DA_project_huanghe

November 23, 2023

0.1 PART1 Android Usage

We would like to determine if the usage patterns for android users differ between different devices. For example, do users using Samsung devices use more call minutes than those using LG devices?

[ ]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

[ ]:
```
import pandas as pd
import numpy as np
import seaborn as sns
from matplotlib import pyplot as plt
```

[ ]:
```
user_dev = pd.read_csv('/content/drive/MyDrive/DA/user_device.csv')
print(f"user_device: {user_dev.shape}")
user_use = pd.read_csv('/content/drive/MyDrive/DA/user_usage.csv')
print(f"user_usage: {user_use.shape}")
android_dev = pd.read_csv('/content/drive/MyDrive/DA/android_devices.csv')
print(f"android_devices: {android_dev.shape}")
```

```
user_device: (272, 6)
user_usage: (240, 4)
android_devices: (14546, 4)
```

[ ]:
```
print(f"user_device:\n {user_dev.head()}")
```

```
user_device:
    use_id  user_id platform  platform_version     device  use_type_id
0   22782    26980      ios              10.2  iPhone7,2            2
1   22783    29628  android               6.0    Nexus 5            3
2   22784    28473  android               5.1   SM-G903F            1
3   22785    15200      ios              10.2  iPhone7,2            3
4   22786    28239  android               6.0  ONE E1003            1
```

[ ]:
```
print(f"user_usage:\n {user_use.head()}")
```

```
user_usage:
    outgoing_mins_per_month  outgoing_sms_per_month  monthly_mb  use_id
0                    21.97                    4.82     1557.33   22787
```

```
1                  1710.08                  136.88     7267.55   22788
2                  1710.08                  136.88     7267.55   22789
3                    94.46                   35.17      519.12   22790
4                    71.59                   79.26     1557.33   22792
```

[ ]:
```
print(f"android_devices:\n {android_dev.head()}")
```

```
android_devices:
   Retail Branding Marketing Name    Device                       Model
0             NaN            NaN    AD681H  Smartfren Andromax AD681H
1             NaN            NaN     FJL21                      FJL21
2             NaN            NaN       T31              Panasonic T31
3             NaN            NaN  hws7721g         MediaPad 7 Youth 2
4              3Q        OC1020A   OC1020A                     OC1020A
```

0.1.1 TO DO

you must "connect" the information in :
— *user_usage* and *user_device* to identify the phone that each user is using ;

I specified `inner` as the merge type to indicate that we take the users displayed only in the two dataframes `user_usage` and `user_device`

[ ]:
```
use_dev = pd.merge(user_dev, user_use, how="inner", on="use_id")
use_dev.head()
```

[ ]:
```
   use_id  user_id platform  platform_version    device  use_type_id  \
0   22787    12921  android              4.3  GT-I9505            1
1   22788    28714  android              6.0  SM-G930F            1
2   22789    28714  android              6.0  SM-G930F            1
3   22790    29592  android              5.1     D2303            1
4   22792    28217  android              5.1  SM-G361F            1

   outgoing_mins_per_month  outgoing_sms_per_month  monthly_mb
0                    21.97                    4.82     1557.33
1                  1710.08                  136.88     7267.55
2                  1710.08                  136.88     7267.55
3                    94.46                   35.17      519.12
4                    71.59                   79.26     1557.33
```

[ ]:
```
use_dev.shape
```

[ ]:
```
(159, 9)
```

[ ]:
```
use_dev_android = use_dev[use_dev['platform']=='android']
print(f"Le résultat pour seulement les clients qui prennent la plateforme␣
 ↪android : \n {use_dev_android.shape}")
```

```
Le résultat pour seulement les clients qui prennent la plateforme android :
 (157, 9)
```

— *user_device* and *android_device* to identify the manufacturer of a phone.

[ ]:
```
use_dev_manu = pd.merge(use_dev_android, android_dev, how='left',␣
↪left_on='device', right_on='Model')
use_dev_manu.head()
```

[ ]:
```
   use_id  user_id platform  platform_version    device  use_type_id  \
0   22787    12921  android              4.3  GT-I9505            1
1   22788    28714  android              6.0  SM-G930F            1
2   22789    28714  android              6.0  SM-G930F            1
3   22790    29592  android              5.1     D2303            1
4   22792    28217  android              5.1  SM-G361F            1

   outgoing_mins_per_month  outgoing_sms_per_month  monthly_mb  \
0                    21.97                    4.82     1557.33
1                  1710.08                  136.88     7267.55
2                  1710.08                  136.88     7267.55
3                    94.46                   35.17      519.12
4                    71.59                   79.26     1557.33

  Retail Branding     Marketing Name          Device     Model
0         Samsung          Galaxy S4           jflte  GT-I9505
1         Samsung          Galaxy S7         herolte  SM-G930F
2         Samsung          Galaxy S7         herolte  SM-G930F
3            Sony          Xperia M2           D2303     D2303
4         Samsung  Galaxy Core Prime  coreprimevelte  SM-G361F
```

[ ]:
```
use_dev_manu.shape
```

[ ]:
```
(209, 13)
```

— for the 4 most commons device manufacturers

[ ]:
```
most_manu = use_dev_manu["Retail Branding"].value_counts()[:4]
most_manu
```

[ ]:
```
Samsung     108
HTC          44
Sony         16
Motorola     16
Name: Retail Branding, dtype: int64
```

— plotting

`pd.isin(values)` which checks whether each retail branding item that would be presented in the`["Samsung", "HTC", "Sony", "Motorola"]`

[ ]:
```
info = use_dev_manu[use_dev_manu["Retail Branding"].isin(["Samsung", "HTC",␣
↪"Sony", "Motorola"])]
```

```
info.shape
```

[ ]: (184, 13)

[ ]:
```
info.head()
```

[ ]:

	use_id	user_id	platform	platform_version	device	use_type_id	\
0	22787	12921	android	4.3	GT-I9505	1	
1	22788	28714	android	6.0	SM-G930F	1	
2	22789	28714	android	6.0	SM-G930F	1	
3	22790	29592	android	5.1	D2303	1	
4	22792	28217	android	5.1	SM-G361F	1	

	outgoing_mins_per_month	outgoing_sms_per_month	monthly_mb	\
0	21.97	4.82	1557.33	
1	1710.08	136.88	7267.55	
2	1710.08	136.88	7267.55	
3	94.46	35.17	519.12	
4	71.59	79.26	1557.33	

	Retail Branding	Marketing Name	Device	Model
0	Samsung	Galaxy S4	jflte	GT-I9505
1	Samsung	Galaxy S7	herolte	SM-G930F
2	Samsung	Galaxy S7	herolte	SM-G930F
3	Sony	Xperia M2	D2303	D2303
4	Samsung	Galaxy Core Prime	coreprimevelte	SM-G361F

[ ]:
```
to_plot = pd.melt(info, id_vars=["Retail Branding"],␣
↪value_vars=["outgoing_mins_per_month", "outgoing_sms_per_month"])
to_plot.head()
```

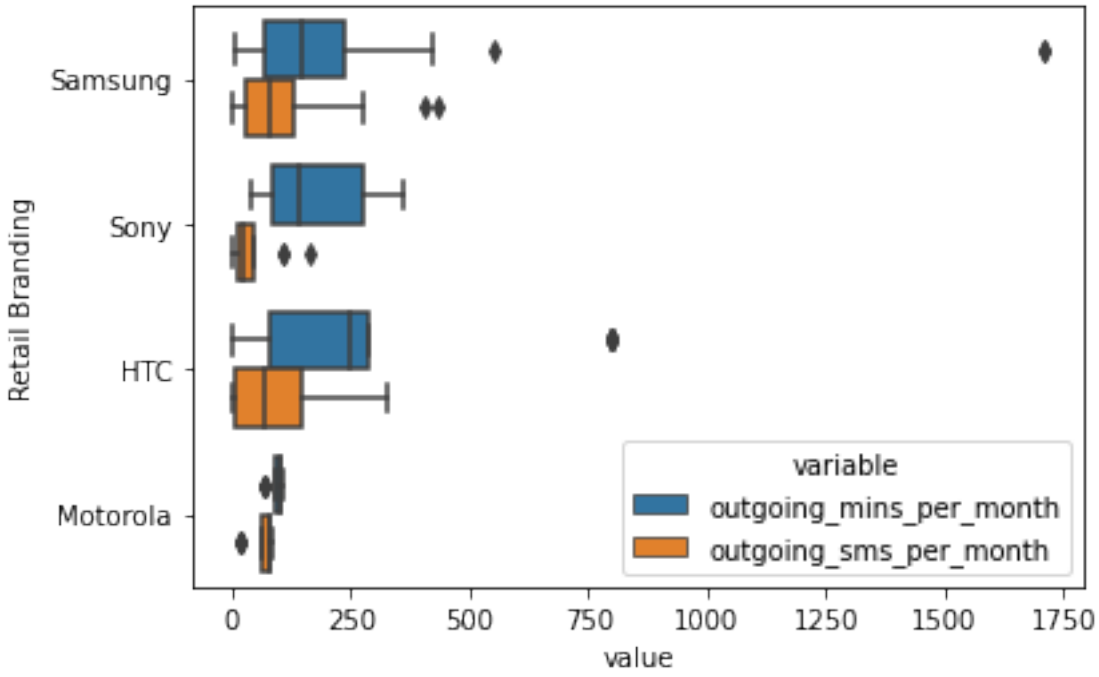
[ ]:

	Retail Branding	variable	value
0	Samsung	outgoing_mins_per_month	21.97
1	Samsung	outgoing_mins_per_month	1710.08
2	Samsung	outgoing_mins_per_month	1710.08
3	Sony	outgoing_mins_per_month	94.46
4	Samsung	outgoing_mins_per_month	71.59

`pd.melt()` is useful for keeping all brands as column and transforming mins and sms expenses as variables.

[ ]:
```
sns.boxplot(data=to_plot, x="value", y="Retail Branding", hue="variable")
```

[ ]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa681417d30>



0.2 PART2 Identifiying Gender Bias in NMT predictions

The corpus is represented by a DataFrame with the following columns :
— *tokenized_fra*, *tokenized_eng* the source sentence and its reference translation (tokenized by SentencePiece);
— *proba_his_tm*, *proba_her_tm* the probability that a MT system generates “his” or “her” when translating the source sentence ;
— *proba_his_lm*, *proba_her_lm* the probability that a MT system generates “his” or “her” when it has no access to the source sentence.

[ ]:
```
corpus = pd.read_csv("/content/drive/MyDrive/DA/corpus.csv")
corpus.head()
```

[ ]:
```
                                    tokenized_fra  \
0       l ' abat teur  a  terminé  son  travail .
1     l ' abat t euse  a  terminé  son  travail .
2           l ' abbé  a  terminé  son  travail .
3       l ' a bb esse  a  terminé  son  travail .
4  l ' aca dé mic ien  a  terminé  son  travail .

                                  tokenized_eng  proba_his_tm  proba_her_tm  \
0  the  slaughter er  has  finished  his  work .      0.464239      0.046879
1  the  slaughter er  has  finished  her  work .      0.461334      0.056800
2        the  abbot  has  finished  his  work .      0.884117      0.010301
3     the  a bb ess  has  finished  her  work .      0.273272      0.098643
```

```
4   the  academic ian  has  finished  his  work .      0.632505      0.066412

   proba_his_lm  proba_her_lm
0      0.135776      0.010176
1      0.135776      0.010176
2      0.221838      0.025174
3      0.038563      0.014677
4      0.217720      0.005785
```

0.2.1 Question 1

[ ]:
```
# How many sentences are there in the corpus?
corpus.shape[0]
```

[ ]:
```
3398
```

0.2.2 Question 2

For each sentence add a column containing the following information :

[ ]:
```
# - the English job name
corpus["eng_job"] = corpus["tokenized_eng"].str.split(r" the  | has  *").str[1].
 ↪str.strip()
corpus["eng_job"]
```

[ ]:
```
0         slaughter er
1         slaughter er
2                abbot
3            a bb ess
4         academic ian
             …
3393    z y th ologist
3394               boy
3395              girl
3396               man
3397             woman
Name: eng_job, Length: 3398, dtype: object
```

[ ]:
```
# - the English pronoun
corpus["eng_pronoun"] = corpus["tokenized_eng"].str.split(r" ").str[-2].str.
 ↪strip()
corpus["eng_pronoun"]
```

[ ]:
```
0       his
1       her
2       his
3       her
4       his
```

```
       …
3393    her
3394    his
3395    her
3396    his
3397    her
Name: eng_pronoun, Length: 3398, dtype: object
```

[ ]:
```
# - the French job name
corpus["fra_job"] = corpus["tokenized_fra"].str.split(r" | a  *|'").str[2].str.
 ↪strip()
corpus["fra_job"]
```

[ ]:
```
0            abat teur
1          abat t euse
2                abbé
3            a bb esse
4       aca dé mic ien
             …
3393      z yth ologue
3394           garçon
3395            fille
3396            homme
3397            femme
Name: fra_job, Length: 3398, dtype: object
```

[ ]:
```
# - the French determiner
corpus["fra_det"] = corpus["tokenized_fra"].str.split(r" |'").str[1].str.strip()
corpus["fra_det"]
```

[ ]:
```
0       l
1       l
2       l
3       l
4       l
       ..
3393    la
3394    le
3395    la
3396     l
3397    la
Name: fra_det, Length: 3398, dtype: object
```

[ ]:
```
# - the number of tokens in the French job name
corpus["job_tk_fr"] = corpus["fra_job"].str.split().str.len()
corpus["job_tk_fr"]
```

[ ]:
```
0       2
1       3
2       1
3       3
4       4
       ..
3393    3
3394    1
3395    1
3396    1
3397    1
Name: job_tk_fr, Length: 3398, dtype: int64
```

[ ]:
```
# - the number of tokens in the English job name
corpus["job_tk_en"] = corpus["eng_job"].str.split().str.len()
corpus["job_tk_en"]
```

[ ]:
```
0       2
1       2
2       1
3       3
4       2
       ..
3393    4
3394    1
3395    1
3396    1
3397    1
Name: job_tk_en, Length: 3398, dtype: int64
```

[ ]:
```
corpus[["tokenized_fra", "tokenized_eng", "fra_job", "fra_det", "eng_job",␣
 ↪"eng_pronoun", "job_tk_fr", "job_tk_en"]]
```

[ ]:
```
                                      tokenized_fra  \
0          l ' abat teur  a  terminé  son  travail .
1        l ' abat t euse  a  terminé  son  travail .
2              l ' abbé  a  terminé  son  travail .
3          l ' a bb esse  a  terminé  son  travail .
4     l ' aca dé mic ien  a  terminé  son  travail .
…                                                 …
3393    la  z yth ologue  a  terminé  son  travail .
3394             le garçon  a  fini  son  travail .
3395              la fille  a  fini  son  travail .
3396              l ' homme  a  fini  son  travail .
3397              la femme  a  fini  son  travail .

                                       tokenized_eng         fra_job  \
```

```
0       the  slaughter er  has  finished  his  work .       abat teur
1       the  slaughter er  has  finished  her  work .     abat t euse
2             the  abbot  has  finished  his  work .            abbé
3           the  a bb ess  has  finished  her  work .       a bb esse
4       the  academic ian  has  finished  his  work .  aca dé mic ien
…                                                  …            …
3393  the  z y th ologist  has  finished  her  work .    z yth ologue
3394            the  boy  has  finished  his  work .          garçon
3395           the  girl  has  finished  her  work .           fille
3396            the  man  has  finished  his  work .           homme
3397          the  woman  has  finished  her  work .           femme
```

```
     fra_det         eng_job eng_pronoun  job_tk_fr  job_tk_en
0          l    slaughter er         his          2          2
1          l    slaughter er         her          3          2
2          l           abbot         his          1          1
3          l       a bb ess          her          3          3
4          l    academic ian         his          4          2
…      …             …         …        …        …
3393      la  z y th ologist         her          3          4
3394      le             boy         his          1          1
3395      la            girl         her          1          1
3396       l             man         his          1          1
3397      la           woman         her          1          1

[3398 rows x 8 columns]
```

0.2.3 Question 3

Add a column indicating whether the French occupational noun is epicene or not ; do the same for the English occupational noun.
What is the proportion of epicene noun in English? in French?

Note

`DataFrame.duplicated(subset=None, keep='first')`
Returns Boolean series indicating duplicate lines. By setting keep to False, all duplicate elements are True.

[ ]:
```
corpus["fra_epicene"] = corpus["fra_job"].duplicated(keep=False)
corpus["eng_epicene"] = corpus["eng_job"].duplicated(keep=False)
```

[ ]:
```
corpus[["fra_job", "fra_epicene", "eng_job", "eng_epicene"]]
```

[ ]:
```
          fra_job  fra_epicene         eng_job  eng_epicene
0       abat teur        False    slaughter er         True
1     abat t euse        False    slaughter er         True
2            abbé        False           abbot        False
3       a bb esse        False       a bb ess        False
```

```
4     aca dé mic ien        False    academic ian         True
…              …          …             …          …
3393    z yth ologue         True  z y th ologist         True
3394          garçon         True             boy        False
3395           fille        False            girl        False
3396           homme        False             man        False
3397           femme        False           woman        False

[3398 rows x 4 columns]
```

[ ]:
```
epicene_fra = corpus["fra_epicene"].value_counts(normalize=True).to_dict()
print("Proportion of epicene nouns in French : {:.2%}".
 ↪format(epicene_fra[True]))
```

```
Proportion of epicene nouns in French : 32.55%
```

[ ]:
```
epicene_eng = corpus["eng_epicene"].value_counts(normalize=True).to_dict()
print("Proportion of epicene nouns in English : {:.2%}".
 ↪format(epicene_eng[True]))
```

```
Proportion of epicene nouns in English : 95.20%
```

0.2.4 Question 4

Compute the accuracy of the MT system, i.e. the proportion of sentences in which the English possessive pronoun is correctly predicted (i.e. p(her) > p(his for a feminine occupational noun)

Note
DataFrame.idxmax(axis=0, skipna=True, numeric_only=False) to compare the values of `proba_his_tm` and `proba_her_tm` and return the index of the maximum value.

[ ]:
```
# Compare the probabilities of the two columns to find the index of the maximum␣
 ↪value
corpus["pred_tm"] = corpus[["proba_his_tm", "proba_her_tm"]].idxmax(axis=1)
```

[ ]:
```
# Extraction of gender pronouns
corpus["pred_tm"] = corpus["pred_tm"].str.split("_").str[1]
```

[ ]:
```
accuracy_tm = corpus['pred_tm'].eq(corpus['eng_pronoun']).sum() / len(corpus)
print('The accuracy of TM system : {:.2%}'.format(accuracy_tm))
```

```
The accuracy of TM system : 69.04%
```

[ ]:
```
corpus["pred_lm"] = corpus[["proba_his_lm", "proba_her_lm"]].idxmax(axis=1)
corpus["pred_lm"]  = corpus["pred_lm"].str.split("_").str[1]
```

[ ]:
```
accuracy_lm = corpus["pred_lm"].eq(corpus["eng_pronoun"]).sum() / len(corpus)
print('The accuracy of LM system : {:.2%}'.format(accuracy_lm))
```

```
The accuracy of LM system : 51.21%
```

Gender can be marked in French in four different ways (by the determiner only, the noun only, the determiner and the noun or it can not be marked.

0.2.5 Question 5

List 5 random examples for each possible way to express gender in French.

[ ]:
```
# Determiner only

det_only = corpus[(corpus['fra_epicene']) & (corpus['fra_det'] != "l")]
det_only.sample(5)
```

[ ]:
```
                                        tokenized_fra  \
1506     le  gem m ologue  a  terminé  son  travail .
1817       la  kayak iste  a  terminé  son  travail .
3394              le  garçon  a  fini  son  travail .
1083  la  disc - jo c key  a  terminé  son  travail .
1390       le  fi ch iste  a  terminé  son  travail .

                                      tokenized_eng  proba_his_tm  \
1506  the  gem m ologist  has  finished  his  work .      0.772477
1817       the  kayak er  has  finished  her  work .      0.420029
3394            the  boy  has  finished  his  work .      0.748713
1083   the  disc  jockey  has  finished  her  work .      0.378013
1390  the  file  keep er  has  finished  his  work .      0.711503

      proba_her_tm  proba_his_lm  proba_her_lm        eng_job eng_pronoun  \
1506      0.013025      0.260967      0.013271  gem m ologist         his
1817      0.160482      0.067639      0.008779       kayak er         her
3394      0.020850      0.111514      0.050345            boy         his
1083      0.040822      0.024312      0.005140   disc  jockey         her
1390      0.010379      0.087557      0.003950  file  keep er         his

              fra_job fra_det  job_tk_fr  job_tk_en  fra_epicene  eng_epicene  \
1506     gem m ologue      le          3          3         True         True
1817       kayak iste      la          2          2         True         True
3394           garçon      le          1          1         True        False
1083  disc - jo c key      la          5          2         True         True
1390       fi ch iste      le          3          3         True         True

     pred_tm pred_lm
1506     his     his
1817     his     his
3394     his     his
1083     his     his
1390     his     his
```

[ ]:
```
# Noun only

noun_only = corpus[(corpus['fra_epicene']==False) & (corpus['fra_det'] == "l")]
noun_only.sample(5)
```

[ ]:
```
                                      tokenized_fra  \
66            l ' agent  a  terminé  son  travail .
1290   l ' es qui sseur  a  terminé  son  travail .
27     l ' ac qué reuse  a  terminé  son  travail .
1734     l ' inspecteur  a  terminé  son  travail .
1181     l ' égout ière  a  terminé  son  travail .

                                       tokenized_eng  proba_his_tm  \
66           the  officer  has  finished  his  work .      0.673676
1290       the  sketch er  has  finished  his  work .      0.540579
27             the  buyer  has  finished  her  work .      0.502121
1734       the  inspector  has  finished  his  work .      0.668345
1181   the  sewer  worker  has  finished  her  work .      0.094032

      proba_her_tm  proba_his_lm  proba_her_lm        eng_job eng_pronoun  \
66        0.047579      0.189192      0.011586        officer         his
1290      0.065499      0.032057      0.014761      sketch er         his
27        0.052266      0.085017      0.000388          buyer         her
1734      0.023499      0.222380      0.014660      inspector         his
1181      0.043475      0.064093      0.002792  sewer  worker         her

           fra_job fra_det  job_tk_fr  job_tk_en  fra_epicene  eng_epicene  \
66           agent       l          1          1        False         True
1290  es qui sseur       l          3          2        False         True
27    ac qué reuse       l          3          1        False         True
1734    inspecteur       l          1          1        False         True
1181    égout ière       l          2          2        False         True

     pred_tm pred_lm
66       his     his
1290     his     his
27       his     his
1734     his     his
1181     his     his
```

[ ]:
```
# Determiner and noun

det_and_noun = corpus[(corpus['fra_epicene']==False) & (corpus['fra_det'] !=␣
 ↪"l")]
det_and_noun.sample(5)
```

[ ]:
```
                                        tokenized_fra  \
1134              le  du c  a  terminé  son  travail .
1035       la  détache use  a  terminé  son  travail .
1070         le  diffuseur  a  terminé  son  travail .
3329       la  vigneron ne  a  terminé  son  travail .
551    la  certificat rice  a  terminé  son  travail .

                                       tokenized_eng  proba_his_tm  \
1134              the  duke  has  finished  his  work .      0.717214
1035   the  stain  remove r  has  finished  her  work .      0.135425
1070       the  broadcaster  has  finished  his  work .      0.201072
3329        the  wine maker  has  finished  her  work .      0.263475
551    the  certifying  officer  has  finished  her …      0.252970

      proba_her_tm  proba_his_lm  proba_her_lm             eng_job  \
1134      0.020016      0.098012      0.011346                duke
1035      0.106736      0.000471      0.000492      stain  remove r
1070      0.056331      0.015483      0.003959          broadcaster
3329      0.276781      0.283786      0.007010           wine maker
551       0.331929      0.096918      0.005919  certifying  officer

     eng_pronoun          fra_job fra_det  job_tk_fr  job_tk_en  fra_epicene  \
1134         his             du c      le          2          1        False
1035         her      détache use      la          2          3        False
1070         his        diffuseur      le          1          1        False
3329         her      vigneron ne      la          2          2        False
551          her  certificat rice      la          2          2        False

      eng_epicene pred_tm pred_lm
1134        False     his     his
1035         True     his     her
1070         True     his     his
3329         True     her     his
551          True     her     his
```

[ ]:
```
# Not be marked

not_marked = corpus[(corpus['fra_epicene']==True) & (corpus['fra_det'] == "l")]
not_marked.sample(5)
```

[ ]:
```
                                     tokenized_fra  \
1136     l ' ébéniste  a  terminé  son  travail .
1295  l ' essa y iste  a  terminé  son  travail .
1314   l ' éth ologue  a  terminé  son  travail .
82           l ' aide  a  terminé  son  travail .
1673  l ' hum or iste  a  terminé  son  travail .
```

```
                                        tokenized_eng  proba_his_tm  \
1136   the  cabinet - maker  has  finished  his  work .      0.619778
1295         the  essay ist  has  finished  her  work .      0.493261
1314       the  eth ologist  has  finished  his  work .      0.698498
82                 the  help  has  finished  his  work .      0.007204
1673         the  humor ist  has  finished  her  work .      0.715079

      proba_her_tm  proba_his_lm  proba_her_lm          eng_job eng_pronoun  \
1136      0.007364      0.072499      0.006010  cabinet - maker         his
1295      0.239437      0.183447      0.029183        essay ist         her
1314      0.042673      0.313248      0.012578      eth ologist         his
82        0.008186      0.000537      0.000729             help         his
1673      0.039858      0.386378      0.045528        humor ist         her

          fra_job fra_det  job_tk_fr  job_tk_en  fra_epicene  eng_epicene  \
1136     ébéniste       l          1          3         True         True
1295  essa y iste       l          3          2         True         True
1314   éth ologue       l          2          2         True         True
82           aide       l          1          1         True         True
1673  hum or iste       l          3          2         True         True

     pred_tm pred_lm
1136     his     his
1295     his     his
1314     his     his
82       her     her
1673     his     his
```

0.2.6 Question 6

Build one DataFrame that contains, for each possible way to express gender, **the number of corresponding sentences**, **the accuracy**, **the mean and standard deviation** of the four probabilities considered (e.g. : the DataFrame should contain a row that indicates the number French sentences in which gender is not marked, the accuracy achieved by the NMT system when translating these sentences and 8 values to describe the probabilities)

[ ]:
```python
def compute(data):
  # the number of corresponding sentences
  nb_sentences = data.shape[0]

  # the accuracy
  accuracy_tm = (data['pred_tm'] == data['eng_pronoun']).sum() / len(data)
  accuracy_lm = (data['pred_lm'] == data['eng_pronoun']).sum() / len(data)

  # the mean and standard deviation of the four probabilities
  stats = data[['proba_his_tm', 'proba_her_tm', 'proba_his_lm',␣
 ↪'proba_her_lm']].agg(['mean', 'std'])
```

```
    his_tm_mean = stats.loc['mean','proba_his_tm']
    her_tm_mean = stats.loc['mean', 'proba_her_tm']
    his_tm_std = stats.loc['std', 'proba_his_tm']
    her_tm_std = stats.loc['std', 'proba_her_tm']

    his_lm_mean = stats.loc['mean','proba_his_lm']
    her_lm_mean = stats.loc['mean', 'proba_her_lm']
    his_lm_std = stats.loc['std', 'proba_his_lm']
    her_lm_std = stats.loc['std', 'proba_her_lm']

    return nb_sentences, accuracy_tm, accuracy_lm, his_tm_mean, her_tm_mean,␣
    ↪his_tm_std, her_tm_std, his_lm_mean, her_lm_mean, his_lm_std, her_lm_std
```

[ ]:
```
df = {'determiner_only': compute(det_only),
      'noun_only': compute(noun_only),
      'det_noun': compute(det_and_noun),
      'not_marked': compute(not_marked)}

express_gender = pd.DataFrame(df, index=['nb_sentences',
                                         'accuracy_tm',
                                         'accuracy_lm',
                                         'his_tm_mean',
                                         'her_tm_mean',
                                         'his_tm_std',
                                         'her_tm_std',
                                         'his_lm_mean',
                                         'her_lm_mean',
                                         'his_lm_std',
                                         'her_lm_std'])
```

[ ]:
```
express_gender = express_gender.transpose()
express_gender['nb_sentences'] = express_gender['nb_sentences'].astype(int)
express_gender
```

[ ]:
```
                nb_sentences  accuracy_tm  accuracy_lm  his_tm_mean  \
determiner_only          834     0.693046     0.503597     0.433031
noun_only                503     0.532803     0.514911     0.484387
det_noun                1789     0.761878     0.516490     0.380134
not_marked               272     0.503676     0.503676     0.589022

                her_tm_mean  his_tm_std  her_tm_std  his_lm_mean  \
determiner_only     0.126115    0.243111    0.155297     0.157196
noun_only           0.074257    0.191173    0.094391     0.107341
det_noun            0.142980    0.242960    0.178194     0.100884
not_marked          0.054622    0.172900    0.058624     0.183914
```

```
                  her_lm_mean  his_lm_std  her_lm_std
determiner_only      0.021855    0.100414    0.023691
noun_only            0.016166    0.080997    0.030368
det_noun             0.019437    0.074651    0.037713
not_marked           0.021298    0.096701    0.027202
```

0.2.7 Question 7

Compute the accuracy for LM and TM for feminine and masculine sentences.

[ ]:
```
# feminine sentences TM & LM
fem = corpus[corpus['eng_pronoun'] == 'her']
accuracy_tm_fm = (fem['pred_tm'] == 'her').sum() / len(fem)
accuracy_lm_fm = (fem['pred_lm'] == 'her').sum() / len(fem)

# masculine sentences TM & LM
mas = corpus[corpus['eng_pronoun'] == 'his']
accuracy_tm_ms = (mas['pred_tm'] == 'his').sum() / len(mas)
accuracy_lm_ms = (mas['pred_lm'] == 'his').sum() / len(mas)

print('The accuracy of TM system for feminine sentences: {:.2%}'.
  ↪format(accuracy_tm_fm))
print('The accuracy of LM system for feminine sentences: {:.2%}'.
  ↪format(accuracy_lm_fm))
print('The accuracy of TM system for masculine sentences: {:.2%}'.
  ↪format(accuracy_tm_ms))
print('The accuracy of LM system for masculine sentences: {:.2%}'.
  ↪format(accuracy_lm_ms))
```

```
The accuracy of TM system for feminine sentences: 38.43%
The accuracy of LM system for feminine sentences: 7.36%
The accuracy of TM system for masculine sentences: 99.65%
The accuracy of LM system for masculine sentences: 95.06%
```

0.2.8 Question 8

Compute the accuracy depending on the number of subtokens the occupational noun is broken into as well as the number of observations for each number of subtokens.

[ ]:
```
accuracy_subtokens = pd.DataFrame()
```

[ ]:
```
def accuracy(df):
  return ((df['pred_tm'] == df['eng_pronoun']).sum() / len(df)).round(2)
```

[ ]:
```
tm_subtokens_accuracy = corpus.groupby('job_tk_fr').apply(accuracy)
```

[ ]:
```
accuracy_subtokens['accuracy_tm'] = tm_subtokens_accuracy
```

[ ]:
```
accuracy_subtokens['nb_observations'] = corpus.value_counts('job_tk_fr')
```

[ ]:
```
accuracy_subtokens
```

[ ]:
```
           accuracy_tm  nb_observations
job_tk_fr
1                 0.84             596
2                 0.71            1168
3                 0.63            1088
4                 0.59             445
5                 0.58              90
6                 0.86               7
7                 0.50               4
```

We will now assess the capacity of subword tokenization to identify gender-specific subtokens :

0.2.9 Question 9

From the data, determine if female occupational nouns are segmented into more units than male ones. Interpret.

[ ]:
```
corpus.groupby('eng_pronoun')['job_tk_fr'].mean()
```

[ ]:
```
eng_pronoun
her    2.642142
his    2.358446
Name: job_tk_fr, dtype: float64
```

The mean value shows that French occupational nouns have more subtokens in the case of females. Female nouns are segmented to more subtokens than male noun on average.

0.2.10 Question 10

Add a column to the DataFrame that contains the suffix of the subword tokenization of the occupational noun (i.e. the last token resulting from the subword tokenization if and only if the noun is split into more than one token)

[ ]:
```
import numpy as np
corpus['fr_suffix'] = corpus['fra_job'].apply(lambda x: x.split(' ')[-1] if␣
 ↪len(x.split(' ')) > 1 else np.nan)
```

[ ]:
```
corpus[['fra_job', 'fr_suffix']]
```

[ ]:
```
             fra_job fr_suffix
0          abat teur      teur
1        abat t euse      euse
2               abbé       NaN
3          a bb esse      esse
4     aca dé mic ien       ien
```

```
…              …       …
3393    z yth ologue    ologue
3394          garçon       NaN
3395           fille       NaN
3396           homme       NaN
3397           femme       NaN

[3398 rows x 2 columns]
```

0.2.11 Question 11

Create a new DataFrame that contains the following information :

— the 20 most frequent suffixes in the corpus ;
— for each suffix, the number of time it appears in the corpus ;
— for each suffix, the number of time it appears in a feminine (resp. masculine) occupa- tional noun.

[ ]:
```
# the 20 most frequent suffixes and their occurrence in the corpus
most_fq = corpus['fr_suffix'].value_counts().head(20).to_dict()
print(f"The 20 most frequent suffixes in the corpus: {most_fq}")
```

```
The 20 most frequent suffixes in the corpus: {'iste': 335, 'use': 211, 'euse':
200, 'eur': 163, 'ur': 163, 'ologue': 152, 'ière': 129, 'e': 128, 'atrice': 76,
'graphe': 62, 'ier': 60, 'ienne': 54, 'ologiste': 52, 'trice': 45, 'ateur': 44,
'liste': 36, 'niste': 34, 'rice': 32, 'ère': 28, 'ien': 28}
```

[ ]:
```
# create a new dataframe
suffixes = pd.DataFrame.from_dict(most_fq, orient='index',␣
 ↪columns=['occurrence'])
suffixes = suffixes.reset_index().rename(columns={'index':'suffixe'})
suffixes
```

[ ]:
```
      suffixe  occurrence
0        iste         335
1         use         211
2        euse         200
3         eur         163
4          ur         163
5      ologue         152
6        ière         129
7           e         128
8      atrice          76
9      graphe          62
10        ier          60
11     ienne          54
12  ologiste          52
13     trice          45
```

```
14     ateur          44
15     liste          36
16     niste          34
17      rice          32
18       ère          28
19       ien          28
```

[ ]:
```
# the occurrence in feminine and masculine occupational nouns

def get_f_occurrence(sf):
  fem_occ = (corpus[(corpus['fr_suffix'] == sf)][corpus['eng_pronoun']=='her']).
 ↪shape[0]
  return fem_occ
```

[ ]:
```
def get_m_occurrence(sf):
  mas_occ = (corpus[(corpus['fr_suffix'] == sf)][corpus['eng_pronoun']=='his']).
 ↪shape[0]
  return mas_occ
```

[ ]:
```
suffixes['occurrence_f'] = suffixes['suffixe'].apply(get_f_occurrence)
suffixes['occurrence_m'] = suffixes['suffixe'].apply(get_m_occurrence)
```

[ ]:
```
suffixes
```

[ ]:

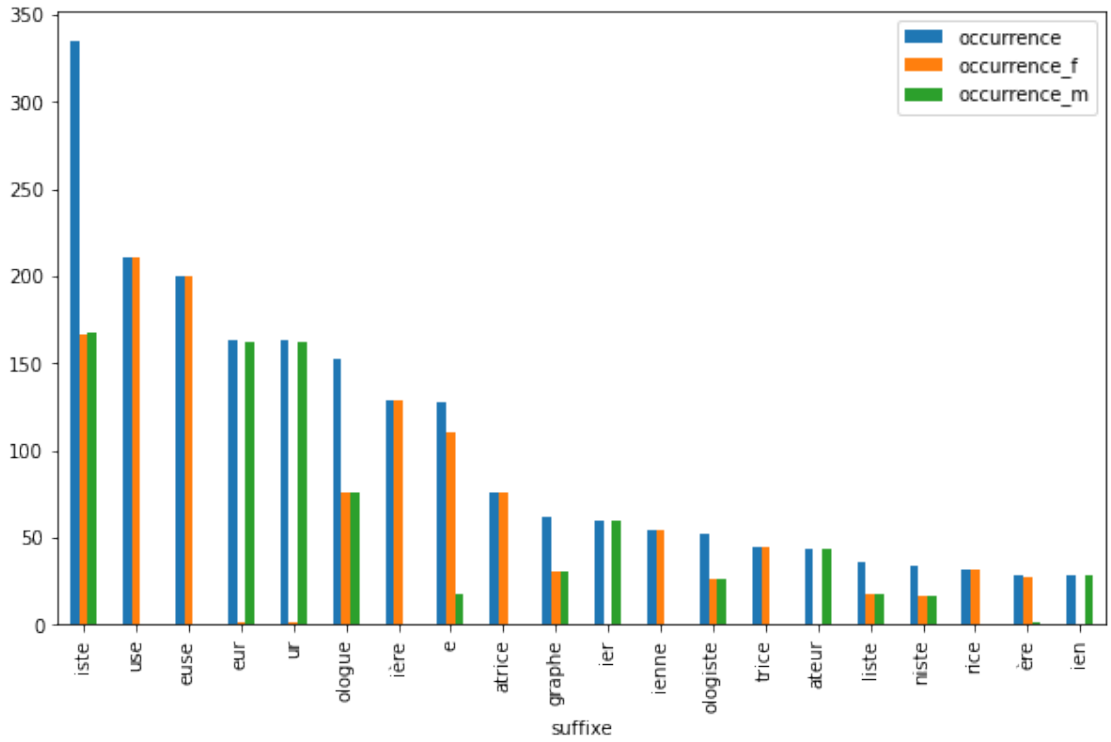
	suffixe	occurrence	occurrence_f	occurrence_m
0	iste	335	167	168
1	use	211	211	0
2	euse	200	200	0
3	eur	163	1	162
4	ur	163	1	162
5	ologue	152	76	76
6	ière	129	129	0
7	e	128	110	18
8	atrice	76	76	0
9	graphe	62	31	31
10	ier	60	0	60
11	ienne	54	54	0
12	ologiste	52	26	26
13	trice	45	45	0
14	ateur	44	0	44
15	liste	36	18	18
16	niste	34	17	17
17	rice	32	32	0
18	ère	28	27	1
19	ien	28	0	28

0.2.12 Question 12

Plot these data with a bar plot. What can you conclude?

[ ]:
```
suffixes.plot.bar(x='suffixe',figsize=(10,6))
```

[ ]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa681c666d0>
```



We observe that there are only three different types of distribution for suffixes in French:

- 9 suffixes often found in the feminine gender (`use`, `euse`, `ière`, `e`, `atrice`, `ienne`, `trice`, `rice`, `ère`);
- 5 suffixes that often indicate male occupational nouns (`eur`, `ur`, `ier`, `ateur`, `ie`)
- The suffixes are epicene (`iste`, `ologue`, `graphe`), and then the occupations are equally distributed between the two sexes