Report

Task - 1: Execute bruteforce computation

读入数据后，用字典计算词频即可，代码如下：

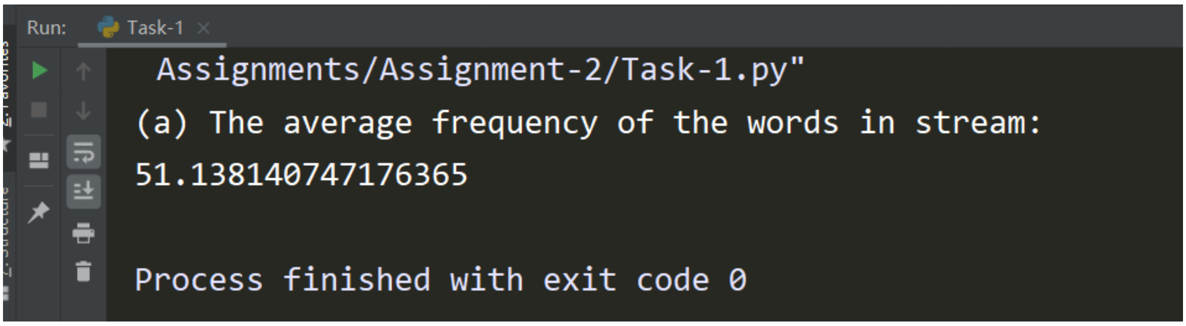
```python
with open(fileName, 'r') as f:
    lines = f.readlines()[3:]
    for line in lines:
        wordList = line.strip('\n').split()
        wordId, docId = int(wordList[1]) - 1, int(wordList[0])
        # dictionary for counting word frequency:
        countDict[wordId] = countDict[wordId] + 1 if wordId in countDict else 1

# sorted by word frequency:
countSortList = sorted(countDict.items(), key=lambda x: x[1], reverse=True)
```

以bruteforce的方式遍历所有document pair，时间复杂度 $\mathcal{O}(n^2)$.

其计算结果被写入文件： `Sorted-Word-Frequency.npy`

数据集描述： `docword.kos`：文档数：3430，单词数：6906，总词量：353160

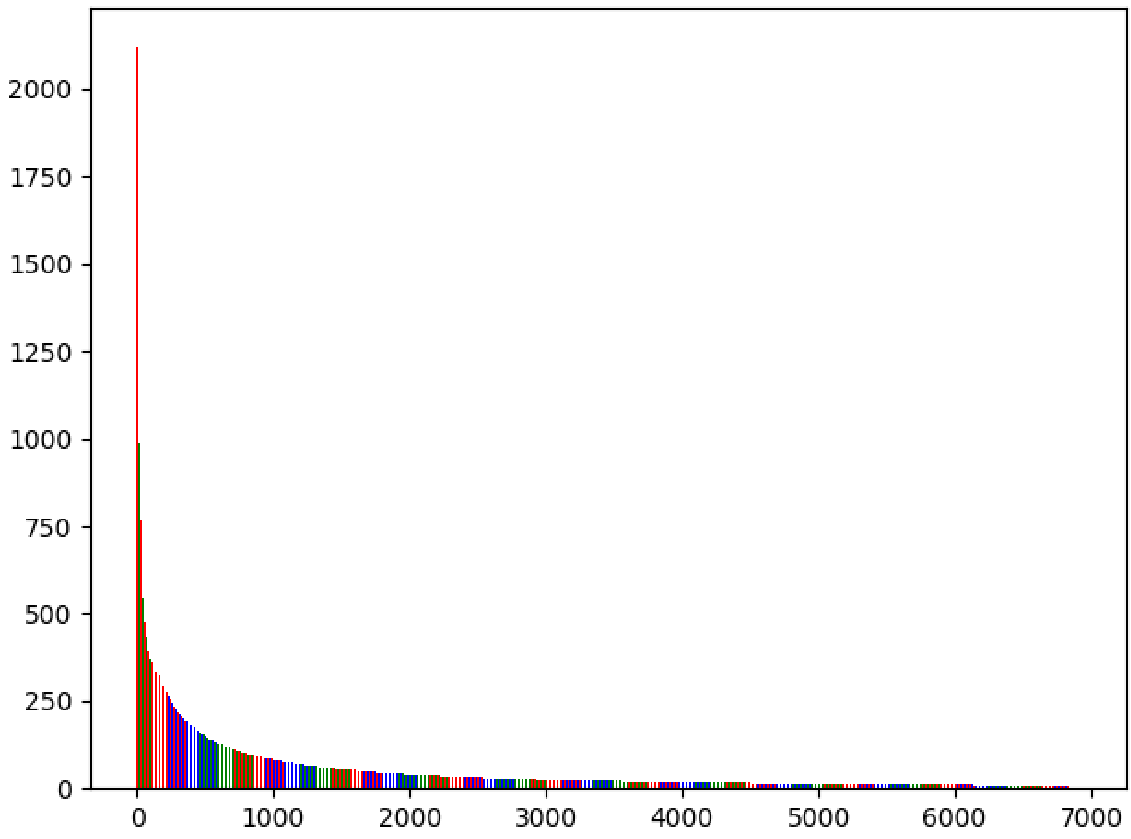
(a) The running time of your bruteforce algorithm



```
 Assignments/Assignment-2/Task-1.py"
(a) The average frequency of the words in stream:
51.138140747176365

Process finished with exit code 0
```

平均词频： `51.1381`

(b) 图像:



其中词频从大到小排列.

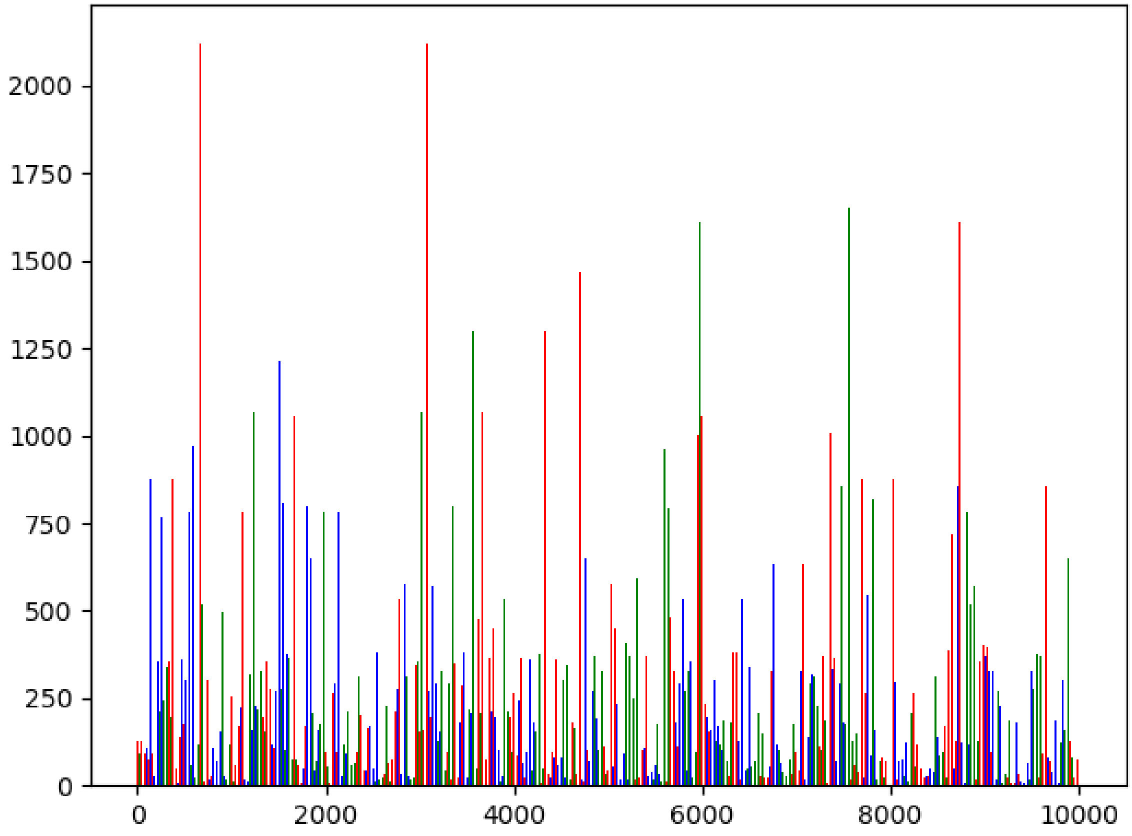
Task - 2: Reservoir Summary

实现Reservoir Sampling函数，由PPT中讲述，我们有：

```python
def selectKItems(stream, k):
    i, n = 0, len(stream)
    reservoir = [0] * k
    for i in range(k):
        reservoir[i] = stream[i]

    while (i < n):
        j = random.randrange(i + 1)
        if (j < k):
            reservoir[j] = stream[i]
        i += 1

    return reservoir
```

如上代码，先取前 k 个元素，然后在每一个 $0 \to i$ 中取随机数，当该随机数 $< k$ 时，将 i 与这个随机数对应的元素互换. 可以证明每个元素被选取的概率是一致的.

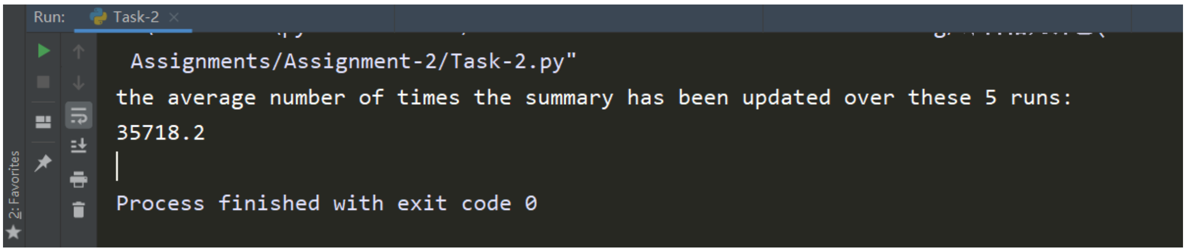
(a) Estimate the frequency vector from our Reservoir Summary, and plot this estimate vector to see the approximation skewness



`S = 10000` 时，用Reservoir Sampling的方法从353160个pair中抽取的词的词频分布结果如上，看得出来足够随机。

(b) Run your Reservoir Sampling 5 times and report the average number of times the summary has been updated over these 5 runs (5 pts).

从 353160 中抽取 10000：



```
 Assignments/Assignment-2/Task-2.py"
the average number of times the summary has been updated over these 5 runs:
35718.2

Process finished with exit code 0
```

平均更新次数： `35718.2`

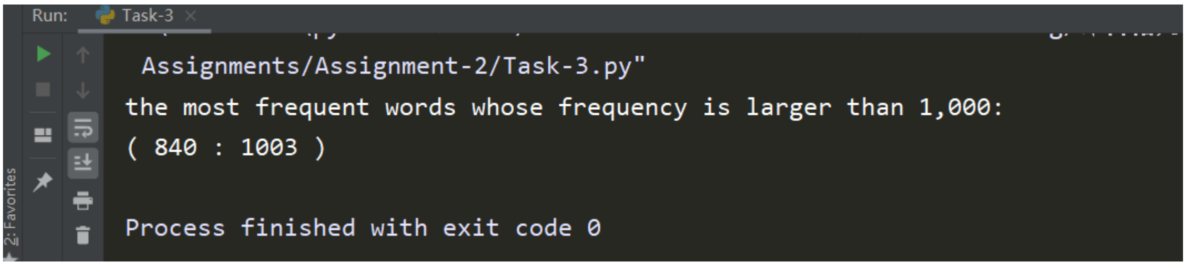
Task - 3: Misra-Gries Summary

由PPT中说明以及例子，Misra-Gries Summary算法的代码如下：

```python
def MisraGriesSummary(stream, k):
    A = {}
    for i in stream:
        if i in A.keys():
            A[i] += 1
        elif len(A) < k - 1:
            A[i] = 1
        else:
            for j in list(A.keys()):
                A[j] -= 1
                if A[j] == 0:
                    del A[j]
    return A
```

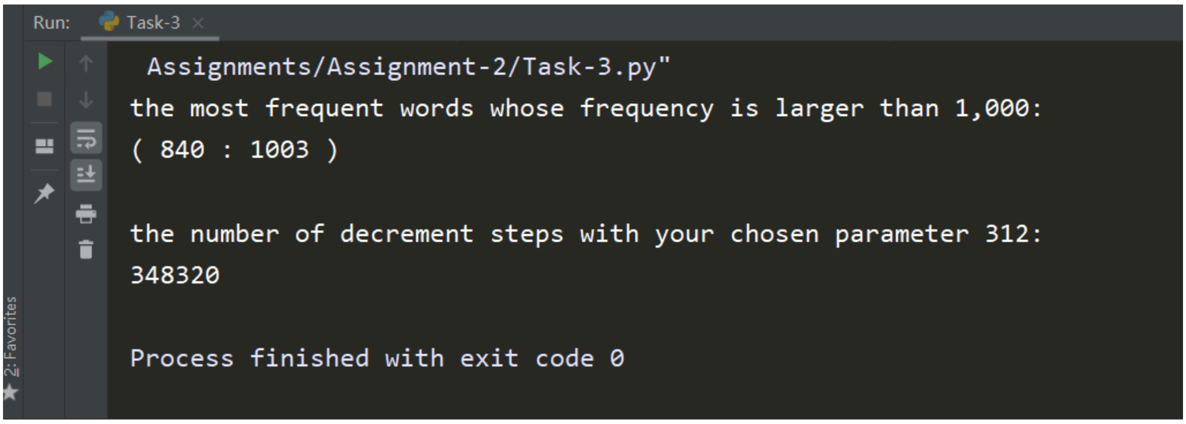
(a)

采用二分法对全空间进行搜索，得到`the size of summary = 312`时，我们可以find the most frequent words whose frequency is larger than 1,000:



```
 Assignments/Assignment-2/Task-3.py"
the most frequent words whose frequency is larger than 1,000:
( 840 : 1003 )

Process finished with exit code 0
```

(b)



```
 Assignments/Assignment-2/Task-3.py"
the most frequent words whose frequency is larger than 1,000:
( 840 : 1003 )

the number of decrement steps with your chosen parameter 312:
348320

Process finished with exit code 0
```

stream的大小为：`353160`,

the number of decrement steps with your chosen parameter 312: `348320`.

Task - 4: CountMin Sketch (15 pts):

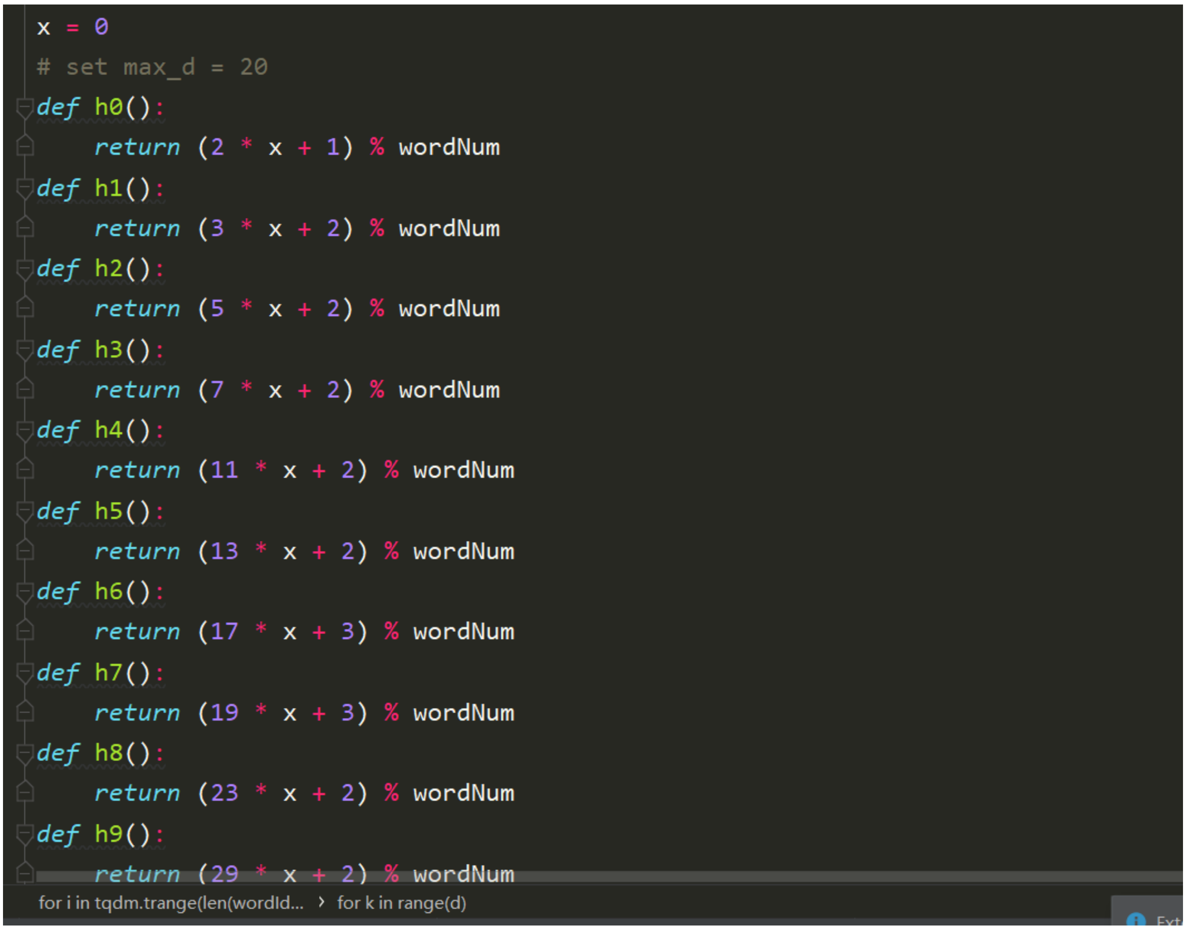
(a)

选择 `d = 9`：

compute the positions for each element in stream && Construct the CountMin Sketch:

```
for i in tqdm.trange(len(wordIdList)):
    for k in range(d):
        x = wordIdList[i]
        # First we compute the positions for each element in stream:
        exec("hList[" + str(k) + "].append(h" + str(k) + "())\n")
        # Construct the CountMin Sketch:
        cur = hList[k][len(hList[k]) - 1]
        hDict[k][cur] = hDict[k][cur] + 1 if cur in hDict[k].keys() else 1
```

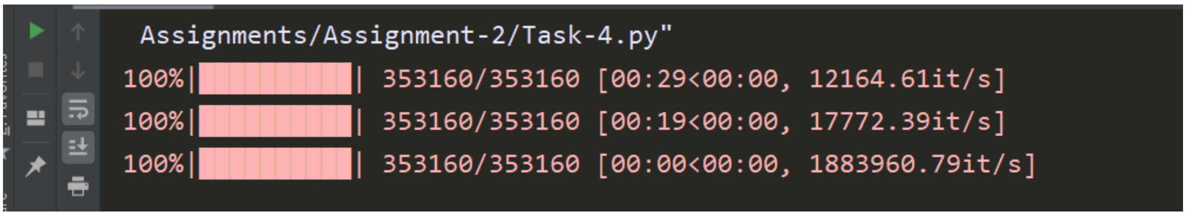
非常多的hash函数选择：



```
x = 0
# set max_d = 20
def h0():
    return (2 * x + 1) % wordNum
def h1():
    return (3 * x + 2) % wordNum
def h2():
    return (5 * x + 2) % wordNum
def h3():
    return (7 * x + 2) % wordNum
def h4():
    return (11 * x + 2) % wordNum
def h5():
    return (13 * x + 2) % wordNum
def h6():
    return (17 * x + 3) % wordNum
def h7():
    return (19 * x + 3) % wordNum
def h8():
    return (23 * x + 2) % wordNum
def h9():
    return (29 * x + 2) % wordNum
```

并且通过 `exec("hList[" + str(k) + "].append(h" + str(k) + "())\n")` 代码，我可以灵活地调整hash函数的个数(也就是`d`的数量).

(b)



```
 Assignments/Assignment-2/Task-4.py"
100%|██████████| 353160/353160 [00:29<00:00, 12164.61it/s]
100%|██████████| 353160/353160 [00:19<00:00, 17772.39it/s]
100%|██████████| 353160/353160 [00:00<00:00, 1883960.79it/s]
```