🦋 Butterfly Detection 🦋

In [ ]:
```
import pandas as pd #to import data
import os
import sys
import matplotlib.pyplot as plt
import cv2 as cv
import numpy as np
from sklearn.utils import shuffle   #unsure if you need this
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense, Dr
from tensorflow.keras.optimizers import Adam
import warnings
warnings.filterwarnings('ignore')
```

Data Processing & Label Encoding

Since this was my first time using Jupyter Notebooks, I had a hard time trying to read in my data. Any time I would get close, I would cause bugs to Rachel's work. So after some research, I decided to install pandas and upload directly in my notebook

In [ ]:
```
df_train = pd.read_csv('train/Training_set.csv')
df_test = pd.read_csv('test/Testing_set.csv')
df_train.sample(10)
```

Out[ ]:

	filename	label
4201	Image_4202.jpg	PEACOCK
4375	Image_4376.jpg	CLEOPATRA
3983	Image_3984.jpg	SLEEPY ORANGE
1286	Image_1287.jpg	RED SPOTTED PURPLE
399	Image_400.jpg	BLUE SPOTTED CROW
928	Image_929.jpg	SOUTHERN DOGFACE
5474	Image_5475.jpg	CLOUDED SULPHUR
4952	Image_4953.jpg	MESTRA
4280	Image_4281.jpg	DANAID EGGFLY
3463	Image_3464.jpg	GREAT JAY

In [ ]:
```
df_test.head()
```

Out[ ]:

	filename
0	Image_1.jpg
1	Image_2.jpg
2	Image_3.jpg
3	Image_4.jpg
4	Image_5.jpg

In [ ]:
```
df_train.info(), df_train.shape
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 6499 entries, 0 to 6498
Data columns (total 2 columns):
 #   Column    Non-Null Count  Dtype 
---  ------    --------------  ----- 
 0   filename  6499 non-null   object
 1   label     6499 non-null   object
dtypes: object(2)
memory usage: 101.7+ KB
```

Out[ ]: (None, (6499, 2))

In [ ]:
```
df_test.info(), df_test.shape
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2786 entries, 0 to 2785
Data columns (total 1 columns):
 #   Column    Non-Null Count  Dtype 
---  ------    --------------  ----- 
 0   filename  2786 non-null   object
dtypes: object(1)
memory usage: 21.9+ KB
```

Out[ ]: (None, (2786, 1))

In [ ]:
```
df = pd.concat([df_train[['filename']], df_test[['filename']]], axis='rows')
df['label'] = [1]*len(df)
df.sample(10)
```

Out[ ]:

	filename	label
5334	Image_5335.jpg	1
4707	Image_4708.jpg	1
4301	Image_4302.jpg	1
3707	Image_3708.jpg	1
3083	Image_3084.jpg	1
3965	Image_3966.jpg	1
2378	Image_2379.jpg	1
4036	Image_4037.jpg	1
2655	Image_2656.jpg	1
834	Image_835.jpg	1

In [ ]:
```
from sklearn.preprocessing import LabelEncoder

encoder = LabelEncoder()
df_train['label_en'] = encoder.fit_transform(df_train['label'])
df_train.sample(10)
```

Out[ ]:

	filename	label	label_en
1529	Image_1530.jpg	ZEBRA LONG WING	74
4090	Image_4091.jpg	ELBOWED PIERROT	29
1307	Image_1308.jpg	ATALA	5
768	Image_769.jpg	MILBERTS TORTOISESHELL	43
6294	Image_6295.jpg	SOUTHERN DOGFACE	66
2530	Image_2531.jpg	IPHICLUS SISTER	36
2192	Image_2193.jpg	YELLOW SWALLOW TAIL	73
1697	Image_1698.jpg	MOURNING CLOAK	45
3551	Image_3552.jpg	RED CRACKER	59
323	Image_324.jpg	BLUE MORPHO	10

In [ ]:
```
non_target = []
MAIN_FILE = 'notbtterfly/'
for img in os.listdir(MAIN_FILE):
    non_target.append(img)
```

In [ ]:
```
non_target[:10]
```

Out[ ]:
```
['23933.jpg',
 '20584.jpg',
 '21842.jpg',
 '22393.jpg',
 '22387.jpg',
 '20590.jpg',
 '21856.jpg',
 '23927.jpg',
 '20221.jpg',
 '22436.jpg']
```

In [ ]:
```
non_target_labels = np.c_[non_target, [0]*len(non_target)]
non_df = pd.DataFrame(non_target_labels, columns=['filename', 'label'])
non_df.head()
```

Out[ ]:

	filename	label
0	23933.jpg	0
1	20584.jpg	0
2	21842.jpg	0
3	22393.jpg	0
4	22387.jpg	0

Adding Non-Butterfly Images & Processing Images

Here I am adding a dataset of pictures that do not contain any butterflies to train my data. While I followed the tutorials I looked up about pandas and jupyter notebooks, the logic stays the same. I am resizing/normalizing, dividing by 255, converting the images to grayscale, and then building a CNN model

In [ ]:
```
non_target = []
IMAGE_SIZE = (40, 40)

for img in non_df['filename']:
    img = cv.imread('notbtterfly/' + img)
    img = cv.resize(img, IMAGE_SIZE)
    non_target.append(img/255.0)

from tensorflow.keras.preprocessing.image import ImageDataGenerator


datagen = ImageDataGenerator(
    rotation_range=30,  # Rotate images by 30 degrees @ random
    width_shift_range=0.2,  # Shift images horizontally 20% of total width @
    height_shift_range=0.2,  # Shift images vertically 20% of total height @
    shear_range=0.3,  # Apply shear transformation with a shear angle of 30
    zoom_range=0.3,  # Zoom images by up to 30% @ random
    horizontal_flip=True,  # Flip images horizontally @ random
    vertical_flip=False  # Do not perform vertical flips
)

# grayscale numpy array of images
```

```
images = non_target

# Generate augmented grayscale images
augmented_images = []

for image in images:
    num_generated_images = 0

    while num_generated_images < 60:
        augmented_image = datagen.random_transform(image)
        augmented_images.append(augmented_image)
        num_generated_images += 1

# Convert augmented grayscale images back to a NumPy array
augmented_images = np.array(augmented_images)
non_target = np.squeeze(augmented_images)
print(non_target.shape)
plt.imshow(non_target[0])
plt.axis('off')
plt.show()
```

```
(181200, 40, 40, 3)
```

In [ ]:

```
IMAGE_SIZE = (40,40)
IMAGE_SIZE_CLASS = (60,60)

train = []

train_class = []
train_labels = []

test = []
```

```
for img,label in zip(df_train['filename'], df_train['label_en']):
    img = cv.imread('train/'+img)
    det = cv.resize(img, IMAGE_SIZE)
    clas = cv.resize(img, IMAGE_SIZE_CLASS)
    train.append(det/255.0)
    train_class.append(clas/255.0)
    train_labels.append(label)

for img in df_test['filename']:
    img = cv.imread('test/' + img)
    img = cv.resize(img, IMAGE_SIZE)
    test.append(img/255.0)

plt.imshow(train[0])
plt.axis('off')
plt.show()
```

In [ ]:
```
images = list(train)+list(test)

# Generate augmented images
augmented_images_target = []
for image in images:
    num_generated_images = 0

    while num_generated_images < 6:
        augmented_image = datagen.random_transform(image)
        augmented_images_target.append(augmented_image)
        num_generated_images += 1

augmented_images_target = np.array(augmented_images_target)
target = np.squeeze(augmented_images_target)
print(target.shape)
```

```
(55710, 40, 40, 3)
```

In [ ]:
```
X = np.array(list(target)+ list(non_target))
Y = np.array([1]*len(target)+[0]*len(list(non_target)))

X.shape, Y.shape
```

Out[ ]:
```
((236910, 40, 40, 3), (236910,))
```

In [ ]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, Y_train, Y_test = train_test_split(X, Y, stratify=Y)
X_train.shape, X_test.shape, Y_train.shape, Y_test.shape
```

Out[ ]:
```
((177682, 40, 40, 3), (59228, 40, 40, 3), (177682,), (59228,))
```

In [ ]:
```
import tensorflow as tf
from tensorflow import keras
```

In [ ]:
```
# Define the CNN model
model = keras.Sequential()
model.add(keras.layers.Conv2D(32, kernel_size=(3, 3), activation='relu', inp
model.add(keras.layers.MaxPooling2D(pool_size=(2, 2)))
model.add(keras.layers.Conv2D(64, kernel_size=(3, 3), activation='relu'))
model.add(keras.layers.MaxPooling2D(pool_size=(2, 2)))
model.add(keras.layers.Flatten())
model.add(keras.layers.Dense(64, activation='relu'))
model.add(keras.layers.Dense(1, activation='sigmoid'))

# Compile the model
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accura

# Train the model
model.fit(X_train, Y_train, epochs=20, batch_size=64)

model.summary()
```

```
Epoch 1/20
2777/2777 [==============================] - 63s 22ms/step - loss: 0.1427 -
accuracy: 0.9453
Epoch 2/20
2777/2777 [==============================] - 66s 24ms/step - loss: 0.0848 -
accuracy: 0.9686
Epoch 3/20
2777/2777 [==============================] - 74s 27ms/step - loss: 0.0680 -
accuracy: 0.9748
Epoch 4/20
2777/2777 [==============================] - 66s 24ms/step - loss: 0.0543 -
accuracy: 0.9801
Epoch 5/20
2777/2777 [==============================] - 63s 23ms/step - loss: 0.0440 -
accuracy: 0.9839
Epoch 6/20
2777/2777 [==============================] - 65s 23ms/step - loss: 0.0368 -
accuracy: 0.9867
Epoch 7/20
2777/2777 [==============================] - 65s 24ms/step - loss: 0.0291 -
accuracy: 0.9895
Epoch 8/20
2777/2777 [==============================] - 64s 23ms/step - loss: 0.0243 -
accuracy: 0.9914
Epoch 9/20
2777/2777 [==============================] - 64s 23ms/step - loss: 0.0196 -
accuracy: 0.9930
Epoch 10/20
2777/2777 [==============================] - 64s 23ms/step - loss: 0.0172 -
accuracy: 0.9939
Epoch 11/20
2777/2777 [==============================] - 64s 23ms/step - loss: 0.0140 -
accuracy: 0.9952
Epoch 12/20
2777/2777 [==============================] - 63s 23ms/step - loss: 0.0129 -
accuracy: 0.9954
Epoch 13/20
2777/2777 [==============================] - 63s 23ms/step - loss: 0.0108 -
accuracy: 0.9965
Epoch 14/20
2777/2777 [==============================] - 65s 23ms/step - loss: 0.0108 -
accuracy: 0.9964
Epoch 15/20
2777/2777 [==============================] - 68s 24ms/step - loss: 0.0094 -
accuracy: 0.9967
Epoch 16/20
2777/2777 [==============================] - 70s 25ms/step - loss: 0.0085 -
accuracy: 0.9972
Epoch 17/20
2777/2777 [==============================] - 71s 26ms/step - loss: 0.0084 -
accuracy: 0.9971
Epoch 18/20
2777/2777 [==============================] - 71s 26ms/step - loss: 0.0079 -
accuracy: 0.9973
Epoch 19/20
2777/2777 [==============================] - 75s 27ms/step - loss: 0.0084 -
```

```
accuracy: 0.9972
Epoch 20/20
2777/2777 [==============================] - 72s 26ms/step - loss: 0.0063 -
accuracy: 0.9978
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 38, 38, 32)        896

 max_pooling2d (MaxPooling2  (None, 19, 19, 32)        0
 D)

 conv2d_1 (Conv2D)           (None, 17, 17, 64)        18496

 max_pooling2d_1 (MaxPoolin  (None, 8, 8, 64)          0
 g2D)

 flatten (Flatten)           (None, 4096)              0

 dense (Dense)               (None, 64)                262208

 dense_1 (Dense)             (None, 1)                 65

=================================================================
Total params: 281665 (1.07 MB)
Trainable params: 281665 (1.07 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

Detection Model Evaluation

I learned the hardway that this will fail if you have too many google chrome tabs open.

In [ ]:
```
model.evaluate(X_test, Y_test)
```

```
1851/1851 [==============================] - 8s 4ms/step - loss: 0.0761 - ac
curacy: 0.9842
```

Out[ ]:
```
[0.07614270597696304, 0.9842135310173035]
```

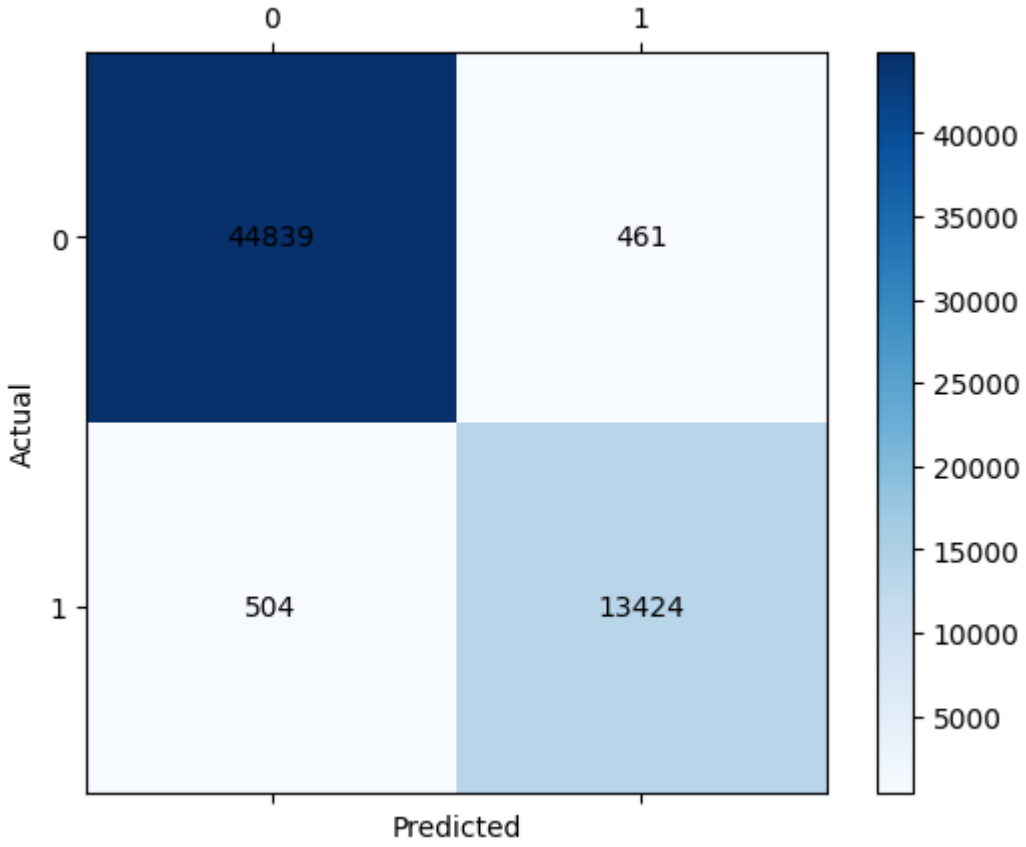
In [ ]:
```
tensors = tf.convert_to_tensor(np.array(X_test))
probabilities = model.predict(tensors)
threshold = 0.3
Y_pred = (probabilities > threshold).astype(int)[:,0]
Y_pred
```

```
1851/1851 [==============================] - 8s 4ms/step
```

Out[ ]:
```
array([0, 0, 0, ..., 0, 0, 0])
```

In [ ]:
```
import matplotlib.pyplot as plt
from sklearn.metrics import confusion_matrix, classification_report
import numpy as np

cm = confusion_matrix(Y_test, Y_pred)
```

```
fig, ax = plt.subplots()
cax = ax.matshow(cm, cmap=plt.cm.Blues)
plt.colorbar(cax)

classes = np.unique(Y_test)
ax.set_xticks(np.arange(len(classes)))
ax.set_yticks(np.arange(len(classes)))
ax.set_xticklabels(classes)
ax.set_yticklabels(classes)

for i in range(len(classes)):
    for j in range(len(classes)):
        plt.text(j, i, str(cm[i, j]), ha='center', va='center')

plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.show()
```



In [ ]:
```
cr = classification_report(Y_test, Y_pred)
print(cr)
```

	precision	recall	f1-score	support
0	0.99	0.99	0.99	45300
1	0.97	0.96	0.97	13928
accuracy			0.98	59228
macro avg	0.98	0.98	0.98	59228
weighted avg	0.98	0.98	0.98	59228

Work Cited

- https://www.youtube.com/playlist?list=PLIRnO_sdVuEfau_eJKVhiaLaqIXCT0F-_
- https://www.tensorflow.org/api_docs/python/tf/keras/preprocessing/image/ImageDataG
- https://www.youtube.com/watch?v=PW9_cK8PR5E
- https://www.kaggle.com/datasets/phucthaiv02/butterfly-image-classification
- https://www.kaggle.com/datasets/pankajkumar2002/random-image-sample-dataset/