Lab 1 - Building dictionary with Selma Lagerlöf novels

Laboration 1 in EDAN20 @ LTH - http://cs.lth.se/edan20/coursework/assignment-1/ (http://cs.lth.se/edan20/coursework/assignment-1/)

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The objectives of this assignment are to:

-Write a program that collects all the words from a set of documents

-Build an index from the words

-Know what indexing is

-Represent a document using the Tf.Idf value

-Write a short report of 1 to 2 pages on the assignment

-Read a short text on an industrial system

Indexing one file

- The index file will contain all the unique words in the document, where each word is associated with the list of its positions in the document.
- You will represent this index as a dictionary where the keys will be the words and the values, the lists of positions
- As words, you will consider all the strings of letters that you will set in lower case. You will not index the rest (i.e. numbers or symbols).
- To extract the words, you will use Unicode regular expressions. Do not use \w+, for instance, but the Unicode equivalent. The word positions will correspond to the number of characters from the beginning of the file. (The word offset from the beginning)
- You will use finditer() to find the positions of the words. This will return you match objects, where you will get the matches and the positions with the group() and start() methods.

In [1]:
```
text = open("Selma/bannlyst.txt").read()
```

In [2]:
```
import regex as re

def toLowercase(matchobj):
    """
    Helper function
    """
    return matchobj.group(1).lower()

def textLowerList(text):
    """
    Make text lowercase and put into list

    :param string:
    :return list:
    """

    textLow = re.sub(r'(\p{Lu})', toLowercase, text) # Lowercase all characters

    stringList = re.findall(r"\p{L}+",textLow) # This finds all words from a txt file. r"[a-zåäö]+ equal to r"\w+"

    return stringList
```

In [3]:
```
def toLowercase(matchobj):
    return matchobj.group(1).lower()

def string2dict(text):
    """
    Creates a dict with (word:list[index apperences]) from input string

    Input string, string
    Output dict
    """
    textLow = re.sub(r'(\p{Lu})', toLowercase, text) # Lowercase all characters
    stringList = textLowerList(text)
    stringDict = {key : list([]) for key in stringList}

    for m in re.finditer(r"\p{L}+", textLow): # Iterate thorugh every word
        s = m.start()
        e = m.end()

        word = textLow[s:e]
        stringDict[word].append(s)


    return stringDict
```

In [4]:
```
txtDict = string2dict(text)
```

In [5]:
```
len(txtDict)
```

Out[5]:
```
7923
```

Test with bannlyst text

The word gjord occurs three times in the text at positions 8551, 183692, and 220875, uppklarnande, once at position 8567, and stjärnor, once at position 8590.

In [6]:
```
txtDict['gjord']
```

Out[6]:
```
[8551, 183692, 220875]
```

In [7]:
```
txtDict['uppklarnande']
```

Out[7]:
```
[8567]
```

In [8]:
```
txtDict['stjärnor']
```

Out[8]:
```
[8590]
```

Pickle

- You will use the pickle package to write your dictionary in an file, see https://wiki.python.org/moin/UsingPickle (https://wiki.python.org/moin/UsingPickle).

In [9]:
```
import pickle

#with open('BannlystTxtDict.pickle', 'wb') as handle:
#    pickle.dump(txtDict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

Open pickle

In [10]:
```
with open('BannlystTxtDict.pickle', 'rb') as handle:
    BannlystTxtDict = pickle.load(handle)
```

Test of pickle

In [11]:
```
BannlystTxtDict == txtDict
```

Out[11]:
```
True
```

Reading the content of a folder

Write a function that reads all the files in a folder with a specific suffix (txt). You will need the Python os package, see https://docs.python.org/3/library/os.html (https://docs.python.org/3/library/os.html). You will return the file names in a list.

Use function:

In [12]:
```
import os

def get_files(fileDir, suffix):
    """
    Returns all the files in a folder ending with suffix
    :param filedir:
    :param suffix:
    :return: the list of file names
    """
    files = []
    for file in os.listdir(fileDir):
        if file.endswith(suffix):
            files.append(file)
    return files
```

In [13]:
```
files = get_files("selma", ".txt")
```

In [14]:
```
files
```

Out[14]:
```
['troll.txt',
 'kejsaren.txt',
 'marbacka.txt',
 'herrgard.txt',
 'nils.txt',
 'osynliga.txt',
 'jerusalem.txt',
 'bannlyst.txt',
 'gosta.txt']
```

Creating a master index

Complete your program with the creation of master index, where you will associate each word of the corpus with the files, where it occur and its positions. (a posting list)

In [15]:
```
def toLowercase(matchobj):
    return matchobj.group(1).lower()

def addAll(fileDir,files):
    """
    This function takes way to long. Do not iterate word in dict but build dict directly.

    Reads all files in list and matches to txt files
    :param dir:
    :param files:
    :return dict:
    """

    totText = []

    for file in files:
        text = open(fileDir+"/"+file).read()
        stringList = textLowerList(text)
        totText.extend(stringList)

    masterDict = {word : {file : list([]) for file in files} for word in totText}

    for file in files:
        text = open(fileDir+"/"+file).read()
        txtDict = string2dict(text)
        for word in txtDict.keys():
            masterDict[word][file] = txtDict[word]

    return masterDict
```

In [16]:
```
masterDict = addAll('selma',files)
```

In [17]:
```
#with open('masterDict.pickle', 'wb') as handle:
#    pickle.dump(masterDict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

In [18]:
```
with open('masterDict.pickle', 'rb') as handle:
    masterDict = pickle.load(handle)
```

Test of master dict. Below is an except of the master index with the words samlar and ände:

'samlar': {'nils.txt': [53499, 120336], 'gosta.txt': [317119, 414300, 543686],'osynliga.txt': [410995, 871322]},

In [19]:
```
masterDict["samlar"]
```

Out[19]:
```
{'troll.txt': [],
 'kejsaren.txt': [],
 'marbacka.txt': [],
 'herrgard.txt': [],
 'nils.txt': [53499, 120336],
 'osynliga.txt': [410995, 871322],
 'jerusalem.txt': [],
 'bannlyst.txt': [],
 'gosta.txt': [317119, 414300, 543686]}
```

'ände':{'nils.txt': [3991],'kejsaren.txt': [51100],'marbacka.txt': [374231],'troll.txt': [39726],'osynliga.txt': [742747]},

In [20]:
```
masterDict["ände"]
```

Out[20]:
```
{'troll.txt': [39726],
 'kejsaren.txt': [51100],
 'marbacka.txt': [374231],
 'herrgard.txt': [],
 'nils.txt': [3991],
 'osynliga.txt': [742747],
 'jerusalem.txt': [],
 'bannlyst.txt': [],
 'gosta.txt': []}
```

Representing Documents with tf-idf

Once you have created the index, you will represent each document in your corpus as a word vector. You will define the value of a word in a document with the tf-idf metric. Tf will be the relative frequency of the term in the document and idf, the logarithm base 10 of the inverse document frequency.

```
In [21]: import math

         def tiIdf(masterDict):
             """
             This function takes way to long. Do not iterate word in dict but build dict directly.

             Creates a ft-idf dict from all files.
             https://www.freecodecamp.org/news/how-to-process-textual-data-using-tf-idf-in-python-cd2bbc0a94a3/
             :Param dict:
             :return dict:
             """

             tfIdfDict = masterDict.copy()
             j = 0

             lenText = {}
             for file in masterDict['nils']: # Read total nbr of words in each text
                 text = open('selma'+"/"+file).read()
                 lenText[file] = len(textLowerList(text)) # nbr of words in textfile

             for word in masterDict:
                 #idf will be the logarithm base 10 of the inverse document frequency.
                 nbrKeys = len(masterDict[word].keys())
                 dictValues = masterDict[word].values()
                 lenDictValues = len(dictValues)

                 i = 0
                 for fileList in dictValues: # Count nbr of empty list. (There is probably a better way to do this)
                     if not fileList:
                         i = i + 1

                 df = (lenDictValues-i)

                 idf = math.log10(nbrKeys/df)

                 for file in masterDict[word]:
                     # Tf will be the relative frequency of the term in the document
                     lenWordVec = len(masterDict[word][file]) # nbr of occurencies of word

                     tf =  lenWordVec / lenText[file]
                     tfIdfDict[word][file] = tf*idf

             return tfIdfDict
```

```
In [22]: tfIdfDict = tiIdf(masterDict)
```

```
In [23]: #with open('tfIdfDict.pickle', 'wb') as handle:
         #    pickle.dump(tfIdfDict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

```
In [24]: with open('tfIdfDict.pickle', 'rb') as handle:
             tfIdfDict = pickle.load(handle)
```

Test of tf idf:

känna :: bannlyst.txt 0.0, gosta.txt 0.0, herrgard.txt 0.0, jerusalem.txt 0.0, nils.txt 0.0

```
In [25]: tfIdfDict['känna']
```

```
Out[25]: {'troll.txt': 0.0,
          'kejsaren.txt': 0.0,
          'marbacka.txt': 0.0,
          'herrgard.txt': 0.0,
          'nils.txt': 0.0,
          'osynliga.txt': 0.0,
          'jerusalem.txt': 0.0,
          'bannlyst.txt': 0.0,
          'gosta.txt': 0.0}
```

gås :: bannlyst.txt 0.0, gosta.txt 0.0, herrgard.txt 0.0, jerusalem.txt 0.0, nils.txt 0.00010123719421964931

```
In [26]: tfIdfDict['gås']
```

```
Out[26]: {'troll.txt': 0.0,
          'kejsaren.txt': 0.0,
          'marbacka.txt': 0.0,
          'herrgard.txt': 0.0,
          'nils.txt': 0.0001012371942196493,
          'osynliga.txt': 0.0,
          'jerusalem.txt': 0.0,
          'bannlyst.txt': 0.0,
          'gosta.txt': 0.0}
```

nils :: bannlyst.txt 0.0, gosta.txt 0.0, herrgard.txt 0.0 jerusalem.txt 4.778415355159037e-06, nils.txt 9.801209641132888e-05

```
In [27]: tfIdfDict['nils']
```

```
Out[27]: {'troll.txt': 3.65803773219228e-06,
          'kejsaren.txt': 8.084511887485742e-06,
          'marbacka.txt': 7.5908443635941025e-06,
          'herrgard.txt': 0.0,
          'nils.txt': 9.801209641132888e-05,
          'osynliga.txt': 0.0,
          'jerusalem.txt': 4.778415355159037e-06,
          'bannlyst.txt': 0.0,
          'gosta.txt': 0.0}
```

et :: bannlyst.txt 6.2846093167673765e-06, gosta.txt 0.0, herrgard.txt 0.0, jerusalem.txt 0.0, nils.txt 0.0

```
In [28]: tfIdfDict['et']
```

```
Out[28]: {'troll.txt': 0.0,
          'kejsaren.txt': 6.0441957178149187e-05,
          'marbacka.txt': 1.4187791927195648e-05,
          'herrgard.txt': 0.0,
          'nils.txt': 0.0,
          'osynliga.txt': 0.0,
          'jerusalem.txt': 0.0,
          'bannlyst.txt': 6.2846093167673765e-06,
          'gosta.txt': 0.0}
```

Comparing Documents

Using the cosine similarity, compare all the pairs of documents with their tfidf representation and present your results in a matrix. You will include this matrix in your report.

Give the name of the two novels that are the most similar.

There are the document representations in term of words. Rows: documents, Col: words.

```
In [29]: import numpy as np

         docMatrix = np.zeros((9,len(tfIdfDict.keys())))
         wordList = tfIdfDict.keys()
         fileList = tfIdfDict['nils']

         for i, word in enumerate(wordList):
             for j, file in enumerate(fileList):
                 docMatrix[j,i] = tfIdfDict[word][file]
```

```
In [30]: import numpy as np; import pandas as pd
         from sklearn.metrics.pairwise import cosine_similarity

         df = pd.DataFrame(docMatrix)

         simularityMatrix = cosine_similarity(df)
```

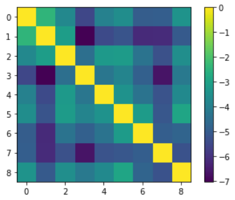
Plot matrix

In [32]:

```
import matplotlib.pyplot as plt

plt.imshow(np.log(simularityMatrix))
plt.colorbar()
plt.show()

for i,file in enumerate(list(fileList.keys())):
    print(i, "=", file)
```



```
0 = troll.txt
1 = kejsaren.txt
2 = marbacka.txt
3 = herrgard.txt
4 = nils.txt
5 = osynliga.txt
6 = jerusalem.txt
7 = bannlyst.txt
8 = gosta.txt
```

In [33]:

```
print("TEXT 1", "TEXT 2", "Simularity Value")
for i,iFile in enumerate(list(fileList.keys())):
    for j, jFile in enumerate(list(fileList.keys())):
        print(iFile, jFile, simularityMatrix[i,j])
```

```
TEXT 1 TEXT 2 Simularity Value
troll.txt troll.txt 1.0
troll.txt kejsaren.txt 0.0883126344462
troll.txt marbacka.txt 0.0236486882832
troll.txt herrgard.txt 0.00398629847309
troll.txt nils.txt 0.0193870728052
troll.txt osynliga.txt 0.0282661230154
troll.txt jerusalem.txt 0.00706370160499
troll.txt bannlyst.txt 0.00733624255343
troll.txt gosta.txt 0.0324940443365
kejsaren.txt troll.txt 0.0883126344462
kejsaren.txt kejsaren.txt 1.0
kejsaren.txt marbacka.txt 0.0445580042426
kejsaren.txt herrgard.txt 0.000892488921853
kejsaren.txt nils.txt 0.00437436632002
kejsaren.txt osynliga.txt 0.00549434528028
kejsaren.txt jerusalem.txt 0.00205720430119
kejsaren.txt bannlyst.txt 0.00214580054521
kejsaren.txt gosta.txt 0.0065098346458
marbacka.txt troll.txt 0.0236486882832
marbacka.txt kejsaren.txt 0.0445580042426
marbacka.txt marbacka.txt 1.0
marbacka.txt herrgard.txt 0.0116979927496
marbacka.txt nils.txt 0.0402145650205
marbacka.txt osynliga.txt 0.0421062692429
marbacka.txt jerusalem.txt 0.012904030053
marbacka.txt bannlyst.txt 0.00509649828077
marbacka.txt gosta.txt 0.0285611065239
herrgard.txt troll.txt 0.00398629847309
herrgard.txt kejsaren.txt 0.000892488921853
herrgard.txt marbacka.txt 0.0116979927496
herrgard.txt herrgard.txt 1.0
herrgard.txt nils.txt 0.0141469836563
herrgard.txt osynliga.txt 0.0212563646664
herrgard.txt jerusalem.txt 0.0076215128127
herrgard.txt bannlyst.txt 0.00129900476994
herrgard.txt gosta.txt 0.0151425493556
nils.txt troll.txt 0.0193870728052
nils.txt kejsaren.txt 0.00437436632002
nils.txt marbacka.txt 0.0402145650205
nils.txt herrgard.txt 0.0141469836563
nils.txt nils.txt 1.0
nils.txt osynliga.txt 0.0321284846367
nils.txt jerusalem.txt 0.0130897803341
nils.txt bannlyst.txt 0.00534349438643
nils.txt gosta.txt 0.025006368728
osynliga.txt troll.txt 0.0282661230154
osynliga.txt kejsaren.txt 0.00549434528028
osynliga.txt marbacka.txt 0.0421062692429
osynliga.txt herrgard.txt 0.0212563646664
osynliga.txt nils.txt 0.0321284846367
osynliga.txt osynliga.txt 1.0
osynliga.txt jerusalem.txt 0.0418440605847
osynliga.txt bannlyst.txt 0.00598462892097
osynliga.txt gosta.txt 0.0557475721521
jerusalem.txt troll.txt 0.00706370160499
jerusalem.txt kejsaren.txt 0.00205720430119
jerusalem.txt marbacka.txt 0.012904030053
jerusalem.txt herrgard.txt 0.0076215128127
jerusalem.txt nils.txt 0.0130897803341
jerusalem.txt osynliga.txt 0.0418440605847
jerusalem.txt jerusalem.txt 1.0
jerusalem.txt bannlyst.txt 0.00731817225312
jerusalem.txt gosta.txt 0.00854010929237
bannlyst.txt troll.txt 0.00733624255343
bannlyst.txt kejsaren.txt 0.00214580054521
bannlyst.txt marbacka.txt 0.00509649828077
bannlyst.txt herrgard.txt 0.00129900476994
bannlyst.txt nils.txt 0.00534349438643
bannlyst.txt osynliga.txt 0.00598462892097
bannlyst.txt jerusalem.txt 0.00731817225312
bannlyst.txt bannlyst.txt 1.0
bannlyst.txt gosta.txt 0.00522987707788
gosta.txt troll.txt 0.0324940443365
gosta.txt kejsaren.txt 0.0065098346458
gosta.txt marbacka.txt 0.0285611065239
gosta.txt herrgard.txt 0.0151425493556
gosta.txt nils.txt 0.025006368728
gosta.txt osynliga.txt 0.0557475721521
gosta.txt jerusalem.txt 0.00854010929237
gosta.txt bannlyst.txt 0.00522987707788
gosta.txt gosta.txt 1.0
```

In [34]:

```
index = simularityMatrix[:,:].flatten().argsort()[-10:][::-1][9] # This is the

print("Position: (", index//9, ",", index, ") has maximum val")

print("Closest documents are:", list(fileList.keys())[index//9], "and", list(fileList.keys())[index], ". With cosine value:", simularityMatrix[0,1])
```

```
Position: ( 0 , 1 ) has maximum val
Closest documents are: troll.txt and kejsaren.txt . With cosine value: 0.0883126344462
```

Reading

Read the text: Challenges in Building Large-Scale Information Retrieval Systems about the history of Google indexing by Jeff Dean. In your report, tell how your index encoding is related to what Google did. You must identify the slide where you have the most similar indexing technique and write the slide number in your report. https://static.googleusercontent.com/media/research.google.com/en//people/jeff/WSDM09-keynote.pdf (https://static.googleusercontent.com/media/research.google.com/en//people/jeff/WSDM09-keynote.pdf)

Answer:

Google had a number of index shards (words). The search time to find the requested sharde could be improved by improving index encoding. Similar to our encoding google searched for a shard (word) to find attributes for that word. In our case file namne + tfidx value is the attribute for each word, but in google case font size, title, etc. This is explained on **page 45.**