Projeto final PLN - Sumarizador de documentos e tradução de sumarização

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Resumo

Esse projeto tem como objetivo realizar melhorias e implementar novos recursos ao projeto realizado anteriormente (https://docs.google.com/document/d/13gVb1IcceNGXlPpneqkVGrRjgrEUrhPk). Portanto, explicaremos o novo processo de sumarização extrativa por clustering baseado no embedding de sentenças pelo modelo BERT e a implementação da tradução da sumarização. Além disso, explicaremos o funcionamento do modelo de tradução XLM utilizado e o porquê de escolhermos esse modelo.

1. Introdução

Este projeto aborda duas áreas de alta relevância universo de Processamento de Linguagem Natural(PLN). São elas a sumarização e a tradução. Os próximos parágrafos irão resumir como essas áreas se conectam com o PLN e porque são tão estudadas. Também serão tratadas algumas das técnicas utilizadas ao longo do estudo.

A sumarização automática de documentos é uma técnica muito importante na área de Processamento de Linguagem Natural pois permite gerar uma representação resumida do conteúdo dos documentos. Assim, após a geração de sumários, não é totalmente necessário tratar documentos inteiros, mas apenas um resumo destes.

Tratando-se de textos, existem dois tipos de sumarização: a sumarização extrativa e a sumarização abtrativa. A extrativa seleciona frases ou pequenas partes do documento para ser o sumário; já a abstrativa gera frases baseadas no conteúdo do texto.

Existem diversos métodos para a realização da sumarização. Porém, o método escolhido é baseado no embedding de sentenças e realizando o clustering entre as sentenças.

O embedding é a transformação de algo em vetores. Isso possibilita desde a realização cálculos entre vetores até a utilização de modelos neurais. Na área de PLN, é commum gerar embeddings de palavras, mas não se limita a este.

O clustering é a prática de agrupar objetos baseado em determinadas caracteristicas. Para isso, há vários algoritmos que realizam a clusterização, como o algoritmo baseado em hierarquia e o algoritmo k-means.

A tradução também é uma técnica muito importante na área de PLN pois pode deixar textos mais acessíveis para línguas não tão populares e, do contrário, aproximar e popularizar textos e culturas de línguas menos conhecidas.

Como pode-se notar, por sí só ambas as áreas, sumarização e tradução, são ferramentas poderosas. Curiosamente, somadas, podem propiciar soluções para problemas ainda mais complexos de diversas naturezas e aplicações. Dentre elas, uma forma de categorizar documentos estrangeiros por tópico e seleção de informação em língua estrangeira. Graças aos avanços acadêmicos e práticos nas diversas áreas do PLN, os modelos que estão sendo desenvolvidos estão se tornando cada vez mais certeiros e, isso é bastante motivante.

Portanto, este trabalho foi realizado com bastante interesse, buscando significado nas esferas acadêmicas e práticas. Ao longo deste notebook serão abordados os processos envolvidos no projeto, bem como, os resultados e considerações dos autores.

2. Metodologia

O projeto segue os passos a seguir:

1. Pré-processamento
2. Tokenização e embedding
3. Clusterização
4. Sumarização
5. Tradução

Todo projeto foi feito em python, mais especificamente baseado na biblioteca de PLN `transformers` (baseado em `torch`) e na biblioteca de análise de dados `scikit-learn` .

O dataset utilizado foi o [cnn-stories-tokenized (https://github.com/JafferWilson/Process-Data-of-CNN-DailyMail)](https://github.com/JafferWilson/Process-Data-of-CNN-DailyMail).

In [ ]:

```
%%capture
# Download da biblioteca transformers e seaborn
import sys
!{sys.executable} -m pip install transformers
!pip3 install seaborn
```

In [ ]:

```
# Imports
from transformers import BertTokenizer, BertModel, XLMTokenizer, XLMWithLMHeadModel, T5
Tokenizer, T5ForConditionalGeneration
import torch
import os
import re
from collections import defaultdict
import nltk
nltk.download('stopwords')
from nltk.corpus import stopwords
from sklearn.cluster import MiniBatchKMeans
from random import random
import pickle
import tensorflow as tf
import tensorflow_hub as hub
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.

/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19: F
utureWarning: pandas.util.testing is deprecated. Use the functions in the
public API at pandas.testing instead.
  import pandas.util.testing as tm
```

In [ ]:

```
# Download do dataset
!wget --load-cookies /tmp/cookies.txt "https://docs.google.com/uc?export=download&confirm=$(wget --quiet --save-cookies /tmp/cookies.txt --keep-session-cookies --no-check-certificate 'https://docs.google.com/uc?export=download&id=0BzQ6rtO2VN95cmNuc2xwUS1wdEE' -O- | sed -rn 's/.*confirm=([0-9A-Za-z_]+).*/\1\n/p')&id=0BzQ6rtO2VN95cmNuc2xwUS1wdEE" -O cnn-stories-tokenized.zip && rm -rf /tmp/cookies.txt
!unzip -q cnn-stories-tokenized.zip
```

```
--2020-06-24 17:19:15--  https://docs.google.com/uc?export=download&confir
m=406v&id=0BzQ6rtO2VN95cmNuc2xwUS1wdEE
Resolving docs.google.com (docs.google.com)... 172.217.204.139, 172.217.20
4.101, 172.217.204.113, ...
Connecting to docs.google.com (docs.google.com)|172.217.204.139|:443... co
nnected.
HTTP request sent, awaiting response... 302 Moved Temporarily
Location: https://doc-0k-58-docs.googleusercontent.com/docs/securesc/kabe2
c7ou0vncf8gvthog4hp1eummv73/ko4dknd4vhnh1fd9c9uef1spsrh8dei3/159301912500
0/14902801042381301132/12277873770934232414Z/0BzQ6rtO2VN95cmNuc2xwUS1wdEE?
e=download [following]
--2020-06-24 17:19:15--  https://doc-0k-58-docs.googleusercontent.com/doc
s/securesc/kabe2c7ou0vncf8gvthog4hp1eummv73/ko4dknd4vhnh1fd9c9uef1spsrh8de
i3/1593019125000/14902801042381301132/12277873770934232414Z/0BzQ6rtO2VN95c
mNuc2xwUS1wdEE?e=download
Resolving doc-0k-58-docs.googleusercontent.com (doc-0k-58-docs.googleuserc
ontent.com)... 172.217.203.132, 2607:f8b0:400c:c07::84
Connecting to doc-0k-58-docs.googleusercontent.com (doc-0k-58-docs.googleu
sercontent.com)|172.217.203.132|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location: https://docs.google.com/nonceSigner?nonce=5ed516cta6hnk&continue
=https://doc-0k-58-docs.googleusercontent.com/docs/securesc/kabe2c7ou0vncf
8gvthog4hp1eummv73/ko4dknd4vhnh1fd9c9uef1spsrh8dei3/1593019125000/14902801
042381301132/12277873770934232414Z/0BzQ6rtO2VN95cmNuc2xwUS1wdEE?e%3Ddownlo
ad&hash=jn6jrerhu24is4eqsfbq68g397ckh7bp [following]
--2020-06-24 17:19:15--  https://docs.google.com/nonceSigner?nonce=5ed516c
ta6hnk&continue=https://doc-0k-58-docs.googleusercontent.com/docs/secures
c/kabe2c7ou0vncf8gvthog4hp1eummv73/ko4dknd4vhnh1fd9c9uef1spsrh8dei3/159301
9125000/14902801042381301132/12277873770934232414Z/0BzQ6rtO2VN95cmNuc2xwUS
1wdEE?e%3Ddownload&hash=jn6jrerhu24is4eqsfbq68g397ckh7bp
Connecting to docs.google.com (docs.google.com)|172.217.204.139|:443... co
nnected.
HTTP request sent, awaiting response... 302 Found
Location: https://doc-0k-58-docs.googleusercontent.com/docs/securesc/kabe2
c7ou0vncf8gvthog4hp1eummv73/ko4dknd4vhnh1fd9c9uef1spsrh8dei3/159301912500
0/14902801042381301132/12277873770934232414Z/0BzQ6rtO2VN95cmNuc2xwUS1wdEE?
e=download&nonce=5ed516cta6hnk&user=12277873770934232414Z&hash=ukgvgjs11fa
coni1fhu84jk3qdo8cqte [following]
--2020-06-24 17:19:15--  https://doc-0k-58-docs.googleusercontent.com/doc
s/securesc/kabe2c7ou0vncf8gvthog4hp1eummv73/ko4dknd4vhnh1fd9c9uef1spsrh8de
i3/1593019125000/14902801042381301132/12277873770934232414Z/0BzQ6rtO2VN95c
mNuc2xwUS1wdEE?e=download&nonce=5ed516cta6hnk&user=12277873770934232414Z&h
ash=ukgvgjs11faconi1fhu84jk3qdo8cqte
Connecting to doc-0k-58-docs.googleusercontent.com (doc-0k-58-docs.googleu
sercontent.com)|172.217.203.132|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: unspecified [application/zip]
Saving to: ‘cnn-stories-tokenized.zip’

cnn-stories-tokeniz     [        <=>         ] 197.67M   108MB/s    in 1.8
s

2020-06-24 17:19:17 (108 MB/s) - ‘cnn-stories-tokenized.zip’ saved [207268
941]
```

2.1 Pré-processamento

Apesar de já estar tokenizado, foi necessário realizar um pré-processamento mais específico sobre o dataset. Portanto, esse pré-processamento é exclusivo para esse dataset. Foram retirados números e stopwords, e para o restante, todas as palavras foram colocadas em minúsculo.

Por causa do tamanho do dataset e do tempo de execução de todos os passos, trabalhadou-se com apenas uma pequena amostra do dataset (1% aprox.), escolhido randomicamente.

In [ ]:

```
def preprocess(sent):
    def convert(word):
        # Verifica se é um número.
        try:
            _ = int(word)
            return '<num>'
        except:
            pass

        if "\n" in word:
            return "<wierd>"

        lower = word.lower()
        if lower == "@highlight":
            return "<wierd>"
        if lower == "-lrb-" or lower == "cnn" or lower == "-rrb-":
            return "<wierd>"
        if lower != "u.s.":
            lowern = re.sub('[^A-Za-z0-9]+', '', lower)
            #lowern = re.sub("!\,\.;:<>\/\?~\^@#\$%&=-\+_´`\(\)\[]{}\\'", "", lower)
            lower = lowern
        if not len(lower):
            return "<wierd>"
        return '<stop>' if lower in STOPWORDS else lower

    processed = [convert(word) for word in sent.split(" ")]
    forbidden_words = set(('<num>', '<stop>', '<wierd>'))
    return [word for word in processed if word not in forbidden_words]
```

In [ ]:

```
try:
    with open("doc_sents.pickle", "rb") as fp:
        doc_sents = pickle.load(fp)
    print("Arquivo 'doc_sents.pickle' carregado")
except FileNotFoundError as e:
    doc_sents = defaultdict(list)
    doc_sents_highlight = defaultdict(list)
    STOPWORDS = set(stopwords.words('english'))
    for r, d, f in os.walk("/content/cnn_stories_tokenized/"):
        for file in f:
            if random() <= 0.992:
                continue
            with open(os.path.join(r, file), "r", encoding="utf-8") as fp:
                highlight = False
                line = fp.readline()
                while line:
                    if line == "@highlight\n":
                        highlight = True
                        line = fp.readline()
                    if line is "\n" or len(line) == 1:
                        line = fp.readline()
                        continue
                    prepro_line = preprocess(line)
                    if not highlight:
                        doc_sents[file].append(prepro_line)
                    else:
                        doc_sents_highlight[file].append(prepro_line)
                    line = fp.readline()
    with open("doc_sents.pickle", "wb") as fp:
        pickle.dump(doc_sents, fp)

print("Quantidade de documentos processados: {}".format(len(doc_sents)))
```

```
Quantidade de documentos processados: 749
```

2.2 Tokenização e embedding

A tokenização e o embedding foram executados através do modelo `bert-base-uncased` , da biblioteca `transformers` . A partir de tokens, esse modelo consegue consegue gerar os embeddings.

Como esse modelo realiza apenas embeddings de palavras, foi necessário utilizar a técnica de Continuous Bag of Words (CBOW) para transformar os conjuntos de vetores de diferentes palavras em apenas um conjunto de vetores, representando a sentença. Basicamente, o CBOW calcula a média entre as palavras de cada sentença para representar a própria sentença. É válido notar que, o CBOW não é a única técnica disponível para se converter embeddings de palavra em embeddings de sentença, no entanto, este é bastante prático de se implementar.

In [ ]:

```
model = BertModel.from_pretrained('bert-base-uncased')
model.eval()
tokenizer = BertTokenizer.from_pretrained('bert-base-uncased')
```

In [ ]:

```
try:
    with open("doc_cbow.pickle", "rb") as fp:
        doc_cbow = pickle.load(fp)
    print("Arquivo 'doc_cbow.pickle' carregado")
except FileNotFoundError as e:
    doc_sents_size = len(doc_sents)
    count = 0
    doc_cbow = {}
    for k in doc_sents.keys():
        print("\r{}/{} - {}".format(count, doc_sents_size, k), end="")
        count += 1
        cbow = []
        for sent in doc_sents[k]:
            if not sent:
                continue
            token_ids = tokenizer.encode(sent)
            tokens_tensor = torch.tensor([token_ids])
            segments_tensors = torch.tensor([0] * len(token_ids))
            with torch.no_grad():
                outputs = model(tokens_tensor, token_type_ids=segments_tensors)
                encoded_layers = outputs[0]
                embedding_words = encoded_layers.numpy().squeeze()
                embedding_sent = embedding_words.mean(axis=0)
            #doc_word_vecs[k].append(embedding_words)
            cbow.append(embedding_sent)

        doc_cbow[k] = cbow
    print("\r{}/{} - {}".format(count, doc_sents_size, k))
    with open("doc_cbow.pickle", "wb") as fp:
        pickle.dump(doc_cbow, fp)
```

```
749/749 - b3858ea6ae71f109a7eac9493a1057f0c4f31996.story
```

2.3 Clusterização

A clusterização foi implementada com o algoritmo k-means, da biblioteca `sklearn` . Esse algoritmo realiza o agrupamento dado uma quantidade k de grupos. Assim, os objetos a serem agrupados são separados baseado na distância da média de cada grupo.

Para cada documento, foram definidos 2 clusters.

In [ ]:

```
try:
    with open("doc_clusters.pickle", "rb") as fp:
        doc_clusters = pickle.load(fp)
    print("Arquivo 'doc_clusters.pickle' carregado")
except FileNotFoundError as e:
    doc_sents_size = len(doc_sents)
    count = 0
    doc_clusters = defaultdict(list)
    n_erros = 0
    for doc in list(doc_cbow.keys()):
        print("\r{}/{} - {}".format(count, doc_sents_size, k), end="")
        count += 1
        try:
            kmeans_cbow = MiniBatchKMeans(n_clusters=2, random_state=42)
            doc_clusters[doc] = (kmeans_cbow, kmeans_cbow.fit_transform(doc_cbow[doc]))
        except ValueError:
            n_erros += 1
            continue
    print("\r{}/{} - {}".format(count, doc_sents_size, k))
    print("N erros: {}".format(n_erros))
    with open("doc_clusters.pickle", "wb") as fp:
        pickle.dump(doc_clusters, fp)
```

```
749/749 - b3858ea6ae71f109a7eac9493a1057f0c4f31996.story
N erros: 1
```

2.4 Sumarização

A sumarização foi simples, dadas as etapas anteriores. Com cada cluster definido, bastou identificar a sentença mais próxima do centro de cluster para ser a frase sumarizadora, finalizando a sumarização extrativa. Como para cada documento foram definidos 2 clusters, a sumarização de cada documento é constituida por duas sentenças.

In [ ]:

```
def get_melhores(l_clusters):
    a = l_clusters[1]
    melhor = [None, None]
    for n_cluster in range(a.shape[1]):
        for i in range(len(a)):
            dist = a[i][n_cluster]

            if melhor[n_cluster] is None:
                melhor[n_cluster] = i
            else:
                dist_melhor = a[melhor[n_cluster]][n_cluster]
                if abs(dist) < abs(dist_melhor):
                    melhor[n_cluster] = i
    return melhor
```

In [ ]:

```
try:
    with open("doc_melhores_sents.pickle", "rb") as fp:
        doc_melhores_sents = pickle.load(fp)
    print("Arquivo 'doc_melhores_sents.pickle' carregado")
except FileNotFoundError as e:
    doc_sents_size = len(doc_sents)
    count = 0
    doc_melhores_sents = {}
    for doc in list(doc_clusters.keys()):
        print("\r{}/{} - {}".format(count, doc_sents_size, k), end="")
        count += 1
        doc_melhores_sents[doc] = get_melhores(doc_clusters[doc])
    print("\r{}/{} - {}".format(count, doc_sents_size, k), end="")
    with open("doc_melhores_sents.pickle", "wb") as fp:
        pickle.dump(doc_melhores_sents, fp)
```

```
748/749 - b3858ea6ae71f109a7eac9493a1057f0c4f31996.story
```

2.5 Tradução

A tradução foi feita com o modelo `XLM` . Mais especificamente, o modelo `xlm-mlm-ende-1024` . Esse é especifico para o inglês e o alemão.

Esse modelo é a implementação do Cross-lingual Language Model Pre Training. Suas funcionalidades são:

- Language model pretraining:
  - Casual Language Model (CLM)
  - Masked Language Model (MLM)
  - Translation Language Model (TLM)
- GLUE e XNLI fine-tuning
- Supervised / Unsupervised Machine Translation training

Para a questão de tradução, as técnicas de pré reinamento mais relevantes são o MLM e TLM.

A técnica MLM consiste em substituir tokens aleatórios da sentença por um token `[MASK]` . Então, o modelo tem a função de indentificar os embeddings mais adequados para substituir os tokens de mask.

O TLM é uma extensão do MLM, porém, para dados paralelos bilíngues. Em vez da entrada ser uma sentença em uma língua, a entrada é uma concatenação de sentenças iguais, porém em línguas diferentes.

De acordo com o prórpio artigo [Cross-lingual Language Model Pretraining (https://arxiv.org/abs/1901.07291)](https://arxiv.org/abs/1901.07291), o XLM apresenta uma melhoria considerável se comparado ao [modelo tradutor com BERT (https://arxiv.org/abs/1810.04805)](https://arxiv.org/abs/1810.04805).

Os autores do modelo deixam o modelo e um programa que utiliza o modelo para tradução no [repositório oficial do github (https://github.com/facebookresearch/XLM)](https://github.com/facebookresearch/XLM)

In [ ]:

```
!git clone https://github.com/facebookresearch/XLM.git
os.chdir("XLM/")
```

```
fatal: destination path 'XLM' already exists and is not an empty director
y.
```

In [ ]:

```
%%capture
!./get-data-nmt.sh --src de --tgt en
!wget https://dl.fbaipublicfiles.com/XLM/mlm_tlm_xnli15_1024.pth
!wget https://dl.fbaipublicfiles.com/XLM/codes_xnli_15
```

In [ ]:

```
!wget -c https://dl.fbaipublicfiles.com/XLM/mlm_ende_1024.pth
#"./mlm_tlm_xnli15_1024"
```

```
--2020-06-24 20:14:04--  https://dl.fbaipublicfiles.com/XLM/mlm_ende_102
4.pth
Resolving dl.fbaipublicfiles.com (dl.fbaipublicfiles.com)... 104.22.75.1
42, 104.22.74.142, 172.67.9.4, ...
Connecting to dl.fbaipublicfiles.com (dl.fbaipublicfiles.com)|104.22.75.
142|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 837060734 (798M) [application/octet-stream]
Saving to: ‘mlm_ende_1024.pth’

mlm_ende_1024.pth   100%[===================>] 798.28M  22.1MB/s    in 3
7s

2020-06-24 20:14:41 (21.7 MB/s) - ‘mlm_ende_1024.pth’ saved [837060734/8
37060734]
```

In [ ]:

```
!python translate.py --model_path="./mlm_ende_1024.pth" --output_path="traduções" --src
_lang="en" --tgt_lang="de" --exp_name="exp"
```

```
FAISS library was not found.
FAISS not available. Switching to standard nearest neighbors search implem
entation.
INFO - 06/24/20 20:14:43 - 0:00:00 - ============ Initialized logger =====
=======
INFO - 06/24/20 20:14:43 - 0:00:00 - batch_size: 32
                                     command: python translate.py --model_
path=./mlm_ende_1024.pth --output_path=traduções --src_lang=en --tgt_lang=
de --exp_name=exp --exp_id "p45890fqfi"
                                     dump_path: ./dumped/exp/p45890fqfi
                                     exp_id: p45890fqfi
                                     exp_name: exp
                                     model_path: ./mlm_ende_1024.pth
                                     output_path: traduções
                                     src_lang: en
                                     tgt_lang: de
INFO - 06/24/20 20:14:43 - 0:00:00 - The experiment will be stored in ./du
mped/exp/p45890fqfi

INFO - 06/24/20 20:14:43 - 0:00:00 - Running command: python translate.py
--model_path=./mlm_ende_1024.pth --output_path=traduções --src_lang=en --t
gt_lang=de --exp_name=exp

INFO - 06/24/20 20:14:43 - 0:00:01 - Supported languages: de, en
Traceback (most recent call last):
  File "translate.py", line 141, in <module>
    main(params)
  File "translate.py", line 71, in main
    setattr(params, name, getattr(model_params, name))
AttributeError: 'AttrDict' object has no attribute 'bos_index'
```

3. Resultados

Os resultados podem ser divididos em duas partes:

1. Sumarização
2. Tradução

3.1 Sumarização

Os sumários obtidos foram comparados com os sumários disponibilizados no próprio dataset do `cnn-stories-tokenized` . Como o objetivo desse projeto é realizar apenas a sumarização e a tradução, a comparação foi feita com o modelo `universal-sentence-encoder` , do `TF-hub` . Com o embedding desse modelo, é possível calcular a similaridade semântica entre as sentenças baseado no produto vetorial da cada embedding de sentança do documento com o de cada sentença obtida pelo sumarizador. Assim, o valor de similaridade varia entre 0 e 1, sendo 1 o valor máximo de similaridade.

Para uma melhor visualização, foi utilizado um heatmap, onde quanto mais vermelho, maior a similaridade entre as sentenças.

In [ ]:

```
def print_melhores(doc_melhores_sents, doc_sents):
    for doc in list(doc_melhores_sents.keys()):
        if len(doc_sents[doc]) == 0:
            continue
        print("Documento {}".format(doc))
        a = doc_melhores_sents[doc]
        if a[0] > a[1]:
            print("\t1- ", end="")
            print(" ".join(doc_sents[doc][a[0]]))
            print("\t2- ", end="")
            print(" ".join(doc_sents[doc][a[1]]))
        elif a[0] == a[1]:
            print("\t1- ", end="")
            print(" ".join(doc_sents[doc][a[0]]))
        elif a[0] < a[1]:
            print("\t1- ", end="")
            print(" ".join(doc_sents[doc][a[1]]))
            print("\t2- ", end="")
            print(" ".join(doc_sents[doc][a[0]]))
        print("-"*40)

def get_melhores_sents(doc_melhores_sents, doc_sents):
    doc_melhores_sents_sents = defaultdict(list)
    for doc in list(doc_melhores_sents.keys()):
        if len(doc_sents[doc]) == 0:
            continue
        a = doc_melhores_sents[doc]
        doc_melhores_sents_sents[doc] = [" ".join(doc_sents[doc][a[1]]), " ".join(doc_s
ents[doc][a[0]])]
    return doc_melhores_sents_sents
```

In [ ]:

```
try:
    with open("doc_melhores_sents_sents.pickle", "rb") as fp:
        doc_melhores_sents_sents = pickle.load(fp)
    print("Arquivo 'doc_melhores_sents_sents.pickle' carregado")
except FileNotFoundError as e:
    doc_melhores_sents_sents = get_melhores_sents(doc_melhores_sents, doc_sents)
    with open("doc_melhores_sents_sents.pickle", "wb") as fp:
        pickle.dump(doc_melhores_sents_sents, fp)
```

In [ ]:

```
# Similaridade semântica do sumarizador com o "gabarito"
# Fonte no link abaixo:
# https://colab.research.google.com/github/tensorflow/hub/blob/master/examples/colab/se
mantic_similarity_with_tf_hub_universal_encoder.ipynb
def plot_similarity(labels1, labels2, features1, features2, rotation, title):
    corr = np.inner(features1, features2)
    sns.set(font_scale=1.2)
    g = sns.heatmap(
      corr,
      xticklabels=labels1,
      yticklabels=labels2,
      vmin=0,
      vmax=1,
      cmap="YlOrRd")
    g.set_xticklabels(labels1, rotation=rotation)
    g.set_title(title)
    plt.figure(figsize=(8, 6))
    plt.show()
```

In [ ]:

```
module_url = "https://tfhub.dev/google/universal-sentence-encoder/4"
model = hub.load(module_url)
```

```
INFO:absl:Using /tmp/tfhub_modules to cache modules.
INFO:absl:Downloading TF-Hub Module 'https://tfhub.dev/google/universal-se
ntence-encoder/4'.
INFO:absl:Downloaded https://tfhub.dev/google/universal-sentence-encoder/
4, Total size: 987.47MB
INFO:absl:Downloaded TF-Hub Module 'https://tfhub.dev/google/universal-sen
tence-encoder/4'.
```

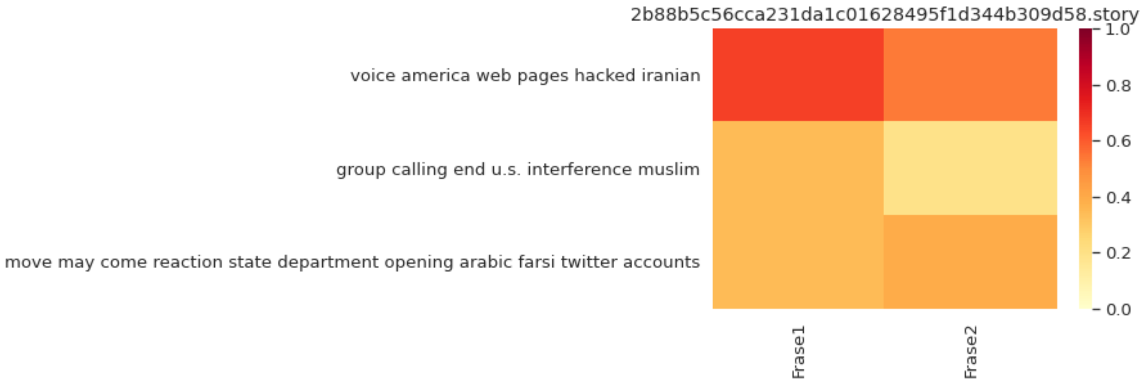
In [ ]:

```
average_corr_list = []
highest_corr_list = []
median_corr_list = []

# Roda a tradução e plota o heatmap da similaridade semântica
for doc in doc_melhores_sents_sents.keys():
    if random() <= 0.97:
        continue
    msgs1 = doc_melhores_sents_sents[doc]
    msgs2 = []
    for sent in doc_sents_highlight[doc]:
        msgs2.append(" ".join(sent))
    f1 = model(msgs1)
    f2 = model(msgs2)
    print(doc)
    for i, sent in enumerate(msgs1):
        print("\tFrase {}: {}".format(i+1, sent))
    corr1 = np.inner(f2,f1)
    avg_corr1 = corr1.mean()
    average_corr_list.append(avg_corr1)
    highest_corr_list.append(np.max(corr1))
    median_corr_list.append(np.median(corr1))
    print(avg_corr1)
    print(np.max(corr1))
    plot_similarity(["Frase1", "Frase2"], msgs2, f2, f1, 90, doc)

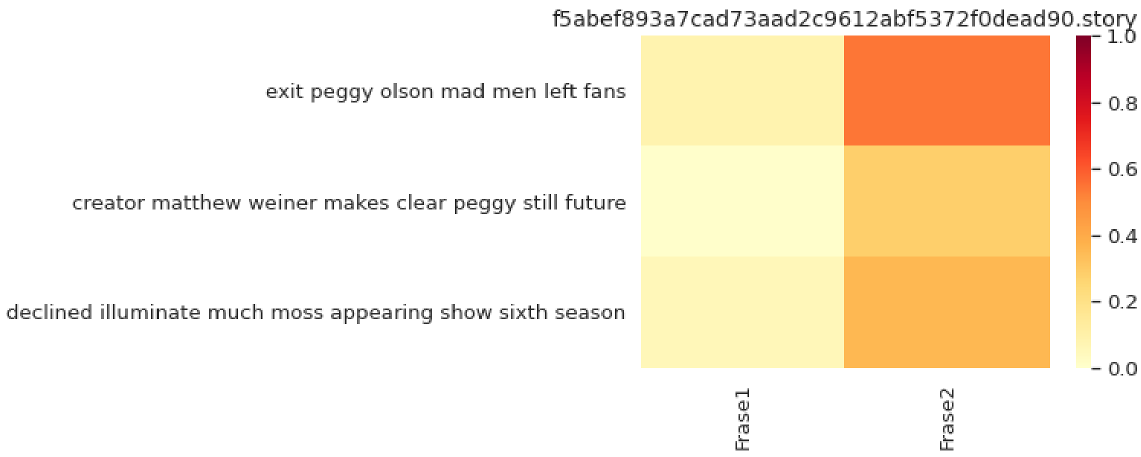

average_corr_total = sum(average_corr_list)/len(average_corr_list)
average_corr_high = sum(highest_corr_list)/len(highest_corr_list)
print("average corr_value for all sumarized docs:")
print(average_corr_total)
print("highest corr_values for each doc: ")
print(highest_corr_list)
print("average high corr_value: ")
print(average_corr_high)
print("median corr_values: ")
print(median_corr_list)
```

```
2b88b5c56cca231da1c01628495f1d344b309d58.story
        Frase 1: group calling iran cyber army claimed responsibility tues
day hacking number voice america internet pages according reports voice am
erica iran semiofficial fars news agency
        Frase 2: voice america noted websites languages including azeri da
ri pashtun urdu also targeted hackers
0.41226497
0.6573256
```



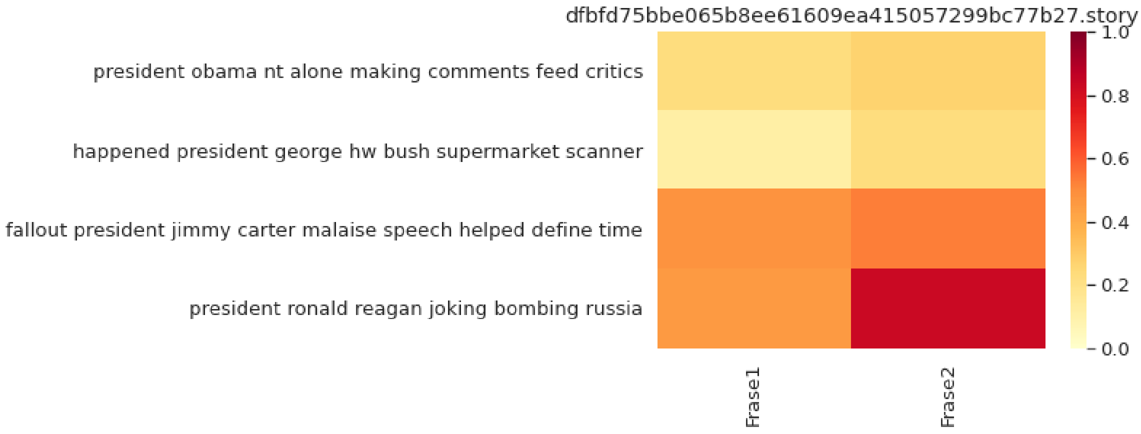

```
<Figure size 576x432 with 0 Axes>
```

```
f5abef893a7cad73aad2c9612abf5372f0dead90.story
        Frase 1: see full story ewcom
        Frase 2: every character show left draper ad agency either never h
eard revisited oneoff episode rarely never heard peggy contrast integral p
art show exploration 1960s thought completely losing emmynominated moss fa
ns wee bit snit course moss appearance final moments season finale certain
ly suggested peggy story complete let get way wild speculation
0.22208893
0.54331803
```



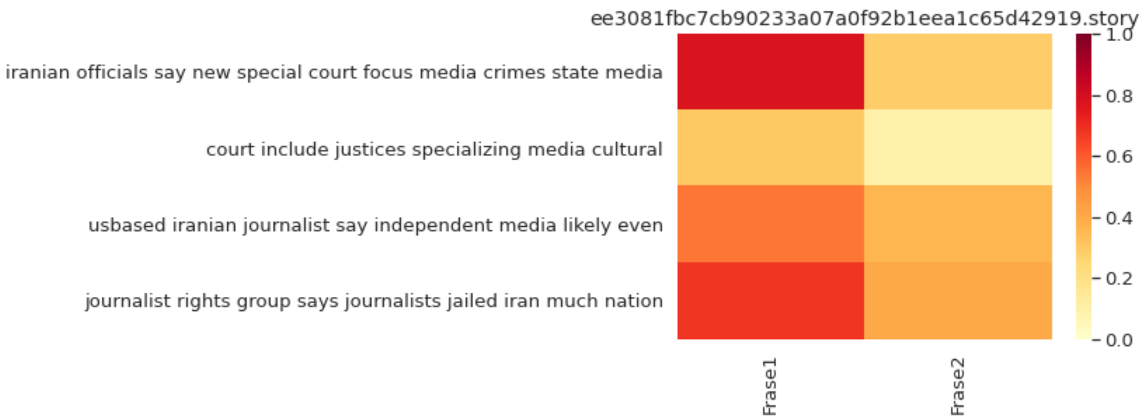

```
<Figure size 576x432 with 0 Axes>
```

```
dfbfd75bbe065b8ee61609ea415057299bc77b27.story
        Frase 1: historian sean wilentz wrote book age reagan carter appea
red abdicating role leader blaming people afflictions
        Frase 2: president ronald reagan bomb
0.39202523
0.8310536
```



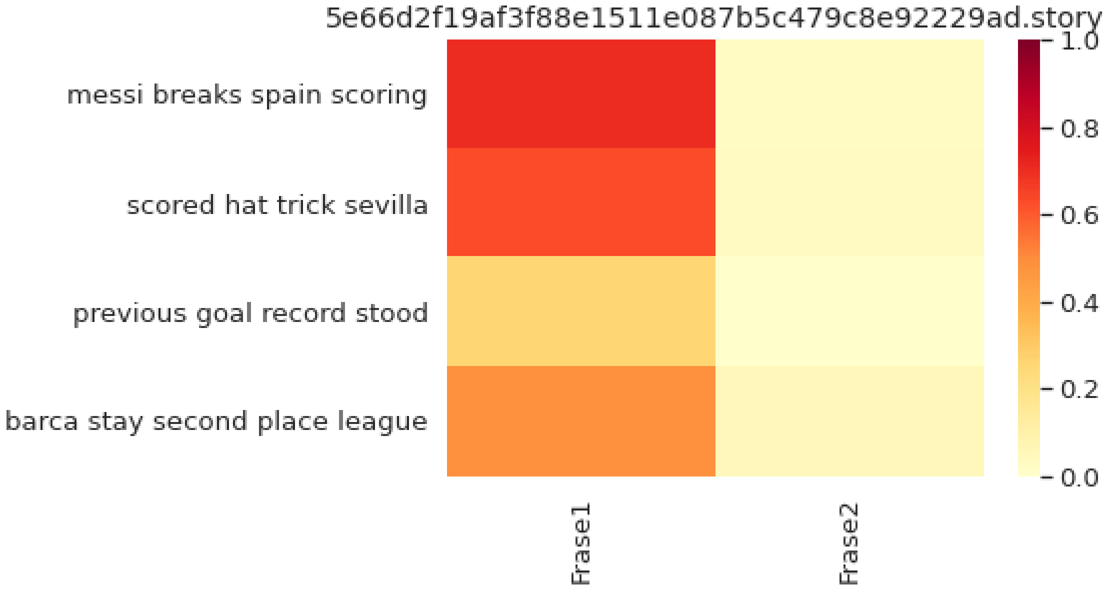

```
<Figure size 576x432 with 0 Axes>

ee3081fbc7cb90233a07a0f92b1eea1c65d42919.story
        Frase 1: iranian officials said sunday middle eastern nation creat
e court focusing media crimes according staterun media reports move fueled
fears tehran intensifying crackdown journalists
        Frase 2: challenge narrative government memarian said noting repor
ts get funneled journalists like posted online anonymously role even nt go
public role
0.43352395
0.7793497
```



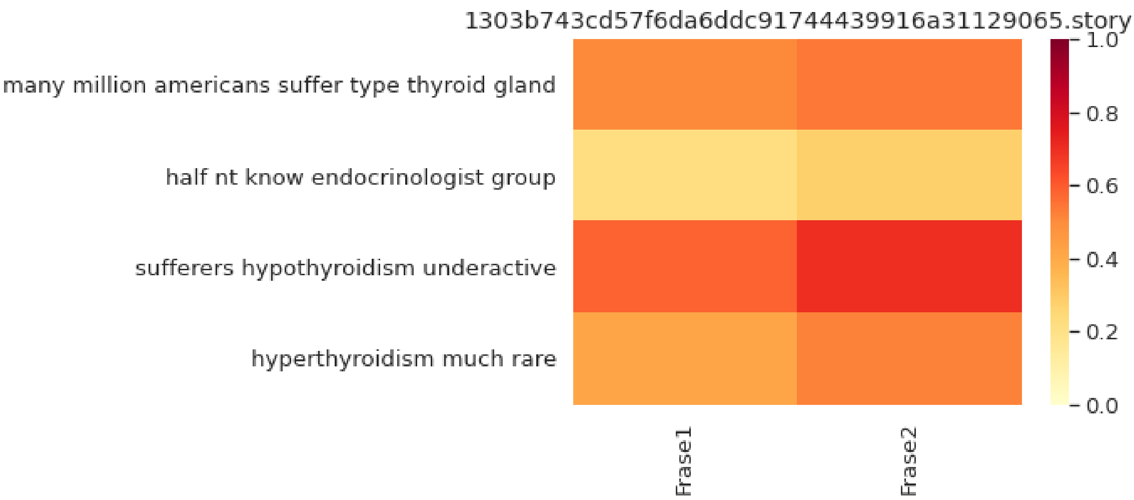

```
<Figure size 576x432 with 0 Axes>

5e66d2f19af3f88e1511e087b5c479c8e92229ad.story
        Frase 1: lionel messi broke spanish league alltime scoring record
hitting hat trick barcelona 51 victory sevilla
        Frase 2: typical
0.2663772
0.7038183
```



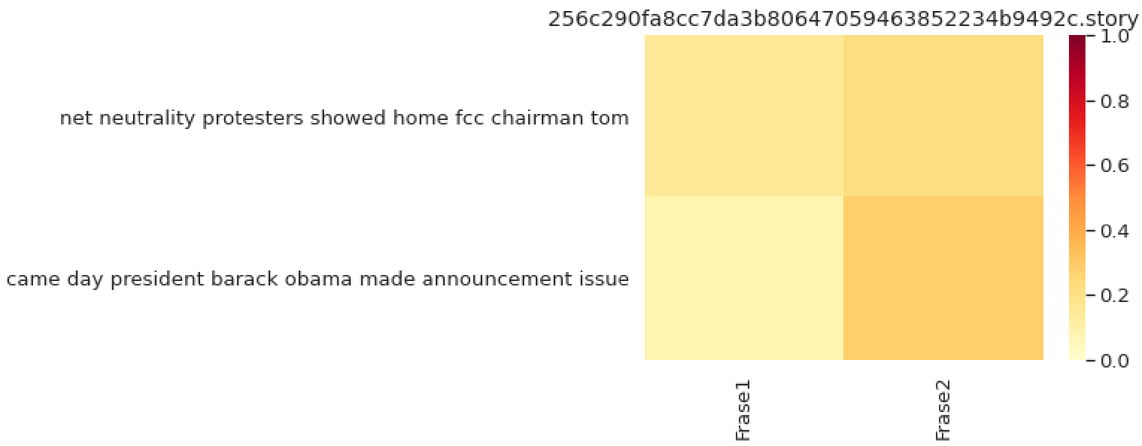

```
<Figure size 576x432 with 0 Axes>
```

```
1303b743cd57f6da6ddc91744439916a31129065.story
        Frase 1: people suffering thyroid dysfunction problems affect wome
n men problem enough hormones made called hypothyroidism symptoms somewhat
elusive probably doctors smith use handy tool help patients identify probl
em actually acronym use hypothyroidism said called sluggish sometimes feel
sluggish might serve red flag might think oh might thyroid
        Frase 2: goiter enlarged thyroid
0.47157514
0.7017699
```



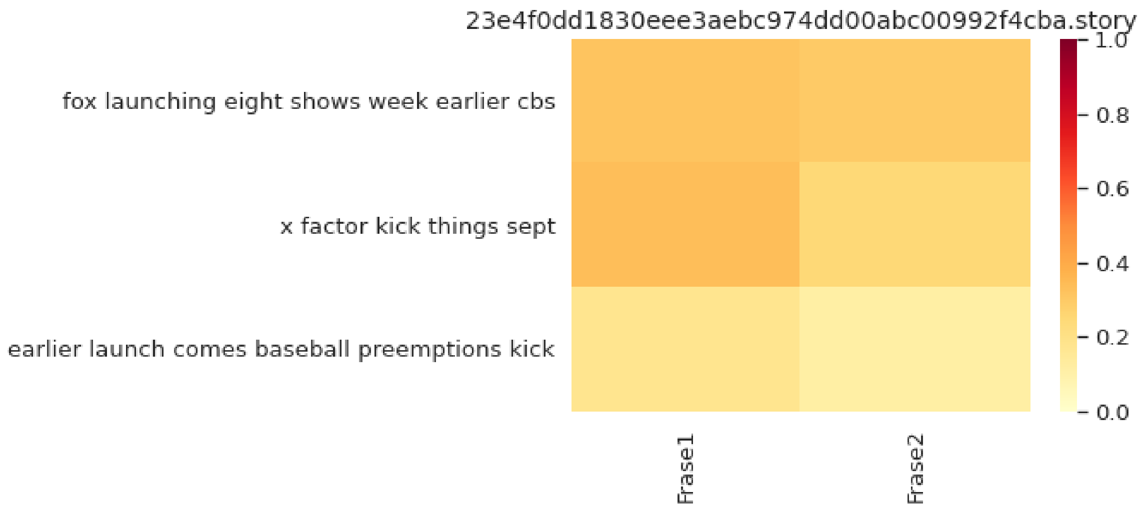

```
<Figure size 576x432 with 0 Axes>
```

```
256c290fa8cc7da3b80647059463852234b9492c.story
        Frase 1: wheeler went inside singing
        Frase 2: margaret flowers organizer popular resistance told decide
d change tone little bit gave wheeler wife bottle wine politely urged chai
rman internet hero adopting president proposals
0.18160552
0.27801406
```



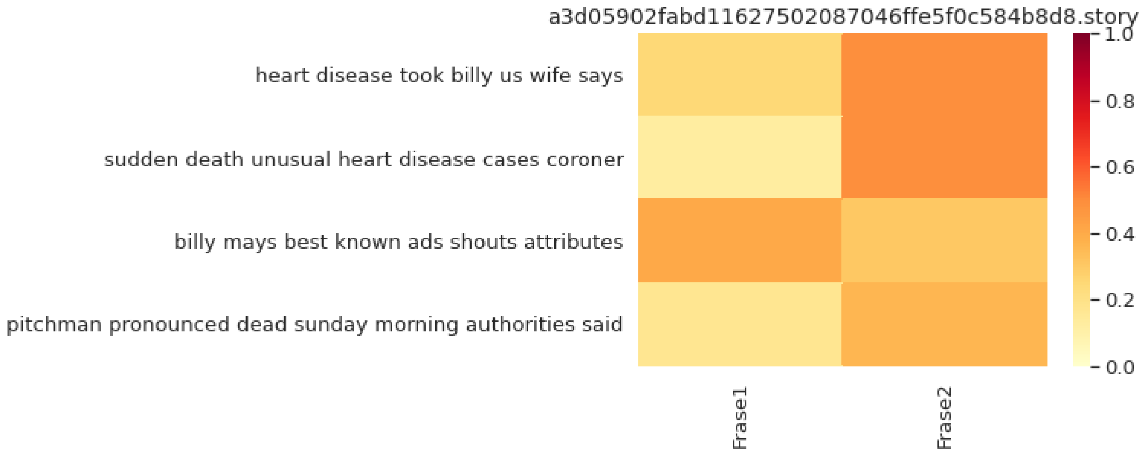

```
<Figure size 576x432 with 0 Axes>

23e4f0dd1830eee3aebc974dd00abc00992f4cba.story
        Frase 1: 900 1000 pm masterchef season finale
        Frase 2: thursday sept
0.24852403
0.33835682
```



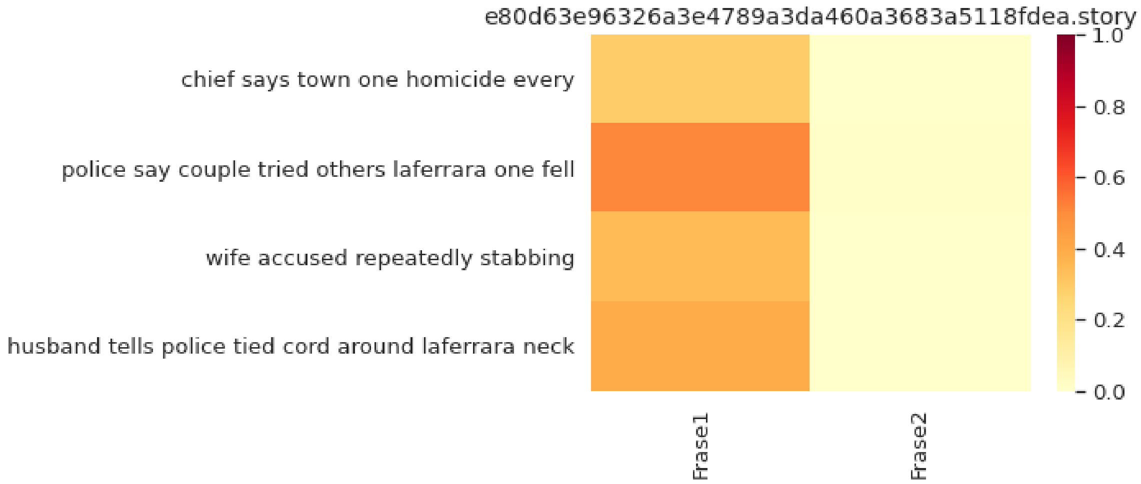

```
<Figure size 576x432 with 0 Axes>

a3d05902fabd11627502087046ffe5f0c584b8d8.story
        Frase 1: discovery channel airs pitchmen cohosted mays issued stat
ement saying incredible sadness report billy mays died sleep last night ev
eryone knows aware largerthanlife personality generosity warmth billy pion
eer field helped many people fulfill dreams greatly missed loyal compassio
nate friend
        Frase 2: autopsy conducted monday morning revealed mays suffered h
ypertensive heart disease adams said
0.3251431
0.49577385
```



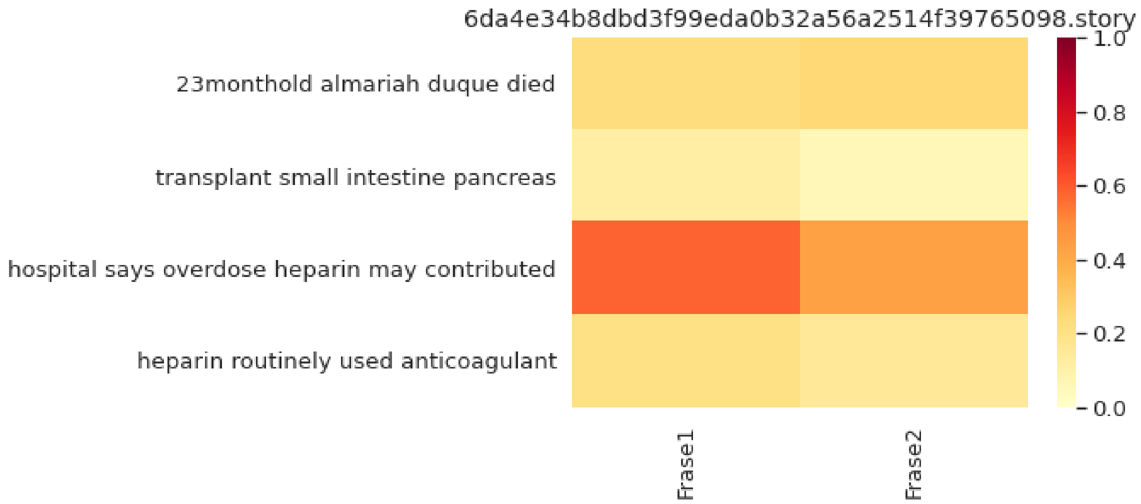

```
<Figure size 576x432 with 0 Axes>

e80d63e96326a3e4789a3da460a3683a5118fdea.story
        Frase 1: barbour told police wife tried kill others plans nt work
        Frase 2:
0.18881646
0.5105136
```



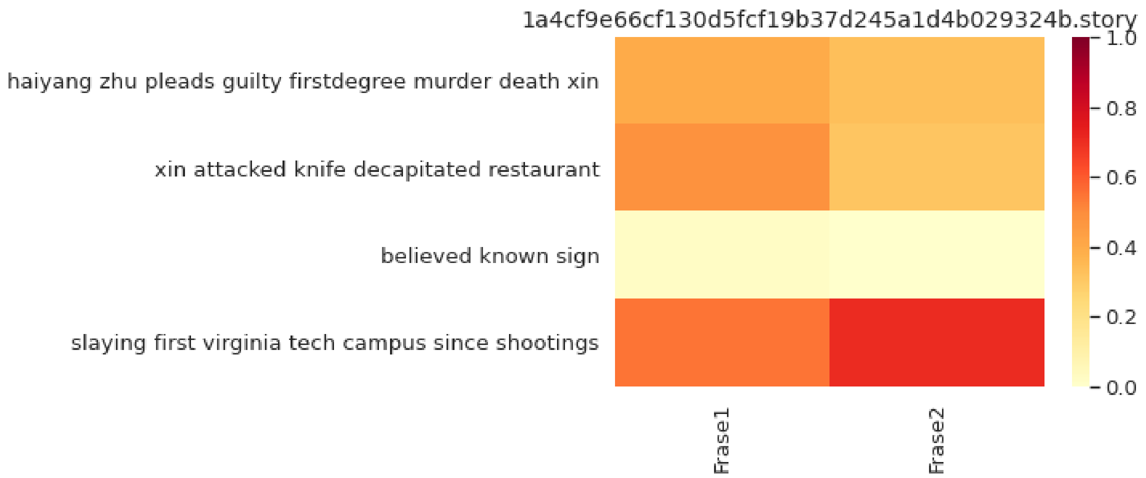

```
<Figure size 576x432 with 0 Axes>

6da4e34b8dbd3f99eda0b32a56a2514f39765098.story
        Frase 1: overdose blood thinner may contributed death nebraska tod
dler omaha hospital treated said thursday
        Frase 2: appears overdose blood thinner heparin may contributed sa
id statement called death deeply troubling emotional incident hospital per
sonnel want extend deepest apologies duque family tragic loss added
0.25362587
0.58291674
```



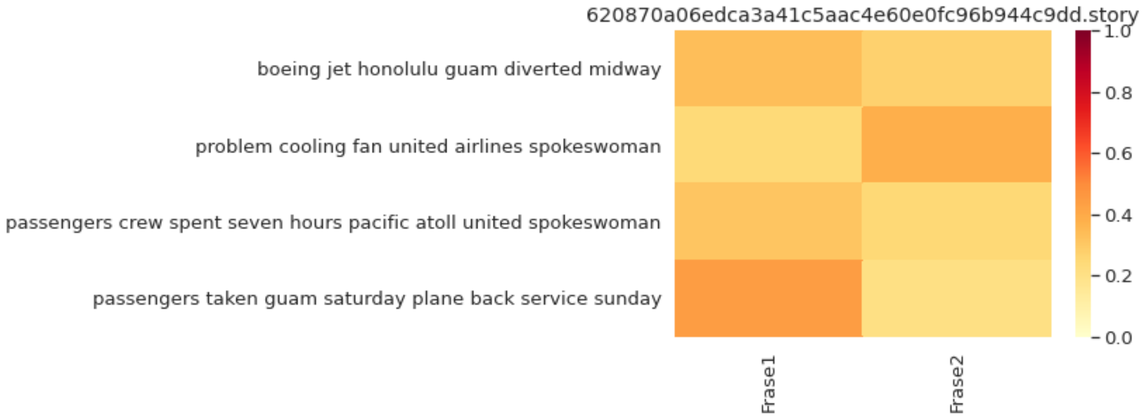

```
<Figure size 576x432 with 0 Axes>

1a4cf9e66cf130d5fcf19b37d245a1d4b029324b.story
        Frase 1: man pleaded guilty monday killing virginia tech graduate
student restaurant january attacking knife decapitating according official
s
        Frase 2: xin slaying first virginia tech campus since april seungh
ui cho killed students professors turning gun
0.34185126
0.7084452
```



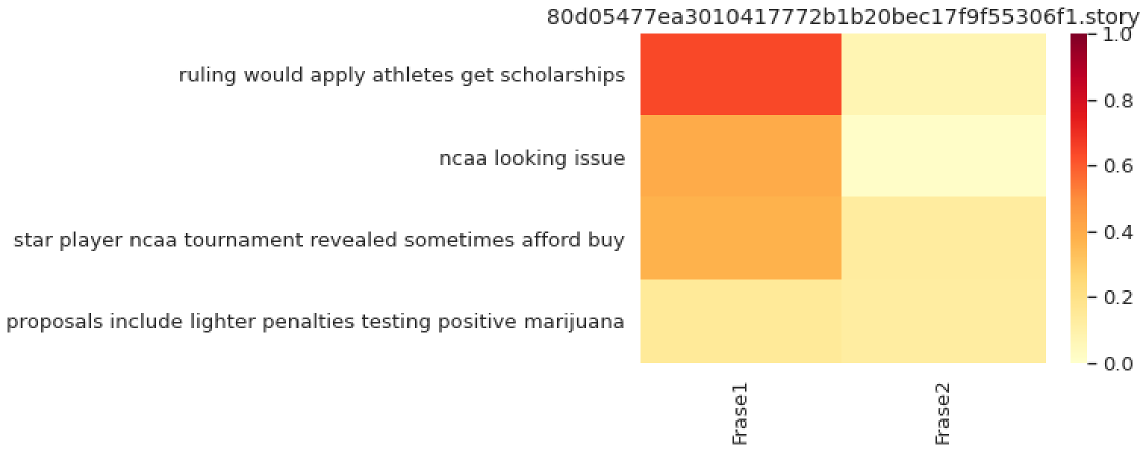

```
<Figure size 576x432 with 0 Axes>
```

```
620870a06edca3a41c5aac4e60e0fc96b944c9dd.story
        Frase 1: guambound united airlines flight forced land remote midwa
y island pilots detected electrical odor experienced mechanical problem ca
rrier said monday
        Frase 2: evacuation slide deploys midair united
0.30863327
0.44882694
```




```
<Figure size 576x432 with 0 Axes>

80d05477ea3010417772b1b20bec17f9f55306f1.story
        Frase 1: ncaa rules say athletes may provided three meals day food
stipend new rule would apply scholarship nonscholarship athletes
        Frase 2: decision legislative council would need approved division
board directors meeting april
0.23752922
0.63704836
```




```
<Figure size 576x432 with 0 Axes>

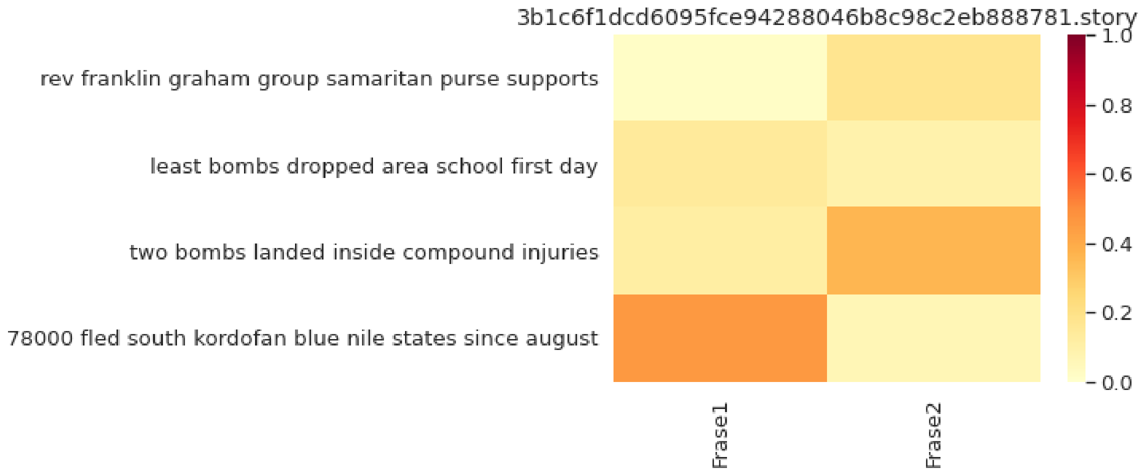
d65e32e79d68a203ce672032446fc2cc5fc6bc89.story
        Frase 1: williams joins martina navratilova steffi graf chris ever
t fourth player ever win wta event six times
        Frase 2: look forward next matches going really fun fans us everyo
ne
0.39866778
0.69921094
```


```
<Figure size 576x432 with 0 Axes>

323c822ef31775a479360563a461074dd9588f4a.story
	Frase 1: even though hillary clinton around nearly entire lifetime 
economist may speak many asks hillary stand paradox presents far bestknown 
presidential candidate across parties moment almost unchallenged within ye
t even though diane feinstein assert confidently hillary nt need white hou
se wants question unanswered liberals believe government something lack de
finition surely disconcerting clinton
	Frase 2: clinton credentials fighter inequality mixed true wall st
reet times notes previously called universal prekindergarten equal pay wom
en increases minimum wage paid family leave higher taxes wealthy expanded 
earned income tax credit workingpoor families counts among friends precise
ly corporate people blamed occupy crowd country inequality clinton wisely 
trying distance clinton foundation fundraising efforts among foreign inter
ests hardly stuff populist liberalism
0.44741216
0.5066891
```

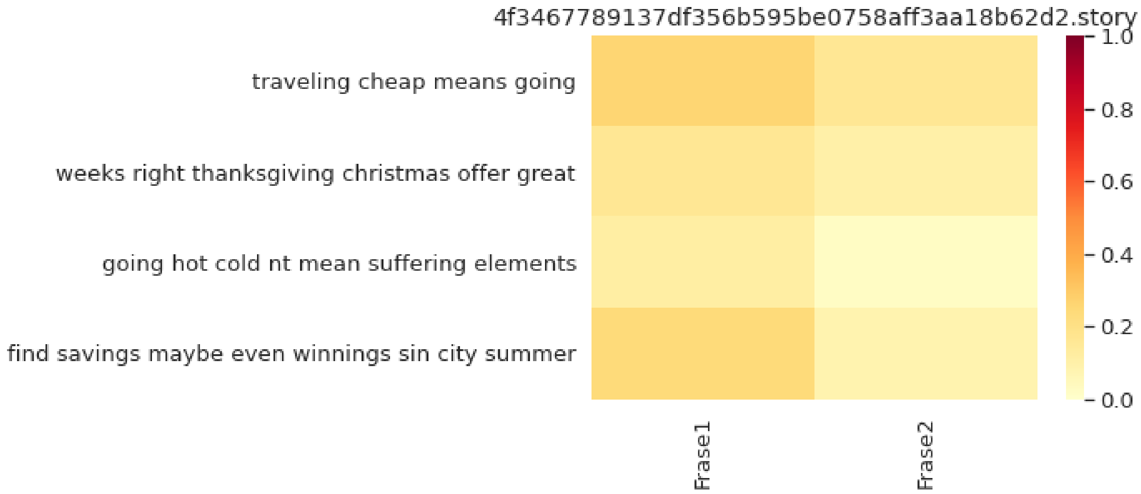

```
<Figure size 576x432 with 0 Axes>

3b1c6f1dcd6095fce94288046b8c98c2eb888781.story
	Frase 1: 78000 people fled south kordofan blue nile states since a
ugust last year armed rebellion took root united nations reported sudanese 
government thought responded rebellion conducting sustained air raids use 
russianmade antonov bombers raised concerns civilian casualties
	Frase 2: miracle one injured statement added
0.17805049
0.45899063
```



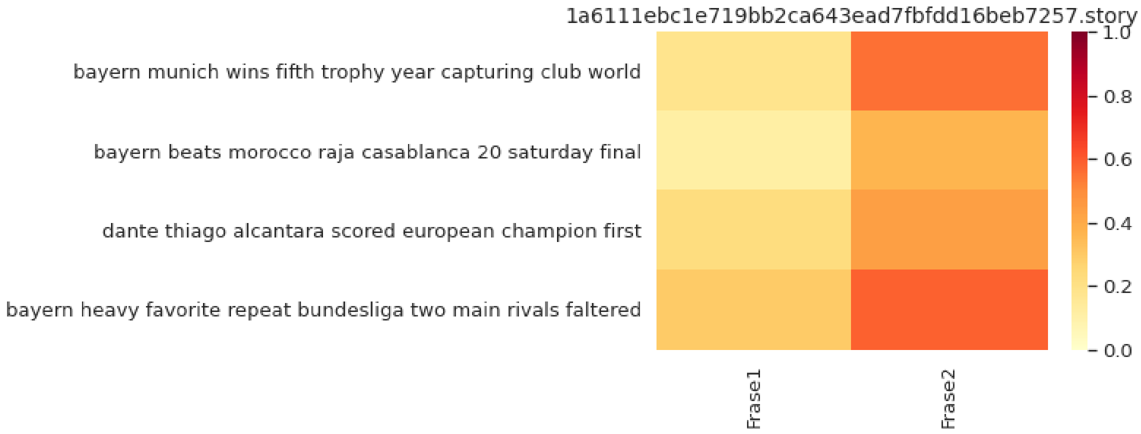

```
<Figure size 576x432 with 0 Axes>

4f3467789137df356b595be0758aff3aa18b62d2.story
	Frase 1: common sense always guide travel europe winter months sta
y deluxe accommodations would cost substantially spring summer seasons sai
d werbin
	Frase 2: want take advantage cheapest time afloat reading cabin ab
oard cruise ship october prethanksgiving november time sail caribbean last
minute deal ohsoeasy wallet fringe hurricane season officially june 1st no
vember 30th remember cruise ships alter routes storm hits whereas resort m
ove path danger
0.14429298
0.26011777
```



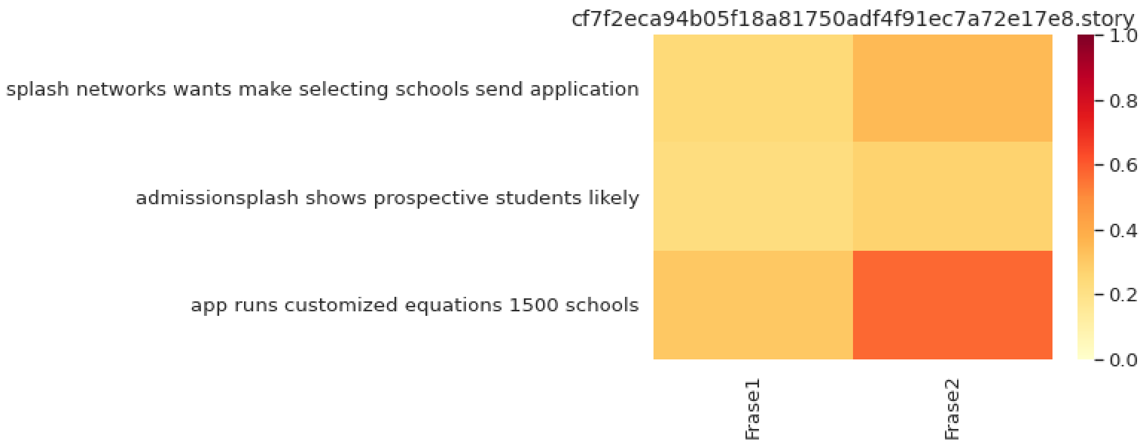

```
<Figure size 576x432 with 0 Axes>

1a6111ebc1e719bb2ca643ead7fbfdd16beb7257.story
	Frase 1: really use break fault klopp told reporters something sta
rted well ended badly
	Frase 2: bayer leverkusen lost second straight league game 10 werd
er bremen borussia dortmund bayern victim champions league final fell 21 h
ome promoted hertha berlin
0.3457499
0.58978564
```



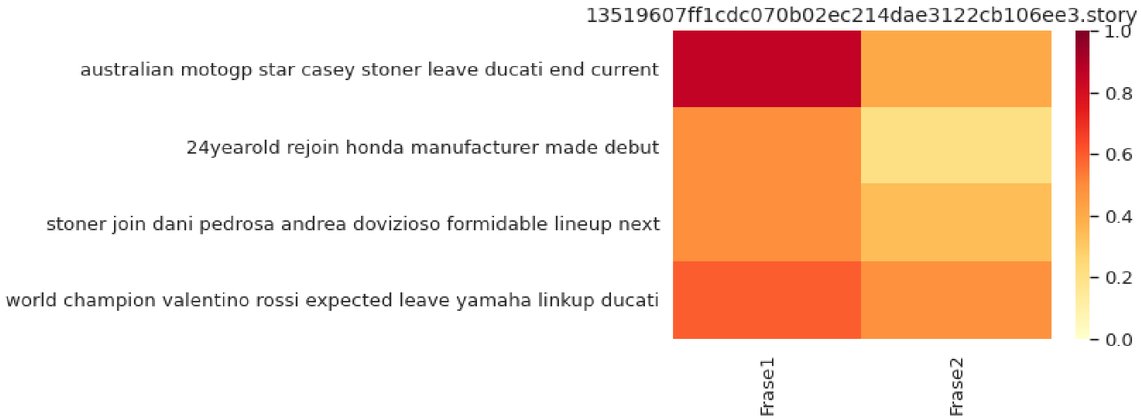

```
<Figure size 576x432 with 0 Axes>

cf7f2eca94b05f18a81750adf4f91ec7a72e17e8.story
        Frase 1: admissionsplash equation definitely nt take essays accoun
t pretty accurate tests use publicly available admissions profiles
        Frase 2: admission splash currently runs customized equations 1500
schools developed using admission data release
0.32815582
0.5741848
```




```
<Figure size 576x432 with 0 Axes>

13519607ff1cdc070b02ec214dae3122cb106ee3.story
        Frase 1: australian motogp star casey stoner leave ducati end seas
on join japanese manufacturer honda
        Frase 2: clearly one top riders motogp bring valuable speed experi
ence team
0.48469913
0.85767806
```




```
<Figure size 576x432 with 0 Axes>
```

```
average corr_value for all sumarized docs:
0.31479106843471527
highest corr_values for each doc:
[0.6573256, 0.54331803, 0.8310536, 0.7793497, 0.7038183, 0.7017699, 0.2780
1406, 0.33835682, 0.49577385, 0.5105136, 0.58291674, 0.7084452, 0.4488269
4, 0.63704836, 0.69921094, 0.5066891, 0.45899063, 0.26011777, 0.58978564,
0.5741848, 0.85767806]
average high corr_value:
0.5791994106201899
median corr_values:
[0.37155735, 0.18378146, 0.36423883, 0.38191545, 0.15478119, 0.51327044,
0.18507472, 0.2723591, 0.33307233, 0.15069698, 0.21647853, 0.3658227, 0.29
544345, 0.13677676, 0.39994246, 0.44859624, 0.12952784, 0.14014912, 0.3290
0342, 0.28963512, 0.4896878]
```

Os resultados mostram que, entre a pequena amostra de validação, a média de similaridade foi de proximadamente 0,3104. Porém, considerando apenas a maior similaridade obtida em cada documento, a média foi de aproximadamente 0,5436 , o que é consideravelmente satisfatório para uma sumarização extrativa.

Há poucos casos em que ambas as frases obtidas apresentam similaridades menores que 0,3. Por outro lado, há poucos casos em que pelo menos uma das frases obtidas apresentam uma similaridade maior que 0,6.

3.2 Tradução

Não foi possível realizar a tradução com o modelo XLM devido a uma [incompatibilidade (https://github.com/facebookresearch/XLM/issues/208)](https://github.com/facebookresearch/XLM/issues/208) do modelo disponibilizado e o método de execução disponibilizado no [repositório oficial (https://github.com/facebookresearch/XLM)](https://github.com/facebookresearch/XLM).

Portanto, provisoriamente, implementou-se o modelo T5, da biblioteca transformers. Para mostrar os resultados, foi selecionada uma pequena amostra de documentos sumarizados. A tradução foi feita do inglês para o alemão, especificado na configuração do modelo.

In [ ]:

```
tokenizer = T5Tokenizer.from_pretrained("t5-base")
model = T5ForConditionalGeneration.from_pretrained("t5-base")

task_specific_params = model.config.task_specific_params
model.config.update(task_specific_params.get("translation_en_to_de", {}))
```

In [ ]:

```
try:
    with open("doc_trans_sents.pickle", "rb") as fp:
        doc_trans_sents = pickle.load(fp)
    print("Arquivo 'doc_trans_sents.pickle' carregado")
except FileNotFoundError as e:
    doc_sents_size = len(doc_sents)
    count = 0
    count2 = 0
    doc_trans_sents = defaultdict(list)
    for doc in list(doc_melhores_sents_sents.keys()):
        if random() <= 0.98:
            print("\r{}/{} - ".format(count, doc_sents_size), end="")
            count += 1
            continue
        print("\r{}/{} - {}".format(count, doc_sents_size, doc), end="")
        count += 1
        count2 += 1
        for sent in doc_melhores_sents_sents[doc]:
            encode_dict = tokenizer.encode_plus(model.config.prefix + " " + sent)     #
 Batch size 1
            input_ids = torch.tensor([encode_dict["input_ids"]])
            translations = model.generate(input_ids=input_ids)
            doc_trans_sents[doc].append(tokenizer.decode(translations[0]))
    print("\r{}/{} - {}".format(count, doc_sents_size, doc))
    print("sumários traduzidos: {} / {}".format(count2, doc_sents_size))
    with open("doc_trans_sents.pickle", "wb") as fp:
        pickle.dump(doc_trans_sents, fp)
```

```
748/749 - b3858ea6ae71f109a7eac9493a1057f0c4f31996.story
sumários traduzidos: 14 / 749
```

In [ ]:

```
for doc in list(doc_trans_sents.keys()):
    print(doc)
    for i in range(len(doc_trans_sents[doc])):
        print("\t{}o - {}".format(i, doc_melhores_sents_sents[doc][i]))
        print("\t{}t - {}".format(i, doc_trans_sents[doc][i]))
```

```
d11cb25a2422515e10b0d3e28dca49e452722248.story
        0o - ashley gallagher alden mahler levine contributed
        0t - ashley gallagher alden mahler levine hat einen Beitrag geleis
tet.
        1o - march government reported abdulhadi alkhawaja low blood press
ure taken bahrain defense force hospital treated returned jau prison follo
wing day
        1t - März Regierung berichtete abdulhadi alkhawaja niedrigen Blutd
ruck genommen bahrain Verteidigungskräfte Krankenhaus behandelt zurück jau
Gefängnis nach Tag.
17811a8d831d26f5a07a7de8cb19aa15d9439491.story
        0o - least two protesters killed oman tv editor asma rshid told
        0t - Mindestens zwei Demonstranten töteten oman TV-Redakteur Asma
rshid erzählte.
        1o - caroline faraj victoria brown contributed report
        1t - caroline faraj victoria brown hat zum Bericht beigetragen.
12cbe2c9597febaf14e4db1e3065d7500082883e.story
        0o - tough night said morgan county executive tim conley fortunate
report four dead could lost whole lot lives thing
        0t - tough night said morgan county executive tim conley lucky rep
ort four dead could lost whole lot lives thing thing.
        1o - storms also moved northern georgia late friday tornado believ
ed struck north georgia paulding county damaging two elementary schools sm
all local airfield undetermined number homes said ashley henson sheriff sp
okesman
        1t - Stürme zogen auch nördlich georgien spät am Freitag Tornado g
laubte getroffen Nord georgien paulding County zerstören zwei Grundschulen
kleine lokale Luftfeld unbestimmt Zahl Häusern sagte Ashley henson Sheriff
Sprecher Sprecher.
e7f3ac9aba6bf4da3ebef503c8aa0dd668d12700.story
        0o - bieber egging silly prank felony lawyers
        0t - bieber egging dumme prank kriminelle Anwälte Anwälte.
        1o - los angeles county sheriff investigators looking evidence bie
ber attacked neighbor home eggs january arrested lil za possession suspect
ed illegal drugs lab tests confirmed one drugs 20yearold rapper possession
mdma also known molly ecstasy sheriff detective said
        1t - los angeles county sheriff investigators looking evidence bie
ber attacked neighbor home eggs january arrested lil za possession suspect
ed illegal drugs lab tests confirmed one drugs 20yearold rapper possession
mdma also known molly ecstasy sheriff detective said.
dd819a01308093d7add90af99ea71728f71aeb25.story
        0o - young man keen disciplined mind buffed body begins presidency
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14c15f0fada8f72953e5c47c73791060ddfb5d28.story
        0o - noe nino de rivera transported hospital november bastrop coun
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attorney adam loewy
        0t - noe nino de rivera transportiert Krankenhaus November Bastrop
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        1o - noe nino de rivera transported hospital november bastrop coun
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4460cac839e1fd62e869482ba11a05d070cf3097.story
        0o - imagine 7yearold boy lsb rsb menace danger family adult peopl
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        1o - case artyem comes russian media focused intense attention sev
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united states surprisingly russians calling end practice foreign adoption
        1t - Fall artyem kommt russischen Medien konzentrierte intensive A
ufmerksamkeit mehrere vorangegangene Fälle in den letzten Jahren Missbrauc
h in Bezug auf adoptierte russische Kinder Vereinigten Staaten überraschen
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47861207a28717d1d99212fdf195fd3e4bb2a469.story
        0o - victory tied vonn austria annemarie moserproell set benchmark
        0t - victory tied vonn austria annemarie moserproell set benchmark
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        1o - although actually stop talking vonn chance hold record outrig
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        1t - obwohl eigentlich aufhören zu reden vonn chance hold record o
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c6f7c3ad07842a4efc05796963dd5ef5c44ec68c.story
        0o - germaphobes take comfort perhaps tanabe tells us soil first l
ab tested heated extreme temperatures kill bacteria process complete tanab
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        0t - germaphobes take comfort vielleicht tanabe sagt uns Boden ers
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        1o - seafood restaurant flavors ocean says also looking flavors ea
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Erde sagt auch Aromen Erde.
07ba82502331100935bbe4033d92e699508737b6.story
        0o - index measured hispanics america first time year index finds
faring slightly better last year compared white counterparts 768 compared
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        0t - index measured hispanics america first time year index finds
faring slightly better last year compared white counterparts 768 compared
revised index 766 league said.
        1o - index also charted growing inequality period rates poverty ho
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ea88f274d215005836beaee5f7bc51bf48aaa210.story
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9236988d18604bb54570c06dc9907c4449caf2c8.story
        0o - roadside bomb smashed army sgt brian saaristo humvee northern
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31868c09854116e5467fdbf968b66a38d57a7638.story
        0o - showing great tennis end last year know dangerous always toug
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        0t - zeigte große Tennis Ende letztes Jahr wissen, gefährlich imme
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        1o - perhaps enticing firstround tussle tournament azarenka ensure
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        1t - vielleicht verlockende erste Runde Kampfturnier azarenka sich
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l jorge bergoglio argentina elected first latino pope nearly 2000year hist
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Os resultados da tradução utilizando o modelo `T5` mostram que, quando ele não é capaz de traduzir ao menos uma parte da sentença esse modelo deixa de realizar a tradução da sentença inteira. Ou seja, há algumas sentenças traduzidas e outras não. Apesar da taxa de tradução não ser tão elevada, as sentenças que foram traduzidas se mostram bem consistentes no quesito de manter o sentido da frase.

Uma das possíveis explicações do porquê o modelo não consegue traduzir algumas sentenças é que estas foram processadas. Portanto, não seguem as regras de sintaxe como o modelo esperava.

4. Conclusão

Pode-se dizer que, em geral, os resultados experimentais deste projeto atingiram um grau de satisfação adequado. Como pretendido, melhorias significativas foram cumpridas no sumarizador do projeto anterior e, foi possível implementar um tradutor, mesmo que este não tenha utilizado o modelo proposto originalmente.

O trabalho também buscou deixar de forma clara, quais foram os métodos utilizados para que se possa trabalhar em melhorias. Apesar de haver muitos pontos que devem e podem ser melhorados, tanto no sumarizador quanto no tradutor, é válido notar que, este trabalho poderá sem dúvida servir como um ponto de partida para outros estudos e projetos no futuro. Por meio desta forma de documentação foi possível trazer o conteúdo estudado de forma sintetizada. Contando também com exemplos práticos e replicáveis.

A satisfação na conclusão deste projeto não está somente nos resultados quantitativos — performance da implementação — mas também na sua documentação. Pois, abre a possibilidade de contribuir com os estudos futuros envolvendo diferentes abordagens.

In [ ]:

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