lab6_writeup_1003998757

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0.1 Lab 6 - Frequency

This lab must be done **individually**. The required packages have been imported for you below.

[1]:
```
import string
import numpy as np
from scipy.stats import pearsonr
import matplotlib.pyplot as plt
```

Load text file. Data from Project Gutenberg (https://www.gutenberg.org/).

[2]:
```
txt = open("ulysses.txt","r")
```

Remove punctuations in text.

[3]:
```
remove = dict.fromkeys(map(ord, string.punctuation))
```

Collapse tokens to lower case.

[4]:
```
txt = txt.read().translate(remove).lower()
```

Construct a dictionary where `key` = word, `value` = count (or frequency).

[5]:
```
wordfreq = {}
for word in txt.split():
    if word not in wordfreq:
        wordfreq[word] = 1
    else:
        wordfreq[word] += 1
```

Hint: Print `wordfreq` to see what this dictionary contains.

To work with keys and values in dictionaries, you may refer to https://docs.python.org/2/tutorial/datastructures.html. Alternatively, refer to the Python tutorial posted on course syllabus.

In this lab, you will reconstruct the classic work by Zipf (1949) on the properties of word frequency—read Zipf's chapter posted. Following these instructions and enjoy this final lab of the course!

0.1.1 Task 1 [2 pts]

Hint: For how to `sort` and use `list` comprehension in Python, see the Python tutorial posted on course syllabus.

Task 1a: Construct an array of sorted word frequency of all words, and a separate array of word lengths.

[6]:
```
# Write your code here.

# Extract frequency from dict and convert to list
wordfreq_list = list(map(lambda x: [x, wordfreq[x]] , wordfreq.keys()))

# Construct sorted word frequency list
sorted_wf_all = sorted(wordfreq_list, key=lambda x: x[1], reverse=True)
sorted_wf = [i[1] for i in sorted_wf_all]
print('Sorted word Frequency List: {}'.format(sorted_wf[:10]))

sorted_wf_len = [len(i[0]) for i in sorted_wf_all]
print('Length of sorted words by their frequencies: {}'.format(sorted_wf_len[:
↪10]))
```

```
Sorted word Frequency List: [15010, 8250, 7216, 6512, 5031, 4974, 3998, 3327,
2586, 2557]
Length of sorted words by their frequencies: [3, 2, 3, 1, 2, 2, 2, 3, 4, 4]
```

Task 1b: Construct an array of ranks from on the sorted frequency array in **Task 1a** (using ordinal rank).

[7]:
```
# Write your code here.
rank = [i for i in range(1, len(sorted_wf) + 1)]
print("Word rank list: ", rank[:10])
```

```
Word rank list:  [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
```

Task 1c: Print the most frequent 20 words and their frequencies. **[1pt]**

[8]:
```
# Write your code here.
sorted_wf_words = [i[0] for i in sorted_wf_all]
print('Most frequent 20 words: {}'.format(sorted_wf_words[:20]))
print()
print('Their frequencies: {}'.format(sorted_wf_len[:20]))
```

```
Most frequent 20 words: ['the', 'of', 'and', 'a', 'to', 'in', 'he', 'his',
'that', 'with', 'i', 'it', 'was', 'on', 'for', 'you', 'her', 'him', 'is', 'all']

Their frequencies: [3, 2, 3, 1, 2, 2, 2, 3, 4, 4, 1, 2, 3, 2, 3, 3, 3, 3, 2, 3]
```

0.1.2 Task 2 [3 pts]

Produce a 2-by-2 set of subplots using `subplot`: https://matplotlib.org/api/_as_gen/matplotlib.pyplot.subplot.ht

Task 2a: Scatter plot word frequency (y-axis) against rank (x-axis). **[.5pt]**

Task 2b: Scatter plot $log(freq)$ against $log(rank)$. **[.5pt]**

Task 2c: Calculate and report the slope from **Task 2b** (via linear regression), i.e. slope of $log(freq)$ vs $log(rank)$. **[.5pt]**

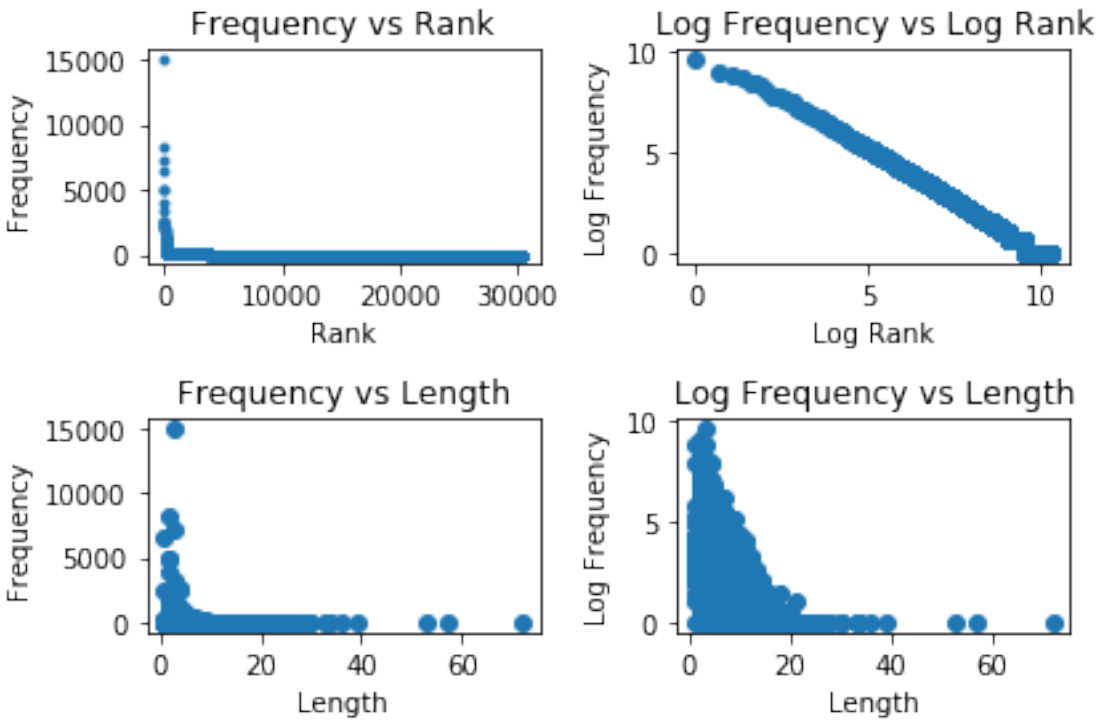
Task 2d: Scatter plot frequency against word length. **[.5pt]**

Task 2e: Scatter plot $log(freq)$ against word length. **[.5pt]**

[9]:
```
from math import log

# Task 2a
# Write your code here.
plt.subplot(2, 2, 1)
plt.scatter(rank, sorted_wf, marker='.')
plt.title("Frequency vs Rank")
plt.xlabel('Rank')
plt.ylabel('Frequency')
plt.tight_layout()

# Task 2b
# Write your code here.
log_rank = [log(x) for x in rank]
log_freq = [log(x) for x in sorted_wf]
plt.subplot(2, 2, 2)
plt.scatter(log_rank, log_freq)
plt.title("Log Frequency vs Log Rank")
plt.xlabel('Log Rank')
plt.ylabel('Log Frequency')
plt.tight_layout()

# Task 2c
# Write your code here.
linefit = np.polyfit(log_rank, log_freq, 1) # 1 degree, straight line
slope = linefit[0]
print("The slope for logarithmic rank line is: ", slope)

linefit_two = np.polyfit(log_freq, log_rank, 1)
slope = linefit_two[0]
print("The slope for logarithmic frequency line is: ", slope)

# Task 2d
# Write your code here.
plt.subplot(2, 2, 3)
```

```
plt.scatter(sorted_wf_len, sorted_wf)
plt.title("Frequency vs Length")
plt.xlabel('Length')
plt.ylabel('Frequency')
plt.tight_layout()

# Task 2e
# Write your code here.
plt.subplot(2, 2, 4)
log_sorted_wf = [log(x) for x in sorted_wf]
plt.scatter(sorted_wf_len, log_sorted_wf)
plt.title("Log Frequency vs Length")
plt.xlabel('Length')
plt.ylabel('Log Frequency')
plt.tight_layout()
```

```
The slope for logarithmic rank line is:  -1.0332621845538867
The slope for logarithmic frequency line is:  -0.9375752989297238
```



0.1.3 Task 3 [1 pt]

Calculate and report the Pearson correlation between $log(freq)$ and word length. **[.5pt]**

Hint: You may use `scipy.stats.pearsonr`; the first output is Pearson correlation.

[10]:
```
# Write your code here.
pearson = pearsonr(log_sorted_wf, sorted_wf_len)
corr = pearson[0]
print("Pearson Correlation. {} ".format(corr))
print("The pearson correlation value aligns with the graph which has a negative␣
 ↪correlation.")
```

```
Pearson Correlation. -0.3111938895177389
The pearson correlation value aligns with the graph which has a negative
correlation.
```

0.1.4 Task 4 [5 pts]

Task 4a: Calculate and report the expected word length of English words based on the given data. **[1pt]**

$E[len] = \sum^i len(i) * prob(i)$, where $prob(i)$ = normalized frequency of word i (over all available words).

[11]:
```
# Write your code here.

def get_expected_word_length(wl, fl):
    total_words = sum(fl)
    word_lengths = []
    for w, f in zip(wl, fl):
        word_length = len(w) * (f / total_words)
        word_lengths.append(word_length)
    return sum(word_lengths)

expected_word_lenghts = get_expected_word_length(sorted_wf_words, sorted_wf)
print("Expected Word Length: {}".format(expected_word_lenghts))
```

```
Expected Word Length: 4.485334736779394
```

Task 4b: Perform a shuffled (permutation) test with 1000 shuffled trials. **[1pt]**

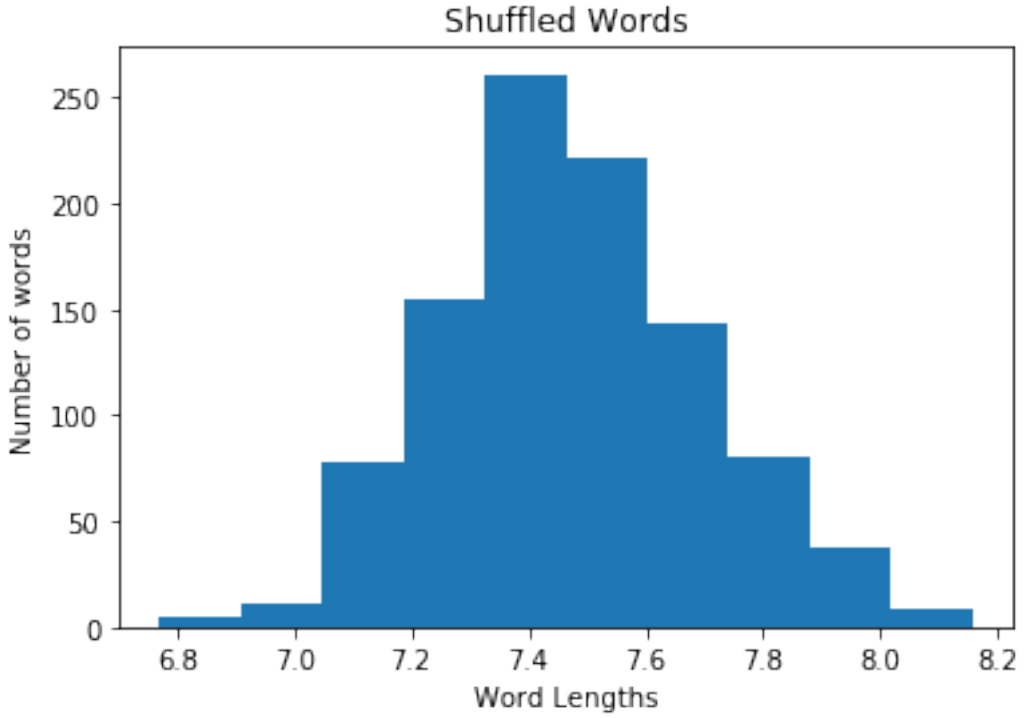
[12]:
```
# Write your code here.
import random
import copy
from functools import reduce

# Helper Function
def average(lst):
    return reduce(lambda a, b: a + b, lst) / len(lst)

def perm_test(wl, fl, trials):
```

```
    wl_deepcopy = copy.deepcopy(wl)
    fl_deepcopy = copy.deepcopy(fl)

    shuffled = []
    for i in range(0, trials):
        random.shuffle(wl_deepcopy)
        random.shuffle(fl_deepcopy)
        lengths = get_expected_word_length(wl_deepcopy, fl_deepcopy)
        shuffled.append(lengths)
    return average(shuffled), shuffled, trials

expected, shuffles, trials = perm_test(sorted_wf_words, sorted_wf, 1000)

print("Expected word length aftr perm test : {}".format(expected))
```

```
Expected word length aftr perm test : 7.473988947863729
```

Task 4c: Based on the shuffled trials, histogram the expected word lengths from the shuffled data. **[.5pt]**

[13]:
```
# Write your code here.

plt.hist(shuffles, bins=10)
plt.title("Shuffled Words")
plt.ylabel("Number of words")
plt.xlabel("Word Lengths")
plt.show()
```



Task 4d: Calculate and report the *p-value* from the shuffled test.

The null hypothesis is that the expected word length is no different from the expected length from shuffled data. Based on the *p-value* you have obtained, conclude whether the null should be rejected ($p < 0.05$). **[.5pt]**

[14]:
```
# Write your code here.

def get_count_longerwords(sf, ewl):
    count_longerwords = [i for i in sf if i >= ewl]
    return len(count_longerwords)

p_value = get_count_longerwords(shuffles, expected_word_lenghts) / trials


print("p-value: ", p_value)
print("The p-value is significant larger than 0.5, which we reject the null␣
 ↪hypothesis.")
```

```
p-value:  1.0
The p-value is significant larger than 0.5, which we reject the null hypothesis.
```

Task 5: Propose an alternative way of mapping words to frequencies and show that it produces a lower expected length than the empirical value you calculated, justify your proposal, and print the top 20 most frequent words under this proposal. **[3pts]**

[15]:
```
# Write your solution here.

# Create deep copies of the word frequency list and words list
wl_deepcopy = copy.deepcopy(sorted_wf_words)
fl_deepcopy = copy.deepcopy(sorted_wf)

# Sort so the longest word maps the lowest frequency
sorted_wl_dc = sorted(wl_deepcopy, key=lambda x: len(x), reverse = True)
sorted_fl_dc = sorted(fl_deepcopy, key=lambda x: x)
print('Sorted longest word list: {}'.format(sorted_wl_dc[:5]))
print('Sorted longest word list frequency: {}'.format(sorted_fl_dc[:5]))
print()


# Print the expected word length
expected_word_len = get_expected_word_length(sorted_wl_dc, sorted_fl_dc)
print('Expected Word Length: {}'.format(expected_word_len))

print()
```

```
# Justification
print('Longest words with the least frequency produces an expected worth length␣
 ↪less than what was calculated.')
print('Even though the words are long, their appearances are so less compared␣
 ↪to the commonly occuring words.' )
print('If we sort the word list and frequency lists in reverse, we get:')

print()

sorted_wl_dc_rev = sorted(wl_deepcopy, key=lambda x: len(x))
sorted_fl_dc_rev = sorted(fl_deepcopy, key=lambda x: x, reverse = True)
print('Reverse word list: {}'.format(sorted_wl_dc_rev[:5]))
print('Reverse word frequency list: {}'.format(sorted_fl_dc_rev[:5]))

print()

print('From the above, we notice that there are many short words that occur␣
 ↪much more frequently.')
print('Therefore, these outliers will cause the expected value to appear lower␣
 ↪than the empirical value calculated.')

print()

print('Top most frequent words in my proposal:')
print (sorted_wl_dc_rev[:20])
```

```
Sorted longest word list:
['nationalgymnasiummuseumsanatoriumandsuspensoriumsordinaryprivatdocentgen',
'sudden-at-the-moment-though-from-lingering-illness-often-',
'handsomemarriedwomanrubbedagainstwidebehindinclonskea',
'mangongwheeltracktrolleyglarejuggernaut',
'contransmagnificandjewbangtantiality']
Sorted longest word list frequency: [1, 1, 1, 1, 1]

Expected Word Length: 2.896570515691917

Longest words with the least frequency produces an expected worth length less
than what was calculated.
Even though the words are long, their appearances are so less compared to the
commonly occuring words.
If we sort the word list and frequency lists in reverse, we get:

Reverse word list: ['a', 'i', 'o', 'j', 's']
Reverse word frequency list: [15010, 8250, 7216, 6512, 5031]

From the above, we notice that there are many short words that occur much more
frequently.
```

```
Therefore, these outliers will cause the expected value to appear lower than the
empirical value calculated.

Top most frequent words in my proposal:
['a', 'i', 'o', 'j', 's', 'c', 'p', '1', '2', 'b', 'm', '5', 'e', 'd', 'h', 'w',
'£', '3', '4', 'f']
```

Export and submit a **fully executable** Python Jupyter Notebook and a PDF copy of your notebook showing all results.