Projeto Inteligência Artifical (Afonso Fernandes - 2221437, Luís Oliveira - 2221441)

- **Conjunto de validação train4**

T

- **Modelo transfer learning**
- **Otimizador:**
- **Com e sem Data Augmentation**

Erros: erros ligados à memória da gpu e cópida de tensors da cpu para a gpu

Tentar resolver problemas relacionados com memória da gpu -> Dor de cabeça

In [1]:

```
import tensorflow as tf
gpus = tf.config.experimental.list_physical_devices('GPU')
if gpus:
    try:
        # Restrict TensorFlow to only allocate 2GB of memory on the first GPU
        tf.config.experimental.set_virtual_device_configuration(
            gpus[0],
            [tf.config.experimental.VirtualDeviceConfiguration(memory_limit=2048)]
        )
        logical_gpus = tf.config.experimental.list_logical_devices('GPU')
        print(len(gpus), "Physical GPUs,", len(logical_gpus), "Logical GPUs")
    except RuntimeError as e:
        print(e)
```

```
1 Physical GPUs, 1 Logical GPUs
```

Utilização extensiva de with tf.device('/device:GPU:0') -> pois também aparenta ter "reparado" um problema

Dados Base:

In [4]:

```
from keras.utils import image_dataset_from_directory
import tensorflow as tf


with tf.device('/device:GPU:0'):
    train_dir_1 = 'trainning/train1'
    train_dir_2 = 'trainning/train2'
    train_dir_3 = 'trainning/train3'
    validation_dir = 'train4' # Validation
    train_dir_5 = 'trainning/train5'
    test_dir = 'test'
```

```
    trainning = [train_dir_1, train_dir_2,train_dir_3,train_dir_5]

    train_dir = train_dir_2
    IMG_SIZE = 150  # InceptionResNetV2 requires 299x299 images

    # image_dataset_from_directory with labels="inferred" for
    # getting the images in the subdirectories and translating the subdirectory as a clas
s
    # of type categorical
    #train_dataset = image_dataset_from_directory(train_dir,image_size=(IMG_SIZE, IMG_SIZ
E),batch_size=32, labels="inferred", label_mode="categorical")
    test_dataset = image_dataset_from_directory(test_dir,image_size=(IMG_SIZE, IMG_SIZE),
labels="inferred",label_mode="categorical")
    validation_dataset = image_dataset_from_directory(validation_dir,image_size=(IMG_SIZE
, IMG_SIZE), labels="inferred",label_mode="categorical")

    train_dataset = tf.data.Dataset

    for i in trainning:
        if i == trainning[0]:
            train_dataset = image_dataset_from_directory(i, image_size=(IMG_SIZE, IMG_SI
ZE), labels="inferred", label_mode="categorical")
            continue
        train_dataset = train_dataset.concatenate( image_dataset_from_directory(i, image
_size=(IMG_SIZE, IMG_SIZE), labels="inferred", label_mode="categorical"))
```

```
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
Found 10000 files belonging to 10 classes.
```

In [3]:

```
import matplotlib.pyplot as plt

def graph(history):
    # Use the correct key names from the history object
    acc = history.history['accuracy']
    val_acc = history.history['val_accuracy']
    loss = history.history['loss']
    val_loss = history.history['val_loss']

    epochs = range(1, len(acc) + 1)

    plt.figure(figsize=(14, 5))

    # Plot training and validation accuracy
    plt.subplot(1, 2, 1)
    plt.plot(epochs, acc, 'bo-', label='Training accuracy')
    plt.plot(epochs, val_acc, 'b-', label='Validation accuracy')
    plt.title('Training and validation accuracy')
    plt.xlabel('Epochs')
    plt.ylabel('Accuracy')
    plt.legend()

    # Plot training and validation loss
    plt.subplot(1, 2, 2)
    plt.plot(epochs, loss, 'bo-', label='Training loss')
    plt.plot(epochs, val_loss, 'b-', label='Validation loss')
    plt.title('Training and validation loss')
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.legend()

    plt.show()
```

Conseguir os features e as labels para um treino sem a necessidade de estar sempre a processar as imagens com o modelo convolucional

processar as imagens com o modelo convolucional

In [ ]:

```
import tensorflow as tf
import numpy as np
from keras.applications.densenet import DenseNet121, preprocess_input
NUM_CLASSES = 10
# Define base model
base_model = DenseNet121(include_top=False, weights='imagenet', input_shape=(IMG_SIZE, I
MG_SIZE, 3))
base_model.trainable = False
def get_features_and_labels(dataset):
    tf.keras.backend.clear_session()

    all_features = []
    all_labels = []
    for images, labels in dataset:
        preprocessed_images = preprocess_input(images)
        features = base_model.predict(preprocessed_images)
        all_features.append(features)
        all_labels.append(labels)
    return np.concatenate(all_features), np.concatenate(all_labels)
with tf.device('/gpu:0'):
    train_features, train_labels = get_features_and_labels(train_dataset)
    val_features, val_labels = get_features_and_labels(validation_dataset)
    test_features, test_labels = get_features_and_labels(test_dataset)

    # Convert the features and labels into tf.data.Dataset
    train_dataset = tf.data.Dataset.from_tensor_slices((train_features, train_labels))
    val_dataset = tf.data.Dataset.from_tensor_slices((val_features, val_labels))
    test_dataset = tf.data.Dataset.from_tensor_slices((test_features, test_labels))
```

In [ ]:

```
np.save('train_features.npy', train_features)
np.save('val_features.npy', val_features)
np.save('test_features.npy', test_features)
np.save('train_labels.npy', train_labels)
np.save('val_labels.npy', val_labels)
np.save('test_labels.npy', test_labels)
```

Classe para definir as batchs, pois o tensorflow estava a dar load da informção toda, o que piorava o problema de espaço na gpu

In [18]:

```
from keras.utils import Sequence

class DataGenerator(Sequence):
    def __init__(self, x_set, y_set, batch_size):
        self.x, self.y = x_set, y_set
        self.batch_size = batch_size

    def __len__(self):
        return int(np.ceil(len(self.x) / float(self.batch_size)))

    def __getitem__(self, idx):
        batch_x = self.x[idx * self.batch_size:(idx + 1) * self.batch_size]
        batch_y = self.y[idx * self.batch_size:(idx + 1) * self.batch_size]
        return batch_x, batch_y
```

In [19]:

```
from numpy import load
import numpy as np
train_features = load('train_features.npy')
val_features = load('val_features.npy')
test_features = load('test_features.npy')
train_labels = load('train_labels.npy')
```

```
val_labels = load('val_labels.npy')
test_labels = load('test_labels.npy')

train_gen = DataGenerator(train_features, train_labels, 32)
val_gen = DataGenerator(val_features, val_labels, 32)
test_gen = DataGenerator(test_features, test_labels, 32)
```

Optimização da procura de hyperparâmetros através do optuna, reutilização do Modus Operandi do modelo S

In [8]:

```
import optuna
import keras
from keras import layers
import tensorflow as tf
import numpy as np

with tf.device('/device:GPU:0'):

    def create_model(trial):
        keras.backend.clear_session()
        # Define the regularization and dropout values
        reg = keras.regularizers.l2(0.005)
        dropFinal = 0.5

        # Add custom top layers
        #inputs = keras.Input(shape=(IMG_SIZE, IMG_SIZE, 3))
        #x = base_model(inputs, training=False)
        inputs = keras.Input(shape=(4, 4, 1024))
        x = layers.Flatten()(inputs)
        x = layers.Dense(trial.suggest_int('dense_units', 256, 512, step=256), activatio
n='relu', kernel_regularizer=reg)(x)
        x = layers.BatchNormalization()(x)
        x = layers.Dropout(dropFinal)(x)
        outputs = layers.Dense(10, activation='softmax')(x)

        model = keras.Model(inputs, outputs)

        lr_schedule = tf.keras.optimizers.schedules.ExponentialDecay(
            initial_learning_rate=trial.suggest_float('learning_rate_IN', 1e-3, 1e-2,log
=True),
            decay_steps=1000,
            decay_rate=0.6,
            staircase=True
        )

        optimizer_options = ['Adam', 'RMSprop']
        optimizer_selected = trial.suggest_categorical('optimizer', optimizer_options)
        if optimizer_selected == 'Adam':
            optimizer = keras.optimizers.Adam(learning_rate=lr_schedule)
        else:
            optimizer = keras.optimizers.RMSprop(learning_rate=lr_schedule)

        model.compile(optimizer=optimizer, loss='categorical_crossentropy', metrics=['ac
curacy'])

        return model

    def objective(trial):
        model = create_model(trial)

        # ModelCheckPoint - por cada trial
        callbacks = [
            keras.callbacks.ModelCheckpoint(
                filepath=f'models_T/model_best_{trial.number}.h5',
                save_best_only=True,
                monitor='val_loss',
                mode='min',
                verbose=0
```

```
            ),# EarlyStopping -> beneficia os modelos e o tempo que o estudo demora
            keras.callbacks.EarlyStopping(
                monitor='val_loss',
                min_delta=0,
                patience=4,
                verbose=0,
                mode='min',
                restore_best_weights=True,
            )
        ]
        # Batch Size pequeno por questões de memória
        batch_size = trial.suggest_int('batch_size', 8, 16, step=8)

        history = model.fit(
            train_gen,
            epochs=50,
            validation_data=val_gen,
            callbacks=callbacks,
            verbose=0
        )

        val_loss = history.history['val_loss'][-1]
        #graph(history)
        return val_loss
```

In [9]:

```
with tf.device('/device:GPU:0'):
    # Criar estudo
    study = optuna.create_study(direction='minimize')
    study.optimize(objective, n_trials=5)

    print("Best trial:")
    trial = study.best_trial

    print(f"Value: {trial.value}")
    print("Params:")
    for key, value in trial.params.items():
        print(f"    {key}: {value}")
```

```
[I 2024-06-21 14:43:13,981] A new study created in memory with name: no-name-539c8147-812
0-45d0-937b-708970b798e4
[I 2024-06-21 14:47:57,126] Trial 0 finished with value: 0.3780383765697479 and parameter
s: {'dense_units': 512, 'learning_rate_IN': 0.005635956693486822, 'optimizer': 'RMSprop',
'batch_size': 16}. Best is trial 0 with value: 0.3780383765697479.
[I 2024-06-21 14:50:26,674] Trial 1 finished with value: 0.40196800231933594 and paramete
rs: {'dense_units': 256, 'learning_rate_IN': 0.003940804197661017, 'optimizer': 'Adam', '
batch_size': 8}. Best is trial 0 with value: 0.3780383765697479.
[I 2024-06-21 14:53:37,403] Trial 2 finished with value: 0.40288031101226807 and paramete
rs: {'dense_units': 512, 'learning_rate_IN': 0.002841172025338205, 'optimizer': 'Adam', '
batch_size': 8}. Best is trial 0 with value: 0.3780383765697479.
[I 2024-06-21 14:56:39,195] Trial 3 finished with value: 0.37962549924850464 and paramete
rs: {'dense_units': 256, 'learning_rate_IN': 0.0027537966766643493, 'optimizer': 'RMSprop
', 'batch_size': 16}. Best is trial 0 with value: 0.3780383765697479.
[I 2024-06-21 14:59:25,703] Trial 4 finished with value: 0.4102380573749542 and parameter
s: {'dense_units': 512, 'learning_rate_IN': 0.0028948439337215513, 'optimizer': 'Adam', '
batch_size': 16}. Best is trial 0 with value: 0.3780383765697479.
```

```
Best trial:
Value: 0.3780383765697479
Params:
    dense_units: 512
    learning_rate_IN: 0.005635956693486822
    optimizer: RMSprop
    batch_size: 16
```

Continuar o treino

In [10]:

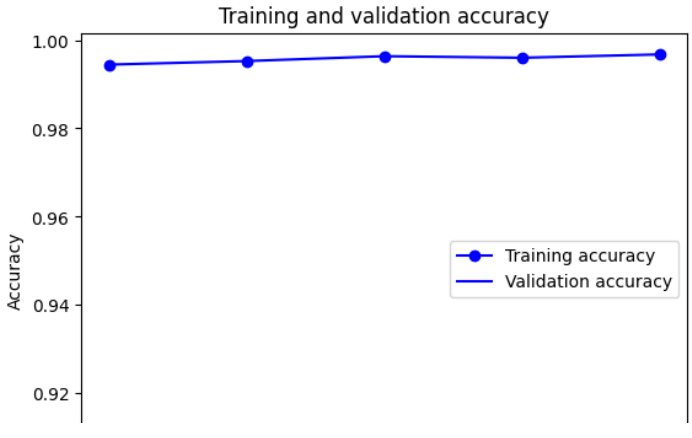
```
import keras
```

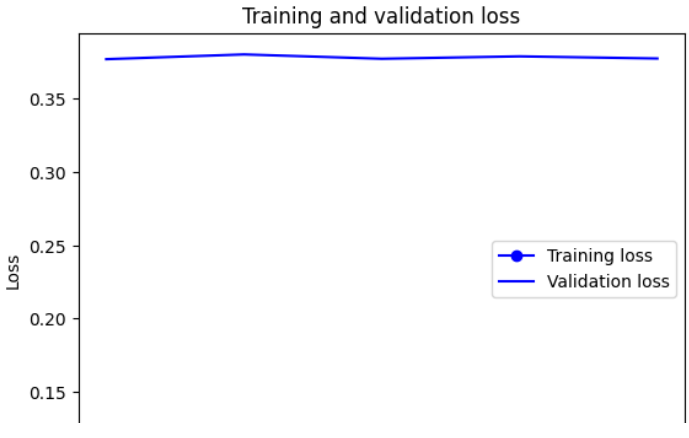
```
# Load do novo melhor modelo
keras.backend.clear_session()

model = keras.models.load_model("models_T\model_best_0.h5")
#model = create_model(study.best_trial)
```

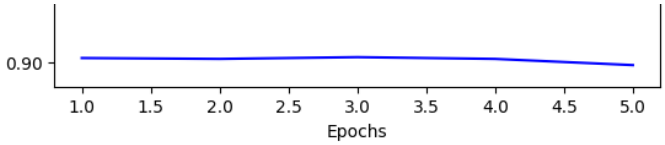
In [11]:

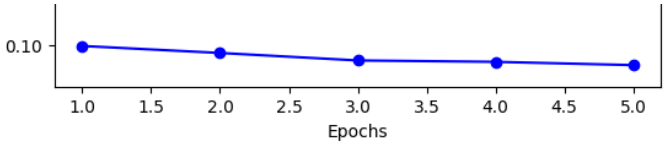
```
with tf.device('/device:GPU:0'):

    callbacks = [
            keras.callbacks.ModelCheckpoint(
                filepath='models_T/model_best_First.h5',
                save_best_only=True,
                monitor='val_loss',
                mode='min',
                verbose=0
            ),
            keras.callbacks.EarlyStopping(
                monitor='val_loss',
                min_delta=0,
                patience=4,
                verbose=1,
                mode='min',
                restore_best_weights=True,
            )
        ]

    history = model.fit(
            train_gen,
            batch_size=16,
            epochs=100,
            validation_data=val_gen,
            callbacks=callbacks,
            verbose=1
        )

    graph(history)
```

```
Epoch 1/100
624/624 [==============================] - 12s 19ms/step - loss: 0.0997 - accuracy: 0.994
4 - val_loss: 0.3771 - val_accuracy: 0.9010
Epoch 2/100
624/624 [==============================] - 11s 17ms/step - loss: 0.0949 - accuracy: 0.995
2 - val_loss: 0.3803 - val_accuracy: 0.9008
Epoch 3/100
624/624 [==============================] - 11s 17ms/step - loss: 0.0898 - accuracy: 0.996
3 - val_loss: 0.3774 - val_accuracy: 0.9012
Epoch 4/100
624/624 [==============================] - 11s 17ms/step - loss: 0.0888 - accuracy: 0.996
0 - val_loss: 0.3790 - val_accuracy: 0.9008
Epoch 5/100
624/624 [==============================] - ETA: 0s - loss: 0.0866 - accuracy: 0.9967Resto
ring model weights from the end of the best epoch: 1.
624/624 [==============================] - 11s 17ms/step - loss: 0.0866 - accuracy: 0.996
7 - val_loss: 0.3776 - val_accuracy: 0.8994
Epoch 5: early stopping
```









Aqui vemos overfitting a ocurrer, com uma grande diferença, quase 10%

In [13]:

```
val_loss, val_acc = model.evaluate(test_gen) #test_gen
print('Test_acc:', val_acc,'\nTest_loss:', val_loss)

#keras.models.save_model(model,'models_T/model_best_First.h5')
```

```
156/156 [==============================] - 1s 5ms/step - loss: 0.4282 - accuracy: 0.8890
Test_acc: 0.8890224099159241
Test_loss: 0.42822524905204773
```

Modelo com Data Augmentation

In [4]:

```
from keras.applications.densenet import DenseNet121

#model = create_model(study.best_trial)
base_model = DenseNet121(include_top=False, weights='imagenet', input_shape=(IMG_SIZE, I
MG_SIZE, 3))
base_model.trainable = False
```

In [ ]:

```
import keras
keras.backend.clear_session()
model = keras.models.load_model("models_T\model_best_DA.h5")
```

In [5]:

```
import optuna
import keras
from keras import layers
import tensorflow as tf
import numpy as np
from keras.applications.densenet import preprocess_input
with tf.device('/device:GPU:0'):

    def create_model1(trial):
        keras.backend.clear_session()
        # Define the regularization and dropout values
        reg = keras.regularizers.l2(0.005)
        dropFinal = 0.5
        data_augmentation = keras.Sequential(
            [
            layers.RandomFlip("horizontal"),
            layers.RandomRotation(0.1),
            layers.RandomZoom(0.2),
            ]
            )

        # Add custom top layers
        inputs = keras.Input(shape=(IMG_SIZE, IMG_SIZE, 3))
        x = data_augmentation(inputs)
        x = preprocess_input(x)
        x = base_model(x)
        x = layers.Flatten()(x)
        x = layers.Dense(trial.suggest_int('dense_units', 256, 512, step=256), activatio
n='relu', kernel_regularizer=reg)(x)
        x = layers.BatchNormalization()(x)
```

```
        x = layers.Dropout(dropFinal)(x)
        outputs = layers.Dense(10, activation='softmax')(x)

        model = keras.Model(inputs, outputs)

        lr_schedule = tf.keras.optimizers.schedules.ExponentialDecay(
            initial_learning_rate=trial.suggest_float('learning_rate_IN', 1e-3, 1e-2,log
=True),
            decay_steps=1000,
            decay_rate=0.6,
            staircase=True
        )

        optimizer_options = ['Adam', 'RMSprop']
        optimizer_selected = trial.suggest_categorical('optimizer', optimizer_options)
        if optimizer_selected == 'Adam':
            optimizer = keras.optimizers.Adam(learning_rate=lr_schedule)
        else:
            optimizer = keras.optimizers.RMSprop(learning_rate=lr_schedule)

        model.compile(optimizer=optimizer, loss='categorical_crossentropy', metrics=['ac
curacy'])
        return model

    def objective1(trial):
        model = create_model1(trial)

        callbacks = [
            keras.callbacks.ModelCheckpoint(
                filepath=f'models_T/model_best_DA_{trial.number}.h5',
                save_best_only=True,
                monitor='val_loss',
                mode='min',
                verbose=0
            ),
            keras.callbacks.EarlyStopping(
                monitor='val_loss',
                min_delta=0,
                patience=4,
                verbose=0,
                mode='min',
                restore_best_weights=True,
            )
        ]
        batch_size = trial.suggest_int('batch_size', 8, 16, step=8)

        history = model.fit(
            train_dataset,
            batch_size=batch_size,
            epochs=20,
            validation_data=validation_dataset,
            callbacks=callbacks,
            verbose=0
        )

        val_loss = history.history['val_loss'][-1]
        graph(history)
        return val_loss
```

```
c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tqdm\auto.py:21: TqdmWarning: IP
rogress not found. Please update jupyter and ipywidgets. See https://ipywidgets.readthedo
cs.io/en/stable/user_install.html
  from .autonotebook import tqdm as notebook_tqdm
```

In [6]:

```
with tf.device('/device:GPU:0'):

    study = optuna.create_study(direction='minimize')
    study.optimize(objective1, n_trials=3)

    print("Best trial:")
```

```python
    trial = study.best_trial

    print(f"Value: {trial.value}")
    print("Params:")
    for key, value in trial.params.items():
        print(f"    {key}: {value}")
```

```
[I 2024-06-21 16:00:05,906] A new study created in memory with name: no-name-710ac114-88a
7-4b12-a922-7f2055f1de80
```

```
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip cause there is no reg
istered converter for this op.
WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered
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WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered
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WARNING:tensorflow:Using a while_loop for converting Bitcast cause there is no registered
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```
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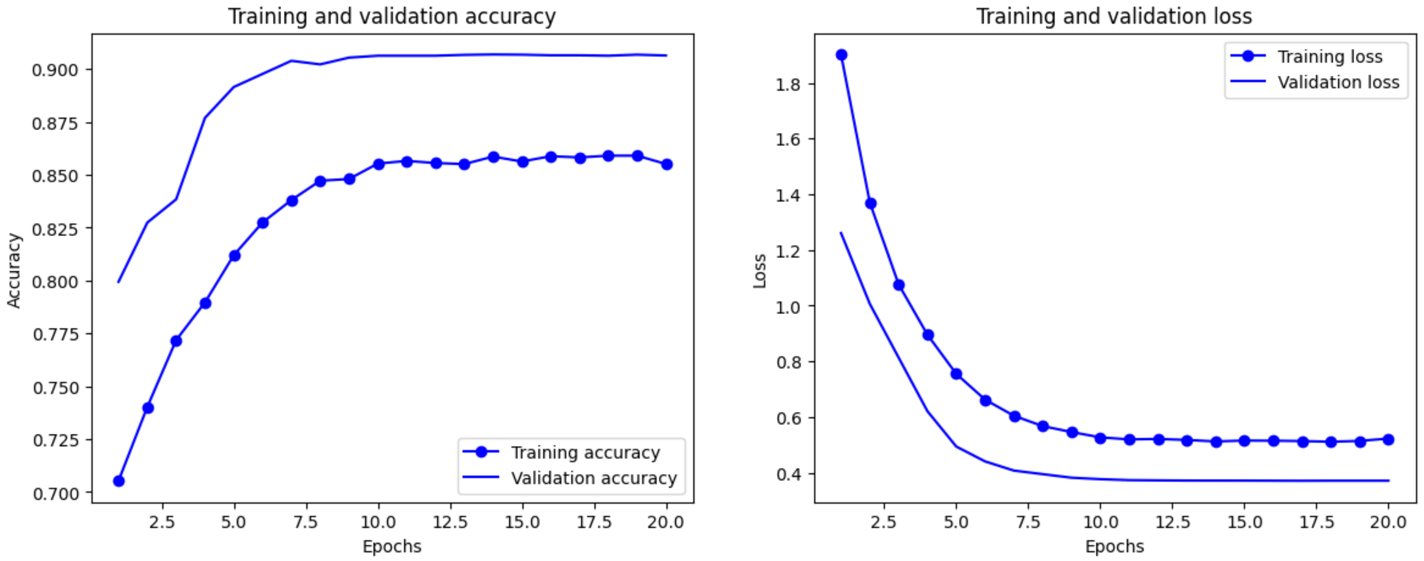
is no registered converter for this op.
WARNING:tensorflow:Using a while_loop for converting ImageProjectiveTransformV3 cause the
re is no registered converter for this op.
```




```
[I 2024-06-21 19:09:35,762] Trial 0 finished with value: 0.3711468577384949 and parameter
s: {'dense_units': 256, 'learning_rate_IN': 0.0022450991228308436, 'optimizer': 'RMSprop'
, 'batch_size': 8}. Best is trial 0 with value: 0.3711468577384949.
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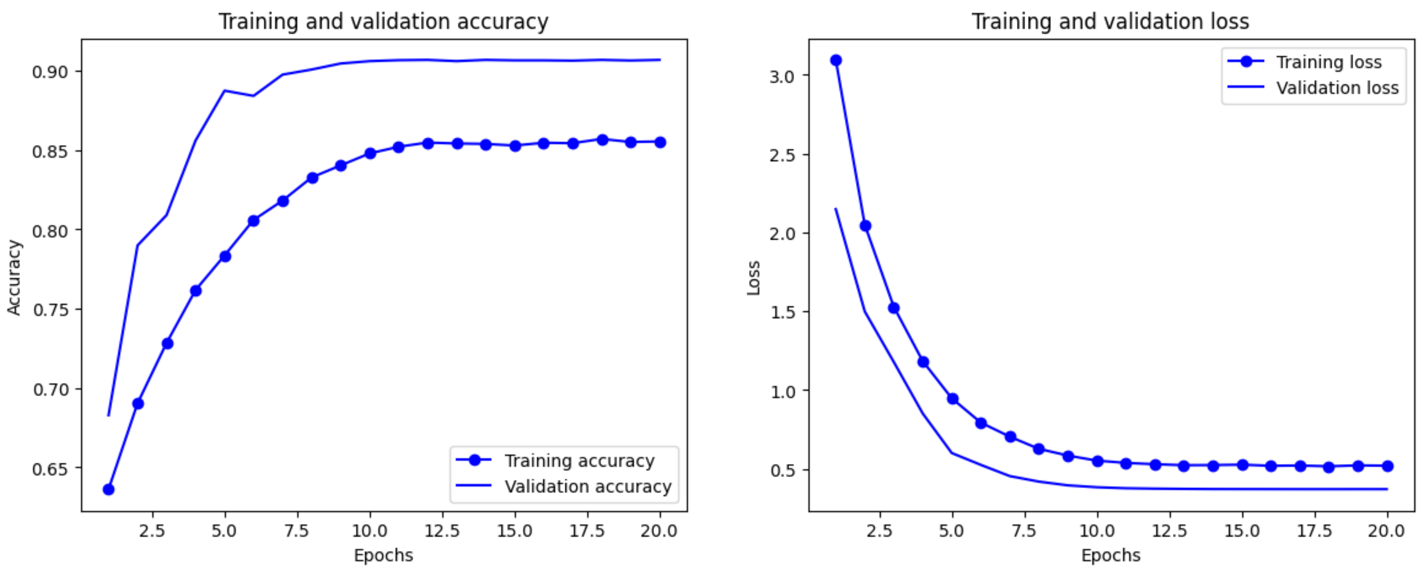
```




```
[I 2024-06-21 22:19:22,902] Trial 1 finished with value: 0.37190961837768555 and paramete
rs: {'dense_units': 256, 'learning_rate_IN': 0.005973644332066574, 'optimizer': 'RMSprop'
```

```
, 'batch_size': 16}. Best is trial 0 with value: 0.3711468577384949.
```

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[W 2024-06-21 22:19:44,275] Trial 2 failed with parameters: {'dense_units': 256, 'learning_rate_IN': 0.004038801351193084, 'optimizer': 'RMSprop', 'batch_size': 16} because of the following error: KeyboardInterrupt().
Traceback (most recent call last):
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\optuna\study_optimize.py", line 196, in _run_trial
    value_or_values = func(trial)
  File "C:\Users\HP\AppData\Local\Temp\ipykernel_17016\728027330.py", line 74, in objective1
    history = model.fit(
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\keras\utils\traceback_utils.py", line 65, in error_handler
    return fn(*args, **kwargs)
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\keras\engine\training.py", line 1564, in fit
    tmp_logs = self.train_function(iterator)
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\util\traceback_utils.py", line 150, in error_handler
    return fn(*args, **kwargs)
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\def_function.py", line 915, in __call__
    result = self._call(*args, **kwds)
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\def_function.py", line 947, in _call
    return self._stateless_fn(*args, **kwds) # pylint: disable=not-callable
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\function.py", line 2496, in __call__
    return graph_function._call_flat(
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\function.py", line 1862, in _call_flat
    return self._build_call_outputs(self._inference_function.call(
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\function.py", line 499, in call
    outputs = execute.execute(
  File "c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\execute.py", line 54, in quick_execute
    tensors = pywrap_tfe.TFE_Py_Execute(ctx._handle, device_name, op_name,
KeyboardInterrupt
[W 2024-06-21 22:19:44,369] Trial 2 failed with value None.

```
KeyboardInterrupt                         Traceback (most recent call last)
Cell In[6], line 4
      1 with tf.device('/device:GPU:0'):
      3     study = optuna.create_study(direction='minimize')
----> 4     study.optimize(objective1, n_trials=3)
      6     print("Best trial:")
      7     trial = study.best_trial

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\optuna\study\study.py:451, in Study.optimize(self, func, n_trials, timeout, n_jobs, catch, callbacks, gc_after_trial, show_progress_bar)
    348 def optimize(
    349     self,
    350     func: ObjectiveFuncType,
   (...)
    357     show_progress_bar: bool = False,
    358 ) -> None:
    359     """Optimize an objective function.
    360
    361     Optimization is done by choosing a suitable set of hyperparameter values from a given
```

```
   (...)
    449             If nested invocation of this method occurs.
    450         """
--> 451         _optimize(
    452             study=self,
    453             func=func,
    454             n_trials=n_trials,
    455             timeout=timeout,
    456             n_jobs=n_jobs,
    457             catch=tuple(catch) if isinstance(catch, Iterable) else (catch,),
    458             callbacks=callbacks,
    459             gc_after_trial=gc_after_trial,
    460             show_progress_bar=show_progress_bar,
    461         )

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\optuna\study\_optimize.py:6
2, in _optimize(study, func, n_trials, timeout, n_jobs, catch, callbacks, gc_after_trial,
show_progress_bar)
     60 try:
     61     if n_jobs == 1:
---> 62         _optimize_sequential(
     63             study,
     64             func,
     65             n_trials,
     66             timeout,
     67             catch,
     68             callbacks,
     69             gc_after_trial,
     70             reseed_sampler_rng=False,
     71             time_start=None,
     72             progress_bar=progress_bar,
     73         )
     74     else:
     75         if n_jobs == -1:

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\optuna\study\_optimize.py:1
59, in _optimize_sequential(study, func, n_trials, timeout, catch, callbacks, gc_after_tr
ial, reseed_sampler_rng, time_start, progress_bar)
    156         break
    158 try:
--> 159     frozen_trial = _run_trial(study, func, catch)
    160 finally:
    161     # The following line mitigates memory problems that can be occurred in some
    162     # environments (e.g., services that use computing containers such as GitHub A
ctions).
    163     # Please refer to the following PR for further details:
    164     # https://github.com/optuna/optuna/pull/325.
    165     if gc_after_trial:

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\optuna\study\_optimize.py:2
47, in _run_trial(study, func, catch)
    240         assert False, "Should not reach."
    242 if (
    243     frozen_trial.state == TrialState.FAIL
    244     and func_err is not None
    245     and not isinstance(func_err, catch)
    246 ):
--> 247     raise func_err
    248 return frozen_trial

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\optuna\study\_optimize.py:1
96, in _run_trial(study, func, catch)
    194 with get_heartbeat_thread(trial._trial_id, study._storage):
    195     try:
--> 196         value_or_values = func(trial)
    197     except exceptions.TrialPruned as e:
    198         # TODO(mamu): Handle multi-objective cases.
    199         state = TrialState.PRUNED

Cell In[5], line 74, in objective1(trial)
     55 callbacks = [
     56     keras.callbacks.ModelCheckpoint(
```

```
     57         filepath=f'models_T/model_best_DA_{trial.number}.h5',
   (...)
     70     )
     71 ]
     72 batch_size = trial.suggest_int('batch_size', 8, 16, step=8)
---> 74 history = model.fit(
     75     train_dataset,
     76     batch_size=batch_size,
     77     epochs=20,
     78     validation_data=validation_dataset,
     79     callbacks=callbacks,
     80     use_multiprocessing=False,
     81     verbose=0
     82 )
     84 val_loss = history.history['val_loss'][-1]
     85 graph(history)

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\keras\utils\traceback_utils
.py:65, in filter_traceback.<locals>.error_handler(*args, **kwargs)
     63 filtered_tb = None
     64 try:
---> 65     return fn(*args, **kwargs)
     66 except Exception as e:
     67     filtered_tb = _process_traceback_frames(e.__traceback__)

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\keras\engine\training.py:15
64, in Model.fit(self, x, y, batch_size, epochs, verbose, callbacks, validation_split, va
lidation_data, shuffle, class_weight, sample_weight, initial_epoch, steps_per_epoch, vali
dation_steps, validation_batch_size, validation_freq, max_queue_size, workers, use_multip
rocessing)
   1556 with tf.profiler.experimental.Trace(
   1557     "train",
   1558     epoch_num=epoch,
   (...)
   1561     _r=1,
   1562 ):
   1563     callbacks.on_train_batch_begin(step)
-> 1564     tmp_logs = self.train_function(iterator)
   1565     if data_handler.should_sync:
   1566         context.async_wait()

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\util\trac
eback_utils.py:150, in filter_traceback.<locals>.error_handler(*args, **kwargs)
    148 filtered_tb = None
    149 try:
--> 150   return fn(*args, **kwargs)
    151 except Exception as e:
    152   filtered_tb = _process_traceback_frames(e.__traceback__)

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\def
_function.py:915, in Function.__call__(self, *args, **kwds)
    912 compiler = "xla" if self._jit_compile else "nonXla"
    914 with OptionalXlaContext(self._jit_compile):
--> 915   result = self._call(*args, **kwds)
    917 new_tracing_count = self.experimental_get_tracing_count()
    918 without_tracing = (tracing_count == new_tracing_count)

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\def
_function.py:947, in Function._call(self, *args, **kwds)
    944   self._lock.release()
    945   # In this case we have created variables on the first call, so we run the
    946   # defunned version which is guaranteed to never create variables.
--> 947   return self._stateless_fn(*args, **kwds)  # pylint: disable=not-callable
    948 elif self._stateful_fn is not None:
    949   # Release the lock early so that multiple threads can perform the call
    950   # in parallel.
    951   self._lock.release()

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\fun
ction.py:2496, in Function.__call__(self, *args, **kwargs)
   2493 with self._lock:
   2494   (graph_function,
```

```
   2495     filtered_flat_args) = self._maybe_define_function(args, kwargs)
-> 2496 return graph_function._call_flat(
   2497     filtered_flat_args, captured_inputs=graph_function.captured_inputs)

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\fun
ction.py:1862, in ConcreteFunction._call_flat(self, args, captured_inputs, cancellation_m
anager)
   1858 possible_gradient_type = gradients_util.PossibleTapeGradientTypes(args)
   1859 if (possible_gradient_type == gradients_util.POSSIBLE_GRADIENT_TYPES_NONE
   1860     and executing_eagerly):
   1861   # No tape is watching; skip to running the function.
-> 1862   return self._build_call_outputs(self._inference_function.call(
   1863       ctx, args, cancellation_manager=cancellation_manager))
   1864 forward_backward = self._select_forward_and_backward_functions(
   1865     args,
   1866     possible_gradient_type,
   1867     executing_eagerly)
   1868 forward_function, args_with_tangents = forward_backward.forward()

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\fun
ction.py:499, in _EagerDefinedFunction.call(self, ctx, args, cancellation_manager)
    497 with _InterpolateFunctionError(self):
    498   if cancellation_manager is None:
--> 499     outputs = execute.execute(
    500         str(self.signature.name),
    501         num_outputs=self._num_outputs,
    502         inputs=args,
    503         attrs=attrs,
    504         ctx=ctx)
    505   else:
    506     outputs = execute.execute_with_cancellation(
    507         str(self.signature.name),
    508         num_outputs=self._num_outputs,
   (...)
    511         ctx=ctx,
    512         cancellation_manager=cancellation_manager)

File c:\Users\HP\.conda\envs\tensorflow_gpu\lib\site-packages\tensorflow\python\eager\exe
cute.py:54, in quick_execute(op_name, num_outputs, inputs, attrs, ctx, name)
     52 try:
     53   ctx.ensure_initialized()
---> 54   tensors = pywrap_tfe.TFE_Py_Execute(ctx._handle, device_name, op_name,
     55                                       inputs, attrs, num_outputs)
     56 except core._NotOkStatusException as e:
     57   if name is not None:

KeyboardInterrupt:
```

Aqui vemos underfitting a ocurrer, com uma grande diferença, quase 5%

In [4]:

```
import keras
# Load do novo melhor modelo
keras.backend.clear_session()

model = keras.models.load_model("models_T\model_best_DA_0.h5")
#model = create_model(study.best_trial)
```

```
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WARNING:tensorflow:Using a while_loop for converting ImageProjectiveTransformV3 cause the
re is no registered converter for this op.
```

In [5]:

```
with tf.device('/device:GPU:0'):

    callbacks = [
            keras.callbacks.ModelCheckpoint(
                filepath='models_T/model_best_DAFirst_0.h5',
                save_best_only=True,
                monitor='val_loss',
                mode='min',
                verbose=0
            ),
            keras.callbacks.EarlyStopping(
                monitor='val_loss',
                min_delta=0,
                patience=3,
                verbose=1,
                mode='min',
                restore_best_weights=True,
            )
        ]

    history = model.fit(
            train_dataset,
            batch_size=16,
            epochs=20,
            validation_data=validation_dataset,
            callbacks=callbacks,
            verbose=0
        )

    graph(history)
```

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re is no registered converter for this op.
Restoring model weights from the end of the best epoch: 7.
Epoch 10: early stopping
```
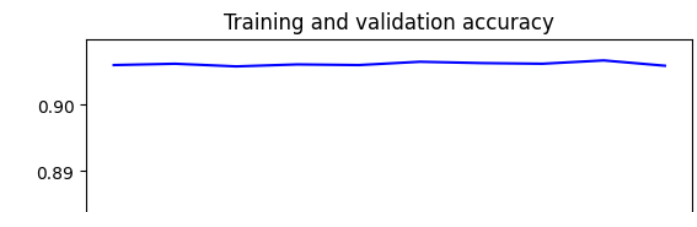
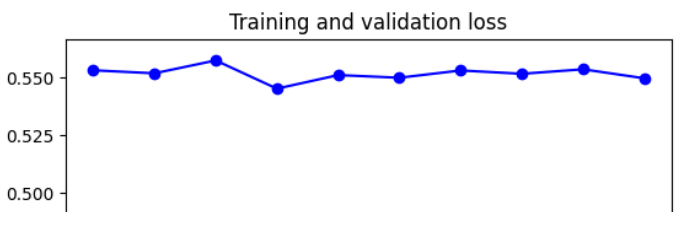
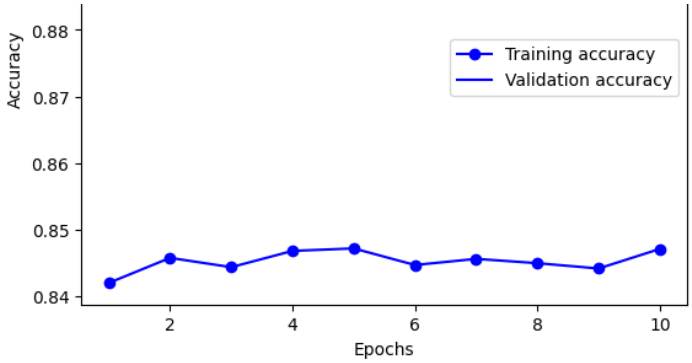
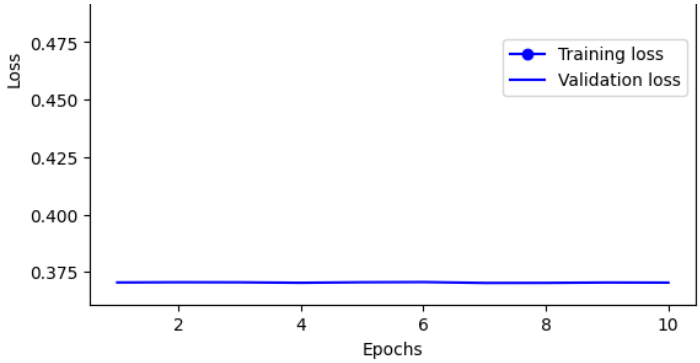









Aqui vemos underfitting a ocurrer, com uma grande diferença, quase 6%

In [19]:

```
base_model = model.get_layer("densenet121")
base_model.trainable = True
print(model.layers)
#agora, aquecimento
for layer in base_model.layers[:-6]:
    layer.trainable = False

for i, layer in enumerate(base_model.layers):
    print(i, layer.name, layer.trainable)
```

```
[<keras.engine.input_layer.InputLayer object at 0x00000240253A10D0>, <keras.engine.sequen
tial.Sequential object at 0x00000240253A1220>, <keras.layers.core.tf_op_layer.TFOpLambda
object at 0x000002402BCD9F40>, <keras.layers.core.tf_op_layer.TFOpLambda object at 0x0000
024025571EB0>, <keras.layers.core.tf_op_layer.TFOpLambda object at 0x00000240255D6400>, <
keras.engine.functional.Functional object at 0x0000024025726A60>, <keras.layers.reshaping
.flatten.Flatten object at 0x0000024025726940>, <keras.layers.core.dense.Dense object at
0x000002402582DD30>, <keras.layers.normalization.batch_normalization.BatchNormalization o
bject at 0x0000024025733190>, <keras.layers.regularization.dropout.Dropout object at 0x00
00024025A308B0>, <keras.layers.core.dense.Dense object at 0x0000024025A49DC0>]
0 input_1 False
1 zero_padding2d False
2 conv1/conv False
3 conv1/bn False
4 conv1/relu False
5 zero_padding2d_1 False
6 pool1 False
7 conv2_block1_0_bn False
8 conv2_block1_0_relu False
9 conv2_block1_1_conv False
10 conv2_block1_1_bn False
11 conv2_block1_1_relu False
12 conv2_block1_2_conv False
13 conv2_block1_concat False
14 conv2_block2_0_bn False
15 conv2_block2_0_relu False
16 conv2_block2_1_conv False
17 conv2_block2_1_bn False
18 conv2_block2_1_relu False
19 conv2_block2_2_conv False
20 conv2_block2_concat False
21 conv2_block3_0_bn False
22 conv2_block3_0_relu False
23 conv2_block3_1_conv False
24 conv2_block3_1_bn False
25 conv2_block3_1_relu False
26 conv2_block3_2_conv False
27 conv2_block3_concat False
28 conv2_block4_0_bn False
29 conv2_block4_0_relu False
30 conv2_block4_1_conv False
31 conv2_block4_1_bn False
32 conv2_block4_1_relu False
33 conv2_block4_2_conv False
34 conv2_block4_concat False
```

```
35 conv2_block5_0_bn False
36 conv2_block5_0_relu False
37 conv2_block5_1_conv False
38 conv2_block5_1_bn False
39 conv2_block5_1_relu False
40 conv2_block5_2_conv False
41 conv2_block5_concat False
42 conv2_block6_0_bn False
43 conv2_block6_0_relu False
44 conv2_block6_1_conv False
45 conv2_block6_1_bn False
46 conv2_block6_1_relu False
47 conv2_block6_2_conv False
48 conv2_block6_concat False
49 pool2_bn False
50 pool2_relu False
51 pool2_conv False
52 pool2_pool False
53 conv3_block1_0_bn False
54 conv3_block1_0_relu False
55 conv3_block1_1_conv False
56 conv3_block1_1_bn False
57 conv3_block1_1_relu False
58 conv3_block1_2_conv False
59 conv3_block1_concat False
60 conv3_block2_0_bn False
61 conv3_block2_0_relu False
62 conv3_block2_1_conv False
63 conv3_block2_1_bn False
64 conv3_block2_1_relu False
65 conv3_block2_2_conv False
66 conv3_block2_concat False
67 conv3_block3_0_bn False
68 conv3_block3_0_relu False
69 conv3_block3_1_conv False
70 conv3_block3_1_bn False
71 conv3_block3_1_relu False
72 conv3_block3_2_conv False
73 conv3_block3_concat False
74 conv3_block4_0_bn False
75 conv3_block4_0_relu False
76 conv3_block4_1_conv False
77 conv3_block4_1_bn False
78 conv3_block4_1_relu False
79 conv3_block4_2_conv False
80 conv3_block4_concat False
81 conv3_block5_0_bn False
82 conv3_block5_0_relu False
83 conv3_block5_1_conv False
84 conv3_block5_1_bn False
85 conv3_block5_1_relu False
86 conv3_block5_2_conv False
87 conv3_block5_concat False
88 conv3_block6_0_bn False
89 conv3_block6_0_relu False
90 conv3_block6_1_conv False
91 conv3_block6_1_bn False
92 conv3_block6_1_relu False
93 conv3_block6_2_conv False
94 conv3_block6_concat False
95 conv3_block7_0_bn False
96 conv3_block7_0_relu False
97 conv3_block7_1_conv False
98 conv3_block7_1_bn False
99 conv3_block7_1_relu False
100 conv3_block7_2_conv False
101 conv3_block7_concat False
102 conv3_block8_0_bn False
103 conv3_block8_0_relu False
104 conv3_block8_1_conv False
105 conv3_block8_1_bn False
106 conv3_block8_1_relu False
```

```
conv3_block8_2_conv False
conv3_block8_concat False
conv3_block9_0_bn False
conv3_block9_0_relu False
conv3_block9_1_conv False
conv3_block9_1_bn False
conv3_block9_1_relu False
conv3_block9_2_conv False
conv3_block9_concat False
conv3_block10_0_bn False
conv3_block10_0_relu False
conv3_block10_1_conv False
conv3_block10_1_bn False
conv3_block10_1_relu False
conv3_block10_2_conv False
conv3_block10_concat False
conv3_block11_0_bn False
conv3_block11_0_relu False
conv3_block11_1_conv False
conv3_block11_1_bn False
conv3_block11_1_relu False
conv3_block11_2_conv False
conv3_block11_concat False
conv3_block12_0_bn False
conv3_block12_0_relu False
conv3_block12_1_conv False
conv3_block12_1_bn False
conv3_block12_1_relu False
conv3_block12_2_conv False
conv3_block12_concat False
pool3_bn False
pool3_relu False
pool3_conv False
pool3_pool False
conv4_block1_0_bn False
conv4_block1_0_relu False
conv4_block1_1_conv False
conv4_block1_1_bn False
conv4_block1_1_relu False
conv4_block1_2_conv False
conv4_block1_concat False
conv4_block2_0_bn False
conv4_block2_0_relu False
conv4_block2_1_conv False
conv4_block2_1_bn False
conv4_block2_1_relu False
conv4_block2_2_conv False
conv4_block2_concat False
conv4_block3_0_bn False
conv4_block3_0_relu False
conv4_block3_1_conv False
conv4_block3_1_bn False
conv4_block3_1_relu False
conv4_block3_2_conv False
conv4_block3_concat False
conv4_block4_0_bn False
conv4_block4_0_relu False
conv4_block4_1_conv False
conv4_block4_1_bn False
conv4_block4_1_relu False
conv4_block4_2_conv False
conv4_block4_concat False
conv4_block5_0_bn False
conv4_block5_0_relu False
conv4_block5_1_conv False
conv4_block5_1_bn False
conv4_block5_1_relu False
conv4_block5_2_conv False
conv4_block5_concat False
conv4_block6_0_bn False
conv4_block6_0_relu False
conv4_block6_1_conv False
```

```
179 conv4_block6_1_bn False
180 conv4_block6_1_relu False
181 conv4_block6_2_conv False
182 conv4_block6_concat False
183 conv4_block7_0_bn False
184 conv4_block7_0_relu False
185 conv4_block7_1_conv False
186 conv4_block7_1_bn False
187 conv4_block7_1_relu False
188 conv4_block7_2_conv False
189 conv4_block7_concat False
190 conv4_block8_0_bn False
191 conv4_block8_0_relu False
192 conv4_block8_1_conv False
193 conv4_block8_1_bn False
194 conv4_block8_1_relu False
195 conv4_block8_2_conv False
196 conv4_block8_concat False
197 conv4_block9_0_bn False
198 conv4_block9_0_relu False
199 conv4_block9_1_conv False
200 conv4_block9_1_bn False
201 conv4_block9_1_relu False
202 conv4_block9_2_conv False
203 conv4_block9_concat False
204 conv4_block10_0_bn False
205 conv4_block10_0_relu False
206 conv4_block10_1_conv False
207 conv4_block10_1_bn False
208 conv4_block10_1_relu False
209 conv4_block10_2_conv False
210 conv4_block10_concat False
211 conv4_block11_0_bn False
212 conv4_block11_0_relu False
213 conv4_block11_1_conv False
214 conv4_block11_1_bn False
215 conv4_block11_1_relu False
216 conv4_block11_2_conv False
217 conv4_block11_concat False
218 conv4_block12_0_bn False
219 conv4_block12_0_relu False
220 conv4_block12_1_conv False
221 conv4_block12_1_bn False
222 conv4_block12_1_relu False
223 conv4_block12_2_conv False
224 conv4_block12_concat False
225 conv4_block13_0_bn False
226 conv4_block13_0_relu False
227 conv4_block13_1_conv False
228 conv4_block13_1_bn False
229 conv4_block13_1_relu False
230 conv4_block13_2_conv False
231 conv4_block13_concat False
232 conv4_block14_0_bn False
233 conv4_block14_0_relu False
234 conv4_block14_1_conv False
235 conv4_block14_1_bn False
236 conv4_block14_1_relu False
237 conv4_block14_2_conv False
238 conv4_block14_concat False
239 conv4_block15_0_bn False
240 conv4_block15_0_relu False
241 conv4_block15_1_conv False
242 conv4_block15_1_bn False
243 conv4_block15_1_relu False
244 conv4_block15_2_conv False
245 conv4_block15_concat False
246 conv4_block16_0_bn False
247 conv4_block16_0_relu False
248 conv4_block16_1_conv False
249 conv4_block16_1_bn False
250 conv4_block16_1_relu False
```

```
251 conv4_block16_2_conv False
252 conv4_block16_concat False
253 conv4_block17_0_bn False
254 conv4_block17_0_relu False
255 conv4_block17_1_conv False
256 conv4_block17_1_bn False
257 conv4_block17_1_relu False
258 conv4_block17_2_conv False
259 conv4_block17_concat False
260 conv4_block18_0_bn False
261 conv4_block18_0_relu False
262 conv4_block18_1_conv False
263 conv4_block18_1_bn False
264 conv4_block18_1_relu False
265 conv4_block18_2_conv False
266 conv4_block18_concat False
267 conv4_block19_0_bn False
268 conv4_block19_0_relu False
269 conv4_block19_1_conv False
270 conv4_block19_1_bn False
271 conv4_block19_1_relu False
272 conv4_block19_2_conv False
273 conv4_block19_concat False
274 conv4_block20_0_bn False
275 conv4_block20_0_relu False
276 conv4_block20_1_conv False
277 conv4_block20_1_bn False
278 conv4_block20_1_relu False
279 conv4_block20_2_conv False
280 conv4_block20_concat False
281 conv4_block21_0_bn False
282 conv4_block21_0_relu False
283 conv4_block21_1_conv False
284 conv4_block21_1_bn False
285 conv4_block21_1_relu False
286 conv4_block21_2_conv False
287 conv4_block21_concat False
288 conv4_block22_0_bn False
289 conv4_block22_0_relu False
290 conv4_block22_1_conv False
291 conv4_block22_1_bn False
292 conv4_block22_1_relu False
293 conv4_block22_2_conv False
294 conv4_block22_concat False
295 conv4_block23_0_bn False
296 conv4_block23_0_relu False
297 conv4_block23_1_conv False
298 conv4_block23_1_bn False
299 conv4_block23_1_relu False
300 conv4_block23_2_conv False
301 conv4_block23_concat False
302 conv4_block24_0_bn False
303 conv4_block24_0_relu False
304 conv4_block24_1_conv False
305 conv4_block24_1_bn False
306 conv4_block24_1_relu False
307 conv4_block24_2_conv False
308 conv4_block24_concat False
309 pool4_bn False
310 pool4_relu False
311 pool4_conv False
312 pool4_pool False
313 conv5_block1_0_bn False
314 conv5_block1_0_relu False
315 conv5_block1_1_conv False
316 conv5_block1_1_bn False
317 conv5_block1_1_relu False
318 conv5_block1_2_conv False
319 conv5_block1_concat False
320 conv5_block2_0_bn False
321 conv5_block2_0_relu False
322 conv5_block2_1_conv False
```

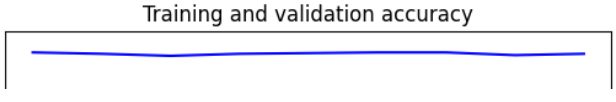
```
conv5_block2_1_bn False
conv5_block2_1_relu False
conv5_block2_2_conv False
conv5_block2_concat False
conv5_block3_0_bn False
conv5_block3_0_relu False
conv5_block3_1_conv False
conv5_block3_1_bn False
conv5_block3_1_relu False
conv5_block3_2_conv False
conv5_block3_concat False
conv5_block4_0_bn False
conv5_block4_0_relu False
conv5_block4_1_conv False
conv5_block4_1_bn False
conv5_block4_1_relu False
conv5_block4_2_conv False
conv5_block4_concat False
conv5_block5_0_bn False
conv5_block5_0_relu False
conv5_block5_1_conv False
conv5_block5_1_bn False
conv5_block5_1_relu False
conv5_block5_2_conv False
conv5_block5_concat False
conv5_block6_0_bn False
conv5_block6_0_relu False
conv5_block6_1_conv False
conv5_block6_1_bn False
conv5_block6_1_relu False
conv5_block6_2_conv False
conv5_block6_concat False
conv5_block7_0_bn False
conv5_block7_0_relu False
conv5_block7_1_conv False
conv5_block7_1_bn False
conv5_block7_1_relu False
conv5_block7_2_conv False
conv5_block7_concat False
conv5_block8_0_bn False
conv5_block8_0_relu False
conv5_block8_1_conv False
conv5_block8_1_bn False
conv5_block8_1_relu False
conv5_block8_2_conv False
conv5_block8_concat False
conv5_block9_0_bn False
conv5_block9_0_relu False
conv5_block9_1_conv False
conv5_block9_1_bn False
conv5_block9_1_relu False
conv5_block9_2_conv False
conv5_block9_concat False
conv5_block10_0_bn False
conv5_block10_0_relu False
conv5_block10_1_conv False
conv5_block10_1_bn False
conv5_block10_1_relu False
conv5_block10_2_conv False
conv5_block10_concat False
conv5_block11_0_bn False
conv5_block11_0_relu False
conv5_block11_1_conv False
conv5_block11_1_bn False
conv5_block11_1_relu False
conv5_block11_2_conv False
conv5_block11_concat False
conv5_block12_0_bn False
conv5_block12_0_relu False
conv5_block12_1_conv False
conv5_block12_1_bn False
conv5_block12_1_relu False
```

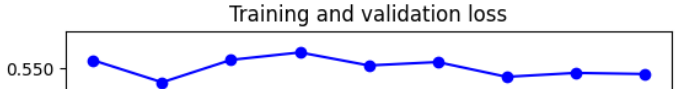
```
395 conv5_block12_2_conv False
396 conv5_block12_concat False
397 conv5_block13_0_bn False
398 conv5_block13_0_relu False
399 conv5_block13_1_conv False
400 conv5_block13_1_bn False
401 conv5_block13_1_relu False
402 conv5_block13_2_conv False
403 conv5_block13_concat False
404 conv5_block14_0_bn False
405 conv5_block14_0_relu False
406 conv5_block14_1_conv False
407 conv5_block14_1_bn False
408 conv5_block14_1_relu False
409 conv5_block14_2_conv False
410 conv5_block14_concat False
411 conv5_block15_0_bn False
412 conv5_block15_0_relu False
413 conv5_block15_1_conv False
414 conv5_block15_1_bn False
415 conv5_block15_1_relu False
416 conv5_block15_2_conv False
417 conv5_block15_concat False
418 conv5_block16_0_bn False
419 conv5_block16_0_relu False
420 conv5_block16_1_conv False
421 conv5_block16_1_bn True
422 conv5_block16_1_relu True
423 conv5_block16_2_conv True
424 conv5_block16_concat True
425 bn True
426 relu True
```

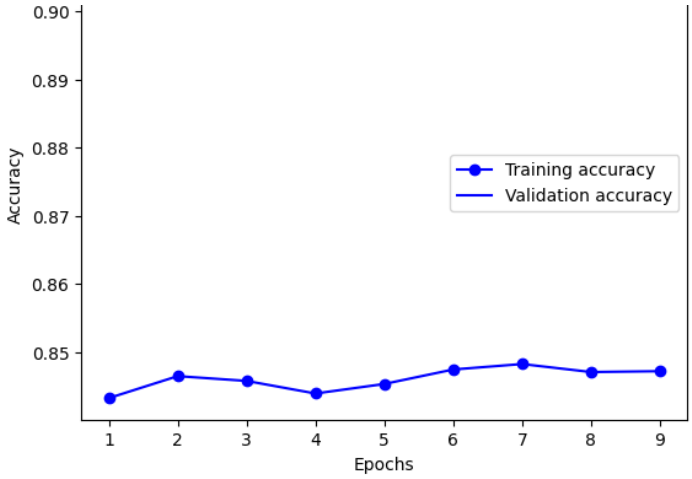
In [20]:

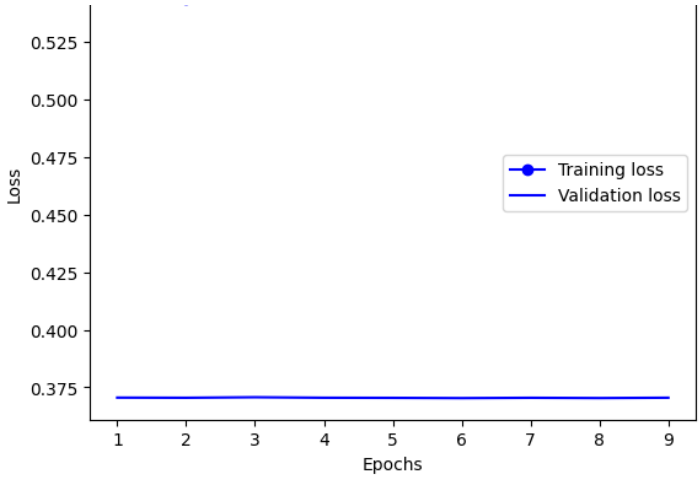
```
with tf.device('/device:GPU:0'):

    callbacks = [
            keras.callbacks.ModelCheckpoint(
                filepath='models_T/model_best_DAFirst_0_FT.h5',
                save_best_only=True,
                monitor='val_loss',
                mode='min',
                verbose=0
            ),
            keras.callbacks.EarlyStopping(
                monitor='val_loss',
                min_delta=0,
                patience=3,
                verbose=1,
                mode='min',
                restore_best_weights=True,
            )
        ]

    history = model.fit(
            train_dataset,
            batch_size=16,
            epochs=20,
            validation_data=validation_dataset,
            callbacks=callbacks,
            verbose=0
        )

    graph(history)
```

```
Restoring model weights from the end of the best epoch: 6.
Epoch 9: early stopping
```









No fim do fine tunning vemos que o underfitting pode ser causado pelas imagens do treino

In [27]:

```
val_loss, val_acc = model.evaluate(test_gen) #test_gen
print('Test_acc:', val_acc,'\nTest_loss:', val_loss)

#keras.models.save_model(model,'models_T/model_best_DAFirst.h5')
```

```
156/156 [==============================] - 1s 6ms/step - loss: 0.4282 - accuracy: 0.8890
Test_acc: 0.8890224099159241
Test_loss: 0.42822524905204773
```