```
# importing required libraries, modules and pretrained model

import os
import tensorflow as tf
from tensorflow import keras
from skimage import io
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from tensorflow.keras.layers import Input, Dense, Conv2D, MaxPool2D, Dropout, Flatten, Ave
from tensorflow.keras.optimizers import RMSprop, SGD
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.callbacks import EarlyStopping, ModelCheckpoint
from tensorflow.keras import Sequential
from tensorflow.keras.models import Model
from tensorflow.keras.applications.xception import Xception
```

```
SEED = 42
SIZE = (224, 224)
BATCH_SIZE = 32

pd.set_option('display.max_rows', None)
```

```
# training and validation data

from google.colab import files
uploaded = files.upload()
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving horse breeds.csv to horse breeds (1).csv
```

```
import io
labels = pd.read_csv(io.BytesIO(uploaded['horse breeds.csv']))
```

```
labels.head()
```

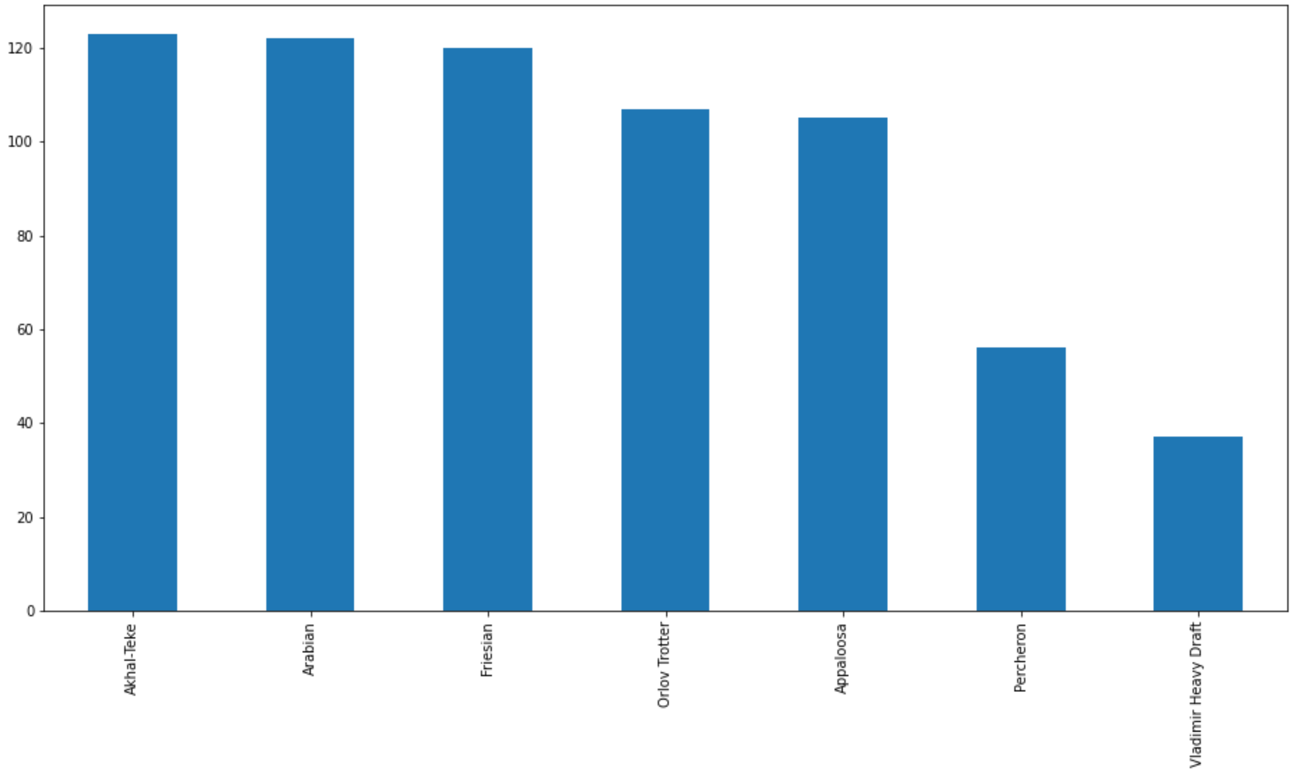
	id	breed
0	01_016	Akhal-Teke
1	01_017	Akhal-Teke
2	01_018	Akhal-Teke
3	01_019	Akhal-Teke
4	01_020	Akhal-Teke

```
labels['id'] = labels['id'].apply(lambda x: x + '.png')
labels.head()
```

	id	breed
0	01_016.png	Akhal-Teke
1	01_017.png	Akhal-Teke
2	01_018.png	Akhal-Teke
3	01_019.png	Akhal-Teke
4	01_020.png	Akhal-Teke

```
labels['breed'].value_counts().plot.bar(figsize=(16, 8))
```

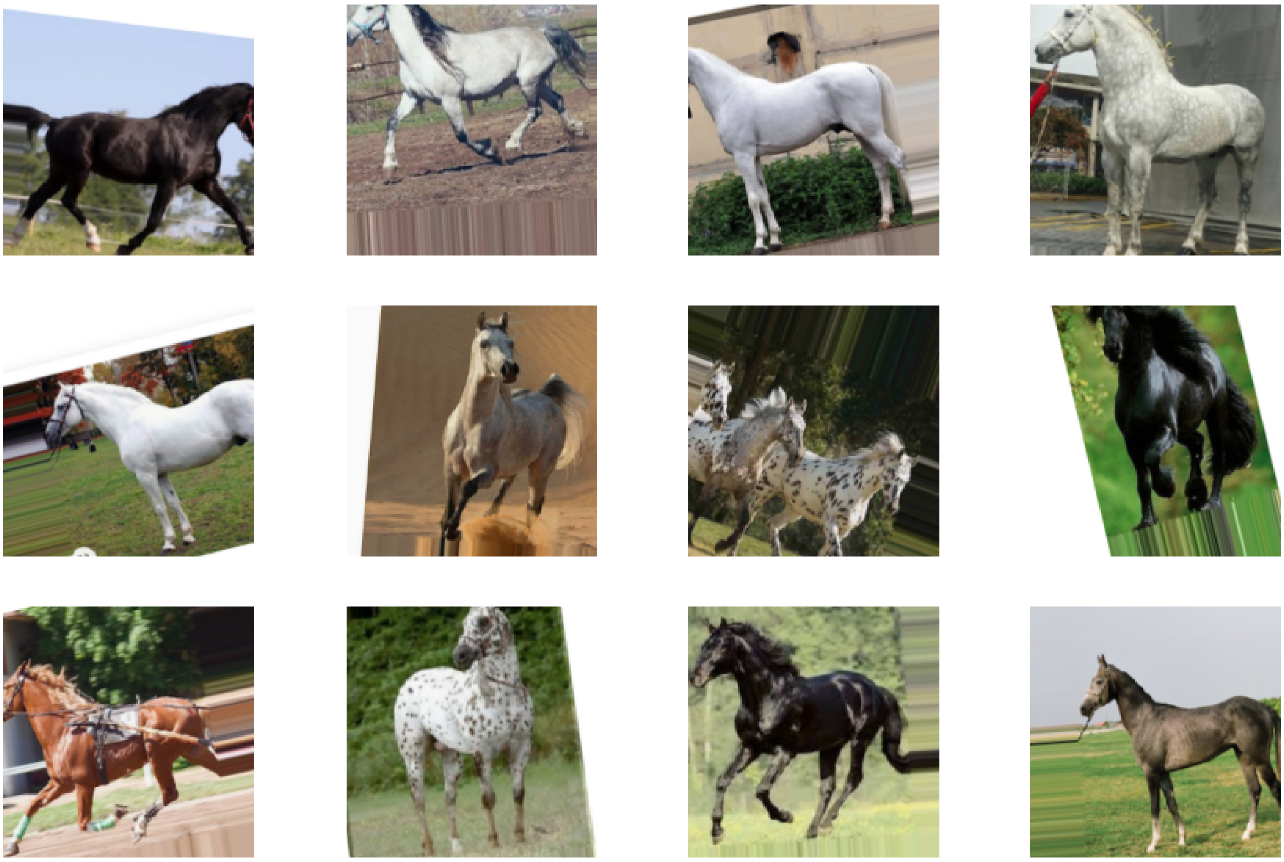
```
<matplotlib.axes._subplots.AxesSubplot at 0x7ff96d3edf10>
```



```
# ImageDatagenerator to load the images in batches and perform data augmentation

data_generator = ImageDataGenerator(rescale= 1./255, validation_split=0.2, rotation_range=
                                    zoom_range=0.1, width_shift_range=0.2, height_shift_ra
                                    shear_range=0.1, horizontal_flip=True, fill_mode="near


train_generator = data_generator.flow_from_dataframe(labels, directory='/content/Images',
val_generator = data_generator.flow_from_dataframe(labels, directory='/content/Images', x_
```

```
     Found 536 validated image filenames belonging to 7 classes.
     Found 134 validated image filenames belonging to 7 classes.
```

```
# 12 images after augmentation

img, label = next(train_generator)

fig = plt.figure(figsize=(15, 10))

for i in range(12):
    fig.add_subplot(3, 4, i+1)
    plt.imshow(img[i])
    plt.axis('off')
```



```
# callbacks that will be used during training

early_stopping = EarlyStopping(monitor='val_loss', mode = 'min', patience=10)
checkpoint = ModelCheckpoint(filepath = './weights.hdf5', verbose=1, save_best_only=True)\
```

```
base_model = Xception(weights="imagenet", include_top=False, input_tensor=Input(shape=(224
base_model.summary()
```

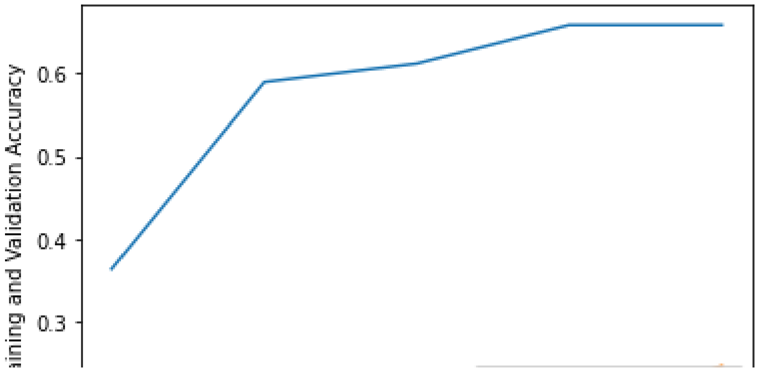
```
 v2D)

 block12_sepconv3_bn (BatchNorm  (None, 14, 14, 728)  2912        ['block12_sepconv
 alization)

 add_10 (Add)                   (None, 14, 14, 728)  0           ['block12_sepconv
                                                                  'add_9[0][0]']

 block13_sepconv1_act (Activati  (None, 14, 14, 728)  0           ['add_10[0][0]']
 on)

 block13_sepconv1 (SeparableCon  (None, 14, 14, 728)  536536      ['block13_sepconv
 v2D)

 block13_sepconv1_bn (BatchNorm  (None, 14, 14, 728)  2912        ['block13_sepconv
 alization)

 block13_sepconv2_act (Activati  (None, 14, 14, 728)  0           ['block13_sepconv
 on)

 block13_sepconv2 (SeparableCon  (None, 14, 14, 1024  752024      ['block13_sepconv
 v2D)                           )

 block13_sepconv2_bn (BatchNorm  (None, 14, 14, 1024  4096        ['block13_sepconv
 alization)                     )

 conv2d_3 (Conv2D)              (None, 7, 7, 1024)   745472      ['add_10[0][0]']

 block13_pool (MaxPooling2D)    (None, 7, 7, 1024)   0           ['block13_sepconv

 batch_normalization_3 (BatchNo  (None, 7, 7, 1024)  4096        ['conv2d_3[0][0]

 rmalization)

 add_11 (Add)                   (None, 7, 7, 1024)   0           ['block13_pool[0
                                                                  'batch_normaliz

 block14_sepconv1 (SeparableCon  (None, 7, 7, 1536)  1582080     ['add_11[0][0]']
 v2D)

 block14_sepconv1_bn (BatchNorm  (None, 7, 7, 1536)  6144        ['block14_sepconv
 alization)

 block14_sepconv1_act (Activati  (None, 7, 7, 1536)  0           ['block14_sepconv
 on)

 block14_sepconv2 (SeparableCon  (None, 7, 7, 2048)  3159552     ['block14_sepconv
 v2D)

 block14_sepconv2_bn (BatchNorm  (None, 7, 7, 2048)  8192        ['block14_sepconv
 alization)

 block14_sepconv2_act (Activati  (None, 7, 7, 2048)  0           ['block14_sepconv
 on)

==================================================================================
Total params: 20,861,480
Trainable params: 20,806,952
```

```
for layer in base_model.layers:
    layer.trainable = False



head_model = AveragePooling2D(pool_size=(4, 4))(base_model.output)
head_model = Flatten(name='flatten')(head_model)
head_model = Dense(1024, activation='relu')(head_model)
head_model = Dropout(0.3)(head_model)
head_model = Dense(512, activation='relu')(head_model)
head_model = Dropout(0.3)(head_model)
head_model = Dense(7, activation='softmax')(head_model)


model = Model(inputs=base_model.input, outputs=head_model)
optimizer = SGD(learning_rate=0.1, momentum=0.9, decay=0.01)
model.compile(loss="categorical_crossentropy", optimizer=optimizer, metrics=["accuracy"])
#model.compile(loss="categorical_crossentropy", optimizer="adam", metrics=['categorical_ac


#first cycle
history1 = model.fit(train_generator, epochs=5, callbacks=[checkpoint], validation_data=va
```

```
Epoch 1/5
17/17 [==============================] - ETA: 0s - loss: 2.1739 - accuracy: 0.3638
Epoch 1: val_loss improved from inf to 2.50501, saving model to ./weights.hdf5
17/17 [==============================] - 129s 7s/step - loss: 2.1739 - accuracy: 0.36
Epoch 2/5
17/17 [==============================] - ETA: 0s - loss: 1.1716 - accuracy: 0.5896
Epoch 2: val_loss improved from 2.50501 to 2.11176, saving model to ./weights.hdf5
17/17 [==============================] - 126s 7s/step - loss: 1.1716 - accuracy: 0.58
Epoch 3/5
17/17 [==============================] - ETA: 0s - loss: 1.1627 - accuracy: 0.6119
Epoch 3: val_loss did not improve from 2.11176
17/17 [==============================] - 126s 7s/step - loss: 1.1627 - accuracy: 0.61
Epoch 4/5
17/17 [==============================] - ETA: 0s - loss: 1.0599 - accuracy: 0.6586
Epoch 4: val_loss did not improve from 2.11176
17/17 [==============================] - 124s 7s/step - loss: 1.0599 - accuracy: 0.65
Epoch 5/5
17/17 [==============================] - ETA: 0s - loss: 1.0217 - accuracy: 0.6586
Epoch 5: val_loss did not improve from 2.11176
17/17 [==============================] - 127s 8s/step - loss: 1.0217 - accuracy: 0.65
```

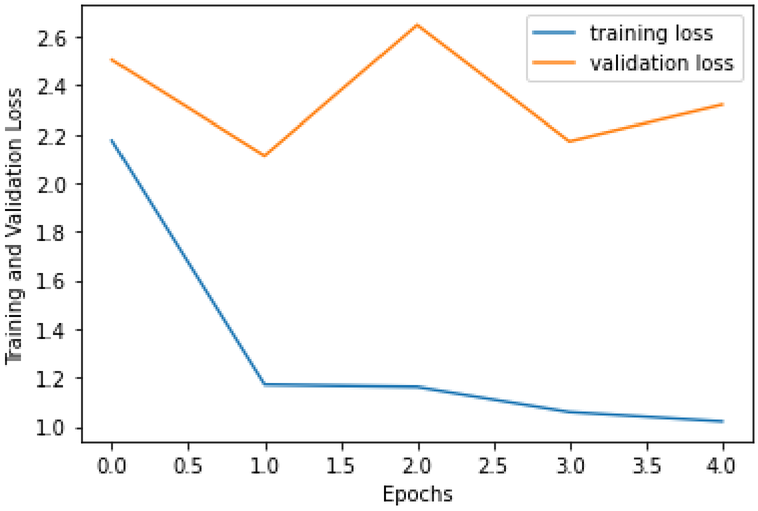
```
plt.plot(history1.history['accuracy'], label='training accuracy')
plt.plot(history1.history['val_accuracy'], label='validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Training and Validation Accuracy')
plt.legend(loc='lower right')
```

```
<matplotlib.legend.Legend at 0x7ff9611ecc10>
```



```
plt.plot(history1.history['loss'], label='training loss')
plt.plot(history1.history['val_loss'], label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Training and Validation Loss')
plt.legend()
```

```
<matplotlib.legend.Legend at 0x7ff9612a2810>
```



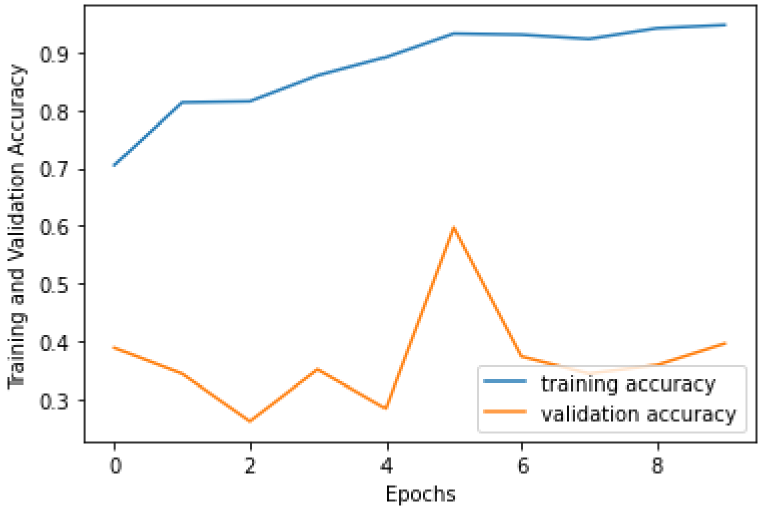
```
#second cycle

for layer in base_model.layers[len(base_model.layers)//2:]:
    layer.trainable = True

optimizer = SGD(learning_rate=0.01, momentum=0.9, decay=0.001)
model.compile(loss="categorical_crossentropy", optimizer=optimizer, metrics=["accuracy"])


history2 = model.fit(train_generator, epochs=10, validation_data=val_generator, callbacks=
```

```
Epoch 1/10
17/17 [==============================] - ETA: 0s - loss: 0.9240 - accuracy: 0.7052
Epoch 1: val_loss improved from 2.11176 to 2.10266, saving model to ./weights.hdf5
17/17 [==============================] - 282s 17s/step - loss: 0.9240 - accuracy: 0.7
Epoch 2/10
17/17 [==============================] - ETA: 0s - loss: 0.5914 - accuracy: 0.8134
Epoch 2: val_loss did not improve from 2.10266
17/17 [==============================] - 273s 16s/step - loss: 0.5914 - accuracy: 0.8
Epoch 3/10
17/17 [==============================] - ETA: 0s - loss: 0.4818 - accuracy: 0.8153
Epoch 3: val_loss did not improve from 2.10266
```

```
17/17 [==============================] - 251s 15s/step - loss: 0.4818 - accuracy: 0.8
Epoch 4/10
17/17 [==============================] - ETA: 0s - loss: 0.4170 - accuracy: 0.8601
Epoch 4: val_loss did not improve from 2.10266
17/17 [==============================] - 251s 15s/step - loss: 0.4170 - accuracy: 0.8
Epoch 5/10
17/17 [==============================] - ETA: 0s - loss: 0.3055 - accuracy: 0.8918
Epoch 5: val_loss did not improve from 2.10266
17/17 [==============================] - 251s 15s/step - loss: 0.3055 - accuracy: 0.8
Epoch 6/10
17/17 [==============================] - ETA: 0s - loss: 0.2024 - accuracy: 0.9328
Epoch 6: val_loss improved from 2.10266 to 1.80999, saving model to ./weights.hdf5
17/17 [==============================] - 253s 15s/step - loss: 0.2024 - accuracy: 0.9
Epoch 7/10
17/17 [==============================] - ETA: 0s - loss: 0.2447 - accuracy: 0.9310
Epoch 7: val_loss did not improve from 1.80999
17/17 [==============================] - 256s 15s/step - loss: 0.2447 - accuracy: 0.9
Epoch 8/10
17/17 [==============================] - ETA: 0s - loss: 0.2101 - accuracy: 0.9235
Epoch 8: val_loss did not improve from 1.80999
17/17 [==============================] - 253s 15s/step - loss: 0.2101 - accuracy: 0.9
Epoch 9/10
17/17 [==============================] - ETA: 0s - loss: 0.1705 - accuracy: 0.9422
Epoch 9: val_loss did not improve from 1.80999
17/17 [==============================] - 250s 15s/step - loss: 0.1705 - accuracy: 0.9
Epoch 10/10
17/17 [==============================] - ETA: 0s - loss: 0.1220 - accuracy: 0.9478
Epoch 10: val_loss did not improve from 1.80999
17/17 [==============================] - 255s 15s/step - loss: 0.1220 - accuracy: 0.9
```

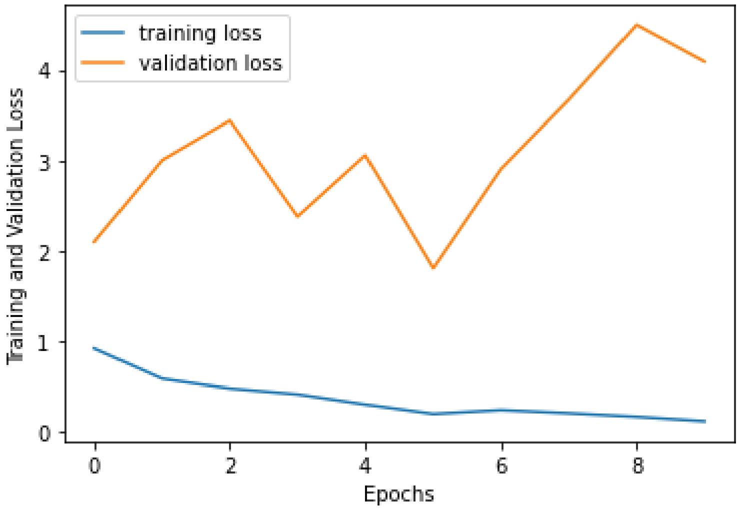
```
plt.plot(history2.history['accuracy'], label='training accuracy')
plt.plot(history2.history['val_accuracy'], label='validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Training and Validation Accuracy')
plt.legend(loc='lower right')
```

```
<matplotlib.legend.Legend at 0x7ff96a33bc50>
```



```
plt.plot(history2.history['loss'], label='training loss')
plt.plot(history2.history['val_loss'], label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Training and Validation Loss')
plt.legend()
```

```
<matplotlib.legend.Legend at 0x7ff9613a0dd0>
```



The model clearly started overfitting after after couple of epochs so the best weights saved in the weigh.hdf5 file will be loaded before the third cycle.

```
model.load_weights('./weights.hdf5')
```

```
# third cycle

for layer in base_model.layers:
    layer.trainable = True

optimizer = SGD(learning_rate=0.01, momentum=0.9, decay=0.001)
model.compile(loss="categorical_crossentropy", optimizer=optimizer, metrics=["accuracy"])
```

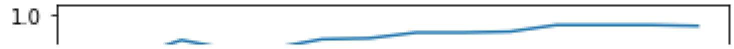
```
history3 = model.fit(train_generator, epochs=100, validation_data=val_generator, callbacks
```

```
Epoch 1/100
17/17 [==============================] - ETA: 0s - loss: 0.2455 - accuracy: 0.9086
Epoch 1: val_loss did not improve from 1.80999
17/17 [==============================] - 454s 26s/step - loss: 0.2455 - accuracy: 0.9
Epoch 2/100
17/17 [==============================] - ETA: 0s - loss: 0.2566 - accuracy: 0.9198
Epoch 2: val_loss did not improve from 1.80999
17/17 [==============================] - 451s 27s/step - loss: 0.2566 - accuracy: 0.9
Epoch 3/100
17/17 [==============================] - ETA: 0s - loss: 0.1879 - accuracy: 0.9496
Epoch 3: val_loss did not improve from 1.80999
17/17 [==============================] - 455s 27s/step - loss: 0.1879 - accuracy: 0.9
Epoch 4/100
17/17 [==============================] - ETA: 0s - loss: 0.1680 - accuracy: 0.9328
Epoch 4: val_loss did not improve from 1.80999
17/17 [==============================] - 456s 27s/step - loss: 0.1680 - accuracy: 0.9
Epoch 5/100
17/17 [==============================] - ETA: 0s - loss: 0.1698 - accuracy: 0.9347
Epoch 5: val_loss did not improve from 1.80999
17/17 [==============================] - 456s 27s/step - loss: 0.1698 - accuracy: 0.9
```

```
Epoch 6/100
17/17 [==============================] - ETA: 0s - loss: 0.1548 - accuracy: 0.9515
Epoch 6: val_loss did not improve from 1.80999
17/17 [==============================] - 454s 27s/step - loss: 0.1548 - accuracy: 0.9
Epoch 7/100
17/17 [==============================] - ETA: 0s - loss: 0.1405 - accuracy: 0.9534
Epoch 7: val_loss did not improve from 1.80999
17/17 [==============================] - 455s 27s/step - loss: 0.1405 - accuracy: 0.9
Epoch 8/100
17/17 [==============================] - ETA: 0s - loss: 0.1576 - accuracy: 0.9646
Epoch 8: val_loss did not improve from 1.80999
17/17 [==============================] - 457s 27s/step - loss: 0.1576 - accuracy: 0.9
Epoch 9/100
17/17 [==============================] - ETA: 0s - loss: 0.1283 - accuracy: 0.9646
Epoch 9: val_loss did not improve from 1.80999
17/17 [==============================] - 457s 27s/step - loss: 0.1283 - accuracy: 0.9
Epoch 10/100
17/17 [==============================] - ETA: 0s - loss: 0.1040 - accuracy: 0.9664
Epoch 10: val_loss did not improve from 1.80999
17/17 [==============================] - 448s 26s/step - loss: 0.1040 - accuracy: 0.9
Epoch 11/100
17/17 [==============================] - ETA: 0s - loss: 0.0572 - accuracy: 0.9795
Epoch 11: val_loss did not improve from 1.80999
17/17 [==============================] - 435s 26s/step - loss: 0.0572 - accuracy: 0.9
Epoch 12/100
17/17 [==============================] - ETA: 0s - loss: 0.1024 - accuracy: 0.9795
Epoch 12: val_loss did not improve from 1.80999
17/17 [==============================] - 427s 25s/step - loss: 0.1024 - accuracy: 0.9
Epoch 13/100
17/17 [==============================] - ETA: 0s - loss: 0.0599 - accuracy: 0.9795
Epoch 13: val_loss did not improve from 1.80999
17/17 [==============================] - 425s 25s/step - loss: 0.0599 - accuracy: 0.9
Epoch 14/100
17/17 [==============================] - ETA: 0s - loss: 0.0697 - accuracy: 0.9776
Epoch 14: val_loss did not improve from 1.80999
17/17 [==============================] - 429s 25s/step - loss: 0.0697 - accuracy: 0.9
```

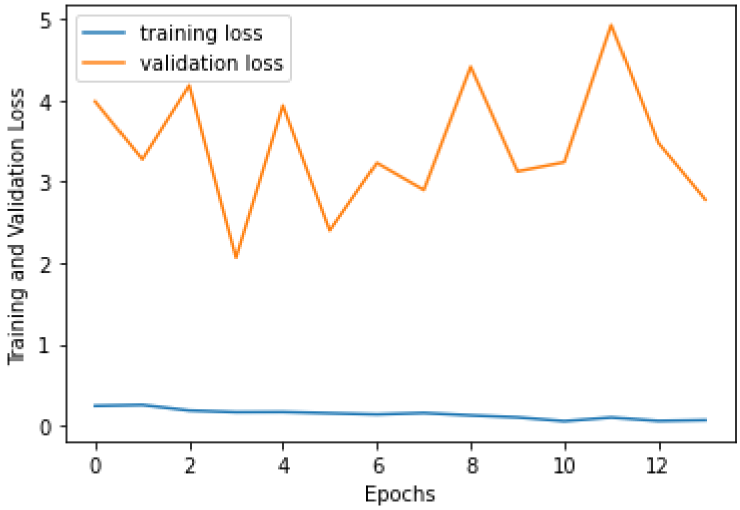
```
plt.plot(history3.history['accuracy'], label='training accuracy')
plt.plot(history3.history['val_accuracy'], label='validation accuracy')
plt.xlabel('Epochs')
plt.ylabel('Training and Validation Accuracy')
plt.legend(loc='lower right')
```

```
    <matplotlib.legend.Legend at 0x7ff962e3e710>
```



```
plt.plot(history3.history['loss'], label='training loss')
plt.plot(history3.history['val_loss'], label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Training and Validation Loss')
plt.legend()
```

```
    <matplotlib.legend.Legend at 0x7ff963bafc50>
```



The model performance did not improve at all so we will return to the best weights reached in the second cycle.

```
# loading the testset

test_images_files_names = os.listdir('/content/Images')
test_set = pd.DataFrame(test_images_files_names, columns=['id'])
test_set.head()
```

	id
0	06_113.png
1	04_012.png
2	06_046.png
3	04_001.png
4	03_052.png

```
test_data_generator = ImageDataGenerator(rescale= 1./255)
test_generator = test_data_generator.flow_from_dataframe(test_set, directory='/content/Ima

    Found 670 validated image filenames.
```

```
model.load_weights('./weights.hdf5')
```

```
y_prop = model.predict(test_generator)
```

```
results = pd.DataFrame(columns=["id"] + [*train_generator.class_indices.keys()])
results
```

id	Akhal-Teke	Appaloosa	Arabian	Friesian	Orlov Trotter	Percheron	Vladimir Heavy Draft

```
results["id"] = [os.path.splitext(file)[0] for file in os.listdir('/content/Images')]
results.head()
```

	id	Akhal-Teke	Appaloosa	Arabian	Friesian	Orlov Trotter	Percheron	Vladimir Heavy Draft
0	06_113	NaN	NaN	NaN	NaN	NaN	NaN	NaN
1	04_012	NaN	NaN	NaN	NaN	NaN	NaN	NaN
2	06_046	NaN	NaN	NaN	NaN	NaN	NaN	NaN
3	04_001	NaN	NaN	NaN	NaN	NaN	NaN	NaN

```
results[[*train_generator.class_indices.keys()]] = y_prop
results.head()
```

```
results.to_csv("results.csv",index=False)
```