CSIT 5930 Search Engine and Applications

Homework 2

Due: See Canvas Home -> Assignments page

In this homework, you build a search engine implementing the vector space model and tf*idf weighting method. You need to use Python to write the program and Flask to build the frontend and backend. If you are not familiar with Python and Flask, you should learn it (you won't regret learning them for your career).

Install packages

- python 3.6+
  - Recommend using python3.6+
  - If you've never installed Python before, I would recommend installing "[Anaconda]". It is a toolkit that equips you with thousands of open-source packages and libraries.
- NLTK 3.2+

If you install Anaconda, you've already installed the NLTK package. If not , run the command below.

```
pip install nltk
```

Check if you've installed NLTK library.

First, type `python` to go into the py env. Then type the command below, and see if there is any error message.

```
>>> from nltk.corpus import stopwords
```

```
LookupError:
**********************************************************************
  Resource 'tokenizers/punkt/english.pickle' not found.  Please
  use the NLTK Downloader to obtain the resource:  >>>
  nltk.download()
  Searched in:
    - 'C:\\Users\\xyu3/nltk_data'
    - 'C:\\nltk_data'
    - 'D:\\nltk_data'
    - 'E:\\nltk_data'
    - 'D:\\anaconda_install\\nltk_data'
    - 'D:\\anaconda_install\\lib\\nltk_data'
    - 'C:\\Users\\xyu3\\AppData\\Roaming\\nltk_data'
    - ''
```

When you see error messages like above, just follow the instructions, because you need to install some other libraries to make it work.

Dataset Description

This dataset consists of **778** papers coming from the accepted papers of [ACL 2000](ACL 2000).

Here is an example for loading the dataset:

```
import json
with open('./paper.json','r') as f:
    papers = json.load(f)
```

```
# papers is a list of dict. Each dict is a record including
title,author,abstract,publish year.
{
    "title": "Low-Resource Generation of Multi-hop Reasoning Questions",
    "authors": ["Jianxing Yu", "Wei Liu", "Shuang Qiu", "Qinliang Su", "Kai
Wang", "Xiaojun Quan", "Jian Yin"],
    "abstract": "This paper focuses on generating multi-hop reasoning questions
from the raw text in a low resource circumstance. Such questions have to be
syntactically valid and need to logically correlate with the answers by deducing
over multiple relations on several sentences in the text. Specifically, we first
build a multi-hop generation model and guide it to satisfy the logical
rationality by the reasoning chain extracted from a given text. Since the labeled
data is limited and insufficient for training, we propose to learn the model with
the help of a large scale of unlabeled data that is much easier to obtain. Such
data contains rich expressive forms of the questions with structural patterns on
syntax and semantics. These patterns can be estimated by the neural hidden semi-
Markov model using latent variables. With latent patterns as a prior, we can
regularize the generation model and produce the optimal results. Experimental
results on the HotpotQA data set demonstrate the effectiveness of our model.
Moreover, we apply the generated results to the task of machine reading
comprehension and achieve significant performance improvements.",
    "year": "2020"
}
```

We will give you a folder called flask_se. The structure is shown below. You will **find the dataset (paper.json) inside the backend folder**. Also, the query file is under the same directory.

```
.
├── backend
│   ├── paper.json
│   ├── __pycache__
│   ├── query.txt
│   ├── se_sample.py
│   └── web.py
└── frontend
    ├── css
    ├── img
    ├── index.html
    ├── js
    └── lib
```

Tasks

The basic task is to implement a search engine that supports **abstract searching**.

a) Preprocess the abstract with NLTK

1. Discard punctuation marks
2. Perform tokenization, stop words removal and stemming

b) Create an index (inverted file) of the preprocessed documents. Each postings (an entry in a postings list) contains the document id, and the positions of the indexed word in the documents. You can use the json format to store the inverted index. More specifically , you can use **dict** to store the information.

```
{
    "live":{
        # 40 is the document id which contains the word live and as for 2,5 is
the position of the word live that appears in the abstract.
        40:[2,5],
        56:[10]
    },
    "only":{
        20:[30],
    }
}
```

Build auxiliary data structures, e.g., word -> document-frequency table. This is helpful when you need to calculate the idf values which need the df (document frequency) values.

c) For each query in the query file, retrieve the top-5 documents using tf*idf weighting and cosine similarity. For each of the top five results, display

1. The document id
2. **Five highest weighted keywords** of the document and the corresponding postings lists
3. The number of unique keywords in the document
4. The magnitude (L2 norm) of the document vector
5. The similarity score

An example is shown below

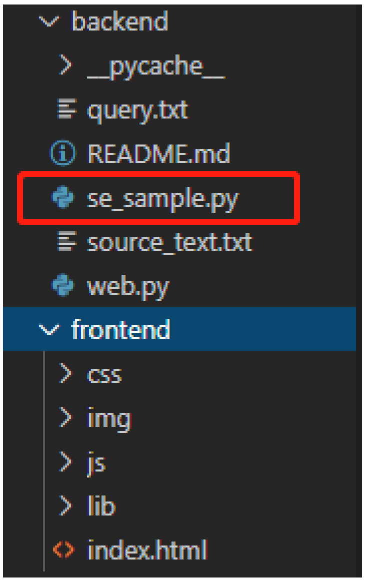
```
DID
First 20 words of the document
live     -> | D2:1,5 | D3:0  | D6:2  |
never    -> | D5:1  |
only     -> | D6:1  |
tomorrow -> | D1:2  | D2:2  |
twice    -> | D1:0,4 | D2:0,4 |

Number of unique keywords in document: ...
Magnitude of the document vector (L2 norm): ...
Similarity score: ...
```

d) In addition to the inverted index. Describe the other data structures you need to support search and ranking.

e) If the text passages are not updated, how would you design your program to speed up the computation of the similarity values?

f) Use Flask to implement a complete search engine application:

- move your py file into the folder "backend" and name it as se_sample.py



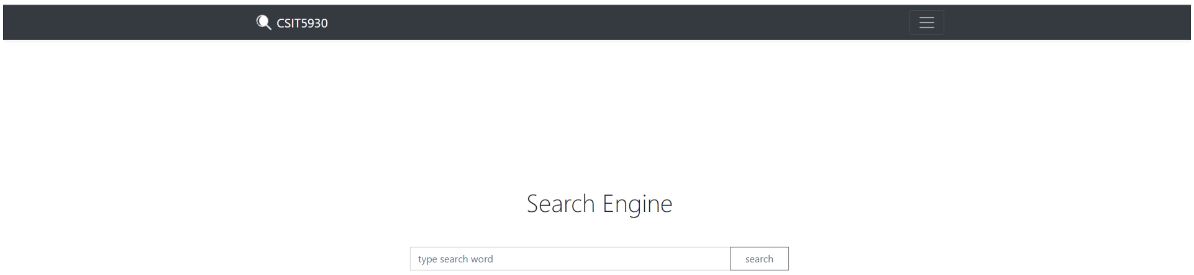
- Make sure your se_sample.py file has a function called search_api, and the param is query. The function returns the corresponding texts sorted by the matching score.

```
def search_api(query):
    '''
    param: query , str
    return [] , list of dict, each dict is a paper record of the original
dataset
    '''
```

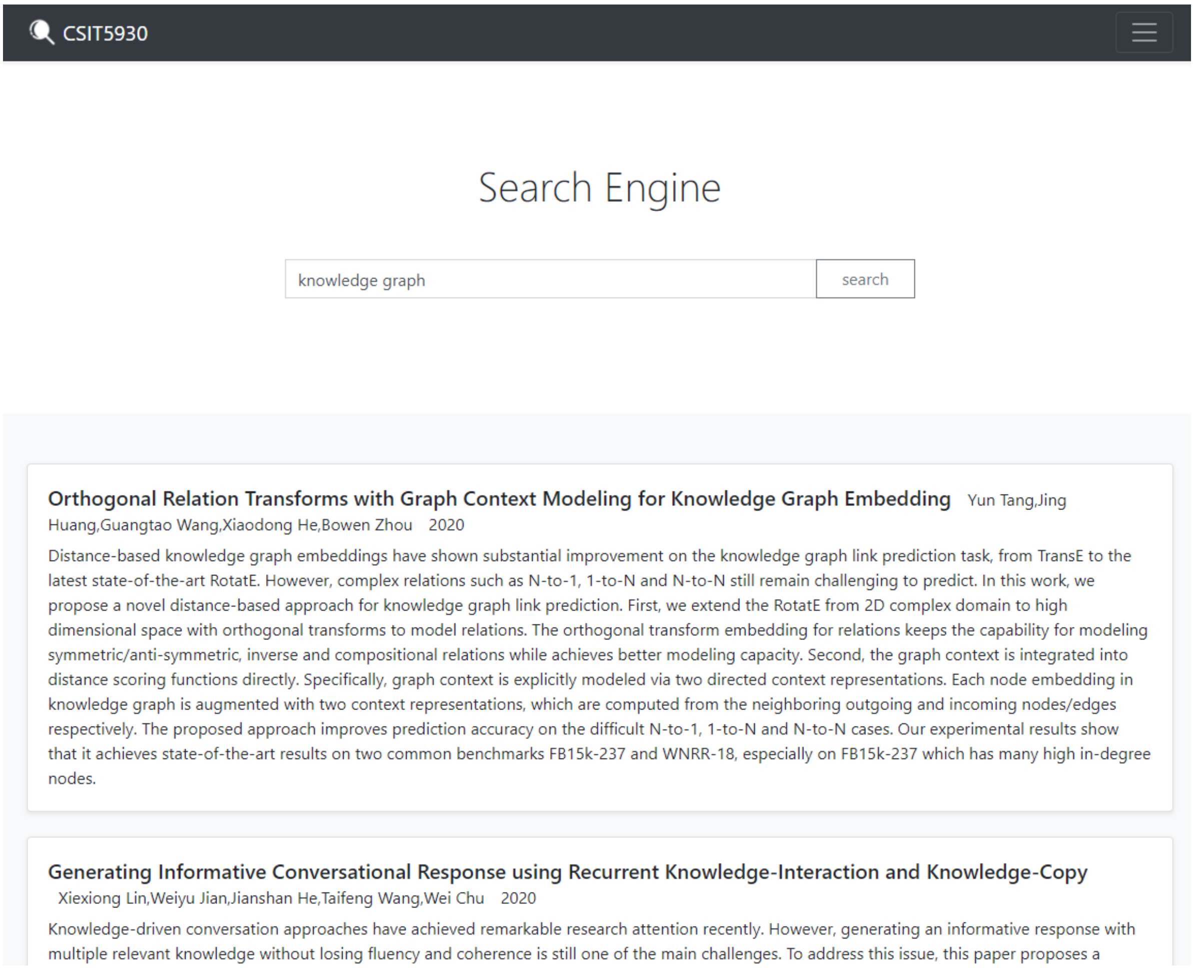
- install flask
  - if you have not installed the Flask before , try the command `pip install flask`
- Run backend
  - under the path of "backend " , type `python web.py`

```
(root) C:\Users\xyu3\Desktop\flask_se\backend>python web.py
 * Restarting with stat
 * Debugger is active!
 * Debugger PIN: 127-116-582
 * Running on http://localhost:4000/ (Press CTRL+C to quit)
```

- When the server is on, go to the frontend folder and just open the `index.html` with your browser.



- Type the query like "knowledge graph", then click search button



What to submit

- **A pdf** including
    - Questions c, d, e described above.
    - Any tricks you have made to improve the searching performance and effectiveness.
- **Code**

- Just submit the code you've implemented by yourself. Do not upload the whole flask_se folder.
    - Make sure your scripts are runnable.
    - Write down the steps about how to run your code.