Problem statement:

To build a CNN based model which can accurately detect melanoma. Melanoma is a type of cancer that can be deadly if not detected early. It accounts for 75% of skin cancer deaths. A solution that can evaluate images and alert dermatologists about the presence of melanoma has the potential to reduce a lot of manual effort needed in diagnosis.

Importing all the important libraries

```
import pathlib
import tensorflow as tf
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import os
import PIL
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.models import Sequential
import warnings
warnings.filterwarnings('ignore')
```

```
from google.colab import drive
drive.mount('/content/gdrive')
```

```
Drive already mounted at /content/gdrive; to attempt to forcibly remount, call drive.mount("/content/gdrive", force_remount=True).
```

This assignment uses a dataset of about 2357 images of skin cancer types. The dataset contains 9 sub-directories in each train and test subdirectories. The 9 sub-directories contains the images of 9 skin cancer types respectively.

```
#/content/gdrive/MyDrive/upgrad/Skin_cancer_ISIC_The_International_Skin_Imaging_Collaboration.zip
```

```
!unzip '/content/gdrive/MyDrive/upgrad/Skin_cancer_ISIC_The_International_Skin_Imaging_Collaboration.zip'
```

```
Archive:  /content/gdrive/MyDrive/upgrad/Skin_cancer_ISIC_The_International_Skin_Imaging_Collaboration.zip
   creating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/
   creating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/actinic kerato
  inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/actinic kerato
  inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/actinic kerato
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   creating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/basal cell car
  inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/basal cell car
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  inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/basal cell car
  inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/basal cell car
   creating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
  inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
  inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
  inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
```

```
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
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   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/dermatofibroma
    creating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/melanoma/
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/melanoma/ISIC_
   inflating: /content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test/melanoma/ISIC
```

```
# Defining the path for train and test images
## Todo: Update the paths of the train and test dataset
data_dir_train = pathlib.Path("/content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Train")
data_dir_test = pathlib.Path('/content/gdrive/MyDrive/upgrad/Dataset/Skin cancer ISIC The International Skin Imaging Collaboration/Test')
```

```
!ls
```

```
gdrive  sample_data
```

```
image_count_train = len(list(data_dir_train.glob('*/*.jpg')))
print(image_count_train)
image_count_test = len(list(data_dir_test.glob('*/*.jpg')))
print(image_count_test)
```

```
2239
118
```

Load using keras.preprocessing

Let's load these images off disk using the helpful image_dataset_from_directory utility.

Create a dataset

Define some parameters for the loader:

```
batch_size = 32
img_height = 180
img_width = 180
```

Use 80% of the images for training, and 20% for validation.

```
## Write your train dataset here
## Note use seed=123 while creating your dataset using tf.keras.preprocessing.image_dataset_from_directory
## Note, make sure your resize your images to the size img_height*img_width, while writting the dataset
train_ds = tf.keras.preprocessing.image_dataset_from_directory(
  data_dir_train,
  seed=123,
  validation_split = 0.2,
  subset = 'training',
  image_size=(img_height, img_width),
  batch_size=batch_size)
```

```
Found 2239 files belonging to 9 classes.
Using 1792 files for training.
```

```
## Write your validation dataset here
## Note use seed=123 while creating your dataset using tf.keras.preprocessing.image_dataset_from_directory
## Note, make sure your resize your images to the size img_height*img_width, while writting the dataset
val_ds = tf.keras.preprocessing.image_dataset_from_directory(
  data_dir_train,
  seed=123,
  validation_split = 0.2,
  subset = 'validation',
```

```
  image_size=(img_height, img_width),
  batch_size=batch_size)
```

```
Found 2239 files belonging to 9 classes.
Using 447 files for validation.
```

```
# List out all the classes of skin cancer and store them in a list.
# You can find the class names in the class_names attribute on these datasets.
# These correspond to the directory names in alphabetical order.
class_names = train_ds.class_names
print(class_names)
```

```
['actinic keratosis', 'basal cell carcinoma', 'dermatofibroma', 'melanoma', 'nevus', 'pigmented benign keratosis', 'seborrheic keratosis
```

```
print(type(train_ds))
```

```
<class 'tensorflow.python.data.ops.dataset_ops.BatchDataset'>
```

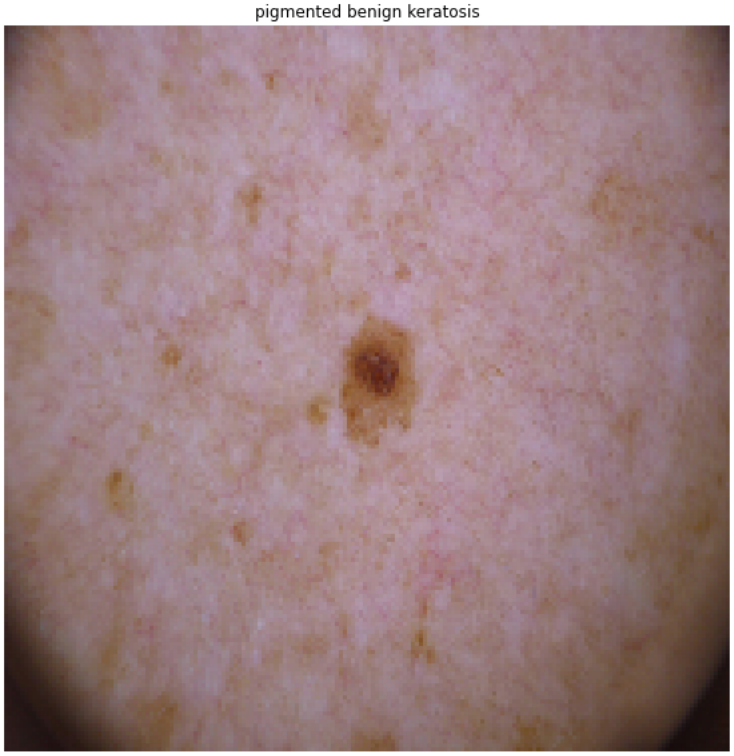
```
for images, labels in train_ds.take(1):
  print(len(images))
  print(len(labels))
```

```
32
32
```

```
import matplotlib.pyplot as plt
plt.figure(figsize=(10, 10))
for images, labels in train_ds.take(1):
  print(len(images))
  print(len(labels))
  plt.imshow(images[0].numpy().astype("uint8"))
  plt.title(class_names[labels[0]])
  plt.axis("off")
```

```
32
32
```

pigmented benign keratosis



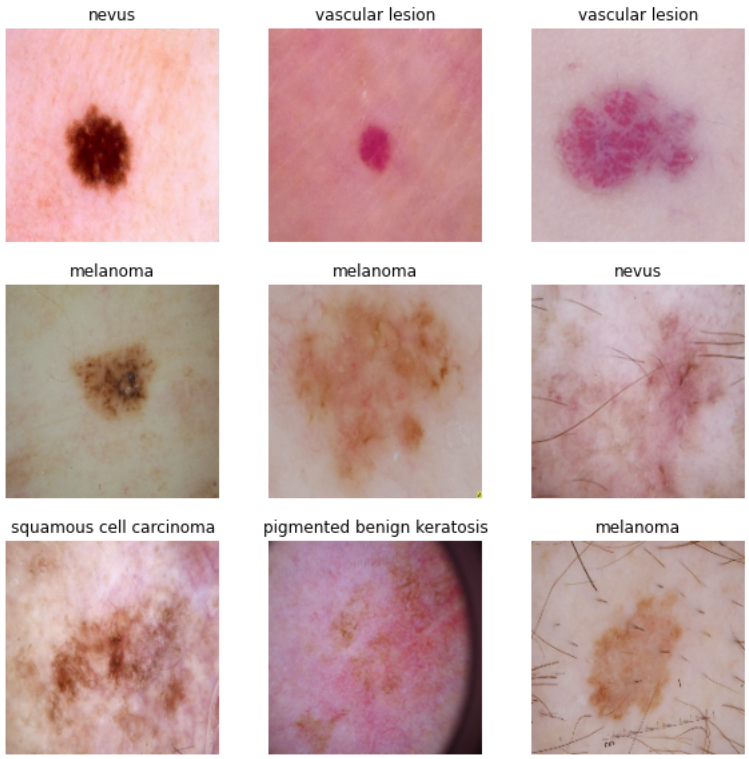
Visualize the data

Todo, create a code to visualize one instance of all the nine classes present in the dataset

```
import matplotlib.pyplot as plt

plt.figure(figsize=(10, 10))
for images, labels in train_ds.take(1):
  for i in range(9):
    ax = plt.subplot(3, 3, i + 1)
    plt.imshow(images[i].numpy().astype("uint8"))
    plt.title(class_names[labels[i]])
    plt.axis("off")

### your code goes here, you can use training or validation data to visualize
```




```
#print(type(train_ds))
#print(len(train_ds)
```

The `image_batch` is a tensor of the shape `(32, 180, 180, 3)`. This is a batch of 32 images of shape `180x180x3` (the last dimension refers to color channels RGB). The `label_batch` is a tensor of the shape `(32,)`, these are corresponding labels to the 32 images.

`Dataset.cache()` keeps the images in memory after they're loaded off disk during the first epoch.

`Dataset.prefetch()` overlaps data preprocessing and model execution while training.

```
#overlaps data preprocessing and model execution while training., Speed up training
AUTOTUNE = tf.data.experimental.AUTOTUNE
train_ds = train_ds.cache().shuffle(1000).prefetch(buffer_size=AUTOTUNE)
val_ds = val_ds.cache().prefetch(buffer_size=AUTOTUNE)
```

Create the model

Todo: Create a CNN model, which can accurately detect 9 classes present in the dataset. Use `layers.experimental.preprocessing.Rescaling` to normalize pixel values between (0,1). The RGB channel values are in the `[0, 255]` range. This is not ideal for a neural network. Here, it is good to standardize values to be in the `[0, 1]`

```
### Your code goes here
num_classes = 9

#A Sequential model is appropriate for a plain stack of layers where each layer has exactly one input tensor and one output tensor
model = Sequential([
```

```
  layers.experimental.preprocessing.Rescaling(1./255, input_shape=(img_height, img_width, 3)),

  #2D convolution layer (e.g. spatial convolution over images).
  layers.Conv2D(16, 3, padding='same', activation='relu'),

  #We slide over the feature map and extract tiles of a specified size.
  #Downsamples the input along its spatial dimensions (height and width) by taking the maximum value over an input window (of size defined by
  layers.MaxPooling2D(),

  #We slide over the feature map and extract tiles of a specified size.
  layers.Conv2D(32, 3, padding='same', activation='relu'),

  layers.MaxPooling2D(),
  layers.Dropout(0.1),

  layers.Conv2D(64, 3, padding='same', activation='relu'),
  layers.Dropout(0.1),

  #We slide over the feature map and extract tiles of a specified size.
  #Advantages of downsampling - Decreased size of input for upcoming layers, Works against overfitting
  layers.MaxPooling2D(),

  #Flattening - Convert into 1D feature vector.  Flattens all its structure to create a single long feature vector
  ##Flattens the input. Does not affect the batch size.
  layers.Flatten(),

  #fully connected layer
  #A hidden layer in which each node is connected to every node in the subsequent hidden layer.
  #A fully connected layer is also known as a dense layer.

  layers.Dense(128, activation='relu'),

  #Dense is the only actual network layer in that model. A Dense layer feeds all outputs from the previous layer to all its neurons, each neu
  #It's the most basic layer in neural networks. A Dense(10) has ten neurons. A Dense(512) has 512 neurons.
  #Dense implements the operation: output = activation(dot(input, kernel)
  #Dense Layer - A dense layer represents a matrix vector multiplication.  each input node is connected to each output node.
  layers.Dense(num_classes)
  #Dense Layer - A dense layer represents a matrix vector multiplication.  each input node is connected to each output node.
])
```

Compile the model

Choose an appropirate optimiser and loss function for model training

```
# View the summary of all layers
model.summary()
```

```
Model: "sequential_3"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 rescaling_2 (Rescaling)     (None, 180, 180, 3)       0

 conv2d_6 (Conv2D)           (None, 180, 180, 16)      448

 max_pooling2d_6 (MaxPooling  (None, 90, 90, 16)       0
 2D)

 conv2d_7 (Conv2D)           (None, 90, 90, 32)        4640

 max_pooling2d_7 (MaxPooling  (None, 45, 45, 32)       0
 2D)

 dropout_1 (Dropout)         (None, 45, 45, 32)        0

 conv2d_8 (Conv2D)           (None, 45, 45, 64)        18496

 dropout_2 (Dropout)         (None, 45, 45, 64)        0

 max_pooling2d_8 (MaxPooling  (None, 22, 22, 64)       0
 2D)

 flatten_2 (Flatten)         (None, 30976)             0

 dense_4 (Dense)             (None, 128)               3965056
```

```
 dense_5 (Dense)             (None, 9)                 1161

=================================================================
Total params: 3,989,801
Trainable params: 3,989,801
Non-trainable params: 0
_________________________________________________________________
```

```
### Todo, choose an appropirate optimiser and loss function
#RMSprop. RMSprop is a very effective, but currently unpublished adaptive learning rate method
#Adam. Adam is a recently proposed update that looks a bit like RMSProp with momentum. The (simplified) update looks as follows:
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])
```

```
epochs = 20
history = model.fit(
  train_ds,
  validation_data=val_ds,
  epochs=epochs
)
```

```
Epoch 1/20
56/56 [==============================] - 4s 36ms/step - loss: 2.0564 - accuracy: 0.2785 - val_loss: 1.8576 - val_accuracy: 0.3244
Epoch 2/20
56/56 [==============================] - 2s 31ms/step - loss: 1.6457 - accuracy: 0.4235 - val_loss: 1.6182 - val_accuracy: 0.4072
Epoch 3/20
56/56 [==============================] - 2s 31ms/step - loss: 1.5058 - accuracy: 0.4704 - val_loss: 1.5280 - val_accuracy: 0.4855
Epoch 4/20
56/56 [==============================] - 2s 30ms/step - loss: 1.4128 - accuracy: 0.5050 - val_loss: 1.4696 - val_accuracy: 0.4586
Epoch 5/20
56/56 [==============================] - 2s 29ms/step - loss: 1.3185 - accuracy: 0.5340 - val_loss: 1.5341 - val_accuracy: 0.4765
Epoch 6/20
56/56 [==============================] - 2s 31ms/step - loss: 1.2714 - accuracy: 0.5502 - val_loss: 1.5264 - val_accuracy: 0.4497
Epoch 7/20
56/56 [==============================] - 2s 31ms/step - loss: 1.1749 - accuracy: 0.5848 - val_loss: 1.3545 - val_accuracy: 0.5324
Epoch 8/20
56/56 [==============================] - 2s 30ms/step - loss: 1.1156 - accuracy: 0.6032 - val_loss: 1.4206 - val_accuracy: 0.4899
Epoch 9/20
56/56 [==============================] - 2s 30ms/step - loss: 1.0398 - accuracy: 0.6166 - val_loss: 1.4654 - val_accuracy: 0.5213
Epoch 10/20
56/56 [==============================] - 2s 29ms/step - loss: 0.9498 - accuracy: 0.6535 - val_loss: 1.3888 - val_accuracy: 0.5548
Epoch 11/20
56/56 [==============================] - 2s 30ms/step - loss: 0.9256 - accuracy: 0.6629 - val_loss: 1.4060 - val_accuracy: 0.5213
Epoch 12/20
56/56 [==============================] - 2s 30ms/step - loss: 0.8247 - accuracy: 0.7009 - val_loss: 1.5385 - val_accuracy: 0.5324
Epoch 13/20
56/56 [==============================] - 2s 42ms/step - loss: 0.7530 - accuracy: 0.7210 - val_loss: 1.6568 - val_accuracy: 0.5190
Epoch 14/20
56/56 [==============================] - 2s 37ms/step - loss: 0.7725 - accuracy: 0.7199 - val_loss: 1.6240 - val_accuracy: 0.5347
Epoch 15/20
56/56 [==============================] - 2s 30ms/step - loss: 0.6511 - accuracy: 0.7561 - val_loss: 1.5359 - val_accuracy: 0.4944
Epoch 16/20
56/56 [==============================] - 2s 30ms/step - loss: 0.6135 - accuracy: 0.7773 - val_loss: 1.6053 - val_accuracy: 0.5347
Epoch 17/20
56/56 [==============================] - 2s 30ms/step - loss: 0.5524 - accuracy: 0.7991 - val_loss: 1.6203 - val_accuracy: 0.4586
Epoch 18/20
56/56 [==============================] - 2s 30ms/step - loss: 0.5176 - accuracy: 0.8097 - val_loss: 1.9381 - val_accuracy: 0.4966
Epoch 19/20
56/56 [==============================] - 2s 30ms/step - loss: 0.4997 - accuracy: 0.8192 - val_loss: 1.7043 - val_accuracy: 0.5235
Epoch 20/20
56/56 [==============================] - 2s 32ms/step - loss: 0.4097 - accuracy: 0.8482 - val_loss: 2.0272 - val_accuracy: 0.5235
```

Train the model

```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)

plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
```

```
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```


```
### Your code goes here
num_classes = 9

model = Sequential([
  layers.experimental.preprocessing.Rescaling(1./255, input_shape=(img_height, img_width, 3)),
  layers.Conv2D(64, 3, padding='same', activation='relu'),
  #We slide over the feature map and extract tiles of a specified size.
  layers.MaxPooling2D(),
  layers.Conv2D(128, 3, padding='same', activation='relu'),
  #We slide over the feature map and extract tiles of a specified size.
  layers.MaxPooling2D(),
  layers.Conv2D(64, 3, padding='same', activation='relu'),
  #We slide over the feature map and extract tiles of a specified size.
  layers.MaxPooling2D(),
  #Advantages of downsampling - Decreased size of input for upcoming layers, Works against overfitting
  layers.Flatten(),
  #Flattening - Convert into 1D feature vector.  Flattens all its structure to create a single long feature vector
  layers.Dense(128, activation='relu'),
  #Dense Layer - A dense layer represents a matrix vector multiplication.  each input node is connected to each output node.
  layers.Dense(num_classes)
  #Dense Layer - A dense layer represents a matrix vector multiplication.  each input node is connected to each output node.
])
```

Visualizing training results

Todo: Write your findings after the model fit, see if there is an evidence of model overfit or underfit

Write your findings here

```
# Todo, after you have analysed the model fit history for presence of underfit or overfit, choose an appropriate data augumentation strategy.
data_augmentation = keras.Sequential(
  [
    layers.experimental.preprocessing.RandomFlip("horizontal",
                                                 input_shape=(img_height,
                                                              img_width,
```

```
                                                              3)),
    layers.experimental.preprocessing.RandomRotation(0.1),
    layers.experimental.preprocessing.RandomZoom(0.1),
    layers.experimental.preprocessing.RandomTranslation(1,.5,fill_mode="reflect",interpolation="bilinear",seed=None,fill_value=0.0),
    layers.experimental.preprocessing.RandomCrop(img_height,img_width),
  ]
)
```

```
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2 cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting ImageProjectiveTransformV3 cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2 cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting ImageProjectiveTransformV3 cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip cause there is no registered converter for this op.
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WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2 cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2 cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformIntV2 cause there is no registered converter for this op.
```

```
# Todo, visualize how your augmentation strategy works for one instance of training image.
plt.figure(figsize=(10, 10))
for images, _ in train_ds.take(1):
  for i in range(9):
    augmented_images = data_augmentation(images)
    ax = plt.subplot(3, 3, i + 1)
    plt.imshow(augmented_images[0].numpy().astype("uint8"))
    plt.axis("off")
```

```
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip cause there is no registered converter for this op.
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```

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```

Todo:

Create the model, compile and train the model

```
## You can use Dropout layer if there is an evidence of overfitting in your findings

model = Sequential([
  data_augmentation,
  layers.experimental.preprocessing.Rescaling(1./255),
  layers.Conv2D(64, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Conv2D(128, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Conv2D(256, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Dropout(0.2),
  layers.Flatten(),
  layers.Dense(128, activation='relu'),
  layers.Dense(num_classes)
])
```

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```

Compiling the model

```
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip cause there is no registered converter for this op.
```

```
## Your code goes here
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])
```

```
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
```

Training the model

```
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered converter for this op.
```

```
## Your code goes here, note: train your model for 20 epochs
epochs = 20
history = model.fit(
  train_ds,
  validation_data=val_ds,
  epochs=epochs
)
```

```
Epoch 1/20
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56/56 [==============================] - 38s 514ms/step - loss: 2.1566 - accuracy: 0.1953 - val_loss: 2.0275 - val_accuracy: 0.1924
Epoch 2/20
56/56 [==============================] - 28s 494ms/step - loss: 1.9958 - accuracy: 0.2383 - val_loss: 1.8819 - val_accuracy: 0.2260
Epoch 3/20
56/56 [==============================] - 27s 484ms/step - loss: 1.8390 - accuracy: 0.3119 - val_loss: 1.7604 - val_accuracy: 0.3043
Epoch 4/20
56/56 [==============================] - 27s 487ms/step - loss: 1.7010 - accuracy: 0.3465 - val_loss: 1.6367 - val_accuracy: 0.3669
Epoch 5/20
56/56 [==============================] - 27s 489ms/step - loss: 1.6554 - accuracy: 0.3638 - val_loss: 1.6713 - val_accuracy: 0.3803
Epoch 6/20
56/56 [==============================] - 27s 487ms/step - loss: 1.6361 - accuracy: 0.3689 - val_loss: 1.6598 - val_accuracy: 0.3848
Epoch 7/20
56/56 [==============================] - 30s 527ms/step - loss: 1.6677 - accuracy: 0.3683 - val_loss: 1.6326 - val_accuracy: 0.3714
```

Visualizing the results

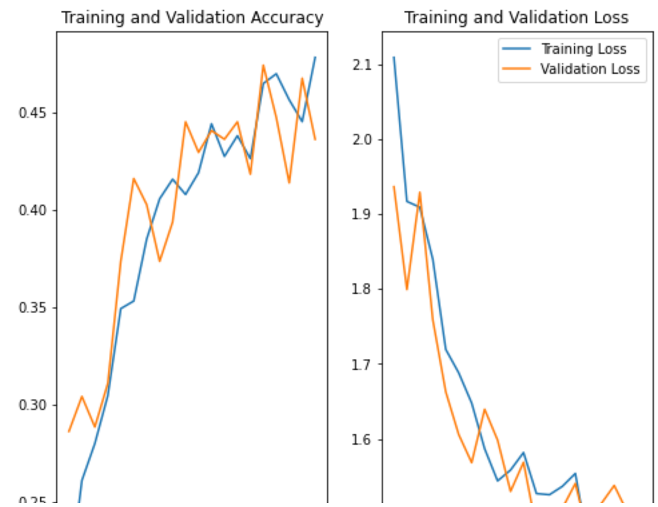
```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)

plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```




```
# For convenience, let us set up the path for the training and validation sets
train_dir = os.path.join('/content/gdrive/MyDrive/Skin cancer ISIC The International Skin Imaging Collaboration/Train')
val_dir = os.path.join('/content/gdrive/MyDrive/Skin cancer ISIC The International Skin Imaging Collaboration/Test')
```

```
import tensorflow as tf
from tensorflow.keras.preprocessing.image import ImageDataGenerator
# Setting batch size and image size
batch_size = 100
IMG_SHAPE = 224

# Create training images generator
#Generate batches of tensor image data with real-time data augmentation.
#https://www.tensorflow.org/api_docs/python/tf/keras/preprocessing/image/ImageDataGenerator
image_gen_train = ImageDataGenerator(
                    rescale=1./255,
                    rotation_range=45,
                    width_shift_range=.15,
                    height_shift_range=.15,
                    horizontal_flip=True,
                    zoom_range=0.5
                    )
#https://keras.io/api/preprocessing/image/
#Then calling image_dataset_from_directory(main_directory, labels='inferred') will return a tf.data.Dataset that yields batches of images fro
train_data_gen = image_gen_train.flow_from_directory(
                                                batch_size=batch_size,
                                                directory=train_dir,
                                                shuffle=True,
                                                target_size=(IMG_SHAPE,IMG_SHAPE),
                                                class_mode='sparse'
                                                )

# Create validation images generator
image_gen_val = ImageDataGenerator(rescale=1./255)
val_data_gen = image_gen_val.flow_from_directory(batch_size=batch_size,
                                                 directory=val_dir,
                                                 target_size=(IMG_SHAPE, IMG_SHAPE),
                                                 class_mode='sparse')
```

```
Found 2239 images belonging to 9 classes.
Found 118 images belonging to 9 classes.
```

```
#Create a CNN model
#Experiment #1
#A Sequential model is appropriate for a plain stack of layers where each layer has exactly one input tensor and one output tensor
import numpy as np
import glob
import shutil
import matplotlib.pyplot as plt

# Import layers explicitly to keep our code compact
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Conv2D, Flatten, Dropout, MaxPooling2D
```

```
model = Sequential()

#2D convolution layer (e.g. spatial convolution over images).
model.add(Conv2D(16, 3, padding='same', activation='relu', input_shape=(IMG_SHAPE,IMG_SHAPE, 3)))
#Downsamples the input along its spatial dimensions (height and width) by taking the maximum value over an input window (of size defined by p
model.add(MaxPooling2D(pool_size=(2, 2)))

model.add(Conv2D(32, 3, padding='same', activation='relu'))

#Downsamples the input along its spatial dimensions (height and width) by taking the maximum value over an input window (of size defined by p
model.add(MaxPooling2D(pool_size=(2, 2)))

model.add(Conv2D(64, 3, padding='same', activation='relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))

#Flattens the input. Does not affect the batch size.
model.add(Flatten())

#https://keras.io/api/layers/regularization_layers/dropout/
#The Dropout layer randomly sets input units to 0 with a frequency of rate at each step during training time, which helps prevent overfitting
model.add(Dropout(0.2))
model.add(Dense(512, activation='relu'))

model.add(Dropout(0.2))

#Just your regular densely-connected NN layer.
#Dense is the only actual network layer in that model. A Dense layer feeds all outputs from the previous layer to all its neurons, each neuro
#It's the most basic layer in neural networks. A Dense(10) has ten neurons. A Dense(512) has 512 neurons.
#Dense implements the operation: output = activation(dot(input, kernel)
model.add(Dense(9))

# Compile the model
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])

# Train the model
epochs = 20

history = model.fit(
  train_data_gen,
  validation_data=val_data_gen,
  epochs=10
)
```

```
Epoch 1/10
23/23 [==============================] - 121s 5s/step - loss: 3.3523 - accuracy: 0.1831 - val_loss: 2.1813 - val_accuracy: 0.2288
Epoch 2/10
23/23 [==============================] - 76s 3s/step - loss: 1.8302 - accuracy: 0.3247 - val_loss: 2.2401 - val_accuracy: 0.1695
Epoch 3/10
23/23 [==============================] - 76s 3s/step - loss: 1.6664 - accuracy: 0.3872 - val_loss: 2.3853 - val_accuracy: 0.3051
Epoch 4/10
23/23 [==============================] - 76s 3s/step - loss: 1.6388 - accuracy: 0.4006 - val_loss: 2.3922 - val_accuracy: 0.2797
Epoch 5/10
23/23 [==============================] - 78s 3s/step - loss: 1.5575 - accuracy: 0.4466 - val_loss: 2.5553 - val_accuracy: 0.2712
Epoch 6/10
23/23 [==============================] - 76s 3s/step - loss: 1.4707 - accuracy: 0.4766 - val_loss: 2.3614 - val_accuracy: 0.3644
Epoch 7/10
23/23 [==============================] - 75s 3s/step - loss: 1.4547 - accuracy: 0.4944 - val_loss: 2.2012 - val_accuracy: 0.3475
Epoch 8/10
23/23 [==============================] - 77s 3s/step - loss: 1.3962 - accuracy: 0.5190 - val_loss: 2.2050 - val_accuracy: 0.3305
Epoch 9/10
23/23 [==============================] - 76s 3s/step - loss: 1.3968 - accuracy: 0.5051 - val_loss: 2.2095 - val_accuracy: 0.3475
Epoch 10/10
23/23 [==============================] - 76s 3s/step - loss: 1.3417 - accuracy: 0.5315 - val_loss: 2.1001 - val_accuracy: 0.3475
```

```
import matplotlib.pyplot as plt
epochs=10
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)
```

```
plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```

Todo: Write your findings after the model fit, see if there is an evidence of model overfit or underfit. Do you think there is some improvement now as compared to the previous model run?

Todo: Find the distribution of classes in the training dataset.

Context: Many times real life datasets can have class imbalance, one class can have proportionately higher number of samples compared to the others. Class imbalance can have a detrimental effect on the final model quality. Hence as a sanity check it becomes important to check what is the distribution of classes in the data.

```
## Your code goes here.
from glob import glob
path_list = [x for x in glob(os.path.join(data_dir_train, '*', '*.jpg'))]
lesion_list = [os.path.basename(os.path.dirname(y)) for y in glob(os.path.join(data_dir_train, '*', '*.jpg'))]
len(path_list)
```

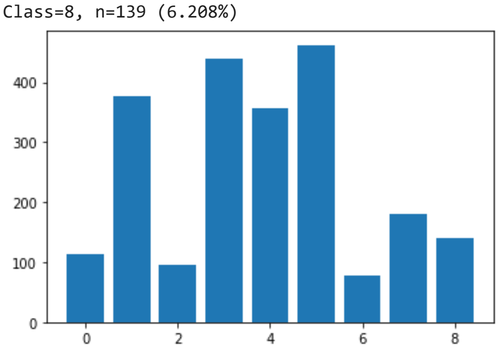
```
2239
```

```
dataframe_dict_original = dict(zip(path_list, lesion_list))
original_df = pd.DataFrame(list(dataframe_dict_original.items()),columns = ['Path','Label'])
original_df
```

	Path	Label
0	/content/gdrive/MyDrive/upgrad/Dataset/Skin ca...	actinic keratosis
1	/content/gdrive/MyDrive/upgrad/Dataset/Skin ca...	actinic keratosis
2	/content/gdrive/MyDrive/upgrad/Dataset/Skin ca...	actinic keratosis
3	/content/gdrive/MyDrive/upgrad/Dataset/Skin ca...	actinic keratosis
4	/content/gdrive/MyDrive/upgrad/Dataset/Skin ca...	actinic keratosis
...	...	...

```
from sklearn.preprocessing import LabelEncoder
from collections import Counter
# split into input and output elements
X, y = original_df['Path'], original_df['Label']
# label encode the target variable
y = LabelEncoder().fit_transform(y)
# summarize distribution
counter = Counter(y)
for k,v in counter.items():
    per = v / len(y) * 100
    print('Class=%d, n=%d (%.3f%%)' % (k, v, per))
# plot the distribution
plt.bar(counter.keys(), counter.values())
plt.show()
```

```
Class=0, n=114 (5.092%)
Class=1, n=376 (16.793%)
Class=2, n=95 (4.243%)
Class=3, n=438 (19.562%)
Class=4, n=357 (15.945%)
Class=5, n=462 (20.634%)
Class=6, n=77 (3.439%)
Class=7, n=181 (8.084%)
Class=8, n=139 (6.208%)
```



Todo: Write your findings here:

- Which class has the least number of samples?

- Which classes dominate the data in terms proportionate number of samples?

Todo: Rectify the class imbalance

Context: You can use a python package known as `Augmentor` (https://augmentor.readthedocs.io/en/master/) to add more samples across all classes so that none of the classes have very few samples.

```
#https://datascience.stackexchange.com/questions/13490/how-to-set-class-weights-for-imbalanced-classes-in-keras

from sklearn.utils import class_weight
#Class=0, n=114 (5.092%)
#Class=1, n=376 (16.793%)
#Class=2, n=95 (4.243%)
#Class=3, n=438 (19.562%)
#Class=4, n=357 (15.945%)
#Class=5, n=462 (20.634%)
#Class=6, n=77 (3.439%)
#Class=7, n=181 (8.084%)
#Class=8, n=139 (6.208%)
```

```
class_weight = {0:5.09,
                1:16.79,
                2:4.24,
                3:19.56,
                4:15.94,
                5:20.63,
                6:3.43,
                7:8.08,
                8:6.20}

#class_weights = class_weight.compute_class_weight('balanced',np.unique(y_train),y_train)

### Your code goes here
num_classes = 9

#A Sequential model is appropriate for a plain stack of layers where each layer has exactly one input tensor and one output tensor
model = Sequential([
  layers.experimental.preprocessing.Rescaling(1./255, input_shape=(img_height, img_width, 3)),

  #2D convolution layer (e.g. spatial convolution over images).
  layers.Conv2D(16, 3, padding='same', activation='relu'),

  #We slide over the feature map and extract tiles of a specified size.
  #Downsamples the input along its spatial dimensions (height and width) by taking the maximum value over an input window (of size defined by
  layers.MaxPooling2D(),

  #We slide over the feature map and extract tiles of a specified size.
  layers.Conv2D(32, 3, padding='same', activation='relu'),

  layers.MaxPooling2D(),
  layers.Dropout(0.1),

  layers.Conv2D(64, 3, padding='same', activation='relu'),

  #We slide over the feature map and extract tiles of a specified size.
  #Advantages of downsampling - Decreased size of input for upcoming layers, Works against overfitting
  layers.MaxPooling2D(),
  layers.Dropout(0.1),

  #Flattening - Convert into 1D feature vector.  Flattens all its structure to create a single long feature vector
  ##Flattens the input. Does not affect the batch size.
  layers.Flatten(),

  #fully connected layer
  #A hidden layer in which each node is connected to every node in the subsequent hidden layer.
  #A fully connected layer is also known as a dense layer.

  layers.Dense(128, activation='relu'),

  #Dense is the only actual network layer in that model. A Dense layer feeds all outputs from the previous layer to all its neurons, each neu
  #It's the most basic layer in neural networks. A Dense(10) has ten neurons. A Dense(512) has 512 neurons.
  #Dense implements the operation: output = activation(dot(input, kernel)
  #Dense Layer - A dense layer represents a matrix vector multiplication.  each input node is connected to each output node.
  layers.Dense(num_classes)
  #Dense Layer - A dense layer represents a matrix vector multiplication.  each input node is connected to each output node.
])


### Todo, choose an appropirate optimiser and loss function
#RMSprop. RMSprop is a very effective, but currently unpublished adaptive learning rate method
#Adam. Adam is a recently proposed update that looks a bit like RMSProp with momentum. The (simplified) update looks as follows:
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])

epochs = 20
history = model.fit(
  train_ds,
  validation_data=val_ds,
  epochs=epochs,
  class_weight=class_weight)
```

```
Epoch 1/20
56/56 [==============================] - 2s 27ms/step - loss: 25.9302 - accuracy: 0.2645 - val_loss: 1.9663 - val_accuracy: 0.3132
Epoch 2/20
```

```
56/56 [==============================] - 1s 24ms/step - loss: 21.5376 - accuracy: 0.3705 - val_loss: 1.8598 - val_accuracy: 0.3468
Epoch 3/20
56/56 [==============================] - 1s 23ms/step - loss: 20.0326 - accuracy: 0.4113 - val_loss: 1.5891 - val_accuracy: 0.4497
Epoch 4/20
56/56 [==============================] - 1s 24ms/step - loss: 17.7326 - accuracy: 0.5000 - val_loss: 1.6388 - val_accuracy: 0.4497
Epoch 5/20
56/56 [==============================] - 1s 24ms/step - loss: 17.4160 - accuracy: 0.4916 - val_loss: 1.8198 - val_accuracy: 0.4430
Epoch 6/20
56/56 [==============================] - 1s 24ms/step - loss: 17.6267 - accuracy: 0.4922 - val_loss: 1.5036 - val_accuracy: 0.5436
Epoch 7/20
56/56 [==============================] - 1s 23ms/step - loss: 15.6782 - accuracy: 0.5352 - val_loss: 1.5514 - val_accuracy: 0.5213
Epoch 8/20
56/56 [==============================] - 1s 24ms/step - loss: 14.5885 - accuracy: 0.5792 - val_loss: 1.5016 - val_accuracy: 0.5481
Epoch 9/20
56/56 [==============================] - 1s 24ms/step - loss: 13.9129 - accuracy: 0.5831 - val_loss: 1.4896 - val_accuracy: 0.5391
Epoch 10/20
56/56 [==============================] - 2s 29ms/step - loss: 13.0691 - accuracy: 0.5949 - val_loss: 1.5191 - val_accuracy: 0.5436
Epoch 11/20
56/56 [==============================] - 1s 25ms/step - loss: 11.3796 - accuracy: 0.6356 - val_loss: 1.5472 - val_accuracy: 0.5414
Epoch 12/20
56/56 [==============================] - 1s 24ms/step - loss: 10.8046 - accuracy: 0.6523 - val_loss: 1.6787 - val_accuracy: 0.5347
Epoch 13/20
56/56 [==============================] - 1s 24ms/step - loss: 10.2840 - accuracy: 0.6669 - val_loss: 1.8275 - val_accuracy: 0.5302
Epoch 14/20
56/56 [==============================] - 1s 24ms/step - loss: 9.1983 - accuracy: 0.7037 - val_loss: 1.8132 - val_accuracy: 0.5302
Epoch 15/20
56/56 [==============================] - 1s 25ms/step - loss: 7.8667 - accuracy: 0.7277 - val_loss: 1.6966 - val_accuracy: 0.5168
Epoch 16/20
56/56 [==============================] - 1s 24ms/step - loss: 8.0918 - accuracy: 0.7372 - val_loss: 1.8011 - val_accuracy: 0.5257
Epoch 17/20
56/56 [==============================] - 1s 24ms/step - loss: 6.1371 - accuracy: 0.7835 - val_loss: 1.8779 - val_accuracy: 0.5347
Epoch 18/20
56/56 [==============================] - 1s 24ms/step - loss: 5.4177 - accuracy: 0.8047 - val_loss: 2.0254 - val_accuracy: 0.5615
Epoch 19/20
56/56 [==============================] - 1s 24ms/step - loss: 4.3347 - accuracy: 0.8421 - val_loss: 2.1452 - val_accuracy: 0.5213
Epoch 20/20
56/56 [==============================] - 1s 24ms/step - loss: 4.3947 - accuracy: 0.8387 - val_loss: 2.2103 - val_accuracy: 0.5548
```

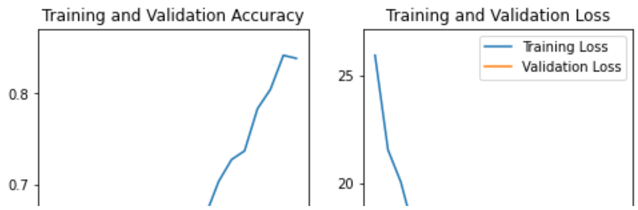
```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)

plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```




```
!pip install Augmentor
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting Augmentor
  Downloading Augmentor-0.2.10-py2.py3-none-any.whl (38 kB)
Requirement already satisfied: future>=0.16.0 in /usr/local/lib/python3.8/dist-packages (from Augmentor) (0.16.0)
Requirement already satisfied: Pillow>=5.2.0 in /usr/local/lib/python3.8/dist-packages (from Augmentor) (7.1.2)
Requirement already satisfied: numpy>=1.11.0 in /usr/local/lib/python3.8/dist-packages (from Augmentor) (1.22.4)
Requirement already satisfied: tqdm>=4.9.0 in /usr/local/lib/python3.8/dist-packages (from Augmentor) (4.64.1)
Installing collected packages: Augmentor
Successfully installed Augmentor-0.2.10
```

```
#https://github.com/mdbloice/Augmentor
#https://github.com/mdbloice/Augmentor
datapath = '/content/gdrive/MyDrive/upgrad/Dataset/SKC/Train/seborrheic keratosis'
import Augmentor
p = Augmentor.Pipeline(datapath)
#Every function requires you to specify a probability, which is used to decide if an operation is applied to an image as it is passed through
p.rotate(probability=0.7, max_left_rotation=10, max_right_rotation=10)
#p.zoom(probability=0.5, min_factor=1.1, max_factor=1.5)
p.sample(200)
p.process()
```

```
Initialised with 77 image(s) found.
Output directory set to /content/gdrive/MyDrive/upgrad/Dataset/SKC/Train/seborrheic keratosis/output.Processing <PIL.JpegImagePlugin.Jpe
Processing <PIL.JpegImagePlugin.JpegImageFile image mode=RGB size=1024x768 at 0x7FCDE53ABAC0>: 100%|██████████| 77/77 [00:06<00:00, 11.6
```

To use `Augmentor`, the following general procedure is followed:

1. Instantiate a `Pipeline` object pointing to a directory containing your initial image data set.
2. Define a number of operations to perform on this data set using your `Pipeline` object.
3. Execute these operations by calling the `Pipeline’s sample()` method.

```
path_to_training_dataset="/content/gdrive/MyDrive/SC/Train//"
import Augmentor
for i in class_names:
    p = Augmentor.Pipeline(path_to_training_dataset + i)
    p.rotate(probability=0.7, max_left_rotation=10, max_right_rotation=10)
    p.sample(500) ## We are adding 500 samples per class to make sure that none of the classes are sparse.
```

Augmentor has stored the augmented images in the output sub-directory of each of the sub-directories of skin cancer types.. Lets take a look at total count of augmented images.

```
image_count_train = len(list(data_dir_train.glob('*/output/*.jpg')))
print(image_count_train)
```

Lets see the distribution of augmented data after adding new images to the original training data.

```
path_list_new = [x for x in glob(os.path.join(data_dir_train, '*','output', '*.jpg'))]
path_list_new
```

```
['Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0031217.jpg_7f885971-40de-416f-93f8-4d940c80ba90.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0025321.jpg_c380f0d6-4c6c-4974-93d7-cf7ca3c69b3f.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0028431.jpg_bcc4e007-ce77-44c2-9e99-0607dba4e661.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0027269.jpg_b6fd7adb-e500-414d-a638-4ead69c06196.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
```

```
lesion_original_ISIC_0030606.jpg_c888632b-43d9-4bb1-844b-5f5347489894.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0032557.jpg_304e812f-0f26-4206-91bd-f36142d97356.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0033092.jpg_a5c96a3a-7a90-4b9d-ae24-82b0a5a14345.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0030070.jpg_50f40a64-0933-454a-bc3c-f361cbdac1b9.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0033135.jpg_230e837f-7592-497e-94be-3c5c2f047b5c.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0033230.jpg_038c6771-b4b9-452b-9a24-19285e10ba81.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0028188.jpg_56f4ff48-f856-4fd5-92c0-33ef7de8afa3.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0028714.jpg_d3d2cebf-bc74-45fa-857b-b063729803f3.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0027522.jpg_a2d5e91d-f18e-4142-b848-47da49001b26.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0031090.jpg_f4e98991-ef03-4be7-9b70-5a1d6d4cd5b9.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0026349.jpg_2e2f747b-4150-4d7f-8b05-c434710dcf8b.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0029877.jpg_cf68d697-c861-41e0-aeca-972fe84ee8ae.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0028885.jpg_040eb75b-22da-4e7d-8e8e-418c92144478.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0032409.jpg_4f19d65a-cc80-4e7b-8f64-c9a0fcc5ba36.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0032076.jpg_670f2683-6415-4479-a98c-a6c63034ccfb.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0027790.jpg_5f7ba2a0-2b8b-4b83-ad88-c926a2c1011f.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0027522.jpg_947246a3-e319-40ec-a810-e3d20fd7a9c8.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0033254.jpg_c5e388f6-3d4d-4807-96cc-6b5520eca9e9.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0027983.jpg_dbf91056-4fff-48c1-a90d-1e27b2207d77.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0024706.jpg_bfb24751-d358-4e5b-b81b-b231302d4e96.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0031090.jpg_4b4b8d04-e978-47c8-934f-2b008e1886e4.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0031996.jpg_4ca92619-103f-45c4-9f20-25f674759e7b.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0032538.jpg_0848e0f3-7d98-4f3b-8263-4aea01423774.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0029404.jpg_ea913a54-2945-4a42-a15e-06731ec83d3d.jpg',
 'Skin cancer ISIC The International Skin Imaging Collaboration/Train/vascular lesion/output/vascular
lesion_original_ISIC_0028680.jpg_76b35b53-5f87-4e5a-b215-84ca78cdb378.jpg',
```

```
lesion_list_new = [os.path.basename(os.path.dirname(os.path.dirname(y))) for y in glob(os.path.join(data_dir_train, '*','output', '*.jpg'))]
lesion_list_new
```

```
['vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
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 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
```

```
 'vascular lesion',
 'vascular lesion',
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 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
 'vascular lesion',
```

```
dataframe_dict_new = dict(zip(path_list_new, lesion_list_new))
```

```
df2 = pd.DataFrame(list(dataframe_dict_new.items()),columns = ['Path','Label'])
new_df = original_df.append(df2)
```

```
new_df['Label'].value_counts()
```

```
pigmented benign keratosis    962
melanoma                      938
basal cell carcinoma          876
nevus                         857
squamous cell carcinoma       681
vascular lesion               639
actinic keratosis             614
dermatofibroma                595
seborrheic keratosis          577
Name: Label, dtype: int64
```

So, now we have added 500 images to all the classes to maintain some class balance. We can add more images as we want to improve training process.

Todo: Train the model on the data created using Augmentor

[ ] ↳ *1 cell hidden*

Todo: Create a training dataset

[ ] ↳ *1 cell hidden*

Todo: Create a validation dataset

```
val_ds = tf.keras.preprocessing.image_dataset_from_directory(
  data_dir_train,
  seed=123,
  validation_split = 0.2,
  subset = 'validation',## Todo choose the correct parameter value, so that only validation data is refered to,
  image_size=(img_height, img_width),
  batch_size=batch_size)
```

```
Found 6739 files belonging to 9 classes.
Using 1347 files for validation.
```

Todo: Create your model (make sure to include normalization)

```
AUTOTUNE = tf.data.experimental.AUTOTUNE

train_ds = train_ds.cache().shuffle(1000).prefetch(buffer_size=AUTOTUNE)
val_ds = val_ds.cache().prefetch(buffer_size=AUTOTUNE)

model = Sequential([
  layers.experimental.preprocessing.Rescaling(1./255),
  layers.Conv2D(16, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Conv2D(32, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Conv2D(64, 3, padding='same', activation='relu'),
  layers.MaxPooling2D(),
  layers.Dropout(0.2),
  layers.Flatten(),
  layers.Dense(128, activation='relu'),
  layers.Dense(num_classes)
])
```

Todo: Compile your model (Choose optimizer and loss function appropriately)

```
## your code goes here
model.compile(optimizer='adam',
              loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
              metrics=['accuracy'])
```

Todo: Train your model

```
epochs = 20
history = model.fit(
  train_ds,
  validation_data=val_ds,
  epochs=epochs
)
```

```
Epoch 1/20
169/169 [==============================] - 11s 62ms/step - loss: 1.9140 - accuracy: 0.2778 - val_loss: 1.5455 - val_accuracy: 0.3987
Epoch 2/20
169/169 [==============================] - 5s 28ms/step - loss: 1.4312 - accuracy: 0.4534 - val_loss: 1.4103 - val_accuracy: 0.4974
Epoch 3/20
169/169 [==============================] - 5s 28ms/step - loss: 1.2410 - accuracy: 0.5351 - val_loss: 1.2357 - val_accuracy: 0.5264
Epoch 4/20
169/169 [==============================] - 5s 28ms/step - loss: 1.0454 - accuracy: 0.6224 - val_loss: 1.2029 - val_accuracy: 0.5516
Epoch 5/20
169/169 [==============================] - 5s 28ms/step - loss: 0.8814 - accuracy: 0.6821 - val_loss: 0.9543 - val_accuracy: 0.6437
Epoch 6/20
169/169 [==============================] - 5s 28ms/step - loss: 0.7177 - accuracy: 0.7361 - val_loss: 1.0184 - val_accuracy: 0.6674
Epoch 7/20
169/169 [==============================] - 5s 28ms/step - loss: 0.5872 - accuracy: 0.7854 - val_loss: 0.8755 - val_accuracy: 0.6971
Epoch 8/20
169/169 [==============================] - 5s 28ms/step - loss: 0.4969 - accuracy: 0.8279 - val_loss: 0.9385 - val_accuracy: 0.6763
Epoch 9/20
169/169 [==============================] - 5s 28ms/step - loss: 0.4206 - accuracy: 0.8516 - val_loss: 0.7863 - val_accuracy: 0.7461
Epoch 10/20
169/169 [==============================] - 5s 28ms/step - loss: 0.3517 - accuracy: 0.8754 - val_loss: 0.7721 - val_accuracy: 0.7661
Epoch 11/20
169/169 [==============================] - 5s 28ms/step - loss: 0.3264 - accuracy: 0.8796 - val_loss: 0.8461 - val_accuracy: 0.7439
Epoch 12/20
169/169 [==============================] - 5s 28ms/step - loss: 0.2863 - accuracy: 0.8909 - val_loss: 0.8874 - val_accuracy: 0.7691
Epoch 13/20
169/169 [==============================] - 5s 28ms/step - loss: 0.2640 - accuracy: 0.9047 - val_loss: 0.8162 - val_accuracy: 0.8033
Epoch 14/20
169/169 [==============================] - 5s 28ms/step - loss: 0.2817 - accuracy: 0.8999 - val_loss: 0.9825 - val_accuracy: 0.7068
Epoch 15/20
169/169 [==============================] - 5s 28ms/step - loss: 0.2236 - accuracy: 0.9171 - val_loss: 0.8275 - val_accuracy: 0.7825
Epoch 16/20
169/169 [==============================] - 5s 29ms/step - loss: 0.1791 - accuracy: 0.9338 - val_loss: 0.7689 - val_accuracy: 0.8070
Epoch 17/20
169/169 [==============================] - 5s 28ms/step - loss: 0.1865 - accuracy: 0.9282 - val_loss: 0.8392 - val_accuracy: 0.8166
Epoch 18/20
169/169 [==============================] - 5s 28ms/step - loss: 0.1616 - accuracy: 0.9403 - val_loss: 0.9834 - val_accuracy: 0.7825
Epoch 19/20
169/169 [==============================] - 5s 28ms/step - loss: 0.1845 - accuracy: 0.9297 - val_loss: 0.8244 - val_accuracy: 0.8033
Epoch 20/20
169/169 [==============================] - 5s 28ms/step - loss: 0.1387 - accuracy: 0.9449 - val_loss: 0.8581 - val_accuracy: 0.7914
```

Todo: Visualize the model results

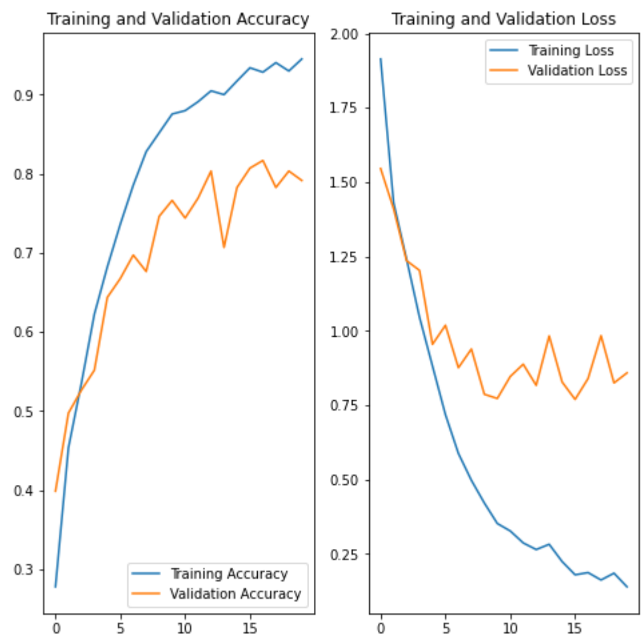
```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs_range = range(epochs)

plt.figure(figsize=(8, 8))
plt.subplot(1, 2, 1)
plt.plot(epochs_range, acc, label='Training Accuracy')
plt.plot(epochs_range, val_acc, label='Validation Accuracy')
plt.legend(loc='lower right')
plt.title('Training and Validation Accuracy')

plt.subplot(1, 2, 2)
plt.plot(epochs_range, loss, label='Training Loss')
plt.plot(epochs_range, val_loss, label='Validation Loss')
plt.legend(loc='upper right')
plt.title('Training and Validation Loss')
plt.show()
```



Todo: Analyze your results here. Did you get rid of underfitting/overfitting? Did class rebalance help?

The class rebalance helped in reducing overfititng of the data and thus the loass is beng reduced But it reduced the Acurracy very low

Initially we tried without the ImageDataGenerator which created data to over fit at high ratio

Then we introduced dropout and ImageDataGenerator which reduced the over fit