Projet 3 "La classification d’images pour détecter le cancer de la peau"

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Ressources:

- https://notebook.community/frreiss/tensorflow-fred/tensorflow/lite/g3doc/tutorials/model_maker_image_classification
- https://levelup.gitconnected.com/custom-image-classification-model-using-tensorflow-lite-model-maker-68ee4514cd45
- https://stackoverflow.com/questions/65438156/tensorflow-keras-error-unknown-image-file-format-one-of-jpeg-png-gif-bmp-re
- https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/tutorials/images/classification.ipynb?hl=fr#scrollTo=H74l2DoDI2XD
- https://notebook.community/frreiss/tensorflow-fred/tensorflow/lite/g3doc/tutorials/model_maker_image_classification

Le but de ce projet est d'analyser les images afin de détecter la présence d'un cancer de la peau. Puisque c'est un projet académique, on s'est concentré sur un seul type de cancer "le mélanome". Il s'agit alors d'une classification binaire. C'est-à-dire l'algorithme détecte s'il s'agit d'un cancer mélanome ou bien un cas normal.

Nous devons d'abord installer plusieurs packages requis, y compris le package Model Maker.

```
!sudo apt -y install libportaudio2
!pip install -q tflite-model-maker
```

```
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following package was automatically installed and is no longer required:
  libnvidia-common-510
Use 'sudo apt autoremove' to remove it.
The following NEW packages will be installed:
  libportaudio2
0 upgraded, 1 newly installed, 0 to remove and 27 not upgraded.
Need to get 65.4 kB of archives.
After this operation, 223 kB of additional disk space will be used.
Get:1 http://archive.ubuntu.com/ubuntu focal/universe amd64 libportaudio2 amd64 19.6.0-1build1 [65.4 kB]
Fetched 65.4 kB in 0s (177 kB/s)
debconf: unable to initialize frontend: Dialog
debconf: (No usable dialog-like program is installed, so the dialog based frontend cannot be used. at /usr/share/perl5/Debconf/Fror
debconf: falling back to frontend: Readline
debconf: unable to initialize frontend: Readline
debconf: (This frontend requires a controlling tty.)
debconf: falling back to frontend: Teletype
dpkg-preconfigure: unable to re-open stdin:
Selecting previously unselected package libportaudio2:amd64.
(Reading database ... 129496 files and directories currently installed.)
Preparing to unpack .../libportaudio2_19.6.0-1build1_amd64.deb ...
Unpacking libportaudio2:amd64 (19.6.0-1build1) ...
Setting up libportaudio2:amd64 (19.6.0-1build1) ...
Processing triggers for libc-bin (2.31-0ubuntu9.9) ...
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 577.3/577.3 KB 16.6 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.1/1.1 MB 15.4 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 238.9/238.9 KB 15.9 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 840.9/840.9 KB 14.8 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 10.9/10.9 MB 35.4 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 88.3/88.3 KB 5.4 MB/s eta 0:00:00
  Preparing metadata (setup.py) ... done
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 60.8/60.8 MB 15.0 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 3.4/3.4 MB 84.3 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.3/1.3 MB 41.5 MB/s eta 0:00:00
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     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 128.6/128.6 KB 17.1 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 25.3/25.3 MB 85.9 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 498.0/498.0 MB 3.4 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 352.1/352.1 KB 34.7 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.4/1.4 MB 82.7 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 462.3/462.3 KB 38.9 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 5.8/5.8 MB 125.4 MB/s eta 0:00:00
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 40.9/40.9 KB 2.5 MB/s eta 0:00:00
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  Building wheel for fire (setup.py) ... done
ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This behaviour is the sc
xarray 2022.12.0 requires packaging>=21.3, but you have packaging 20.9 which is incompatible.
```

On importe par la suite les packages requis.

```
import os
import numpy as np

import tensorflow as tf
assert tf.__version__.startswith('2')

from tflite_model_maker import model_spec
from tflite_model_maker import image_classifier
from tflite_model_maker.config import ExportFormat
from tflite_model_maker.config import QuantizationConfig
from tflite_model_maker.image_classifier import DataLoader

import matplotlib.pyplot as plt
```

```
/usr/local/lib/python3.8/dist-packages/tensorflow_addons/utils/ensure_tf_install.py:53: UserWarning: Tensorflow Addons supports usi
 The versions of TensorFlow you are currently using is 2.8.4 and is not supported.
Some things might work, some things might not.
If you were to encounter a bug, do not file an issue.
If you want to make sure you're using a tested and supported configuration, either change the TensorFlow version or the TensorFlow
You can find the compatibility matrix in TensorFlow Addon's readme:
https://github.com/tensorflow/addons
  warnings.warn(
```

On définit le chemin d'accès à notre données d'image. Dans mon cas, j'ai mis toute la base de données dans /content/drive/MyDrive/Dataset

```
import·os

root_path·=·"/content/drive/MyDrive/"····
image_path·=·os.path.join(os.path.dirname(root_path),·'Dataset/')
print·(image_path)
```

```
/content/drive/MyDrive/Dataset/
```

Double-cliquez (ou appuyez sur Entrée) pour modifier

```
!rmdir /content/drive/MyDrive/Dataset/Cancer_Skin/.ipynb_checkpoints
!rmdir /content/drive/MyDrive/Dataset/Safe_Skin/.ipynb_checkpoints
!rmdir /content/drive/MyDrive/Dataset/.ipynb_checkpoints
```

```
rmdir: failed to remove '/content/drive/MyDrive/Dataset/Cancer_Skin/.ipynb_checkpoints': No such file or directory
rmdir: failed to remove '/content/drive/MyDrive/Dataset/Safe_Skin/.ipynb_checkpoints': No such file or directory
rmdir: failed to remove '/content/drive/MyDrive/Dataset/.ipynb_checkpoints': No such file or directory
```

On fait une première répartition de données 80/20 entre les données d'entraînement et les données de test.

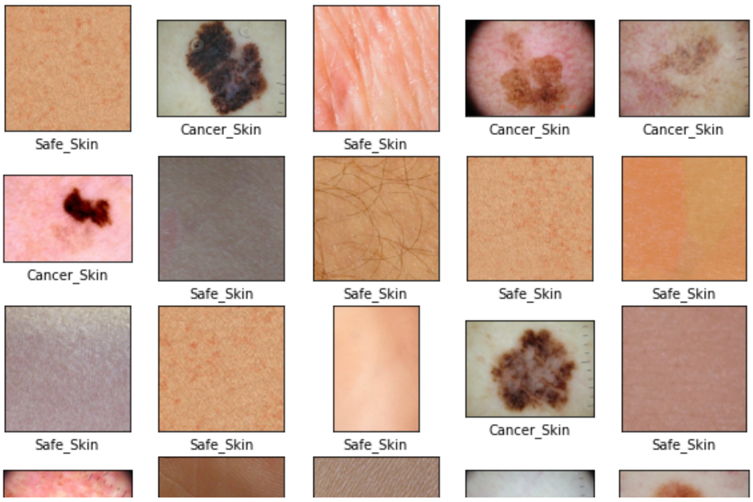
```
data = DataLoader.from_folder(image_path)
train_data, rest_data = data.split(0.8)
```

On fait une deuxième répartition 50/50 des données de test qui restent en "test_data" et "validation_data"

```
validation_data, test_data = rest_data.split(0.5)
```

On peut afficher 25 exemples d'images avec des étiquettes (labels) juste pour vérifier que les deux classes (catégories) d'images ont été bien lues.

```
plt.figure(figsize=(10,10))
for i, (image, label) in enumerate(data.gen_dataset().unbatch().take(25)):
  plt.subplot(5,5,i+1)
  plt.xticks([])
  plt.yticks([])
  plt.grid(False)
  plt.imshow(image.numpy(), cmap=plt.cm.gray)
  plt.xlabel(data.index_to_label[label.numpy()])
plt.show()
```



```
!pip install tensorflow==2.7
```

```
    Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (1.15.0)
    Requirement already satisfied: absl-py>=0.4.0 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (1.4.0)
    Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (0.2.0)
    Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (1.14.1)
    Requirement already satisfied: typing-extensions>=3.6.6 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (4.4.0)
    Collecting flatbuffers<3.0,>=1.12
      Downloading flatbuffers-2.0.7-py2.py3-none-any.whl (26 kB)
    Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (1.6.3)
    Requirement already satisfied: tensorboard~=2.6 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (2.8.0)
    Requirement already satisfied: wheel<1.0,>=0.32.0 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (0.38.4)
    Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.21.0 in /usr/local/lib/python3.8/dist-packages (from tensorflow==
    Requirement already satisfied: h5py>=2.9.0 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (3.1.0)
    Requirement already satisfied: libclang>=9.0.1 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (15.0.6.1)
    Requirement already satisfied: numpy>=1.14.5 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (1.21.6)
    Requirement already satisfied: keras-preprocessing>=1.1.1 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (1.1.
    Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.8/dist-packages (from tensorflow==2.7) (1.51.1)
    Collecting tensorflow-estimator<2.8,~=2.7.0rc0
      Downloading tensorflow_estimator-2.7.0-py2.py3-none-any.whl (463 kB)
         ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 463.1/463.1 KB 45.0 MB/s eta 0:00:00
    Requirement already satisfied: werkzeug>=0.11.15 in /usr/local/lib/python3.8/dist-packages (from tensorboard~=2.6->tensorflow==2
    Requirement already satisfied: tensorboard-data-server<0.7.0,>=0.6.0 in /usr/local/lib/python3.8/dist-packages (from tensorboard
    Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.8/dist-packages (from tensorboard~=2.6->tensorflow==2.7
    Requirement already satisfied: google-auth<3,>=1.6.3 in /usr/local/lib/python3.8/dist-packages (from tensorboard~=2.6->tensorflo
    Requirement already satisfied: setuptools>=41.0.0 in /usr/local/lib/python3.8/dist-packages (from tensorboard~=2.6->tensorflow==
    Requirement already satisfied: google-auth-oauthlib<0.5,>=0.4.1 in /usr/local/lib/python3.8/dist-packages (from tensorboard~=2.6
    Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in /usr/local/lib/python3.8/dist-packages (from tensorboard~=2.6->t
    Requirement already satisfied: requests<3,>=2.21.0 in /usr/local/lib/python3.8/dist-packages (from tensorboard~=2.6->tensorflow=
    Requirement already satisfied: cachetools<6.0,>=2.0.0 in /usr/local/lib/python3.8/dist-packages (from google-auth<3,>=1.6.3->ten
    Requirement already satisfied: pyasn1-modules>=0.2.1 in /usr/local/lib/python3.8/dist-packages (from google-auth<3,>=1.6.3->tens
    Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.8/dist-packages (from google-auth<3,>=1.6.3->tensorboard~
    Requirement already satisfied: requests-oauthlib>=0.7.0 in /usr/local/lib/python3.8/dist-packages (from google-auth-oauthlib<0.5
    Requirement already satisfied: importlib-metadata>=4.4 in /usr/local/lib/python3.8/dist-packages (from markdown>=2.6.8->tensorbo
    Requirement already satisfied: urllib3<1.27,>=1.21.1 in /usr/local/lib/python3.8/dist-packages (from requests<3,>=2.21.0->tensor
    Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.8/dist-packages (from requests<3,>=2.21.0->tensorboard~=2.
    Requirement already satisfied: chardet<5,>=3.0.2 in /usr/local/lib/python3.8/dist-packages (from requests<3,>=2.21.0->tensorboar
    Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.8/dist-packages (from requests<3,>=2.21.0->tensorboa
    Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.8/dist-packages (from importlib-metadata>=4.4->markdown>=2.6.
    Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in /usr/local/lib/python3.8/dist-packages (from pyasn1-modules>=0.2.1->googl
    Requirement already satisfied: oauthlib>=3.0.0 in /usr/local/lib/python3.8/dist-packages (from requests-oauthlib>=0.7.0->google-
    Installing collected packages: tensorflow-estimator, keras, flatbuffers, tensorflow
      Attempting uninstall: tensorflow-estimator
        Found existing installation: tensorflow-estimator 2.8.0
        Uninstalling tensorflow-estimator-2.8.0:
          Successfully uninstalled tensorflow-estimator-2.8.0
      Attempting uninstall: keras
        Found existing installation: keras 2.8.0
        Uninstalling keras-2.8.0:
          Successfully uninstalled keras-2.8.0
      Attempting uninstall: flatbuffers
        Found existing installation: flatbuffers 23.1.21
        Uninstalling flatbuffers-23.1.21:
          Successfully uninstalled flatbuffers-23.1.21
      Attempting uninstall: tensorflow
        Found existing installation: tensorflow 2.8.4
        Uninstalling tensorflow-2.8.4:
          Successfully uninstalled tensorflow-2.8.4
    ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This behaviour is the
    scann 1.2.6 requires tensorflow~=2.8.0, but you have tensorflow 2.7.0 which is incompatible.
```

Python a de nombreux modules dans sa bibliothèque standard, et celui qui aide ici est imghdr. Il vous permet d'identifier le type d'image contenu dans un fichier. L'imghdr peut reconnaître les types d'images suivants : rgb, gif, pbm, pgm, ppm, tiff, rast, xbm, jpeg/jpg, bmp, png, webp et exr. C'est indispensable de vérifier si l'image est utilisable ou non avant de générer le modèle. On peut rechercher un type d'image, pas un nom d'extension, par le code suivant:

```
import os
import cv2
import imghdr

def check_images( s_dir, ext_list):
    bad_images=[]
    bad_ext=[]
    s_list= os.listdir(s_dir)
    for klass in s_list:
        klass_path=os.path.join (s_dir, klass)
        print ('processing class directory ', klass)
        if os.path.isdir(klass_path):
            file_list=os.listdir(klass_path)
            for f in file_list:
                f_path=os.path.join (klass_path,f)
                tip = imghdr.what(f_path)
                if ext_list.count(tip) == 0:
                  bad_images.append(f_path)
                if os.path.isfile(f_path):
                    try:
                        img=cv2.imread(f_path)
                        shape=img.shape
                    except:
                        print('file ', f_path, ' is not a valid image file')
                        bad_images.append(f_path)
                else:
                    print('*** fatal error, you a sub directory ', f, ' in class directory ', klass)
        else:
            print ('*** WARNING*** you have files in ', s_dir, ' it should only contain sub directories')
    return bad_images, bad_ext

source_dir =r'/content/drive/MyDrive/Dataset/'
good_exts=['jpg', 'png', 'jpeg', 'gif', 'bmp' ] # list of acceptable extensions
bad_file_list, bad_ext_list=check_images(source_dir, good_exts)
if len(bad_file_list) !=0:
    print('improper image files are listed below')
    for i in range (len(bad_file_list)):
        print (bad_file_list[i])
else:
    print(' no improper image files were found')
```

```
processing class directory  Safe_Skin
processing class directory  Cancer_Skin
 no improper image files were found
```

On passe maintenant à l'entraînement du modèle. Les paramaitres sont:

- Les données d'entraînement seront utilisées pour réellement former le modèle.
- Les données de validation seront utilisées pour vérifier les performances du modèle après chaque cycle d'entraînement.
- Le nombre d'époques qui définit le nombre de cycles d'entraînement (plus il y a d'époques, plus votre modèle mettra de temps à s'entraîner)
- La spécification du modèle qui est un modèle d'image générique pré-entraîné.

```
model = image_classifier.create(train_data, model_spec=model_spec.get('efficientnet_lite0'), validation_data=validation_data, epochs = 2
```

```
_________________________________________________________________
None
Epoch 1/20
WARNING:tensorflow:AutoGraph could not transform <function Model.make_train_function.<locals>.train_function at 0x7f6036453ca0>
```

```
Epoch 2/20
21/21 [==============================] - 33s 2s/step - loss: 0.2630 - accuracy: 0.9955 - val_loss: 0.2316 - val_accuracy: 1.0000
Epoch 3/20
21/21 [==============================] - 33s 2s/step - loss: 0.2276 - accuracy: 0.9970 - val_loss: 0.2199 - val_accuracy: 1.0000
Epoch 4/20
21/21 [==============================] - 36s 2s/step - loss: 0.2225 - accuracy: 1.0000 - val_loss: 0.2169 - val_accuracy: 1.0000
Epoch 5/20
21/21 [==============================] - 32s 2s/step - loss: 0.2189 - accuracy: 1.0000 - val_loss: 0.2143 - val_accuracy: 1.0000
Epoch 6/20
21/21 [==============================] - 32s 2s/step - loss: 0.2197 - accuracy: 1.0000 - val_loss: 0.2132 - val_accuracy: 1.0000
Epoch 7/20
21/21 [==============================] - 33s 2s/step - loss: 0.2159 - accuracy: 1.0000 - val_loss: 0.2134 - val_accuracy: 1.0000
Epoch 8/20
21/21 [==============================] - 33s 2s/step - loss: 0.2138 - accuracy: 1.0000 - val_loss: 0.2127 - val_accuracy: 1.0000
Epoch 9/20
21/21 [==============================] - 33s 2s/step - loss: 0.2140 - accuracy: 1.0000 - val_loss: 0.2113 - val_accuracy: 1.0000
Epoch 10/20
21/21 [==============================] - 36s 2s/step - loss: 0.2144 - accuracy: 0.9985 - val_loss: 0.2101 - val_accuracy: 1.0000
Epoch 11/20
21/21 [==============================] - 33s 2s/step - loss: 0.2134 - accuracy: 1.0000 - val_loss: 0.2099 - val_accuracy: 1.0000
Epoch 12/20
21/21 [==============================] - 33s 2s/step - loss: 0.2123 - accuracy: 1.0000 - val_loss: 0.2094 - val_accuracy: 1.0000
Epoch 13/20
21/21 [==============================] - 33s 2s/step - loss: 0.2121 - accuracy: 1.0000 - val_loss: 0.2092 - val_accuracy: 1.0000
Epoch 14/20
21/21 [==============================] - 33s 2s/step - loss: 0.2121 - accuracy: 1.0000 - val_loss: 0.2092 - val_accuracy: 1.0000
Epoch 15/20
21/21 [==============================] - 37s 2s/step - loss: 0.2123 - accuracy: 1.0000 - val_loss: 0.2094 - val_accuracy: 1.0000
Epoch 16/20
21/21 [==============================] - 32s 2s/step - loss: 0.2104 - accuracy: 1.0000 - val_loss: 0.2093 - val_accuracy: 1.0000
Epoch 17/20
21/21 [==============================] - 32s 2s/step - loss: 0.2094 - accuracy: 1.0000 - val_loss: 0.2084 - val_accuracy: 1.0000
Epoch 18/20
21/21 [==============================] - 32s 2s/step - loss: 0.2110 - accuracy: 1.0000 - val_loss: 0.2083 - val_accuracy: 1.0000
Epoch 19/20
21/21 [==============================] - 33s 2s/step - loss: 0.2106 - accuracy: 1.0000 - val_loss: 0.2089 - val_accuracy: 1.0000
Epoch 20/20
```

Une fois que le modèle a fini de s'exécuter, on peut l'évaluer par rapport aux "test_data" qu'il n'a jamais vus auparavant.

```
loss, accuracy = model.evaluate(test_data)
```

```
3/3 [==============================] - 6s 803ms/step - loss: 0.2106 - accuracy: 1.0000
```

Ensuite, On convertit le modèle existant au format de modèle TensorFlow Lite et on enregistre les étiquettes d'image dans le fichier d'étiquettes (labels). Le nom de fichier TFLite par défaut est model.tflite, le nom de fichier d'étiquette (fichier qui contient les labels) est label.txt.

```
model.export(export_dir='.')
```

```
WARNING:tensorflow:AutoGraph could not transform <function canonicalize_signatures.<locals>.signature_wrapper at 0x7f603390a8b0> ar
Please report this to the TensorFlow team. When filing the bug, set the verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`)
Cause: closure mismatch, requested ('signature_function', 'signature_key'), but source function had ()
To silence this warning, decorate the function with @tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function canonicalize_signatures.<locals>.signature_wrapper at 0x7f603390a8b0> and will rur
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Cause: closure mismatch, requested ('signature_function', 'signature_key'), but source function had ()
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Cause: could not parse the source code of <function _trace_resource_initializers.<locals>._wrap_obj_initializer.<locals>.<lambda> a
# coding=utf-8
(lambda : _wrap_initializer(obj))
To silence this warning, decorate the function with @tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function _trace_resource_initializers.<locals>._wrap_obj_initializer.<locals>.<lambda> at 0
Cause: could not parse the source code of <function _trace_resource_initializers.<locals>._wrap_obj_initializer.<locals>.<lambda> a
# coding=utf-8
(lambda : _wrap_initializer(obj))
To silence this warning, decorate the function with @tf.autograph.experimental.do_not_convert
/usr/local/lib/python3.8/dist-packages/tensorflow/lite/python/convert.py:746: UserWarning: Statistics for quantized inputs were exp
  graph's last operation is a Print op, just specify that op's name in
```

Voici la structure détaillée du modèle:

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 hub_keras_layer_v1v2 (HubKe  (None, 1280)             3413024   
 rasLayerV1V2)                                                   
                                                                 
 dropout (Dropout)           (None, 1280)              0         
                                                                 
 dense (Dense)               (None, 2)                 2562      
                                                                 
=================================================================
Total params: 3,415,586
Trainable params: 2,562
Non-trainable params: 3,413,024
_________________________________________________________________
```

On peut remarquer maintenant un fichier model.tflite dans le dossier '/content/'. Pour accéder aux données sérialisées de notre programme, nous devons les compiler dans l'exécutable et les stocker en Flash. La façon la plus simple de le faire est de convertir le fichier en un tableau de données C. Ceci peut être fait par les commandes suivantes:

```
# Install xxd if it is not available
! apt-get -qq install xxd
# Save the file as a C source file
! xxd -i model.tflite > model_data.cc
```

Afin de réduire la taille de modèle, il est commode de l'optimiser. La quantification post-formation est une technique de conversion qui peut réduire la taille du modèle et la latence d’inférence, tout en améliorant la latence du processeur et de l’accélérateur matériel, avec peu de dégradation de la précision du modèle.

```
config = QuantizationConfig.for_int8(representative_data=test_data)
```

```
model.export(export_dir='.', tflite_filename='model_quant.tflite', quantization_config=config)
```

```
WARNING:tensorflow:AutoGraph could not transform <function canonicalize_signatures.<locals>.signature_wrapper at 0x7f60484f8820> ar
Please report this to the TensorFlow team. When filing the bug, set the verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`)
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Cause: closure mismatch, requested ('signature_function', 'signature_key'), but source function had ()
To silence this warning, decorate the function with @tf.autograph.experimental.do_not_convert
WARNING:tensorflow:AutoGraph could not transform <function Layer._handle_weight_regularization.<locals>._loss_for_variable at 0x7f6
Please report this to the TensorFlow team. When filing the bug, set the verbosity to 10 (on Linux, `export AUTOGRAPH_VERBOSITY=10`)
Cause: closure mismatch, requested ('name', 'regularizer'), but source function had ()
To silence this warning, decorate the function with @tf.autograph.experimental.do_not_convert
WARNING: AutoGraph could not transform <function Layer._handle_weight_regularization.<locals>._loss_for_variable at 0x7f603646e790>
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  graph's last operation is a Print op, just specify that op's name in
```

```
# Install xxd if it is not available
! apt-get -qq install xxd
# Save the file as a C source file
! xxd -i model_quant.tflite > model_quant_data.cc
```

Exécution (14 s)… C. › ex… › _export… › export… › wra… › _convert_and_expo… › con… › con… › wra… › _optimize_tflit… › _qua… › wra… › calib… › _feed_ten… ••• ×