gptzero_column

April 2, 2023

1 Imports and Data Loading

[ ]:
```
import pandas as pd
import requests
import os
```

[ ]:
```
DATADIR = r"D:\data\claim_identification_corpus"
```

[ ]:
```
essays = pd.read_excel(os.path.join(DATADIR, "essay_scores.xlsx"))
```

2 Extract Essays

[ ]:
```
def get_essay(filename):
    df = pd.read_csv(os.path.join(DATADIR, "Data", filename + ".csv"))

    res = []

    ind_para = 1
    while ind_para < len(df):
        this_para = df['discourse_part'] == "Paragraph_" + str(ind_para)
        if not any(this_para):
            break
        text = ' '.join(df['discourse_text'][this_para])
        res.append(text)
        ind_para += 1

    return '\n'.join(res)
```

[ ]:
```
essays['Text'] = essays['Essay'].apply(get_essay)
```

[ ]:
```
max(essays['Text'].apply(len))
```

[ ]:
```
4273
```

3 Extract Essays by Annotation

[ ]:
```
all_essays = []

for i, row in essays.iterrows():
    try:
        filepath = f"{DATADIR}/Data/{row['Essay']}.csv"
        df = pd.read_csv(filepath)
    except FileNotFoundError as e:
        print(e)
        continue

    df['essay'] = row['Essay']
    df['score'] = row['Holistic Score']

    all_essays.append(df)
```

[ ]:
```
annot = pd.concat(all_essays, ignore_index=True)
annot
```

[ ]:
```
                                    discourse_id discourse_part  \
0         1_MSU_essay|Paragraph_1|Nonannotated|0,20    Paragraph_1
1        1_MSU_essay|Paragraph_2|Nonannotated|0,565    Paragraph_2
2       1_MSU_essay|Paragraph_2|Final_Claim|567,660    Paragraph_2
3               1_MSU_essay|Paragraph_3|Data|0,519    Paragraph_3
4     1_MSU_essay|Paragraph_3|Primary_Claim|521,628    Paragraph_3
…                                               …            …
2259          9b_MSU_essay|Paragraph_2|Data|130,443    Paragraph_2
2260   9b_MSU_essay|Paragraph_3|Primary_Claim|0,170    Paragraph_3
2261          9b_MSU_essay|Paragraph_3|Data|172,489    Paragraph_3
2262   9b_MSU_essay|Paragraph_4|Primary_Claim|0,174    Paragraph_4
2263          9b_MSU_essay|Paragraph_4|Data|176,368    Paragraph_4

     discourse_boundary                                      discourse_text  \
0              (0, 20)                                 Heroes or Celebrities
1             (0, 565)  Celebrities and heroes are often confused in t…
2           (567, 660)  This idea of a hero has been forgotten and sho…
3             (0, 519)  How does one define a hero? Is it because of t…
4           (521, 628)  Although many people do heroic things, they ar…
…                  …                                                  …
2259        (130, 443)  The first time a person learns that a certain …
2260          (0, 170)  It is hard for people to develop new original …
2261        (172, 489)  For example, producers of TV shows strive to p…
2262          (0, 174)  Almost every product one can think of has alre…
2263        (176, 368)  For example, video game consoles have been aro…

     adjudicated_discourse_type adjudicated_effectiveness  \
```

```
0                  Nonannotated                          -
1                  Nonannotated                          -
2                   Final_Claim                   adequate
3                          Data                  effective
4                 Primary_Claim                  effective
…                           …                          …
2259                       Data                   adequate
2260              Primary_Claim                   adequate
2261                       Data                   adequate
2262              Primary_Claim                   adequate
2263                       Data                   adequate

              adjudicated_hierarchical  \
0                                    -
1                                    -
2                                    -
3     Paragraph_3|Primary_Claim|521,628
4       Paragraph_2|Final_Claim|567,660
…                                    …
2259    Paragraph_2|Primary_Claim|0,128
2260    Paragraph_1|Final_Claim|142,726
2261    Paragraph_3|Primary_Claim|0,170
2262    Paragraph_1|Final_Claim|142,726
2263    Paragraph_4|Primary_Claim|0,174

                                    adjudicated_parallel         essay  score
0                                                      -   1_MSU_essay    5.0
1                                                      -   1_MSU_essay    5.0
2                                                      -   1_MSU_essay    5.0
3                                                      -   1_MSU_essay    5.0
4                     Paragraph_4|Primary_Claim|449,553   1_MSU_essay    5.0
…                                                     …           …    …
2259                                                   -  9b_MSU_essay    3.5
2260  Paragraph_2|Primary_Claim|0,128; Paragraph_4|P…  9b_MSU_essay    3.5
2261                                                   -  9b_MSU_essay    3.5
2262  Paragraph_2|Primary_Claim|0,128; Paragraph_3|P…  9b_MSU_essay    3.5
2263                                                   -  9b_MSU_essay    3.5

[2264 rows x 10 columns]
```

[ ]:
```
gpt_sifr = GPT2PPL()
```

[ ]:
```
gpt_sifr.getPPL(annot['discourse_text'][0])
```

[ ]:
```
421
```

[ ]:
```
annot['ppl'] = annot['discourse_text'].apply(gpt_sifr.getPPL)
```

[ ]:
```
annot.to_csv(f"{DATADIR}/AnnotsWithPPL.csv")
```

3.1 For uploading to GPTZero

[ ]:
```
def export_essays(essays, folder = "Exports", extension = "txt"):
    assert 'Text' in essays.columns

    def export(row):
        filename = os.path.join(DATADIR, folder, f"{row['Essay']}.{extension}")
        with open(filename, 'w', encoding='utf-8') as file:
            file.write(row['Text'])

    essays.apply(export, axis=1)
```

[ ]:
```
export_essays(essays)
```

4 GPTZero

The class GPTZeroAPI comes courtesy of https://github.com/Haste171/gptzero.

See https://gptzero.me/docs for more details.

[ ]:
```
class GPTZeroAPI:

    def __init__(self, api_key):
        self.api_key = api_key
        self.base_url = 'https://api.gptzero.me/v2/predict'

    def text_predict(self, document):
        url = f'{self.base_url}/text'
        headers = {
            'accept': 'application/json',
            'X-Api-Key': self.api_key,
            'Content-Type': 'application/json'
        }
        data = {
            'document': document
        }
        response = requests.post(url, headers=headers, json=data)
        return response.json()
```

5 Tayyab and Chua's Implementation

GPTZero costs money to use the API :(

Let's try this version instead, where Tayyab and Chua attempt to imitate GPTZero's methods. They claim that they achieve the same results.

https://github.com/BurhanUlTayyab/GPTZero

[ ]:
```
import torch
import re
from transformers import GPT2LMHeadModel, GPT2TokenizerFast
from collections import OrderedDict
```

```
d:\SadPrograms\anaconda\envs\openai\lib\site-packages\tqdm\auto.py:22:
TqdmWarning: IProgress not found. Please update jupyter and ipywidgets. See
https://ipywidgets.readthedocs.io/en/stable/user_install.html
  from .autonotebook import tqdm as notebook_tqdm
```

[ ]:
```
class GPT2PPL:

    def __init__(self, device = "cpu", model_id = "gpt2"):
        self.device = device
        self.model_id = model_id
        self.model = GPT2LMHeadModel.from_pretrained(model_id).to(device)
        self.tokenizer = GPT2TokenizerFast.from_pretrained(model_id)

        self.max_length = self.model.config.n_positions
        self.stride = 512

    def __call__(self, sentence):
        """Take a sentence split by full stop and print perplexity.

        Burstiness is the max perplexity of each sentence.
        """
        results = OrderedDict()

        total_valid_char = re.findall("[a-zA-Z0-9]+", sentence)
        total_valid_char = sum([len(x) for x in total_valid_char])

        # print(total_valid_char)
        # assert total_valid_char >= 100
        if total_valid_char < 100:
            return

        lines = re.split(r'(?<=[.?!][ \[\(])|(?<=\n)\s*', sentence)
        lines = list(filter(lambda x: (x is not None) and (len(x) > 0), lines))

        ppl = self.getPPL(sentence)
        results['perplexity'] = ppl

        offset = ""
        ppl_per_line = []
        for line in lines:
            if re.search("[a-zA-Z0-9]+", line) == None:
```

```
                continue
            if len(offset) > 0:
                line = offset + line
                offset = ""

            # remove the new line or space in the first sentence if it exists
            if line[0] == '\n' or line[0] == ' ':
                line = line[1:]
            if line[-1] == '\n' or line[-1] == ' ':
                line = line[:-1]
            elif line[-1] == '[' or line[-1] == '(':
                offset = line[-1]
                line = line[:-1]

            ppl = self.getPPL(line)
            ppl_per_line.append(ppl)

        results['ppl_per_line'] = sum(ppl_per_line) / len(ppl_per_line)
        results['burstiness'] = max(ppl_per_line)

        return results

    def getPPL(self, sentence):
        encodings = self.tokenizer(sentence, return_tensors = "pt")
        seq_len = encodings.input_ids.size(1)

        nlls = []
        likelihoods = []
        prev_end_loc = 0
        for begin_loc in range(0, seq_len, self.stride):
            end_loc = min(begin_loc + self.max_length, seq_len)
            trg_len = end_loc - prev_end_loc
            input_ids = encodings.input_ids[:, begin_loc:end_loc]
            input_ids = input_ids.to(self.device)
            target_ids = input_ids.clone()
            target_ids[:, :-trg_len] = -100

            with torch.no_grad():
                outputs = self.model(input_ids, labels = target_ids)
                neg_log_likelihood = outputs.loss * trg_len
                likelihoods.append(neg_log_likelihood)

            nlls.append(neg_log_likelihood)

            prev_end_loc = end_loc
            if end_loc == seq_len:
                break
```

```
        ppl = int(torch.exp(torch.stack(nlls).sum() / end_loc))
        return ppl
```

[ ]:
```
gpt_sifr = GPT2PPL()
```

[ ]:
```
gpt_sifr(essays['Text'][0])
```

```
1965
```

[ ]:
```
OrderedDict([('perplexity', 21),
             ('ppl_per_line', 64.375),
             ('burstiness', 421)])
```

[ ]:
```
def averagePPL(text):
    data = gpt_sifr(text)
    return data['ppl_per_line']
```

[ ]:
```
essays['LinePPL'] = essays['Text'].apply(averagePPL)
```

[ ]:
```
essays
```

[ ]:

	Essay	Number of words	Holistic Score	\
0	1_MSU_essay	426	5.0	
1	10_MSU_essay	262	3.5	
2	100_MSU_essay	191	2.5	
3	100b_MSU_essay	233	3.5	
4	101_MSU_essay	365	1.5	
..	…	…	…	
309	98_MSU_essay	542	4.5	
310	98b_MSU_essay	480	4.0	
311	99_MSU_essay	357	2.5	
312	99b_MSU_essay	378	2.0	
313	9b_MSU_essay	358	3.5	

	Text	LinePPL
0	Heroes or Celebrities\nCelebrities and heroes …	64.375000
1	Musicians, artists, writers, scientists, and m…	46.083333
2	People have the freedom to choose what they wa…	73.214286
3	Anyone can become a celebrity, but to become a…	69.727273
4	Most people at a young age have those certain …	94.900000
..	…	…
309	In our modern day society, it has become commo…	46.407407
310	In an age of celebrity worship, where movie st…	71.562500
311	A limo pulls up, cameras are constantly flashi…	60.941176
312	Heroes and celebrities are clearly different. …	57.136364
313	Originality is purely a measure of what one kn…	46.687500

```
[314 rows x 5 columns]
```

[ ]:
```
essays.to_csv(os.path.join(DATADIR, "EssaysWithPPL.csv"))
```

6 Testing for Difference between GPTZero and TayyabChua

(Written 6pm, 4/2/2023)

The TayyabChua algorithm is identifying as many essays as being as human-written as they are AI-generated. This is a mistake, as all of the essays were human-written. Is this an issue of GPTZero having a lot of false positives, or is it an issue of TayyabChua's implementation being imperfect?

To test this, I am grabbing a random sample of 30 human-written essays from the Claim Identifican Corpus and finding their scores for both GPTZero and TayyabChua.

[ ]:
```
import rpy2

%load_ext rpy2.ipython
```

```
d:\SadPrograms\anaconda\envs\openai\lib\site-
packages\rpy2\robjects\packages.py:367: UserWarning: The symbol 'quartz' is not
in this R namespace/package.
  warnings.warn(
```

[ ]:
```
%%R
library(tidyverse)  # for data manipulation and cleanup
library(magrittr)   # for %>%
library(stats)      # for qqnorm, qqplot

setwd("D:/data/claim_identification_corpus")
```

6.1 Test 1

We expect the result for the TayyabChua to be exactly the same as the result for GPTZero for every essay.

$H_0 : p_{\text{same}} = 0$

$H_\alpha : p_{\text{same}} > 0$

p_{same} is the proportion of all essays in the Claim Identification Corpus that have the exact same perplexity score between GPTZero and TayyabChua (rounded to the nearest whole number).

6.1.1 Random Sample

[ ]:
```
%%R
set.seed(0)

df <- read.csv("EssaysWithPPL.csv") %>%
    rename(filename = Essay,
```

```
            nwords = Number.of.words,
            score = Holistic.Score,
            text = Text,
            tayyabchao = LinePPL)

rows <- df %>%
    nrow %>%
    sample(size=30) %>%
    sort
df <- df[rows, ]

write.csv(df[c("filename", "tayyabchao")], file='RandomSample.csv',
          quote=FALSE)

glimpse(df)
```

```
Rows: 30
Columns: 6
$ X          <int> 19, 24, 36, 38, 39, 41, 43, 69, 78, 84, 88, 104, 110, 120, ~
$ filename   <chr> "108b_MSU_essay", "111_MSU_essay", "125_MSU_essay", "126_MS~
$ nwords     <int> 523, 308, 449, 351, 544, 387, 285, 261, 264, 398, 179, 348,~
$ score      <dbl> 3.0, 4.0, 2.5, 2.0, 4.0, 4.5, 4.5, 4.0, 5.0, 3.5, 3.5, 3.0,~
$ text       <chr> "Heroes are those select people that we should look up to a~
$ tayyabchao <dbl> 66.68000, 104.45000, 98.80000, 79.16000, 110.80488, 91.0625~

Columns: 6
$ X          <int> 19, 24, 36, 38, 39, 41, 43, 69, 78, 84, 88, 104, 110, 120, ~
$ filename   <chr> "108b_MSU_essay", "111_MSU_essay", "125_MSU_essay", "126_MS~
$ nwords     <int> 523, 308, 449, 351, 544, 387, 285, 261, 264, 398, 179, 348,~
$ score      <dbl> 3.0, 4.0, 2.5, 2.0, 4.0, 4.5, 4.5, 4.0, 5.0, 3.5, 3.5, 3.0,~
$ text       <chr> "Heroes are those select people that we should look up to a~
$ tayyabchao <dbl> 66.68000, 104.45000, 98.80000, 79.16000, 110.80488, 91.0625~
```

All files selected in the random sample were uploaded, one-by-one and manually, into the website app.gptzero.me/app/welcome. The average perplexity scores, burtiness scores, highest perplexities, and overall decisions were manually recorded in the file "RandomSampleWithGPTZero.csv".

Notes: - The essay "18b_MSU_essay" has a TayyabChao score of 54.35 and a GPTZero score of 53.350. This is not a typo. - The qualitative category "Your text may include parts written by an AI." seems to partition the analyzed text in a way that is out of the scope of Tayyab & Chao's algorithm.

6.1.2 Proportions Test

[ ]:
```
%%R
df <- read.csv("RandomSampleWithGPTZero.csv")
glimpse(df)
```

```
Rows: 30
```

```
Columns: 7
$ X          <int> 20, 25, 37, 39, 40, 42, 44, 70, 79, 85, 89, 105, 111, 121, ~
$ filename   <chr> "108b_MSU_essay", "111_MSU_essay", "125_MSU_essay", "126_MS~
$ tayyabchao <dbl> 66.68000, 104.45000, 98.80000, 79.16000, 110.80488, 91.0625~
$ gptzero    <dbl> 66.680, 104.450, 98.800, 79.160, 112.850, 91.063, 71.200, 3~
$ burstiness <dbl> 61.515, 83.414, 98.235, 72.862, 150.151, 77.658, 32.601, 18~
$ decision   <chr> "Your text is likely to be written entirely by a human.", "~
$ highestppl <int> 305, 283, 475, 333, 782, 288, 134, 75, 254, 182, 180, 247, ~

Columns: 7
$ X          <int> 20, 25, 37, 39, 40, 42, 44, 70, 79, 85, 89, 105, 111, 121, ~
$ filename   <chr> "108b_MSU_essay", "111_MSU_essay", "125_MSU_essay", "126_MS~
$ tayyabchao <dbl> 66.68000, 104.45000, 98.80000, 79.16000, 110.80488, 91.0625~
$ gptzero    <dbl> 66.680, 104.450, 98.800, 79.160, 112.850, 91.063, 71.200, 3~
$ burstiness <dbl> 61.515, 83.414, 98.235, 72.862, 150.151, 77.658, 32.601, 18~
$ decision   <chr> "Your text is likely to be written entirely by a human.", "~
$ highestppl <int> 305, 283, 475, 333, 782, 288, 134, 75, 254, 182, 180, 247, ~
```

[ ]:
```
%%R
df$exactmatch <- round(df$tayyabchao) == round(df$gptzero)
prop <- sum(!df$exactmatch) / nrow(df)
prop
```

```
[1] 0.2333333
 0.2333333
```

The proportion of essays in this random sample that do not have the same perplexity scores between GPTZero and the TayyabChao algorithm is 23.33%. This value is, well, greater than 0%, so we can be sure that the TayyabChao algorithm does not exactly match GPTZero's scores.

Perhaps it would be worthwhile to find out what the distribution of differences looks like.

6.2 Test 2: Difference Distribution

We'd expect the perplexities given by TayyabChao and GPTZero to at least be similar. Therefore, we predict that the difference between the perplexity for a given essay as determined by TayyabChao and the perplexity determined by GPTZero is approximately 0.

$H_0 : \mu_d = 0$

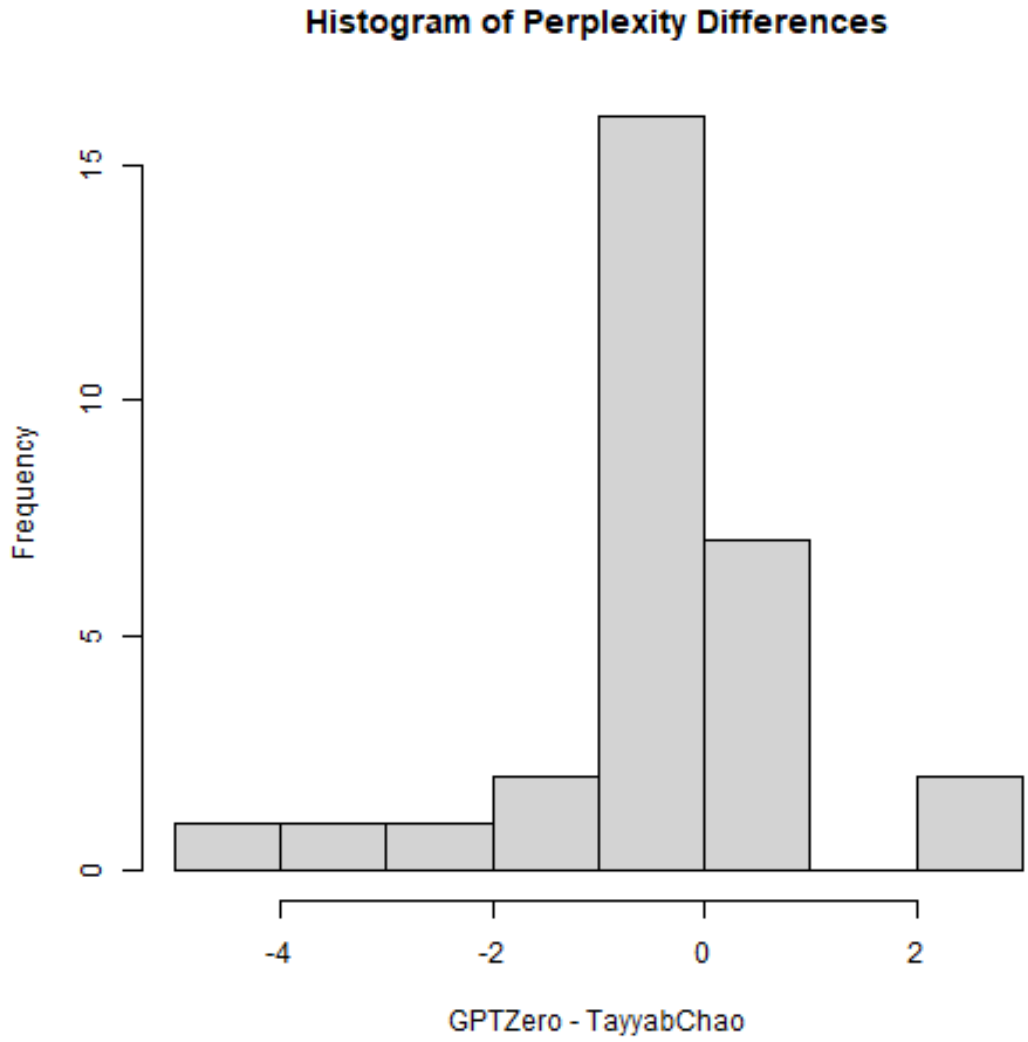
$H_\alpha : \mu_d \neq 0$

μ_d is the average difference between the TayyabChao perplexity and the GPTZero perplexity for each essay in the Claim Identification Corpus.

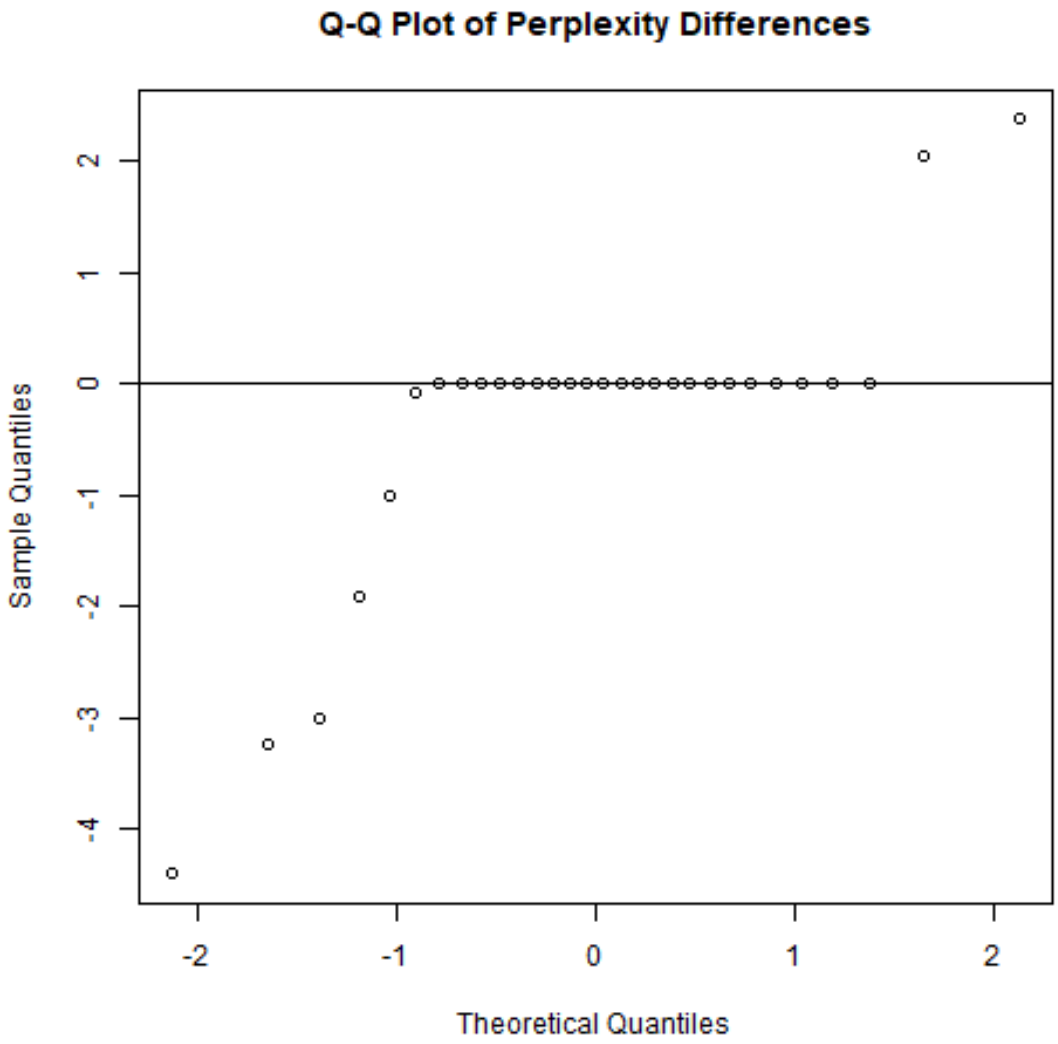
6.2.1 Visualizations

[ ]:
```
%%R
df$difference <- df$gptzero - df$tayyabchao
hist(df$difference,
     main = "Histogram of Perplexity Differences",
```

```
    xlab = "GPTZero - TayyabChao")
```



[ ]:
```
%%R
qqnorm(df$difference, main = "Q-Q Plot of Perplexity Differences")
qqline(df$difference)
```



[ ]:
```
%%R
t.test(x = df$gptzero, y = df$tayyabchao,
       alternative = "two.sided", mu = 0, paired = TRUE, conf.level = 0.99)
```

```
        Paired t-test

data:  df$gptzero and df$tayyabchao
t = -1.2757, df = 29, p-value = 0.2122
alternative hypothesis: true difference in means is not equal to        Paired
t-test

data:  df$gptzero and df$tayyabchao
```

```
t = -1.2757, df = 29, p-value = 0.2122
alternative hypothesis: true difference in means is not equal to 0
99 percent confidence interval:
 -0.9710903  0.3566243
sample estimates:
mean of the differences
              -0.307233
```

Based on the resuling p-value of 0.2122, there is not enough evidence to reject the null hypothesis that $\mu_d = 0$. Furthermore, we can expect 99% of all differences to be between -0.97 and 0.36, so the difference between GPTZero and TayyabChao's perplexities should be negligible.