing the data using SMOTE Over sampling method
# (Synthetic Minority Over Sampling Technique)

sm = SMOTE()
all_data = all_data.reshape(all_data.shape[0],-1)
all_data, labels = sm.fit_resample(all_data, labels)
all_data = all_data.reshape(all_data.shape[0],150,150,3)

In [11]: print("Max pixel value = ",all_data.max())

# one hot encoding for class label
labels = to_categorical(labels)

print("Shape of images = ",all_data.shape)
print("Shape of labels = ",labels.shape)

Max pixel value =  1.0
Shape of images =  (24696, 150, 150, 3)
Shape of labels =  (24696, 7)

In [12]: # plot Training images

def plot_images(images_arr, labels):
    fig, axes=plt.subplots(1, 4, figsize=(20,20))
    axes= axes.flatten()
    j=0
    for img, ax in zip(images_arr, axes):
        ax.imshow(img)
        ax.axis("off")
        ax.title("Class Label ="+str(labels[j]))
        ax.set_title(title)
        j+=1
    plt.tight_layout()
    plt.show()

plot_images(all_data[:10],labels[:10])
```






```
In [13]: # Train and valid split
X_train, X_test, y_train, y_test = train_test_split(all_data, labels, test_size=0.3, random_state=0)

del(all_data)
del(labels)

print("Shape of training images = ",X_train.shape)
print("Shape of training labels = ",y_train.shape)
print("Shape of validation images = ",X_test.shape)
print("Shape of validation labels = ",y_test.shape)

Shape of training images =  (17287, 150, 150, 3)
Shape of training labels =  (17287, 7)
Shape of validation images =  (7409, 150, 150, 3)
Shape of validation labels =  (7409, 7)

In [14]: # plot accuracy, loss curve (graph)
class PlotLearning(keras.callbacks.Callback):
    def on_train_begin(self, logs={}):
        self.i = 0
        self.x = []
        self.losses = []
        self.val_losses = []
        self.acc = []
        self.val_acc = []
        self.fig = plt.figure()

        self.logs = []

    def on_epoch_end(self, epoch, logs={}):

        self.logs.append(logs)
        self.x.append(self.i)
        self.losses.append(logs.get("loss"))
        self.val_losses.append(logs.get("val_loss"))
        self.acc.append(logs.get("accuracy"))
        self.val_acc.append(logs.get("val_accuracy"))
        self.i += 1
        f, (ax1, ax2) = plt.subplots(1, 2, sharex=True)

        clear_output(wait=True)

        ax1.set_yscale("log")
        ax1.plot(self.x, self.losses, label="loss")
        ax1.plot(self.x, self.val_losses, label="val_loss")
        ax1.legend()

        ax2.plot(self.x, self.acc, label="accuracy")
        ax2.plot(self.x, self.val_acc, label="validation accuracy")
        ax2.legend()

        plt.show();

accuracy_loss_plot = PlotLearning()
```

Model

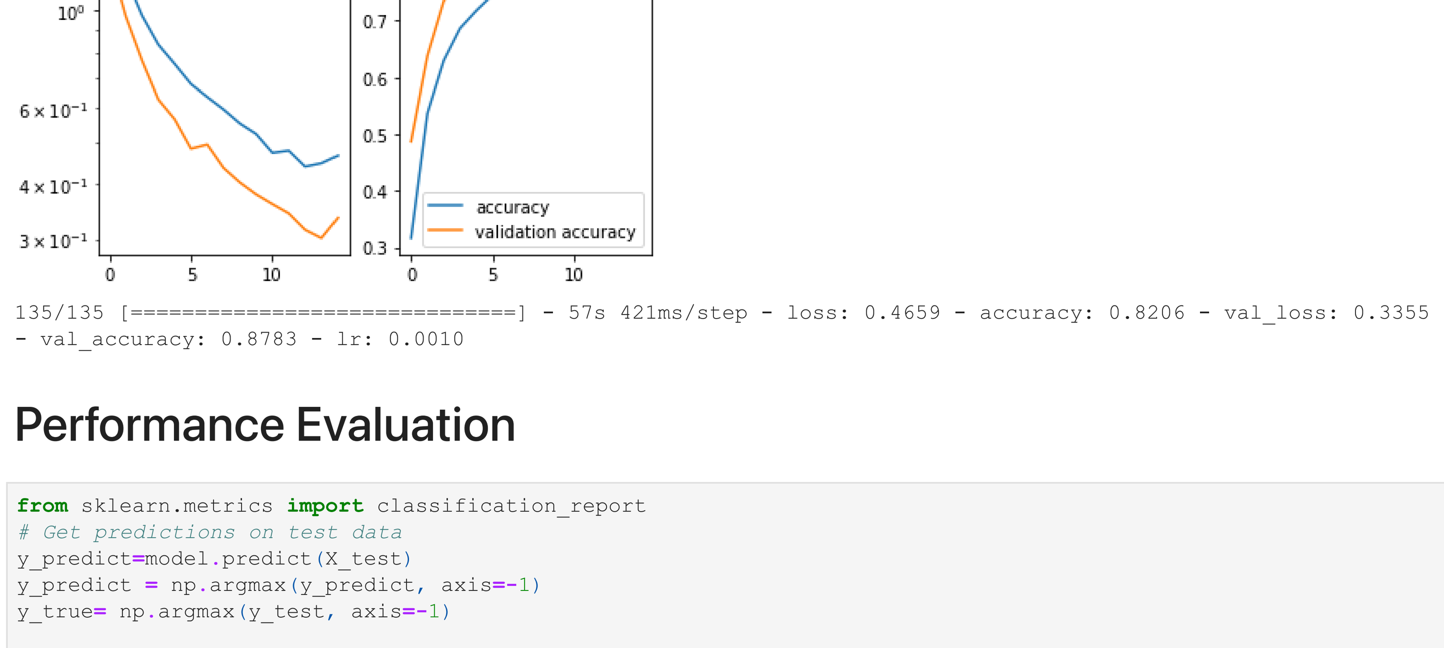
```
In [15]: # initializing the model

input_shape = (150, 150, 3)
num_classes = 7

# creating sequential model
model = Sequential()

# adding extra conv2D, pooling layer(s)
model.add(Conv2D(32, kernel_size=(3, 3),activation='relu',padding = 'Same',input_shape=input_shape))
model.add(Conv2D(32,kernel_size=(3, 3), activation='relu',padding = 'Same'))
model.add(MaxPool2D(pool_size = (2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(64, (3, 3), activation='relu',padding = 'Same'))
model.add(Conv2D(64, (3, 3), activation='relu',padding = 'Same'))
model.add(MaxPool2D(pool_size = (2, 2)))
model.add(Dropout(0.40))

model.add(Flatten())
model.add(Dense(128, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))
model.summary()

Metal device set to: Apple M1 Pro
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 150, 150, 32)      896

 conv2d_1 (Conv2D)           (None, 150, 150, 32)      9248

 max_pooling2d (MaxPooling2D  (None, 75, 75, 32)       0
 )

 dropout (Dropout)           (None, 75, 75, 32)        0

 conv2d_2 (Conv2D)           (None, 75, 75, 64)        18496

 conv2d_3 (Conv2D)           (None, 75, 75, 64)        36928

 max_pooling2d_1 (MaxPooling  (None, 37, 37, 64)       0
 2D)

 dropout_1 (Dropout)         (None, 37, 37, 64)        0

 flatten (Flatten)           (None, 87616)             0

 dense (Dense)               (None, 128)               11214976

 dropout_2 (Dropout)         (None, 128)               0

 dense_1 (Dense)             (None, 7)                 903

=================================================================
Total params: 11,281,447
Trainable params: 11,281,447
Non-trainable params: 0
_________________________________________________________________

2022-04-24 19:31:07.523830: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305] Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel may not have been built with NUMA support.
2022-04-24 19:31:07.530229: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271] Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0 MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id: <undefined>)

In [16]: model.compile(loss='categorical_crossentropy',optimizer='adam',metrics=["accuracy"])
```

Define callbacks

```
In [17]: # Set a learning rate annealer
learning_rate_reduction = ReduceLROnPlateau(monitor='val_loss',
                                            patience=3,
                                            verbose=1,
                                            factor=0.0001,
                                            min_lr=0.00001)

callbacks = [ModelCheckpoint('.mdl_wts.hdf5', monitor='val_loss', save_best_only=True),accuracy_loss_plot,learning_rate_reduction]
```

Training the model

```
In [18]: datagen = ImageDataGenerator(
        rotation_range=10,  # randomly rotate images in the range (degrees, 0 to 180)
        zoom_range = 0.1 # Randomly zoom image
        )

# fit the model
epochs = 20
batch_size = 128
history = model.fit(datagen.flow(X_train,y_train, batch_size=batch_size),
                    epochs = epochs, validation_data=(X_test,y_test),
                    verbose = 1, steps_per_epoch=X_train.shape[0] // batch_size
                    ,callbacks=callbacks ,shuffle = True)
```




```
135/135 [==============================] - 67s 496ms/step - loss: 0.4809 - accuracy: 0.8206 - val_loss: 0.3355 - val_accuracy: 0.8781 - lr: 0.0010
```

Performance Evaluation

```
In [19]: from sklearn.metrics import classification_report
# Get predictions on test data
y_pred=model.predict(X_test)
y_pred = np.argmax(y_pred,axis=1)
y_true=np.argmax(y_test, axis=1)

# print confusion metrics
cm=confusion_matrix(y_true,y_pred)
plt.figure(figsize=(10,10))
ConfusionMatrixDisplay(cm).plot()

# check performance
print("Accuracy on test data",accuracy_score(y_true,y_pred))
print(classification_report(y_true,y_pred))

2022-04-24 19:51:25.367896: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
Accuracy on test data 0.8780544068025346
              precision    recall  f1-score   support

           0       0.97      0.96      0.96      1084
           1       0.92      0.95      0.93      1060
           2       0.79      0.82      0.80      1067
           3       0.99      0.99      0.99      1080
           4       0.93      0.57      0.70      1051
           5       0.69      0.87      0.77      1077
           6       0.98      1.00      0.99      1000

    accuracy                           0.88      7409
   macro avg       0.89      0.88      0.88      7409
weighted avg       0.89      0.88      0.88      7409

<Figure size 1080x720 with 0 Axes>
```