0. Install and Import Dependencies

```
!pip list

!pip install opencv-python matplotlib imageio gdown tensorflow

import os
import cv2
import tensorflow as tf
import numpy as np
from typing import List
from matplotlib import pyplot as plt
import imageio

tf.config.list_physical_devices('GPU')

physical_devices = tf.config.list_physical_devices('GPU')
try:
    tf.config.experimental.set_memory_growth(physical_devices[0],
True)
except:
    pass
```

1. Build Data Loading Functions

```
import gdown

url = 'https://drive.google.com/uc?id=1YlvpDLix3S-U8fd-
gqRwPcWXAXm8JwjL'
output = 'data.zip'
gdown.download(url, output, quiet=False)
gdown.extractall('data.zip')

def load_video(path:str) -> List[float]:

    cap = cv2.VideoCapture(path)
    frames = []
    for _ in range(int(cap.get(cv2.CAP_PROP_FRAME_COUNT))):
        ret, frame = cap.read()
        frame = tf.image.rgb_to_grayscale(frame)
        frames.append(frame[190:236,80:220,:])
    cap.release()

    mean = tf.math.reduce_mean(frames)
    std = tf.math.reduce_std(tf.cast(frames, tf.float32))
    return tf.cast((frames - mean), tf.float32) / std
```

```
vocab = [x for x in "abcdefghijklmnopqrstuvwxyz'?!123456789 "]

char_to_num = tf.keras.layers.StringLookup(vocabulary=vocab,
oov_token="")
num_to_char = tf.keras.layers.StringLookup(
    vocabulary=char_to_num.get_vocabulary(), oov_token="", invert=True
)

print(
    f"The vocabulary is: {char_to_num.get_vocabulary()} "
    f"(size ={char_to_num.vocabulary_size()})"
)

char_to_num.get_vocabulary()

char_to_num(['n','i','c','k'])

num_to_char([14,  9,  3, 11])

def load_alignments(path:str) -> List[str]:
    with open(path, 'r') as f:
        lines = f.readlines()
    tokens = []
    for line in lines:
        line = line.split()
        if line[2] != 'sil':
            tokens = [*tokens,' ',line[2]]
    return char_to_num(tf.reshape(tf.strings.unicode_split(tokens,
input_encoding='UTF-8'), (-1)))[1:]

def load_data(path: str):
    path = bytes.decode(path.numpy())
    #file_name = path.split('/')[-1].split('.')[0]
    # File name splitting for windows
    file_name = path.split('\\')[-1].split('.')[0]
    video_path = os.path.join('data','s1',f'{file_name}.mpg')
    alignment_path =
os.path.join('data','alignments','s1',f'{file_name}.align')
    frames = load_video(video_path)
    alignments = load_alignments(alignment_path)

    return frames, alignments

test_path = '.\\data\\s1\\bbal6n.mpg'

tf.convert_to_tensor(test_path).numpy().decode('utf-8').split('\\')[-
1].split('.')[0]

frames, alignments = load_data(tf.convert_to_tensor(test_path))

plt.imshow(frames[40])
```

```
alignments
```

```
tf.strings.reduce_join([bytes.decode(x) for x in
num_to_char(alignments.numpy()).numpy()])
```

```
def mappable_function(path:str) ->List[str]:
    result = tf.py_function(load_data, [path], (tf.float32, tf.int64))
    return result
```

2. Create Data Pipeline

```
from matplotlib import pyplot as plt
```

```
data = tf.data.Dataset.list_files('./data/s1/*.mpg')
data = data.shuffle(500, reshuffle_each_iteration=False)
data = data.map(mappable_function)
data = data.padded_batch(2, padded_shapes=([75,None,None,None],[40]))
data = data.prefetch(tf.data.AUTOTUNE)
# Added for split
train = data.take(450)
test = data.skip(450)
```

```
len(test)
```

```
frames, alignments = data.as_numpy_iterator().next()
```

```
len(frames)
```

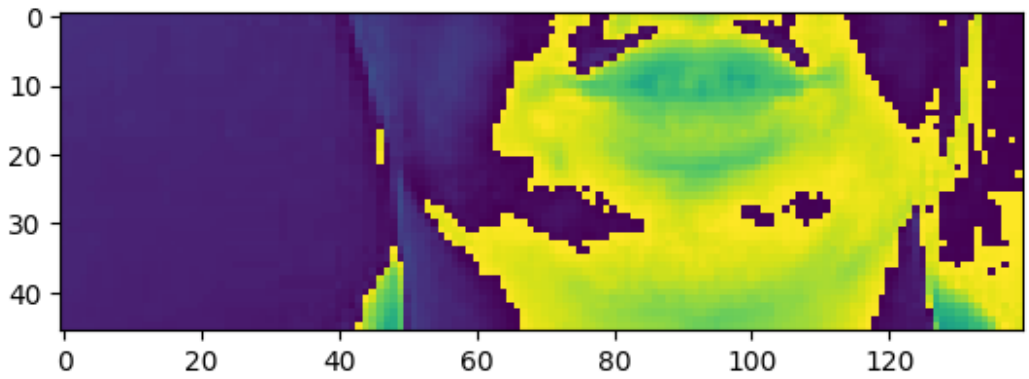
```
sample = data.as_numpy_iterator()
```

```
val = sample.next(); val[0]
```

```
imageio.mimsave('./animation.gif', val[0][0], fps=10)
```

```
# 0:videos, 0: 1st video out of the batch,  0: return the first frame
in the video
plt.imshow(val[0][0][35])
```

```
<matplotlib.image.AxesImage at 0x10c2ead8d30>
```




```
tf.strings.reduce_join([num_to_char(word) for word in val[1][0]])
```

```
<tf.Tensor: shape=(), dtype=string, numpy=b'lay blue by e two please'>
```

3. Design the Deep Neural Network

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv3D, LSTM, Dense, Dropout,
Bidirectional, MaxPool3D, Activation, Reshape, SpatialDropout3D,
BatchNormalization, TimeDistributed, Flatten
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import ModelCheckpoint,
LearningRateScheduler
```

```
data.as_numpy_iterator().next()[0][0].shape
```

```
(75, 46, 140, 1)
```

```
model = Sequential()
model.add(Conv3D(128, 3, input_shape=(75,46,140,1), padding='same'))
model.add(Activation('relu'))
model.add(MaxPool3D((1,2,2)))

model.add(Conv3D(256, 3, padding='same'))
model.add(Activation('relu'))
model.add(MaxPool3D((1,2,2)))

model.add(Conv3D(75, 3, padding='same'))
model.add(Activation('relu'))
model.add(MaxPool3D((1,2,2)))

model.add(TimeDistributed(Flatten()))

model.add(Bidirectional(LSTM(128, kernel_initializer='Orthogonal',
return_sequences=True)))
model.add(Dropout(.5))
```

```
model.add(Bidirectional(LSTM(128, kernel_initializer='Orthogonal',
return_sequences=True)))
model.add(Dropout(.5))

model.add(Dense(char_to_num.vocabulary_size()+1,
kernel_initializer='he_normal', activation='softmax'))

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv3d (Conv3D)             (None, 75, 46, 140, 128)  3584

 activation (Activation)     (None, 75, 46, 140, 128)  0

 max_pooling3d (MaxPooling3D  (None, 75, 23, 70, 128)  0
 )

 conv3d_1 (Conv3D)           (None, 75, 23, 70, 256)   884992

 activation_1 (Activation)   (None, 75, 23, 70, 256)   0

 max_pooling3d_1 (MaxPooling  (None, 75, 11, 35, 256)  0
 3D)

 conv3d_2 (Conv3D)           (None, 75, 11, 35, 75)    518475

 activation_2 (Activation)   (None, 75, 11, 35, 75)    0

 max_pooling3d_2 (MaxPooling  (None, 75, 5, 17, 75)    0
 3D)

 time_distributed (TimeDistr  (None, 75, 6375)         0
 ibuted)

 bidirectional (Bidirectiona  (None, 75, 256)          6660096
 l)

 dropout (Dropout)           (None, 75, 256)           0

 bidirectional_1 (Bidirectio  (None, 75, 256)          394240
 nal)

 dropout_1 (Dropout)         (None, 75, 256)           0

 dense (Dense)               (None, 75, 41)            10537
```

```
=================================================================
Total params: 8,471,924
Trainable params: 8,471,924
Non-trainable params: 0
_________________________________________________________________
```

```
5*17*75
```

```
yhat = model.predict(val[0])
```

```
1/1 [==============================] - 3s 3s/step
```

```
tf.strings.reduce_join([num_to_char(x) for x in
tf.argmax(yhat[0],axis=1)])
```

```
<tf.Tensor: shape=(), dtype=string,
numpy=b'444iiiiiiiiiiiiiimmmmmmmmmmmmmmmmmmmmmmiiiiiiiiiiimmmmmmmmiiii
iiiiiiixxxxxx'>
```

```
tf.strings.reduce_join([num_to_char(tf.argmax(x)) for x in yhat[0]])
```

```
<tf.Tensor: shape=(), dtype=string,
numpy=b'444iiiiiiiiiiiiiimmmmmmmmmmmmmmmmmmmmmmiiiiiiiiiiimmmmmmmmiiii
iiiiiiixxxxxx'>
```

```
model.input_shape
```

```
(None, 75, 46, 140, 1)
```

```
model.output_shape
```

```
(None, 75, 41)
```

4. Setup Training Options and Train

```
def scheduler(epoch, lr):
    if epoch < 30:
        return lr
    else:
        return lr * tf.math.exp(-0.1)

def CTCLoss(y_true, y_pred):
    batch_len = tf.cast(tf.shape(y_true)[0], dtype="int64")
    input_length = tf.cast(tf.shape(y_pred)[1], dtype="int64")
    label_length = tf.cast(tf.shape(y_true)[1], dtype="int64")

    input_length = input_length * tf.ones(shape=(batch_len, 1),
dtype="int64")
    label_length = label_length * tf.ones(shape=(batch_len, 1),
dtype="int64")
```

```
    loss = tf.keras.backend.ctc_batch_cost(y_true, y_pred,
input_length, label_length)
    return loss

class ProduceExample(tf.keras.callbacks.Callback):
    def __init__(self, dataset) -> None:
        self.dataset = dataset.as_numpy_iterator()

    def on_epoch_end(self, epoch, logs=None) -> None:
        data = self.dataset.next()
        yhat = self.model.predict(data[0])
        decoded = tf.keras.backend.ctc_decode(yhat, [75,75],
greedy=False)[0][0].numpy()
        for x in range(len(yhat)):
            print('Original:',
tf.strings.reduce_join(num_to_char(data[1][x])).numpy().decode('utf-
8'))
            print('Prediction:',
tf.strings.reduce_join(num_to_char(decoded[x])).numpy().decode('utf-
8'))
            print('~'*100)

model.compile(optimizer=Adam(learning_rate=0.0001), loss=CTCLoss)

checkpoint_callback =
ModelCheckpoint(os.path.join('models','checkpoint'), monitor='loss',
save_weights_only=True)

schedule_callback = LearningRateScheduler(scheduler)

example_callback = ProduceExample(test)

model.fit(train, validation_data=test, epochs=100,
callbacks=[checkpoint_callback, schedule_callback, example_callback])
```

```
Epoch 1/100
  2/450 [..............................] - ETA: 3:03 - loss: 213.9969


KeyboardInterrupt
```

5. Make a Prediction

```
url = 'https://drive.google.com/uc?id=1vWscXs4Vt0a_1IH1-ct2TCgXAZT-
N3_Y'
output = 'checkpoints.zip'
gdown.download(url, output, quiet=False)
gdown.extractall('checkpoints.zip', 'models')
```

```
model.load_weights('models/checkpoint')
```

```
<tensorflow.python.checkpoint.checkpoint.CheckpointLoadStatus at
0x10cfb56c6a0>
```

```
test_data = test.as_numpy_iterator()
```

```
sample = test_data.next()
```

```
yhat = model.predict(sample[0])
```

```
1/1 [==============================] - 1s 973ms/step
```

```
print('~'*100, 'REAL TEXT')
[tf.strings.reduce_join([num_to_char(word) for word in sentence]) for
sentence in sample[1]]
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ REAL TEXT
```

```
[<tf.Tensor: shape=(), dtype=string, numpy=b'place white at x six
please'>,
 <tf.Tensor: shape=(), dtype=string, numpy=b'lay blue in x four now'>]
```

```
decoded = tf.keras.backend.ctc_decode(yhat, input_length=[75,75],
greedy=True)[0][0].numpy()
```

```
print('~'*100, 'PREDICTIONS')
[tf.strings.reduce_join([num_to_char(word) for word in sentence]) for
sentence in decoded]
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ PREDICTIONS
```

```
[<tf.Tensor: shape=(), dtype=string, numpy=b'place white at x six
please'>,
 <tf.Tensor: shape=(), dtype=string, numpy=b'lay blue in x four now'>]
```

Test on a Video

```
sample = load_data(tf.convert_to_tensor('.\\data\\s1\\bras9a.mpg'))
```

```
print('~'*100, 'REAL TEXT')
[tf.strings.reduce_join([num_to_char(word) for word in sentence]) for
sentence in [sample[1]]]
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ REAL TEXT
```

```
[<tf.Tensor: shape=(), dtype=string, numpy=b'bin red at s nine
again'>]
```

```
yhat = model.predict(tf.expand_dims(sample[0], axis=0))
```

```
1/1 [==============================] - 1s 720ms/step
```

```
decoded = tf.keras.backend.ctc_decode(yhat, input_length=[75],
greedy=True)[0][0].numpy()
```

```
print('~'*100, 'PREDICTIONS')
[tf.strings.reduce_join([num_to_char(word) for word in sentence]) for
sentence in decoded]
```

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~~~~ PREDICTIONS
```

```
[<tf.Tensor: shape=(), dtype=string, numpy=b'bin red at s nine
again'>]
```