Introduction to Information Retrieval and Text Mining

Programming Assignment 2

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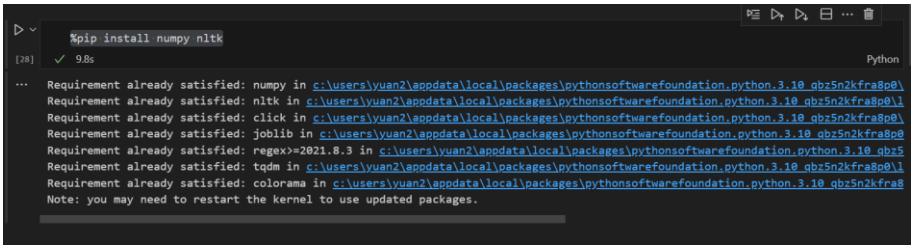
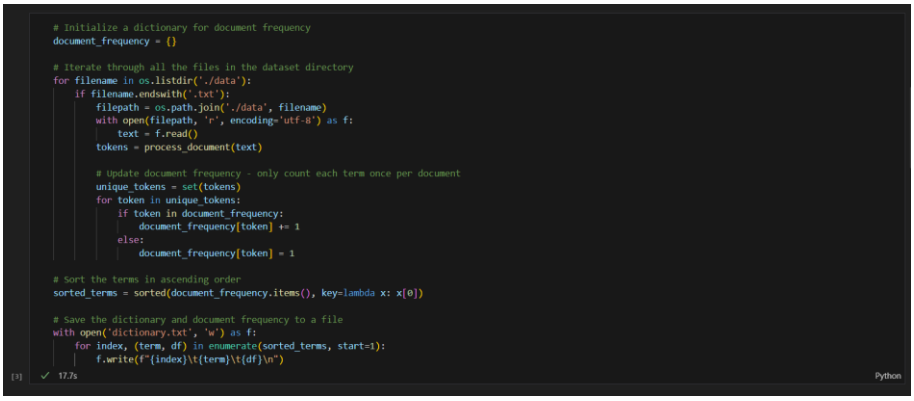
1. 執行環境：VS code
2. 程式語言：python 3.10
3. 執行方式：
   I. 使用 VS code 或 Jupyter Notebook 打開 **pa2.ipynb**
   II. 執行第一個 cell 安裝需要的 packages（**numpy, nltk**）



   III. 確保 stopwords.txt 在相同的目錄中，執行第二個 cell，import 必要的 packages 以及 pa1 tokenize 的處理函數

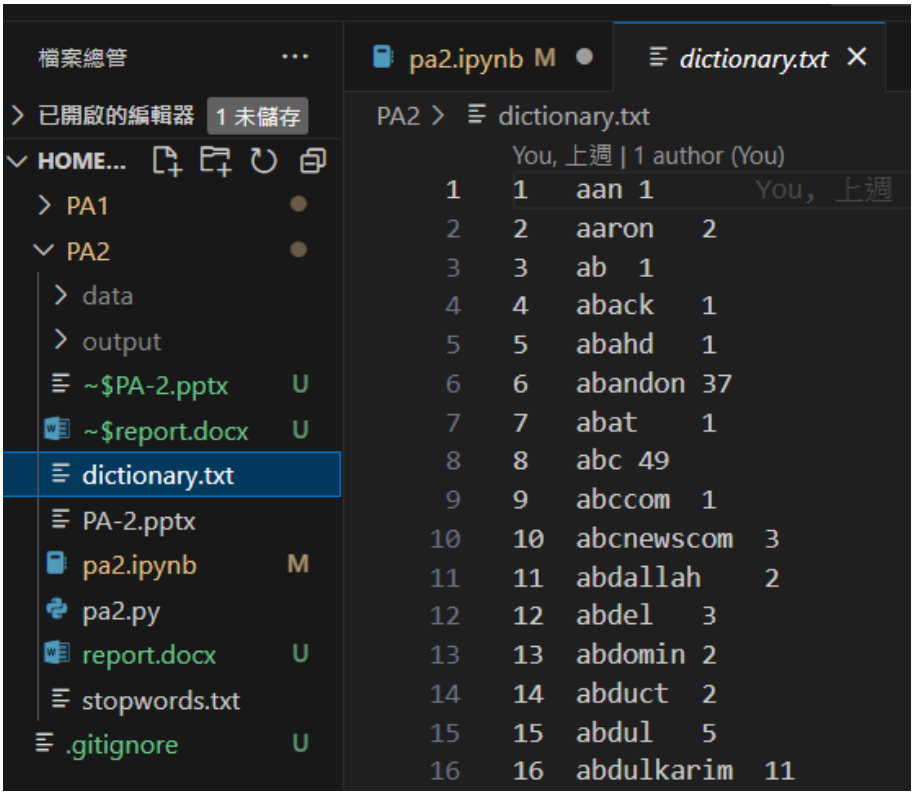
IV. 執行第三個 cell，會在目錄下產生 `dictionary.txt`



```python
# Initialize a dictionary for document frequency
document_frequency = {}

# Iterate through all the files in the dataset directory
for filename in os.listdir('./data'):
    if filename.endswith('.txt'):
        filepath = os.path.join('./data', filename)
        with open(filepath, 'r', encoding='utf-8') as f:
            text = f.read()
        tokens = process_document(text)

        # Update document frequency - only count each term once per document
        unique_tokens = set(tokens)
        for token in unique_tokens:
            if token in document_frequency:
                document_frequency[token] += 1
            else:
                document_frequency[token] = 1

# Sort the terms in ascending order
sorted_terms = sorted(document_frequency.items(), key=lambda x: x[0])

# Save the dictionary and document frequency to a file
with open('dictionary.txt', 'w') as f:
    for index, (term, df) in enumerate(sorted_terms, start=1):
        f.write(f"{index}\t{term}\t{df}\n")
```

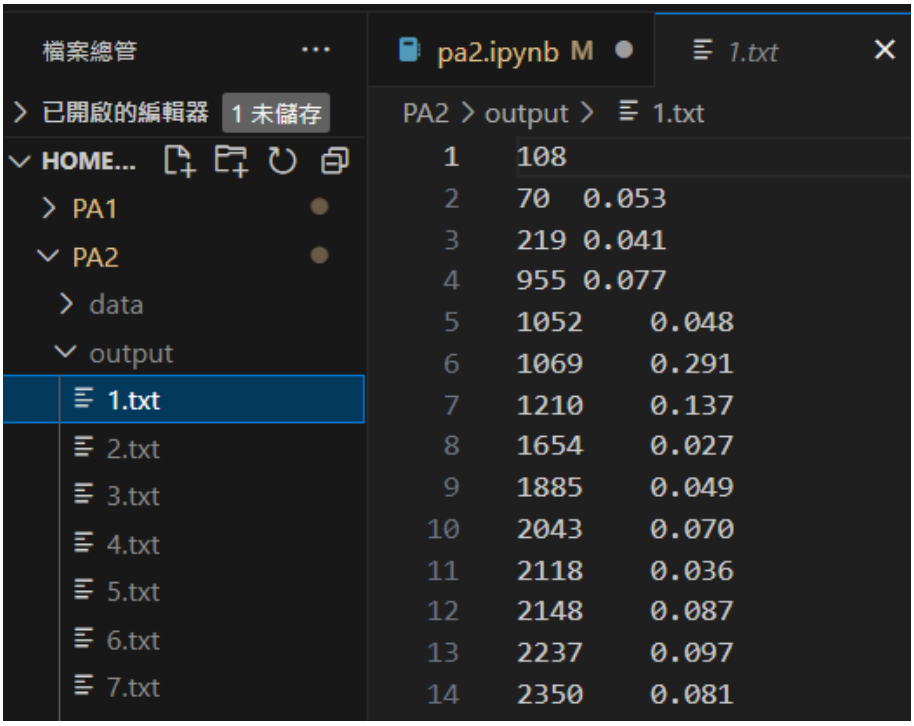
[3] ✓ 17.7s Python

`dictionary.txt` 截圖



V. 執行第四個 cell，會在 `./output` 資料夾中，產生每一個文件的 `{DocID.txt}`，裡面包含所有的 unit tfidf vectors

`1.txt` 截圖



VI. 執行第五個 cell，會將指定 documents 的 vector 載入並且計算 cosine similarity（更改不同的 docx 以及 docy 編號，可以計算不同的文章相似性）

4. 作業處理邏輯說明：

Construct a dictionary based on the terms extracted from the given documents.

I. 先將 pa1 的 tokenization 寫成一個函數，處理依序為，移除數字、移除標點符號、Lowercasing、移除 stopwords、移除長度為一或零的字串、使用 NLTK library 中的 PorterStemmer 進行 stemming。

```
def process_document(text):
    # Remove digits
    text = re.sub(r'\d+', '', text)
    # Remove punctuation
    translator = str.maketrans('', '',
'''!"#$%&'()*+,-./:;<=>?@[\\]^_`{|}~''')
    text = text.translate(translator)
    tokens = text.split()
    # Convert to lowercase
    tokens = [word.lower() for word in tokens]
    # Remove stopwords
    tokens = [word for word in tokens if word not in stop_words]
    # Remove single-character words and empty strings
    tokens = [word for word in tokens if len(word) > 1]
```

```
    # Stem the tokens
    tokens = [ps.stem(word) for word in tokens]
    return tokens
```

II. 計算 document frequency 以及建立 **dictionary.txt**

將 **./data** 中 1095 個 txt 檔案依序讀入，對於單一個 document，先使用前述 **process_document** 的函數進行 tokenization，獲得單一 document 的 tokens 之後，用 **set** 轉換為 **unique_tokens**，並更新整個 collection 的 document frequency。

```
document_frequency = {}
# Iterate through all the files in the dataset directory
for filename in os.listdir('./data'):
    if filename.endswith('.txt'):
        filepath = os.path.join('./data', filename)
        with open(filepath, 'r', encoding='utf-8') as f:
            text = f.read()
        tokens = process_document(text)
        # Update document frequency - only count each term once per
document
        unique_tokens = set(tokens)
        for token in unique_tokens:
            if token in document_frequency:
                document_frequency[token] += 1
            else:
                document_frequency[token] = 1
```

最後以 ascending order 重新排序 document frequency，並存入 **dictionary.txt** 中

```
# Sort the terms in ascending order
sorted_terms = sorted(document_frequency.items(), key=lambda x:
x[0])
# Save the dictionary and document frequency to a file
with open('dictionary.txt', 'w') as f:
    for index, (term, df) in enumerate(sorted_terms, start=1):
        f.write(f"{index}\t{term}\t{df}\n")
```

Transfer each document into a tfidf unit vector.

III. 計算 term frequency (tf)，從 **./data** 中 1095 個 txt 檔案中，再次經由 **process_document** 提取出單一 document 的 tokens，接著計算這些 document 的 term frequency。

```
# Build a term index dictionary for easy lookup
term_index = {term: index for index, (term, df) in
enumerate(sorted_terms, start=1)}

# Now compute the tf-idf vectors for each document
for filename in os.listdir('./data'):
    if filename.endswith('.txt'):
        filepath = os.path.join('./data', filename)
        with open(filepath, 'r', encoding='utf-8') as f:
            text = f.read()
        tokens = process_document(text)

        # Compute term frequency
        tf = {}
        for token in tokens:
            if token in tf:
                tf[token] += 1
            else:
                tf[token] = 1
```

接著，使用先前已經在計算 document frequency 時，建立好的 **term_index** 以及 document frequency 來計算 tfidf 的值。

```
 # Create a zero vector of length equal to the number of terms
        tfidf_vector = np.zeros(len(term_index))

        for term, freq in tf.items():
            if term in term_index:
                tf_t = freq
                df_t = document_frequency[term]
                N = len(os.listdir('./data'))  # Assuming all files
in the dataset directory are text documents
```

```
                idf_t = math.log10(N / df_t)
                tfidf_t = tf_t * idf_t
                tfidf_vector[term_index[term] - 1] = tfidf_t  # -1
because indices start from 1
```

將計算計算好的 tfidf 值轉換為 unit-tfidf，並且防止除以零的情況。

```
# Normalize the tf-idf vector to unit length
        norm = np.linalg.norm(tfidf_vector)
        if norm > 0:
            tfidf_vector_unit = tfidf_vector / norm
        else:
            tfidf_vector_unit = tfidf_vector  # avoid division by
zero
```

最後將單一 document 中有的 term，依照 term index 以及 tfidf 的值，儲存在 {DocID.txt} 中。

```
        # Get non-zero entries for the sparse representation
        non_zero_entries = [(index + 1, tfidf) for index, tfidf in
enumerate(tfidf_vector_unit) if tfidf > 0]

        # Save the tf-idf unit vector to a file
        doc_id = os.path.splitext(filename)[0]  # Assuming filename
is 'DocID.txt'
        with open(f'./output/{doc_id}.txt', 'w') as f:
            f.write(f"{len(non_zero_entries)}\n")  # Write the
number of non-zero entries
            for index, tfidf in non_zero_entries:
                f.write(f"{index}\t{tfidf:.3f}\n")  # Write the term
index and tf-idf value, formatted to 3 decimal places
```

Write a function ***cosine(Doc$_x$, Doc$_y$)*** *which loads the tf-idf vectors of documents x and y and returns their cosine similarity.*

IV. 最後，寫一個函數，先載入單一 document 的 unit tfidf vectors，然後再計算 cosine similarity。

```
def cosine(docx, docy):
    # Inline function to load vector
    def load(doc_id):
        with open(f'./output/{doc_id}.txt', 'r') as f:
            lines = f.readlines()
        vector = np.zeros(len(term_index))  # Ensure all vectors are
of same length as term_index
        for line in lines[1:]:
            index, tfidf = line.strip().split()
            index = int(index) - 1  # Indices start from 1 in the
file
            tfidf = float(tfidf)
            vector[index] = tfidf
        return vector

    vector_x = load(docx)
    vector_y = load(docy)

    # The vectors are already normalized (unit vectors), so just
compute the dot product.
    cosine_similarity = np.dot(vector_x, vector_y)

    return cosine_similarity
```

以下為範例用法，輸出為 `Cosine similarity between 1 and 2: 0.195`

```
# Example usage:
docx = '1'
docy = '2'
similarity = cosine(docx, docy)
print(f'Cosine similarity between {docx} and {docy}:
{similarity:.3f}')
```