Documentation

Grammar Website and Search System

Development Setup

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Table of Contents

Chapter 1

Introduction

This document is a tutorial on the setup of the grammar practice website on the Django development web server in Windows 10 environment. The website provides three types of grammar question search:

- *Database search* using Django API
- Solr search with original ranking, by BM25 (which we will call *basic Solr search*)
- Solr search by ranking models (which we will call *intelligent Solr search*)

Intelligent Solr search uses machine-learned ranking models to rerank the original ranking in basic Solr search.

The website is at https://ronkow.com/grammar and the source files are at https://github.com/ronkow/solr-learning-to-rank. Any information on new features in future will be posted on the website home page.

Setup of Django and Solr in a production environment requires setting up security measures. These are not covered here. You may refer to my documentation on production setup at https://www.ronkow.com/documentation/.

I welcome any feedback and correction of errors. You can contact me at ronkow2020@gmail.com.

Chapter 2

Project Requirements and Virtual Environment

2.1 Major Requirements

The following are the software requirements which we will install when we set up the virtual environment for the project. We will install additional libraries after that.

- Python 3.7.* (the latest version of Python that Stanford Stanza 1.1.1 supports)
- Django 2.2.*

Create a directory for the project. Let's name the directory `grammar`. We will download the required libraries and save them in `/grammar/downloads`. First, we need Solr and Standford CoreNLP:

- Solr 7.7.3 (https://archive.apache.org/dist/lucene/solr/)
- Stanford CoreNLP 4.2.0 (https://stanfordnlp.github.io/CoreNLP/)

Java Runtime Environment (JRE) is required to run Solr and RankLib. Download and install JRE:

- JRE 1.8 or later (https://www.java.com/en/download/)

We will use the Learning To Rank library RankLib to train the ranking models. We will need to download these two libraries:

- RankLib 2.15 (https://sourceforge.net/projects/lemur/files/lemur/RankLib-2.15/)
- Apache Commons Mathematics 3.5 (http://commons.apache.org/proper/commons-math/)

Lastly, we will use the software **DB Browser for SQLite** to view the database schema and populate the database with data. Download and install it from:

https://sqlitebrowser.org/dl/

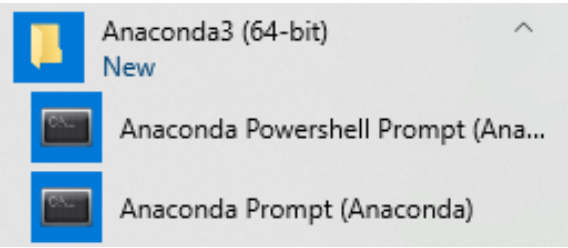
2.2 Anaconda and Miniconda

2.2.1 Installation

To create the project virtual environment, we use the package manager `conda` from the Miniconda repository, which is a small version (i.e., less packages) of the Anaconda repository. Download and install **Miniconda3 Windows 64-bit for Python 3.8** from:

https://docs.conda.io/en/latest/miniconda.html

After installation, we will see the two command line applications provided by Anaconda:



We will use Anaconda Powershell Prompt. Open the Anaconda Powershell and we will see the default virtual environment named `base`:

```
(base) PS D:>
```

The following is the list of libraries installed in this default environment:

```
(base) PS D:\> conda list
# packages in environment at C:\Anaconda:
#
# Name                    Version                   Build  Channel
asgiref                   3.3.1                     pypi_0    pypi
brotlipy                  0.7.0           py38h2bbff1b_1003
ca-certificates           2020.11.8            h5b45459_0    conda-forge
certifi                   2020.11.8         py38haa244fe_0    conda-forge
cffi                      1.14.3            py38hcd4344a_2
chardet                   3.0.4           py38haa95532_1003
conda                     4.9.2             py38haa244fe_0    conda-forge
conda-package-handling    1.7.2             py38h76e460a_0
console_shortcut          0.1.1                        4
cryptography              3.2.1             py38hcd4344a_1
django                    3.1.4                     pypi_0    pypi
git                       2.23.0                h6bb4b03_0
idna                      2.10                        py_0
kaggle                    1.5.9             py38h32f6830_0    conda-forge
menuinst                  1.4.16            py38he774522_1
numpy                     1.19.4                    pypi_0    pypi
openssl                   1.1.1h               he774522_0    conda-forge
pip                       20.2.4            py38haa95532_0
powershell_shortcut       0.0.1                        3
protobuf                  3.14.0                    pypi_0    pypi
pycosat                   0.6.3             py38h2bbff1b_0
pycparser                 2.20                        py_2
pyopenssl                 19.1.0              pyhd3eb1b0_1
pysocks                   1.7.1             py38haa95532_0
python                    3.8.5                h5fd99cc_1
python-dateutil           2.8.1                       py_0    conda-forge
python-slugify            4.0.1               pyh9f0ad1d_0    conda-forge
python_abi                3.8                       1_cp38    conda-forge
pytz                      2020.4                    pypi_0    pypi
pywin32                   227               py38he774522_1
requests                  2.24.0                      py_0
ruamel_yaml               0.15.87           py38he774522_1
setuptools                50.3.1            py38haa95532_1
six                       1.15.0            py38haa95532_0
sqlite                    3.33.0               h2a8f88b_0
sqlparse                  0.4.1                     pypi_0    pypi
text-unidecode            1.3                         py_0    conda-forge
torch                     1.7.1                     pypi_0    pypi
tqdm                      4.51.0              pyhd3eb1b0_0
typing-extensions         3.7.4.3                   pypi_0    pypi
unidecode                 1.1.1                       py_0    conda-forge
urllib3                   1.24.3                      py_1    conda-forge
vc                        14.1                 h0510ff6_4
vs2015_runtime            14.16.27012          hf0eaf9b_3
wheel                     0.35.1              pyhd3eb1b0_0
win_inet_pton             1.1.0             py38haa95532_0
wincertstore              0.2                       py38_0
yaml                      0.2.5                he774522_0
zlib                      1.2.11               h62dcd97_4
```

2.2.2 Virtual Environment

Create a YAML file with the following definitions and name it `environment_grammar.yml`. In the YAML file, we specify the name of the virtual environment (`grammar`) and the list of libraries to be installed during the creation of the virtual environment:

```
name: grammar
dependencies:
- python==3.7.*
- Django==2.2.*
```

Create the virtual environment:

```
(base) PS D:\> conda env create -f environment_grammar.yml
Collecting package metadata (repodata.json): done
Solving environment: done
Preparing transaction: done
Verifying transaction: done
Executing transaction: done
```

Activate the `grammar` environment and display the list of libraries installed:

```
(base) PS D:\> conda activate grammar
(grammar) PS D:\> conda list
# packages in environment at C:\Anaconda\envs\grammar:
#
# Name                    Version                   Build  Channel
ca-certificates           2020.12.8            haa95532_0
certifi                   2020.12.5        py37haa95532_0
django                    2.2.5                    py37_1
openssl                   1.1.1i               h2bbff1b_0
pip                       20.3.3           py37haa95532_0
python                    3.7.9                h60c2a47_0
pytz                      2020.5             pyhd3eb1b0_0
setuptools                51.1.2           py37haa95532_3
sqlite                    3.33.0               h2a8f88b_0
sqlparse                  0.4.1                      py_0
vc                        14.2                 h21ff451_1
vs2015_runtime            14.27.29016          h5e58377_2
wheel                     0.36.2             pyhd3eb1b0_0
wincertstore              0.2                      py37_0
zlib                      1.2.11               h62dcd97_4
```

In my system, the directory for the virtual environment is in the following location:

```
C:\Anaconda\envs\grammar
```

Note that my installation of Anaconda is in `C` drive while my project files are in `D` drive.

2.2.3 `conda` and `pip`

We use `conda` to install additional packages or libraries from the Anaconda repository:

```
(environment_name) PS D:\> conda install package_name
```

For Python 3.7 and 64-bit Windows, the complete list of available packages in Anaconda is shown in:

https://docs.anaconda.com/anaconda/packages/py3.7_win-64/

We may need a package not found in Anaconda. Anaconda documentation (https://docs.conda.io/projects/conda/en/master/user-guide/tasks/manage-pkgs.html) recommends trying to find such packages in **conda-forge** (https://conda-forge.org/feedstock-outputs/) first and use `conda` if found:

```
(environment_name) PS D:\> conda install -c conda-forge package_name
```

For Python packages not found in Anaconda, we can use `pip` instead. `conda` (package manager for packages of any language) is designed to be as compatible with `pip` (package manager for Python packages only) as possible. Always try using `conda` to install any Python package first. If that does not work (i.e., the package is not found in Anaconda), use `pip`:

```
(environment_name) PS D:\> pip install package_name
```

2.2.4 Other `conda` Commands

To create a new virtual environment with no libraries:

```
(base) PS D:\> conda create --name environment_name
```

To delete a virtual environment:

```
(base) PS D:\> conda remove --name environment_name --all
```

To uninstall a package in a virtual environment:

```
(environment_name) PS D:\> conda uninstall package_name
```

To exit from a virtual environment:

```
(environment_name) PS D:\> conda deactivate
```

2.3 Additional Requirements

We will now install the additional requirements. Install the following libraries using `conda`:

```
(grammar) PS D:\> conda install -c stanfordnlp stanza==1.1.*
(grammar) PS D:\> conda install nltk==3.5.*
(grammar) PS D:\> conda install pandas==1.2.*
(grammar) PS D:\> conda install jupyterlab
```

Install the following libraries using `pip`:

```
(grammar) PS D:\> pip install django-crispy-forms==1.10.*
(grammar) PS D:\> pip install pycorenlp==0.3.*
```

Jupyter Lab is required to run our code. **NLTK** is used to generate POS tags. **Stanford Stanza** is required as a client for **CoreNLP** server, which we use to generate grammar production rules. **pycorenlp** provides the Python API for **CoreNLP**. **django-crispy-forms** is used for front-end web page design. **pandas** is required to run the code to create the model datasets.

We may also use **Haystack** API to upload data to Solr from the database. However, as I will explain in Section 6.5, this is optional as we can also use the Solr API to upload data. If you wish to experiment with **Haystack**, install the following:

```
(grammar) PS D:\> pip install pysolr==3.9.*
(grammar) PS D:\> pip install django-haystack==2.8.*
```

The following is the complete list of libraries installed in the virtual environment (excluding **pysolr** and **Haystack**):

```
(grammar) PS D:\> conda list
# packages in environment at C:\Anaconda\envs\grammar:
#
_pytorch_select           1.1.0                      cpu
argon2-cffi               20.1.0           py37he774522_1
async_generator           1.10             py37h28b3542_0
attrs                     20.3.0             pyhd3eb1b0_0
backcall                  0.2.0                     py_0
blas                      1.0                        mkl
bleach                    3.2.3              pyhd3eb1b0_0
brotlipy                  0.7.0           py37h2bbff1b_1003
ca-certificates           2021.1.19            haa95532_0
certifi                   2020.12.5        py37haa95532_0
cffi                      1.14.4           py37hcd4344a_0
chardet                   4.0.0           py37haa95532_1003
click                     7.1.2              pyhd3eb1b0_0
colorama                  0.4.4              pyhd3eb1b0_0
cryptography              3.3.1            py37hcd4344a_0
decorator                 4.4.2                     py_0
```

```
defusedxml                0.6.0                    py_0
django                    2.2.5                   py37_1
django-crispy-forms       1.10.0                   pypi_0    pypi
entrypoints               0.3                      py37_0
idna                      2.10                pyhd3eb1b0_0
importlib-metadata        2.0.0                     py_1
importlib_metadata        2.0.0                        1
intel-openmp              2020.2                     254
ipykernel                 5.3.4            py37h5ca1d4c_0
ipython                   7.19.0           py37hd4e2768_0
ipython_genutils          0.2.0               pyhd3eb1b0_1
jedi                      0.18.0           py37haa95532_1
jinja2                    2.11.2              pyhd3eb1b0_0
joblib                    1.0.0               pyhd3eb1b0_0
json5                     0.9.5                     py_0
jsonschema                3.2.0                     py_2
jupyter_client            6.1.7                     py_0
jupyter_core              4.7.0            py37haa95532_0
jupyterlab                2.2.6                     py_0
jupyterlab_pygments       0.1.2                     py_0
jupyterlab_server         1.2.0                     py_0
libprotobuf               3.13.0.1             h200bbdf_0
libsodium                 1.0.18               h62dcd97_0
m2w64-gcc-libgfortran     5.3.0                        6
m2w64-gcc-libs            5.3.0                        7
m2w64-gcc-libs-core       5.3.0                        7
m2w64-gmp                 6.1.0                        2
m2w64-libwinpthread-git   5.0.0.4634.697f757           2
markupsafe                1.1.1            py37hfa6e2cd_1
mistune                   0.8.4           py37hfa6e2cd_1001
mkl                       2020.2                     256
mkl-service               2.3.0            py37h196d8e1_0
mkl_fft                   1.2.0            py37h45dec08_0
mkl_random                1.1.1            py37h47e9c7a_0
msys2-conda-epoch         20160418                     1
nbclient                  0.5.1                     py_0
nbconvert                 6.0.7                    py37_0
nbformat                  5.1.2               pyhd3eb1b0_1
nest-asyncio              1.4.3               pyhd3eb1b0_0
ninja                     1.10.2           py37h6d14046_0
nltk                      3.5                       py_0
notebook                  6.2.0            py37haa95532_0
numpy                     1.19.2           py37hadc3359_0
numpy-base                1.19.2           py37ha3acd2a_0
openssl                   1.1.1i               h2bbff1b_0
packaging                 20.8                pyhd3eb1b0_0
pandas                    1.2.1            py37hf11a4ad_0
pandoc                    2.11                 h9490d1a_0
pandocfilters             1.4.3            py37haa95532_1
parso                     0.8.1               pyhd3eb1b0_0
pickleshare               0.7.5           pyhd3eb1b0_1003
```

```
pip                       20.3.3           py37haa95532_0
prometheus_client         0.9.0              pyhd3eb1b0_0
prompt-toolkit            3.0.8                     py_0
protobuf                  3.13.0.1         py37ha925a31_1
pycorenlp                 0.3.0                   pypi_0    pypi
pycparser                 2.20                      py_2
pygments                  2.7.4              pyhd3eb1b0_0
pyopenssl                 20.0.1             pyhd3eb1b0_1
pyparsing                 2.4.7              pyhd3eb1b0_0
pyrsistent                0.17.3           py37he774522_0
pysocks                   1.7.1                   py37_1
python                    3.7.9               h60c2a47_0
python-dateutil           2.8.1                     py_0
pytorch                   1.3.1          cpu_py37h9f948e0_0
pytz                      2020.5             pyhd3eb1b0_0
pywin32                   227              py37he774522_1
pywinpty                  0.5.7                   py37_0
pyzmq                     20.0.0           py37hd77b12b_1
regex                     2020.11.13       py37h2bbff1b_0
requests                  2.25.1             pyhd3eb1b0_0
send2trash                1.5.0              pyhd3eb1b0_1
setuptools                52.0.0           py37haa95532_0
six                       1.15.0           py37haa95532_0
sqlite                    3.33.0              h2a8f88b_0
sqlparse                  0.4.1                     py_0
stanza                    1.1.1                   py37_0    stanfordnlp
terminado                 0.9.2            py37haa95532_0
testpath                  0.4.4                     py_0
tornado                   6.1              py37h2bbff1b_0
tqdm                      4.55.1             pyhd3eb1b0_0
traitlets                 5.0.5                     py_0
urllib3                   1.26.3             pyhd3eb1b0_0
vc                        14.2                h21ff451_1
vs2015_runtime            14.27.29016         h5e58377_2
wcwidth                   0.2.5                     py_0
webencodings              0.5.1                   py37_1
wheel                     0.36.2             pyhd3eb1b0_0
win_inet_pton             1.1.0            py37haa95532_0
wincertstore              0.2                     py37_0
winpty                    0.4.3                        4
zeromq                    4.3.3               ha925a31_3
zipp                      3.4.0              pyhd3eb1b0_0
zlib                      1.2.11              h62dcd97_4
```

2.4 GitHub Repository

To use the most updated code, download the project repository from GitHub:

```
(grammar) PS D:\grammar> git clone https://github.com/ronkow/solr-learning-to-rank
```

2.5 Project Directory Structure

When we complete the entire setup, the project directory will have the following structure:

```
grammar/
    corenlp4
    data
    django
    downloads
    model
    ranklib2
    solr7
    solr-learning-to-rank
```

Within the directory `data`, there will be three sub-directories `raw`, `feature`, and `model` to store the different types of datasets. In subsequent chapters, we will call the directory `solr-learning-to-rank` the *repository directory*.

Chapter 3

Django Setup on Development Server

We will now set up the default Django web site (i.e., the official page from Django). For the official tutorial, visit:

https://www.djangoproject.com/start/

3.1 Default Django Website and SQLite Database

Create the directory `django`. In this directory, we create a Django project. Every Django project has one configuration directory containing the configuration files for the project. Let's name this directory `config`:

```
(grammar) PS D:\grammar\django> django-admin startproject config .
```

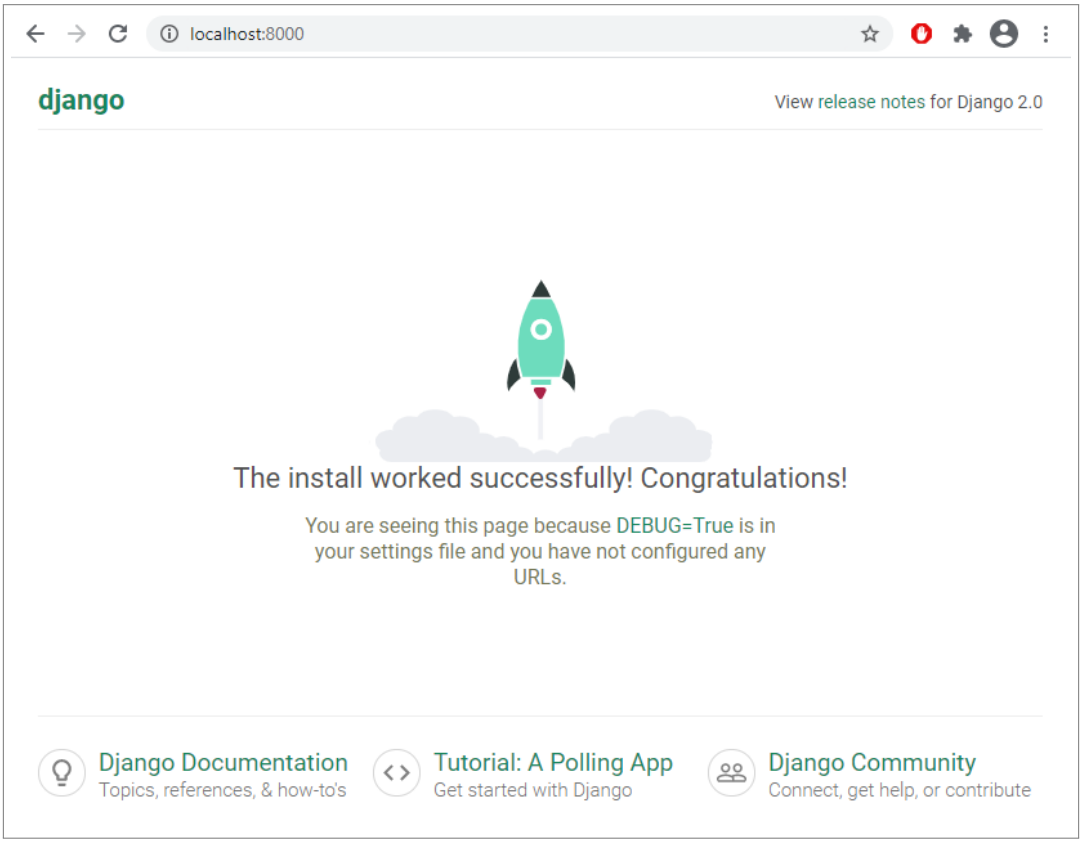
Note the dot at the end of the command above. This creates the following Django directory structure with five Python scripts:

```
django/
    config/
        __init__.py
        settings.py
        urls.py
        wsgi.py
    manage.py
```

Django includes a basic web server for development. Run this development server:

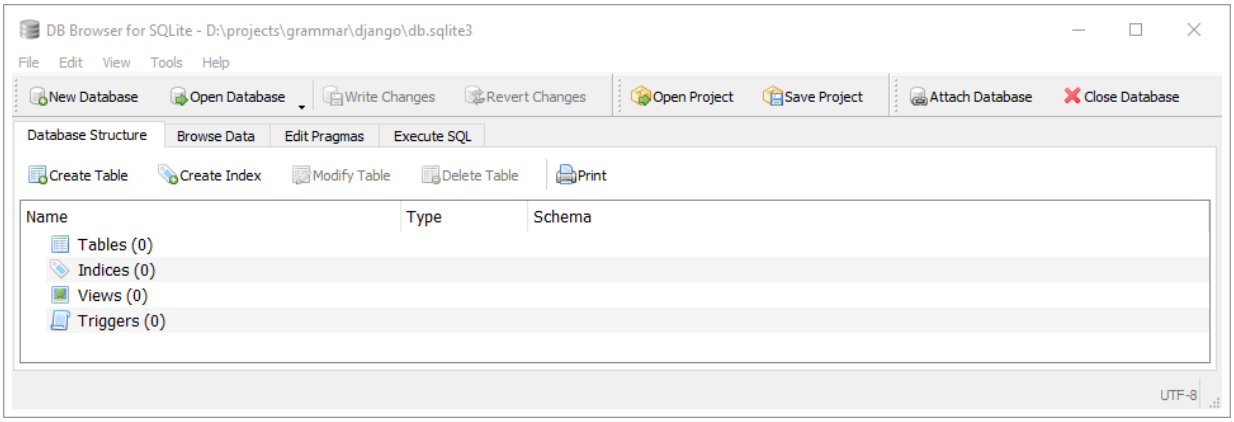
```
(grammar) PS D:\grammar\django> python manage.py runserver
Watching for file changes with StatReloader
Performing system checks...

System check identified no issues (0 silenced).

You have 17 unapplied migration(s).
Your project may not work properly until you apply the migrations for app(s):
admin, auth, contenttypes, sessions.
Run 'python manage.py migrate' to apply them.
January 28, 2021 - 05:27:38
Django version 2.2.5, using settings 'config.settings'
Starting development server at http://127.0.0.1:8000/
Quit the server with CTRL-BREAK.
```

When the server is running, we will see the following official page from Django at `http://127.0.0.1:8000/`, or equivalently, `http://localhost:8000/`:



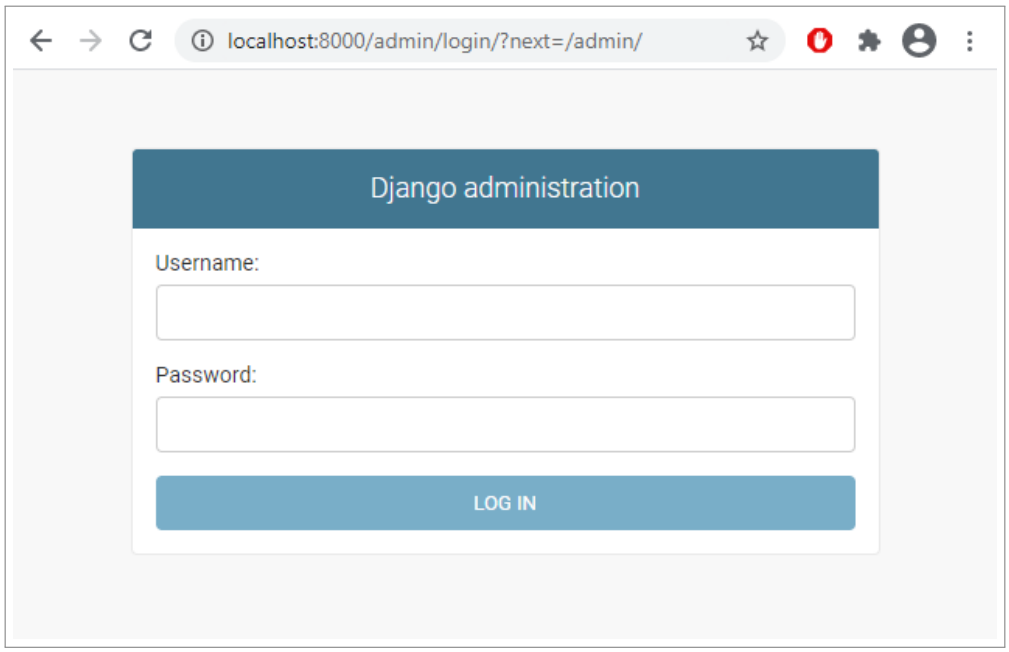
To quit the server, press **Ctrl-C**. We need to quit the server before we can run any command from `manage.py`.

Running the command `runserver` the first time will also create the SQLite database named `db.sqlite3` in `/grammar/django`. Using **DB Browser** (download and install it from https://sqlitebrowser.org/dl/), we can open the database, which currently has no tables:



3.2 Django Admin Site

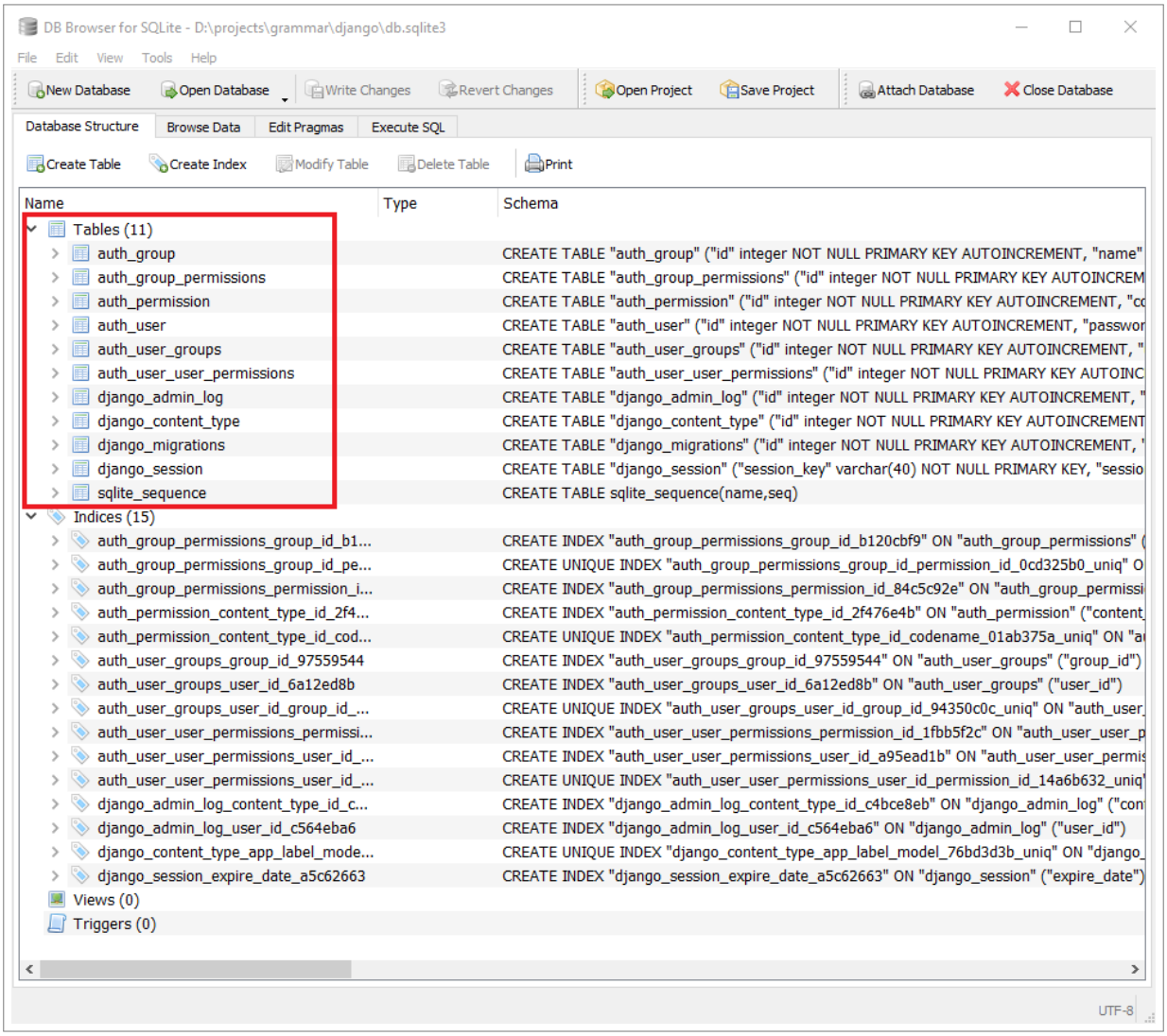
The next step is to set up the Django admin site. Go to `http://localhost:8000/admin/` and we will see the admin site login page:



However, we will not be able to log in to the admin site until we create the required database tables for user data and create an admin user account. Run the command `migrate`:

```
(grammar) PS D:\grammar\django> python manage.py migrate
Operations to perform:
  Apply all migrations: admin, auth, contenttypes, sessions
Running migrations:
  Applying contenttypes.0001_initial... OK
  Applying auth.0001_initial... OK
  Applying admin.0001_initial... OK
  Applying admin.0002_logentry_remove_auto_add... OK
  Applying admin.0003_logentry_add_action_flag_choices... OK
  Applying contenttypes.0002_remove_content_type_name... OK
  Applying auth.0002_alter_permission_name_max_length... OK
  Applying auth.0003_alter_user_email_max_length... OK
  Applying auth.0004_alter_user_username_opts... OK
  Applying auth.0005_alter_user_last_login_null... OK
  Applying auth.0006_require_contenttypes_0002... OK
  Applying auth.0007_alter_validators_add_error_messages... OK
  Applying auth.0008_alter_user_username_max_length... OK
  Applying auth.0009_alter_user_last_name_max_length... OK
  Applying auth.0010_alter_group_name_max_length... OK
  Applying auth.0011_update_proxy_permissions... OK
  Applying sessions.0001_initial... OK
```

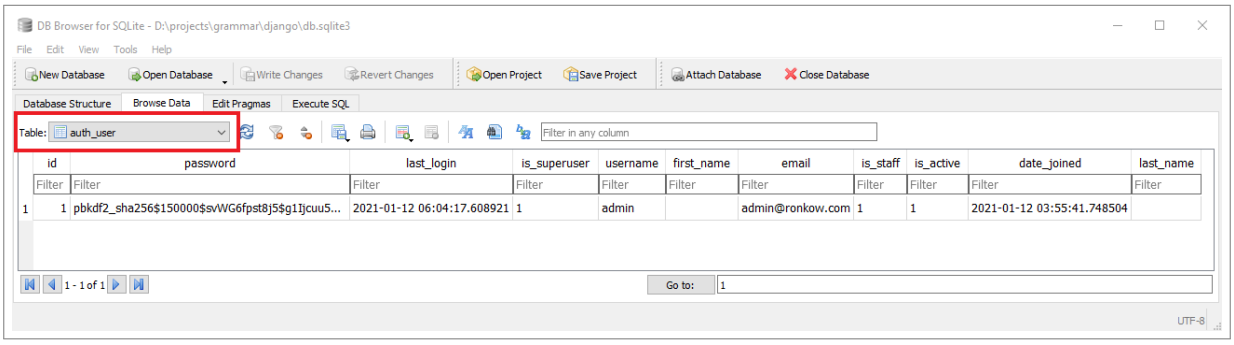
This will create the following tables:



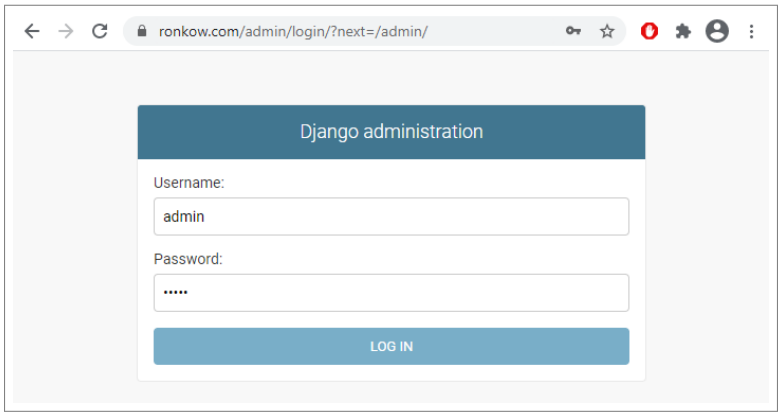
Next, create an admin user account:

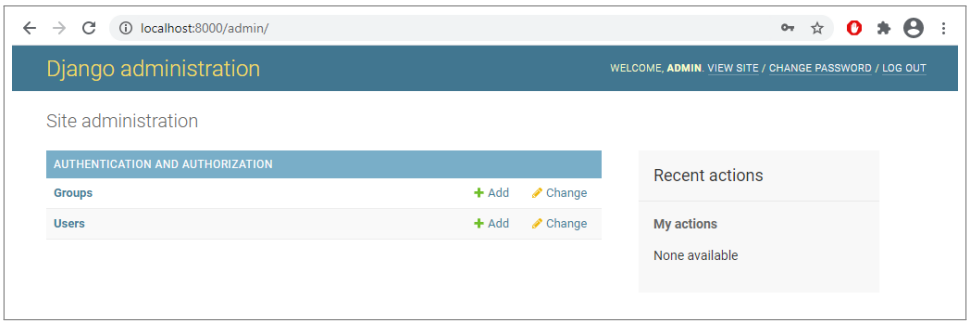
```
(grammar) PS D:\grammar\django> python manage.py createsuperuser
Username (leave blank to use 'myusername'): admin
Email address: admin@mydomain.com
Password:
Password (again):
Superuser created successfully.
```

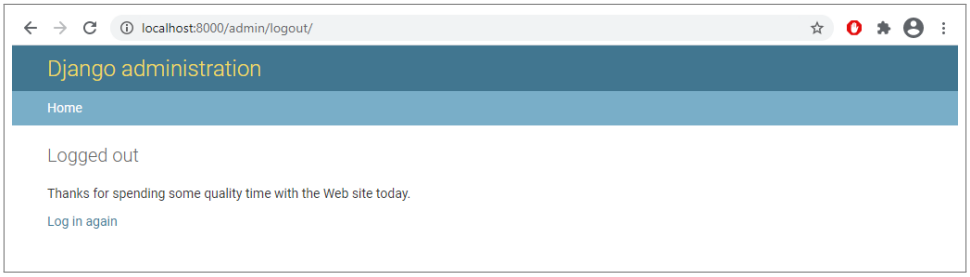
User data are stored in the table `auth_user`:



Log in to the admin site at `http://localhost:8000/admin/` using the admin user account created:







3.3 Templates and Static Files

We will now create a "hello world" page and a CSS file. Create the directories as follows:

```
(grammar) PS D:\grammar\django> mkdir static_files/css
(grammar) PS D:\grammar\django> mkdir templates
```

Create a CSS file with the following code and save the file as `style.css` in `/grammar/django/static_files/css`:

```
p {
    color: blue;
}
```

Create the a HTML file for a "hello world" page and save it as `helloworld.html` in `/grammar/django/templates`:

```
{% load static %}
<!doctype html>
<html>
  <head>
    <meta charset="utf-8">
    <title>Hello World</title>
    <link rel="stylesheet" href="{% static 'css/style.css' %}">
  </head>
  <body>
    <p>Hello world!</p>
  </body>
</html>
```

In `helloworld.html`, we use the Django Template Language with HTML:

https://docs.djangoproject.com/en/3.1/topics/templates/#the-django-template-language

Next, in `settings.py`, add the path of the directory `templates` to the list `TEMPLATES`. At the last line of `settings.py`, add the path of the directory `static_files`:

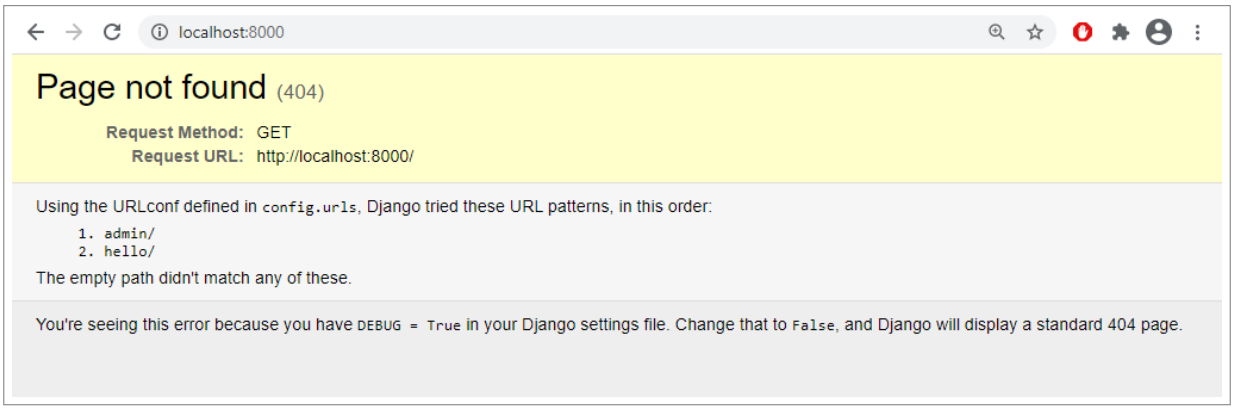
```
TEMPLATES = [
    {
        'DIRS': [os.path.join(BASE_DIR, 'templates')],
    },
]

STATICFILES_DIRS = [os.path.join(BASE_DIR, 'static_files')]
```

In `urls.py`, add the URL path for the "hello world" page:

```
from django.views.generic.base import TemplateView

urlpatterns = [
    path('hello/', TemplateView.as_view(template_name = 'helloworld.html')),
]
```

Check that the "hello world" page loads at `http://localhost:8000/hello/` and that the text color is blue:

The default Django page at `http://localhost:8000/` will no longer load. Instead, we will see an error page:



If there are errors while loading pages, this error page will be displayed if the variable `DEBUG` is set to `True` in `settings.py`. The error messages will also be displayed in Anaconda Powershell.

3.4 Django Directory Structure

At this point, we have the following Django directory structure:

```
django/
    config/
        __pycache__/
            __init__.cpython-37.pyc
            settings.cpython-37.pyc
            urls.cpython-37.pyc
            wsgi.cpython-37.pyc
        __init__.py
        settings.py
        urls.py
        wsgi.py
    static_files/
        css/
            style.css
    templates/
        helloworld.html
    db.sqlite3
    manage.py
```

Chapter 4

Grammar Practice Website

We will build the grammar practice website step-by-step, by adding files or directories from the repository directory to the project file system, or by adding code to existing files.

The setup of user and authentication features (i.e., user sign up and sign in, password features, etc.) in http://ronkow.com/grammar/ are omitted here. I will only describe the setup of the search system and any features linked to it, such as quizzes.

4.1 `settings.py` and `urls.py`

We will organize the website features (i.e., quizzes, search, and other pages) into three Django applications: `apppage`, `appquiz`, and `appsearch`. These must be declared in the list `INSTALLED_APPS` in `settings.py`. We also declare the application `crispy_forms` and the variable `CRISPY_TEMPLATE_PACK`:

```
INSTALLED_APPS = [
    # local apps
    'apppage.apps.ApppageConfig',
    'appquiz.apps.AppquizConfig',
    'appsearch.apps.AppsearchConfig',

    # Third-party apps
    'crispy_forms',
]

CRISPY_TEMPLATE_PACK = 'bootstrap4'
```

Next, we define the URL paths in `urls.py`:

```
from django.urls import include
urlpatterns = [
    path('', include('apppage.urls')),
    path('quiz/', include('appquiz.urls')),
    path('search/', include('appsearch.urls')),
]
```

4.2 Source Files

Copy `base.html` (which define the common navigation header on every page) and `base.css` from the repository directory:

- `/grammar/django/templates/base.html`
- `/grammar/django/static_files/css/base.css`

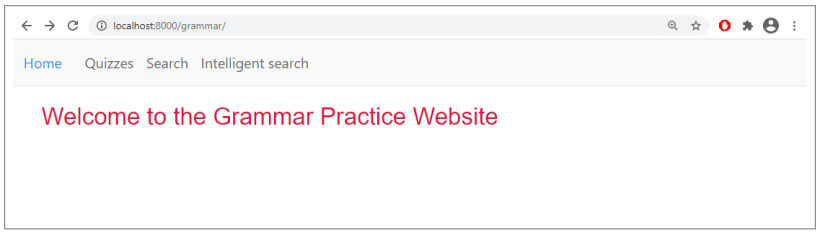
Copy these application and template directories:

- `/grammar/django/apppage`
- `/grammar/django/appquiz`
- `/grammar/django/appsearch`
- `/grammar/django/templates/page`
- `/grammar/django/templates/quiz`
- `/grammar/django/templates/search`

In `/grammar/django/apppage/urls.py`, note that we have defined the URL path of the home page:

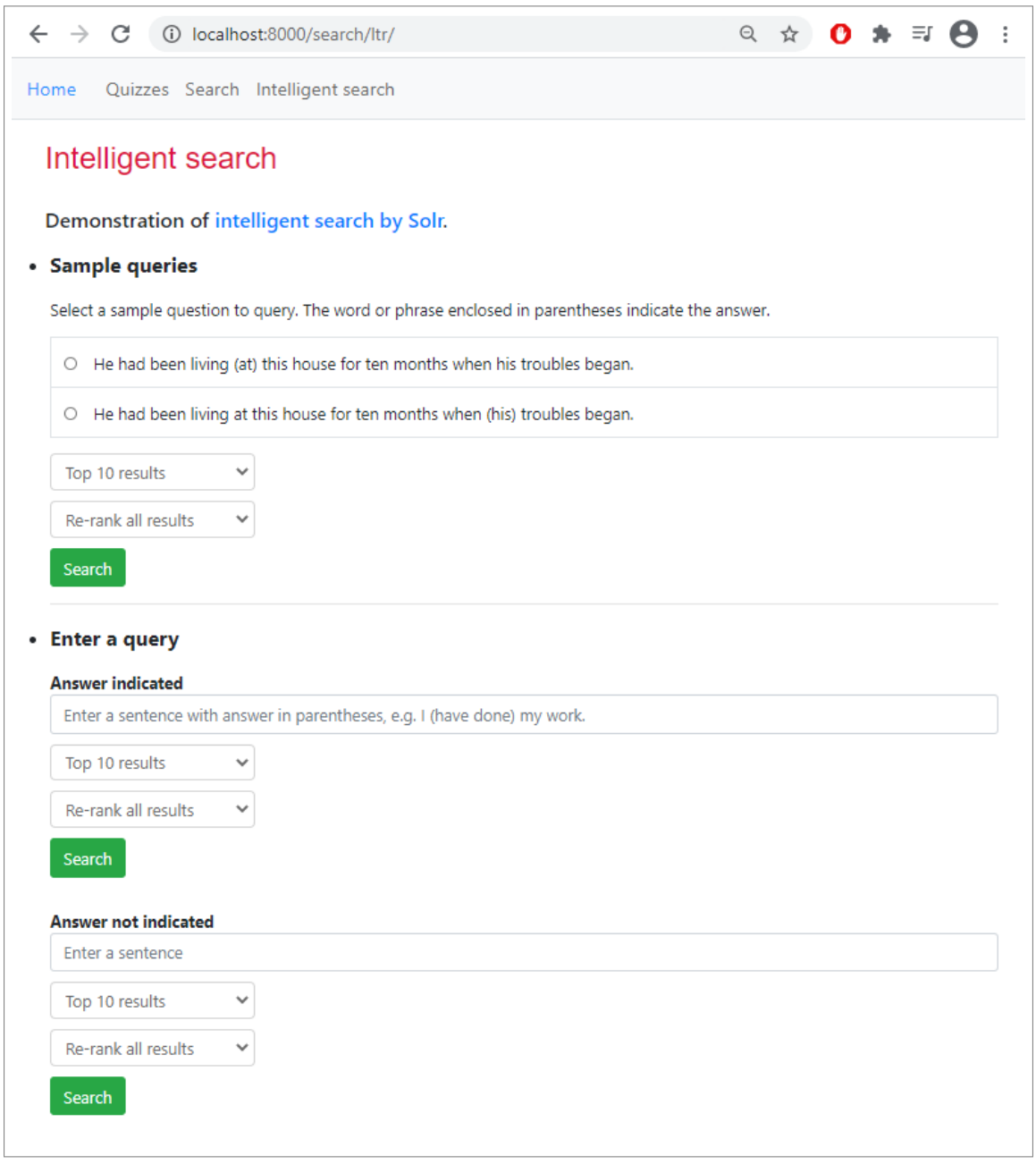
```
urlpatterns = [
    path('grammar/',
        views.HomeView.as_view(),
        name = 'homeview'),
```

Connect to the internet and run the development server. Check that the home page loads at `http://localhost:8000/grammar/`:



The template `base.html` references the **Bootstrap** stylesheet and JavaScript code at the Bootstrap repository, and also the JavaScript libraries **JQuery** and **Popper** at their respective websites. Therefore we must be connected to the internet in order for the development server to run.

If we click on the links for **Quizzes** and **Search**, we will see an error page because we have not yet created the database tables which these two pages depend on. However the **Intelligent Search** page will load, since it does not depend on the database:



Chapter 5

Quizzes and Database Search

5.1 Raw Data

Copy the raw data directory from the repository directory:

- `/grammar/data/raw`

This directory contains the following four datasets:

- `rawdata_quiz.csv` (46 *quiz questions*, for the database table `appquiz_modelquestion`)
- `rawdata_doc.csv` (850 *question bank questions*, for the database table `appsearch_modelquestion`, also used as documents for training of ranking models)
- `rawdata_query.csv` (152 *question bank questions*, for the database table `appsearch_modelquestion`, also used as queries for training of ranking models)
- `rawdata_query_validate_test.csv` (152 questions used as queries for validation and testing of ranking models)

We will import the first three datasets to the database. Thus we will have 46 quiz questions and a total of 1002 question bank questions. First, we need to create the database tables, as described in the next section.

5.2 Data Models

Django automatically creates database tables according to *data models* we define in the script `models.py` for a particular application.

In `/grammar/django/appquiz/models.py`, we have defined the following data model. Django will create the database tables `appquiz_modeltopic`, `appquiz_modelquiz`, and `appquiz_modelquestion` according to this data model definition:

```
class ModelTopic(models.Model):
    topic_name = models.CharField(max_length=100, unique=True)
    topic_examples = models.TextField(null=True)
    topic_slug = models.SlugField()

class ModelQuiz(models.Model):
    QUIZ_NUMBER = ((1, 'Quiz 1'),(2, 'Quiz 2'),)
    quiz_topic = models.ForeignKey(ModelTopic, on_delete=models.CASCADE, related_name='modelquiztopic')
    quiz_number = models.IntegerField(choices=QUIZ_NUMBER)

class ModelQuestion(models.Model):
    q_topic = models.ForeignKey(ModelTopic, on_delete=models.CASCADE, related_name='modelquestiontopic')
    q_quiz = models.ForeignKey(ModelQuiz, on_delete=models.CASCADE, related_name='modelquestionquiz')
    q_question = models.TextField(unique=True)
    q_answer = models.CharField(max_length=50)
    q_choice1 = models.CharField(max_length=50)
    q_choice2 = models.CharField(max_length=50)
    q_choice3 = models.CharField(max_length=50)
```

In `/grammar/django/appsearch/models.py`, we have defined the following data model. Django will create the database table `appsearch_modelquestionbank` accordingly:

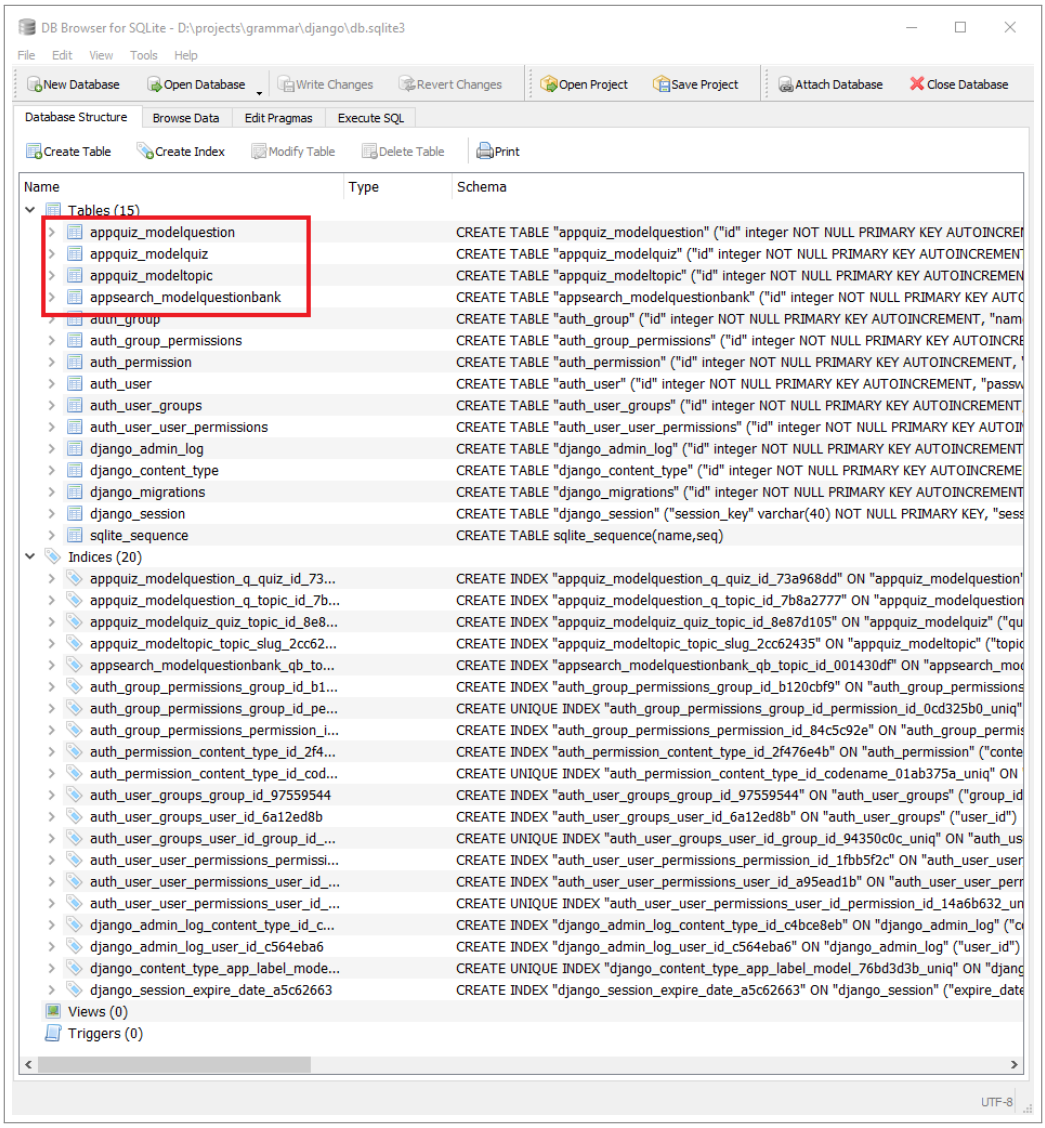
```
class ModelQuestionbank(models.Model):
    qb_topic = models.ForeignKey('appquiz.ModelTopic',
        on_delete=models.CASCADE, related_name='modelqbtopic')
    qb_question = models.TextField(unique=True)
    qb_answer = models.CharField(max_length=50)
    qb_choice1 = models.CharField(max_length=50)
    qb_choice2 = models.CharField(max_length=50)
    qb_choice3 = models.CharField(max_length=50)
```

5.3 Database Tables

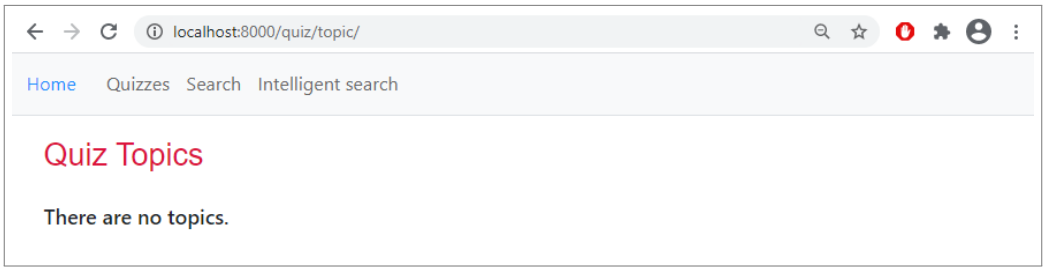
We now tell Django to create the database tables which the **Quizzes** and **Search** pages depend on. Run the command `migrate`:

```
(grammar) PS D:\grammar\django> python manage.py migrate
Operations to perform:
  Apply all migrations: admin, appquiz, appsearch, auth, contenttypes, sessions
Running migrations:
  Applying appquiz.0001_initial... OK
  Applying appsearch.0001_initial... OK
```

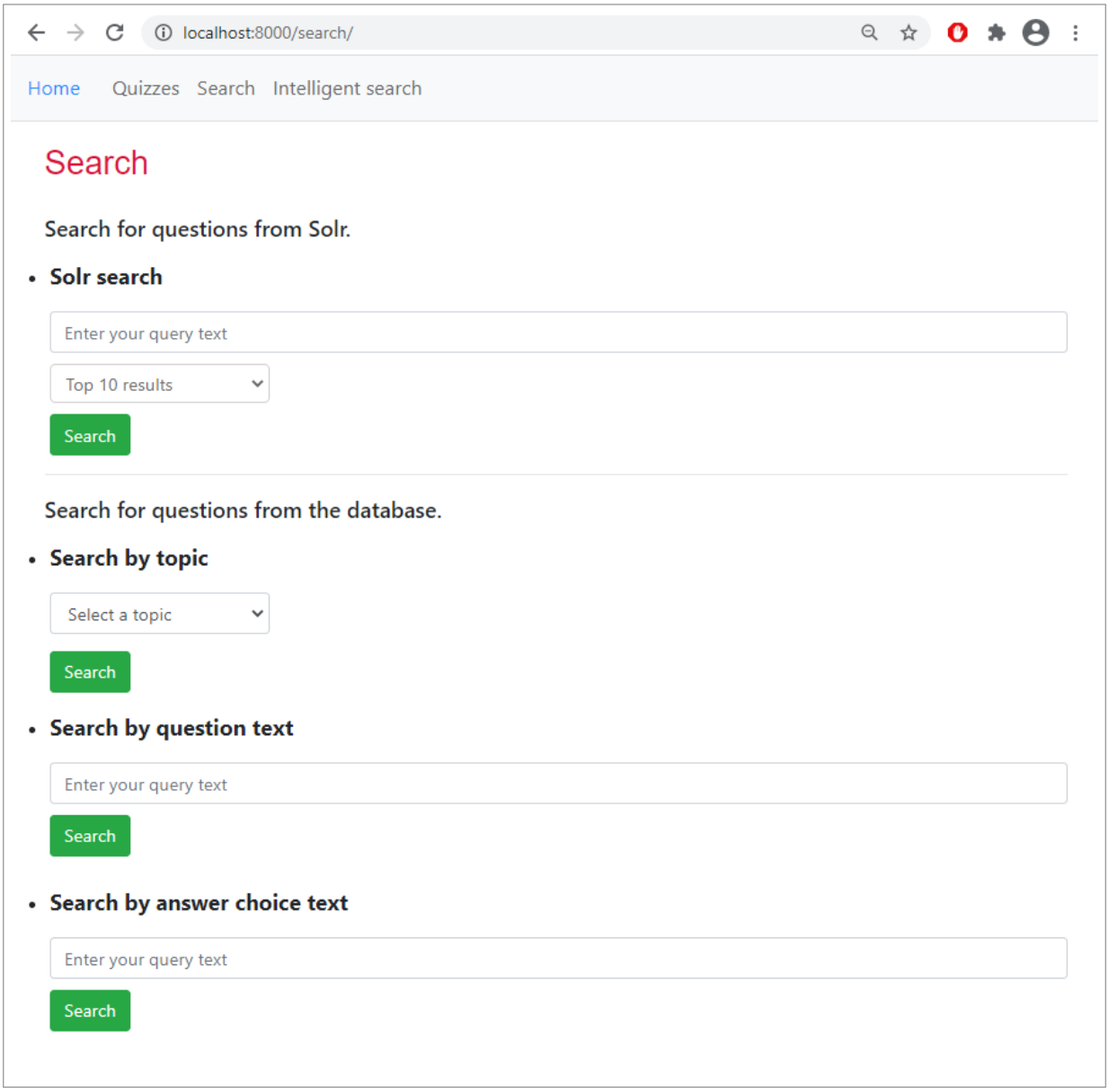
Four tables will be created in the database:



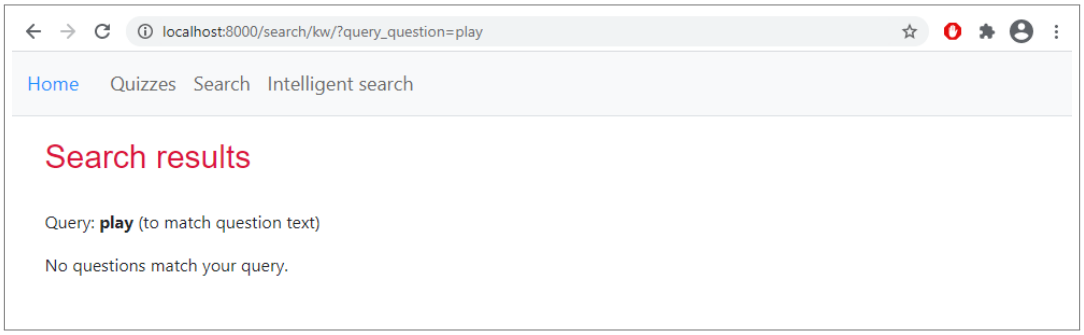
As there are no data in the database, the **Quizzes** page will now load showing no information:

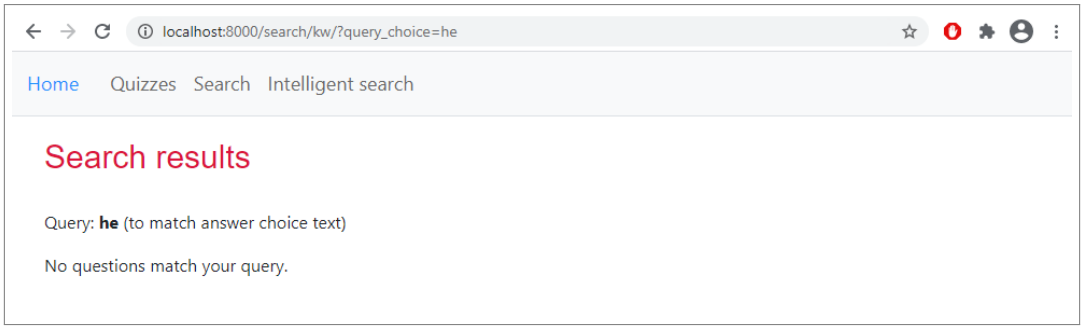


The **Search** page will also load:

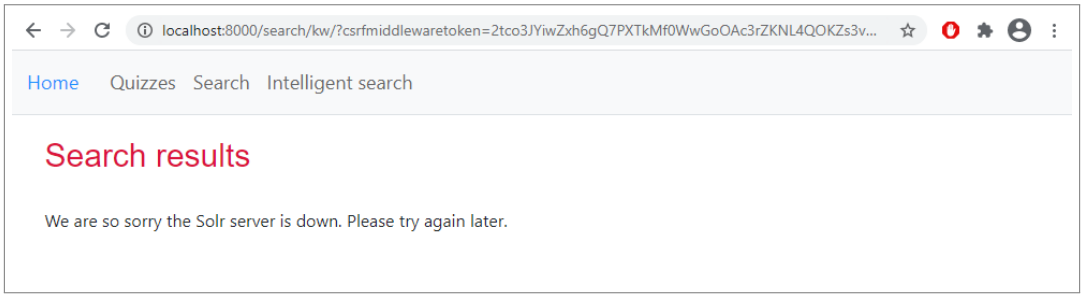


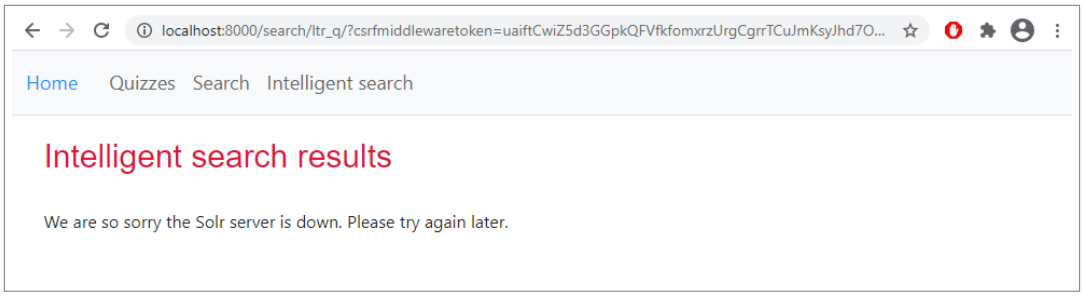
If we try to do a database search, there will be no results, as the database has no data:





If we try to do a Solr search on the **Search** page and **Intelligent search** page, there will also be no results as we have not yet set up the Solr server:





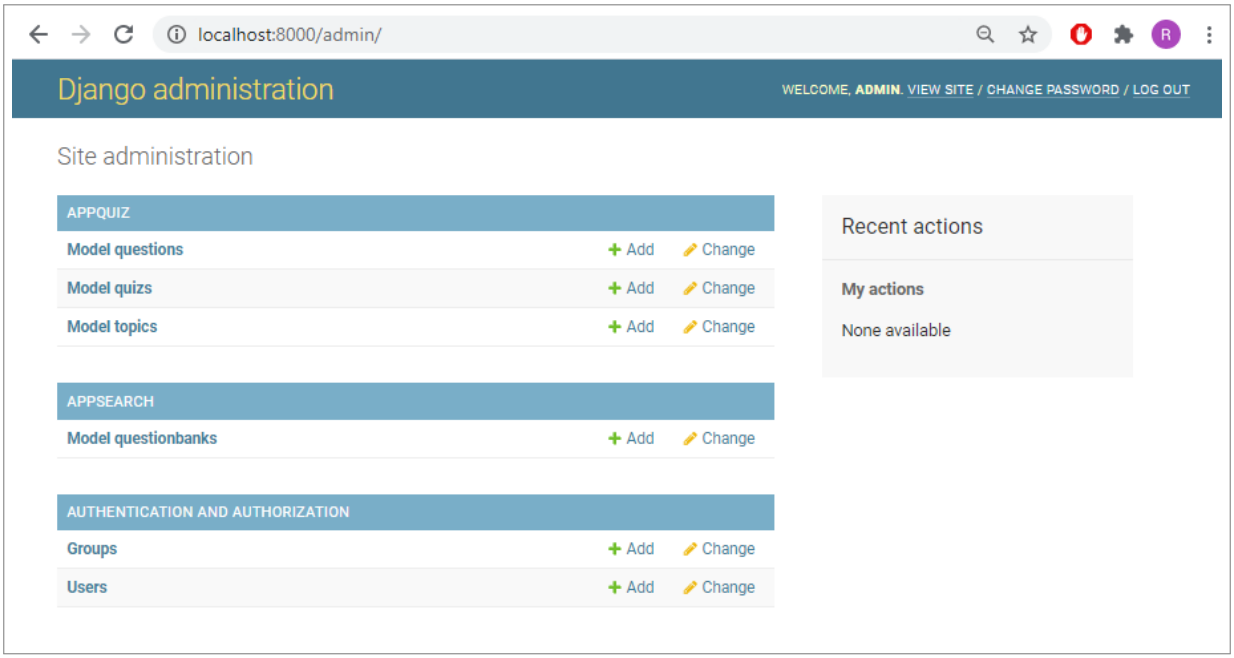
5.4 Populating the Database

There are two ways to populate the database. We can either create new data row by row from the Django admin site, or we can import data to the database from a CSV file.

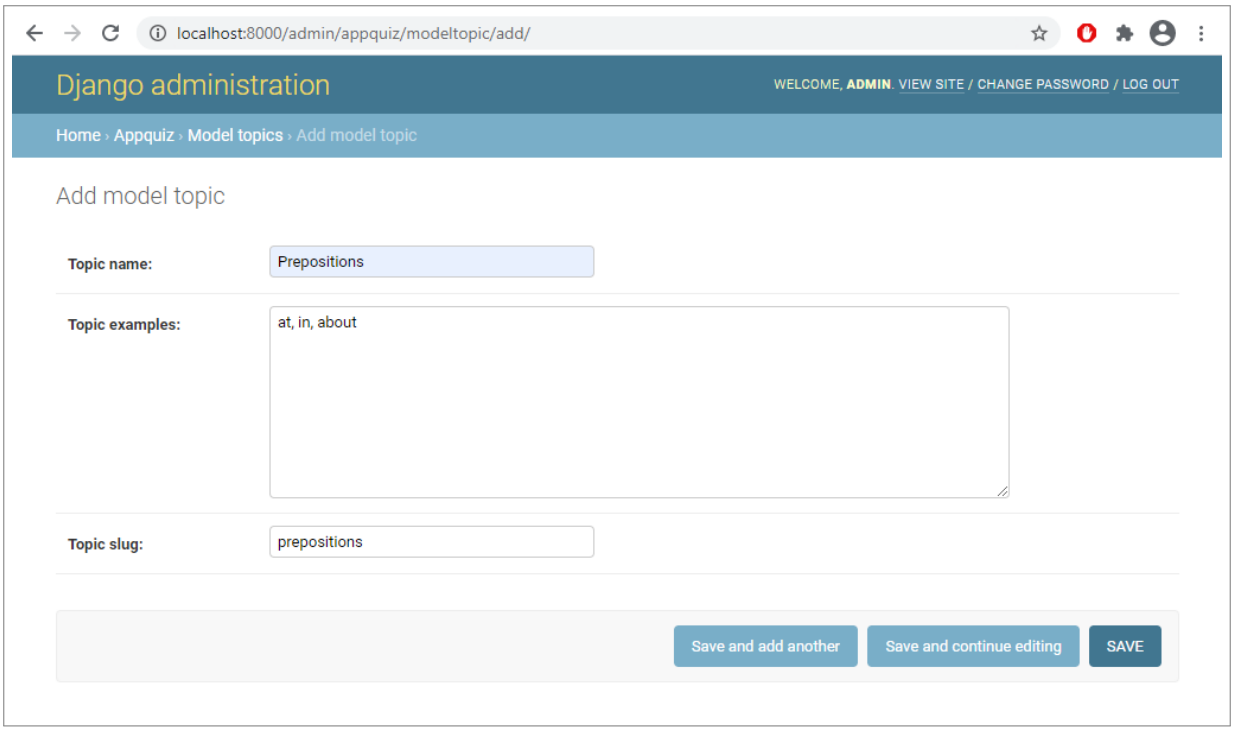
We will use the Django admin site to create the topics in the table `appquiz_modeltopic` and the quiz numbers in the table `appquiz_modelquiz`. Then we will import the remaining data from CSV files to the other two tables `appquiz_modelquestion` and `appsearch_modelquestionbank`.

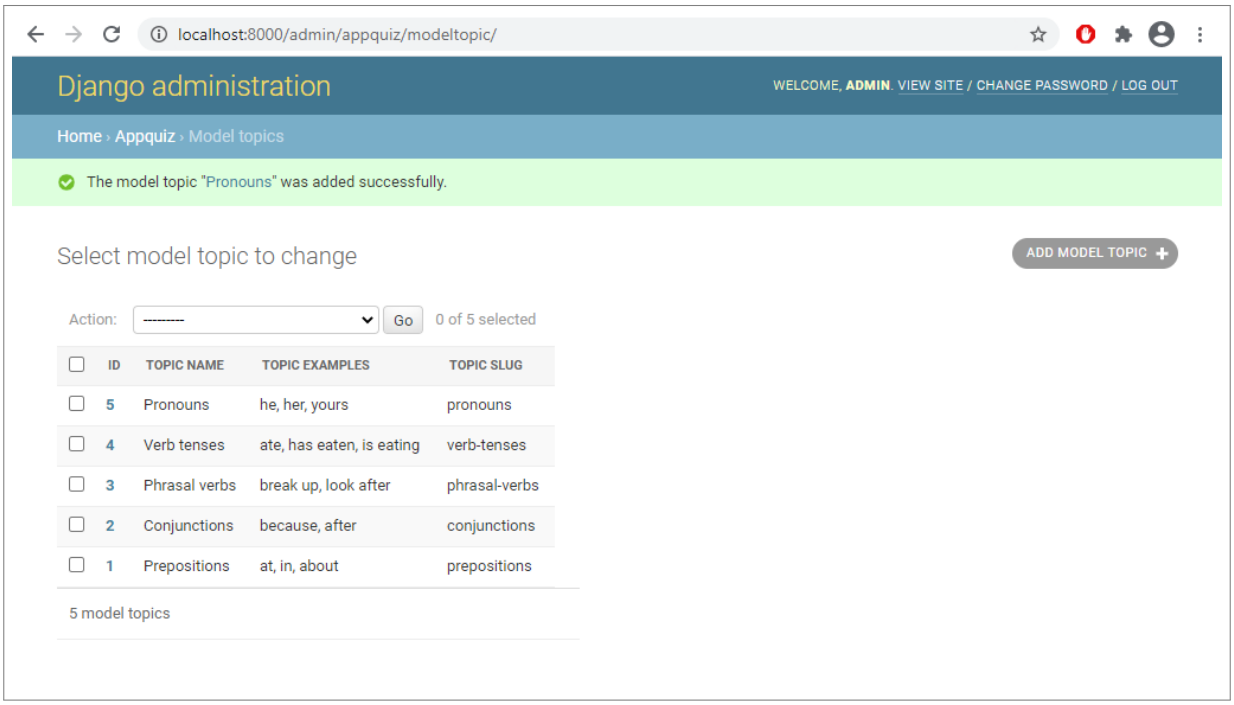
5.4.1 Django Admin Site

In the admin site, we will see the four database tables:

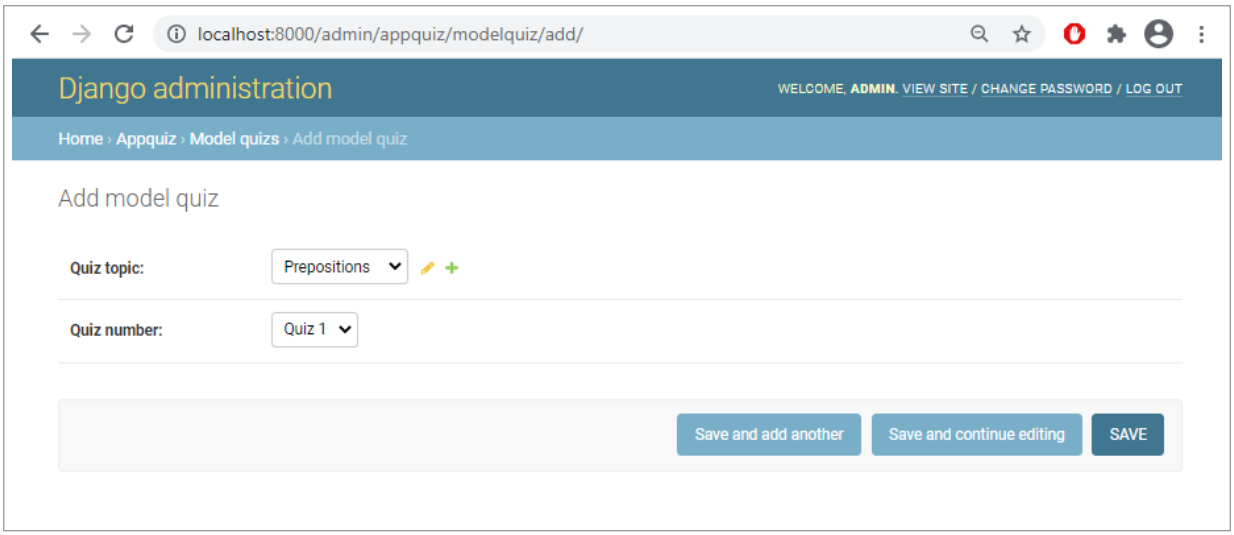


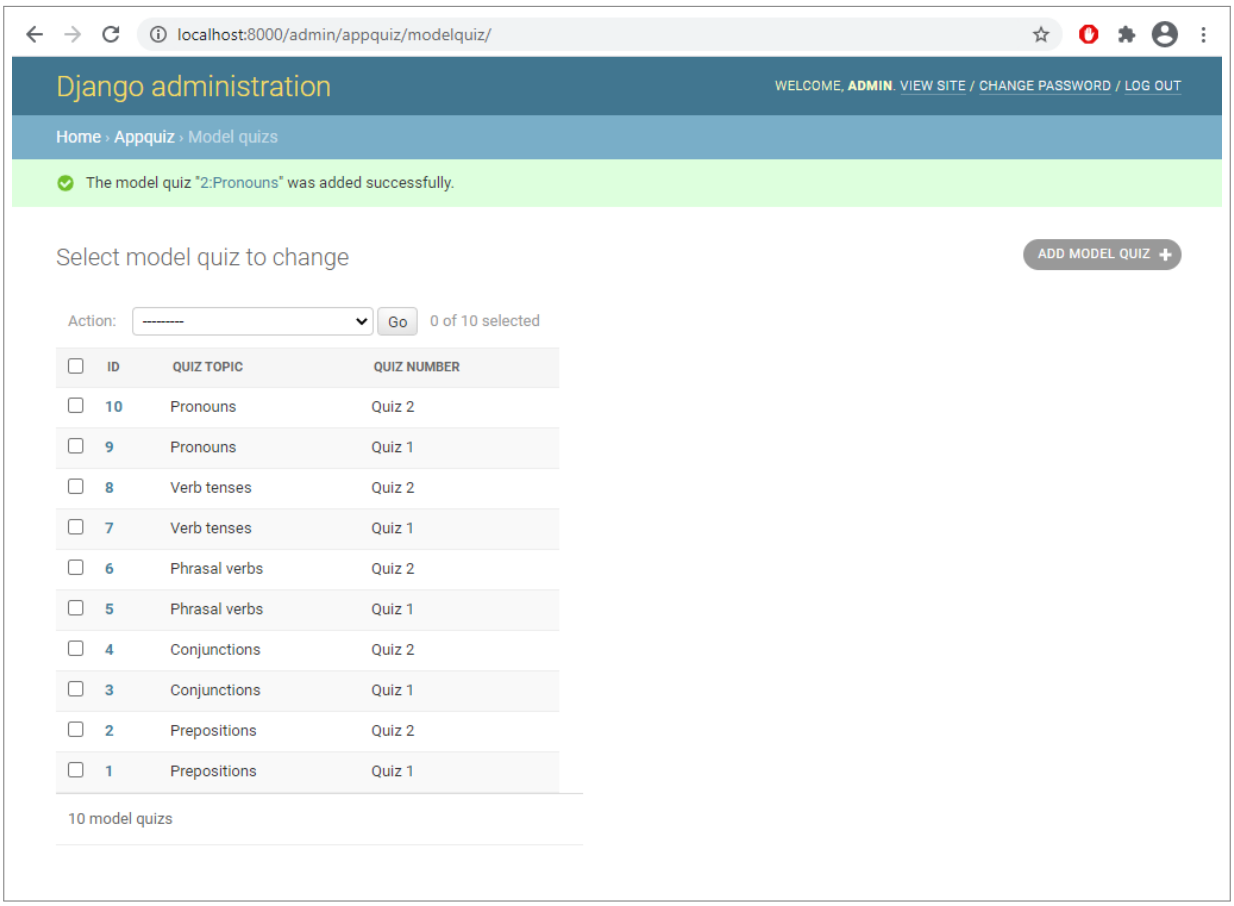
Enter data for the five topics in the table `appquiz_modeltopic`:



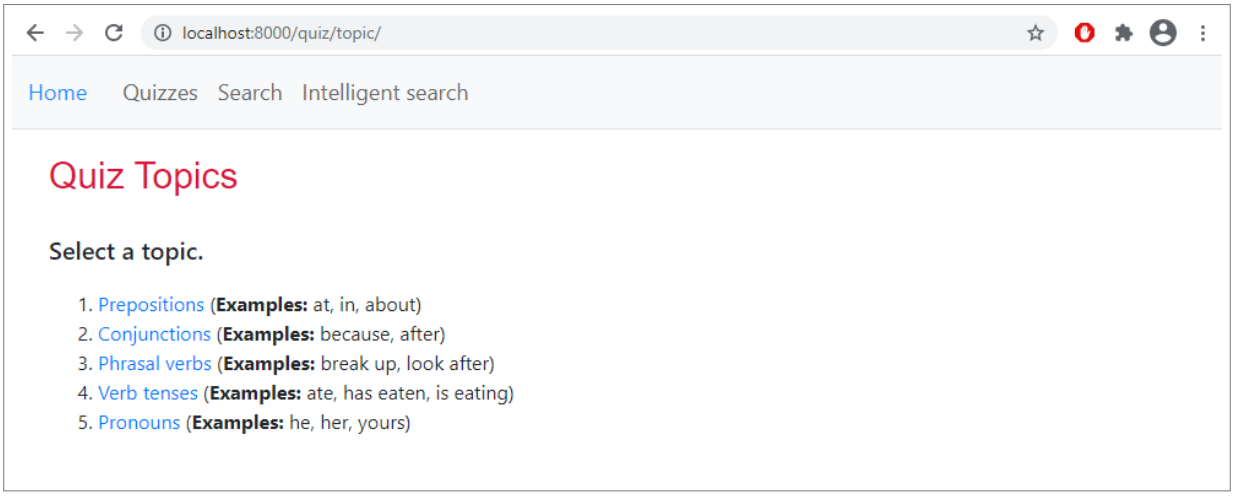


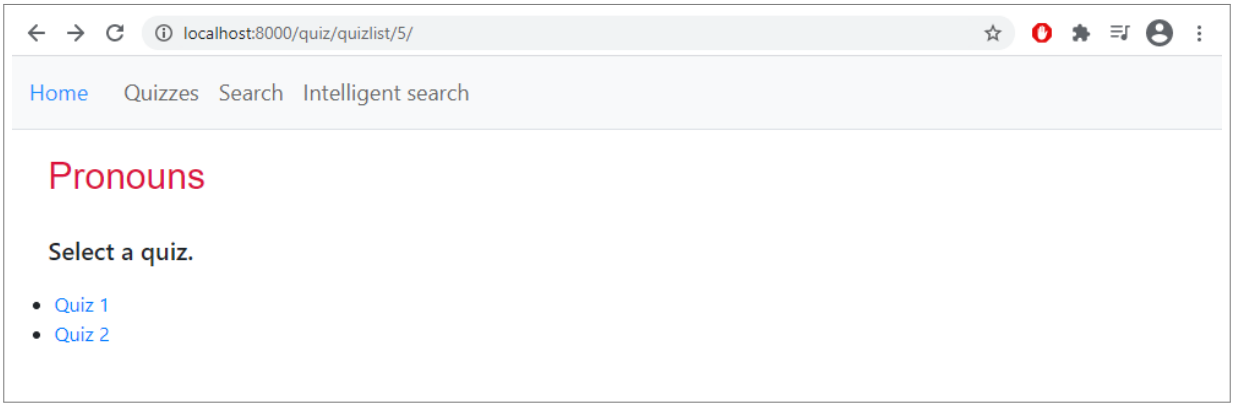
Next, we create two quizzes for each topic in the table `appquiz_modelquiz`:





The **Quizzes** page will now show the list of topics. Selecting a topic will lead to the next page to select a quiz number.





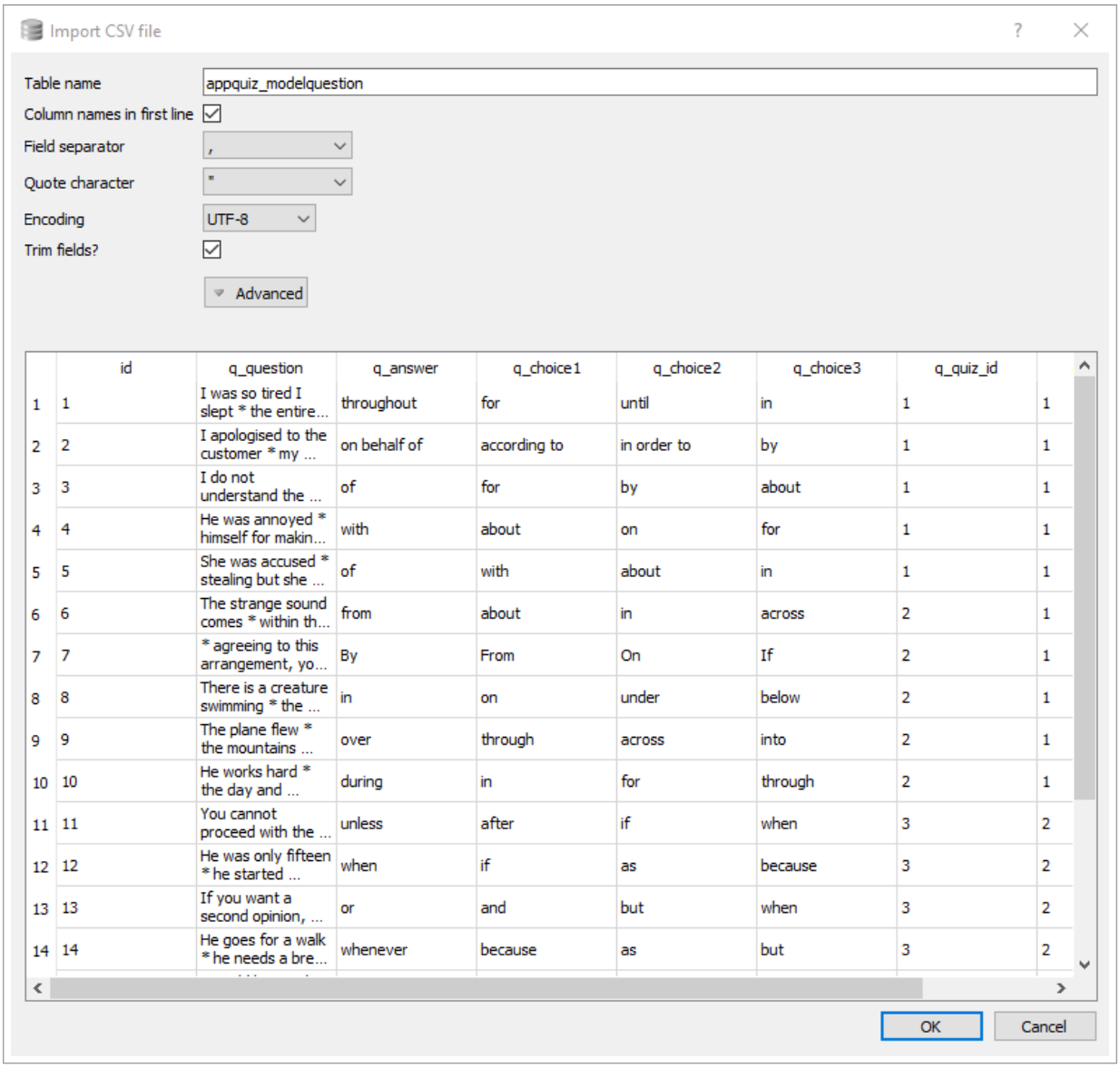
5.4.2 Importing Data

Earlier, we copied the following three datasets of raw data:

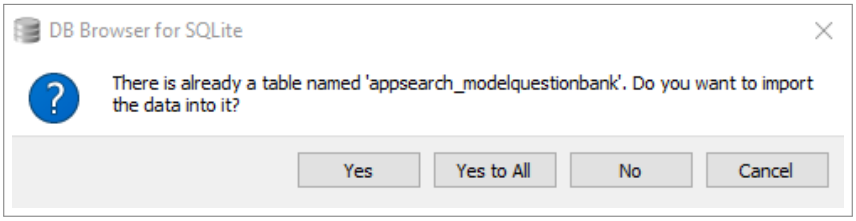
- `rawdata_quiz.csv` (46 *quiz questions*, for the database table `appquiz_modelquestion`)
- `rawdata_doc.csv` (850 *question bank questions*, for the database table `appsearch_modelquestionbank`)
- `rawdata_query.csv` (152 *question bank questions*, for the database table `appsearch_modelquestionbank`)

We will import the data in these three datasets to the database.

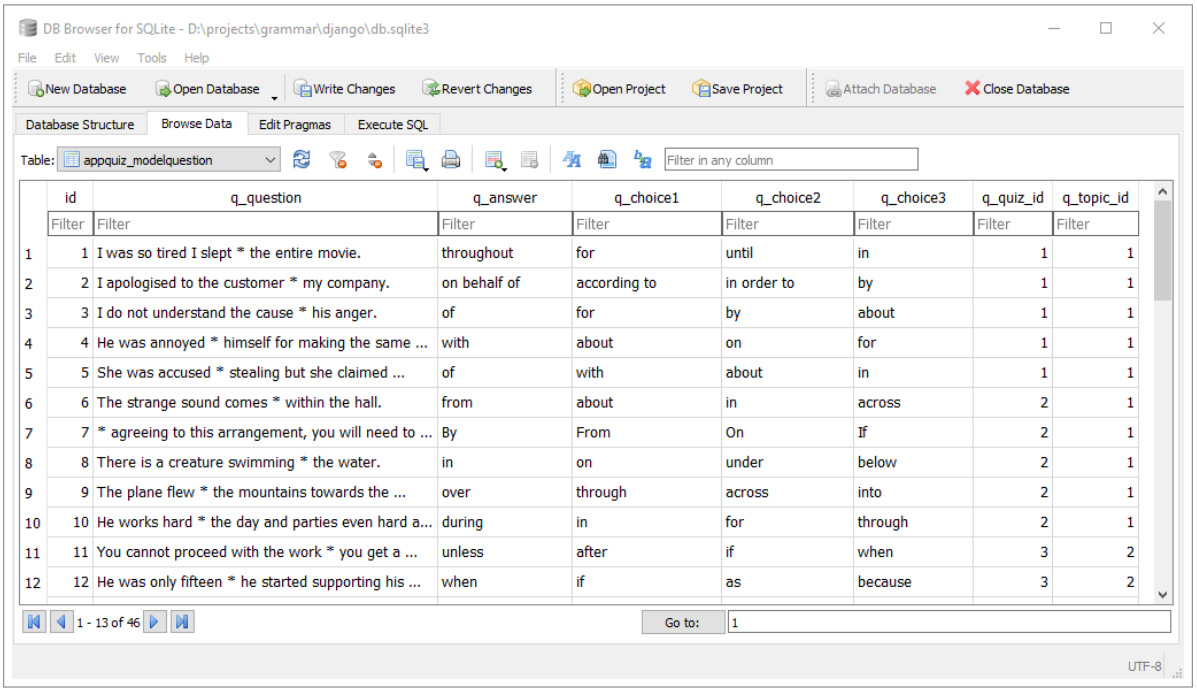
Using **DB Browser**, import the data (`File > Import > Table from CSV file...`) from `rawdata_quiz.csv` to the table `appquiz_modelquestion`. We need to amend the **Table name** field:



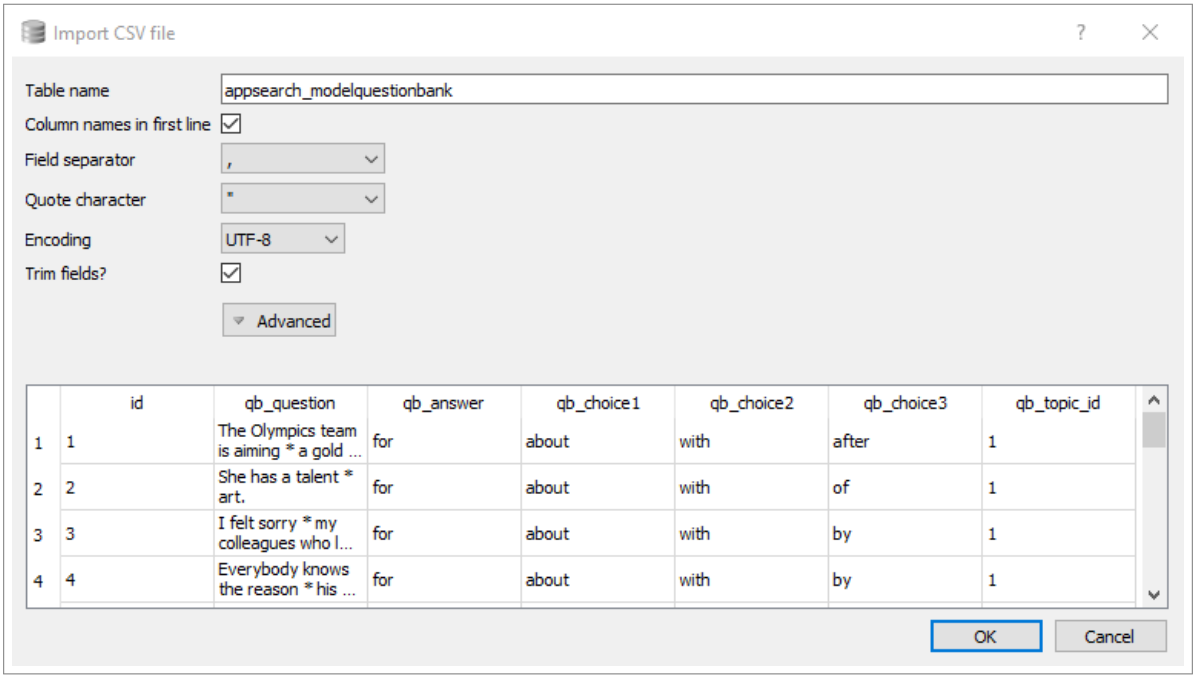
	id	q_question	q_answer	q_choice1	q_choice2	q_choice3	q_quiz_id	
1	1	I was so tired I slept * the entire...	throughout	for	until	in	1	1
2	2	I apologised to the customer * my ...	on behalf of	according to	in order to	by	1	1
3	3	I do not understand the ...	of	for	by	about	1	1
4	4	He was annoyed * himself for makin...	with	about	on	for	1	1
5	5	She was accused * stealing but she ...	of	with	about	in	1	1
6	6	The strange sound comes * within th...	from	about	in	across	2	1
7	7	* agreeing to this arrangement, yo...	By	From	On	If	2	1
8	8	There is a creature swimming * the ...	in	on	under	below	2	1
9	9	The plane flew * the mountains ...	over	through	across	into	2	1
10	10	He works hard * the day and ...	during	in	for	through	2	1
11	11	You cannot proceed with the ...	unless	after	if	when	3	2
12	12	He was only fifteen * he started ...	when	if	as	because	3	2
13	13	If you want a second opinion, ...	or	and	but	when	3	2
14	14	He goes for a walk * he needs a bre...	whenever	because	as	but	3	2



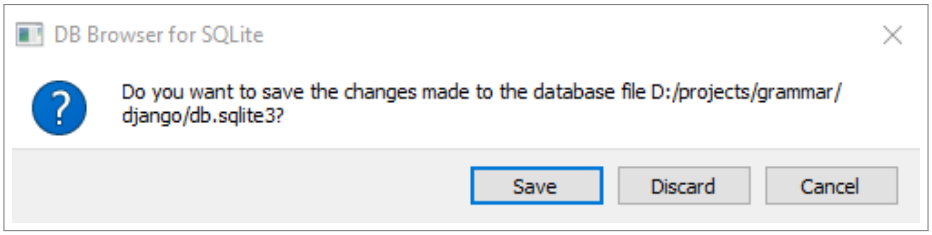
Now we can browse the data:



Next, import the data from from `rawdata_doc.csv` and `rawdata_query.csv` to the table `appsearch_modelquestionbank`:



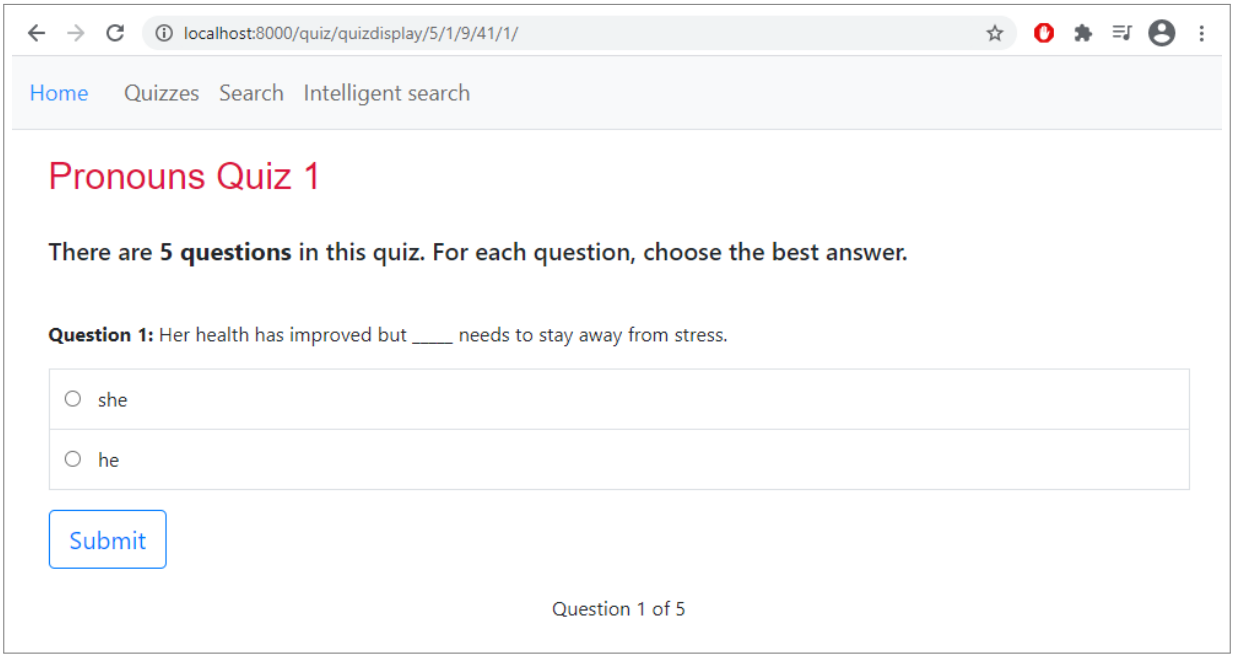
We need to close and save the database (`File > Close Database`):

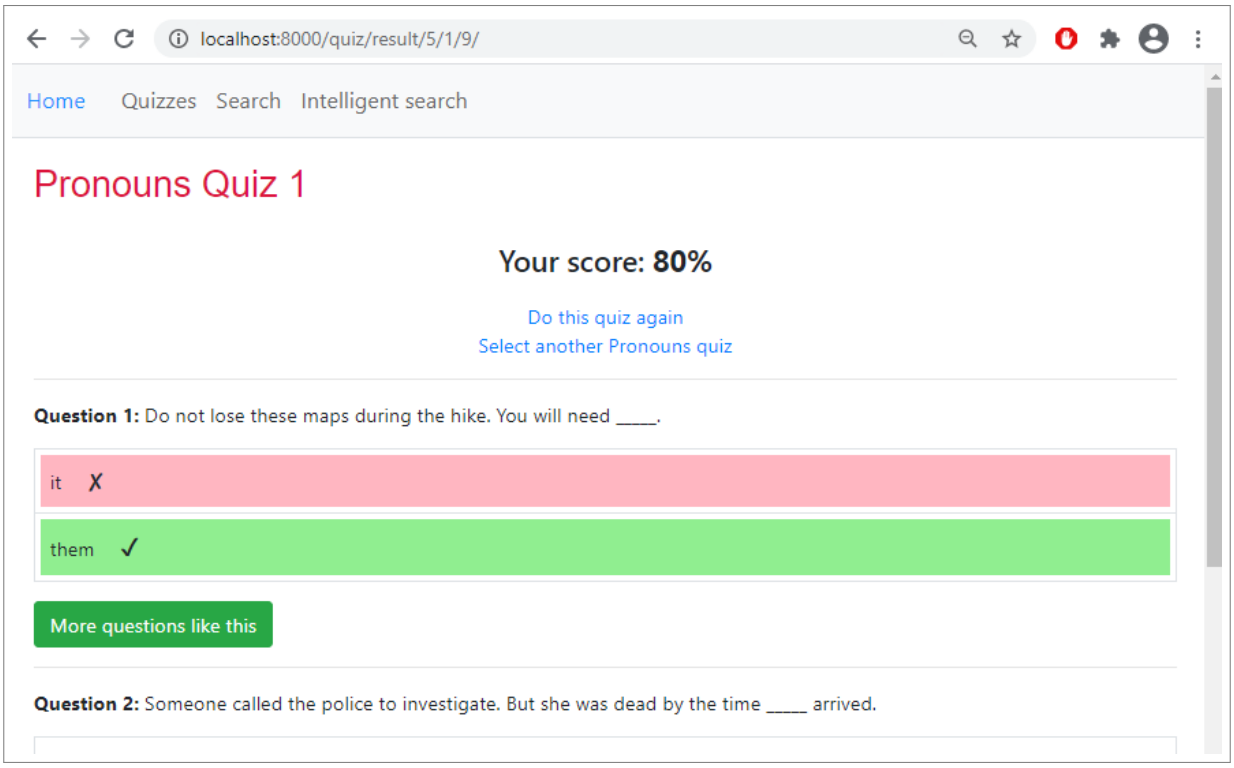


5.5 Quizzes and Search

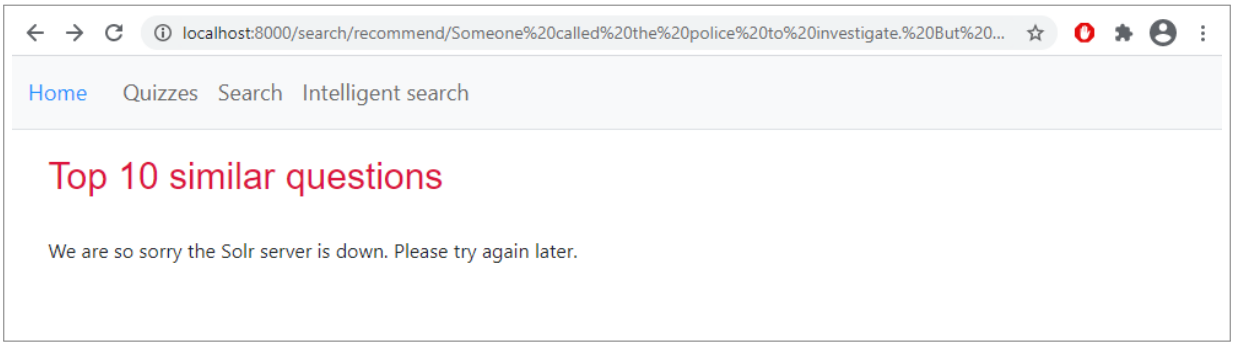
5.5.1 Quizzes Page

On the **Quizzes** page, we will be able to select a quiz number and do the quiz questions, leading to a page showing the quiz results and answers:





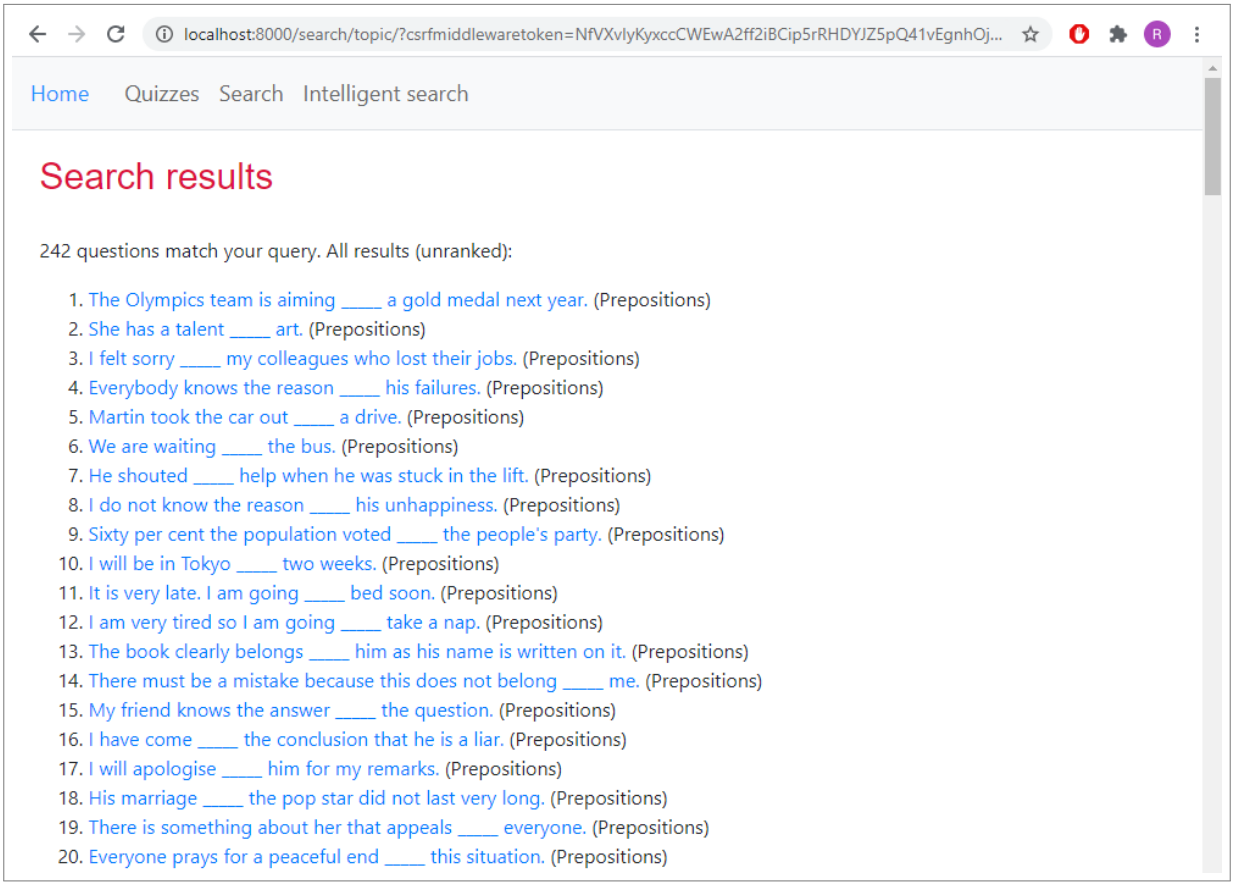
Clicking **More questions like this** on the quiz results page will send a query to the Solr server which will return the top 10 similar questions. As we have not set up the Solr server yet, we will again see the following message:



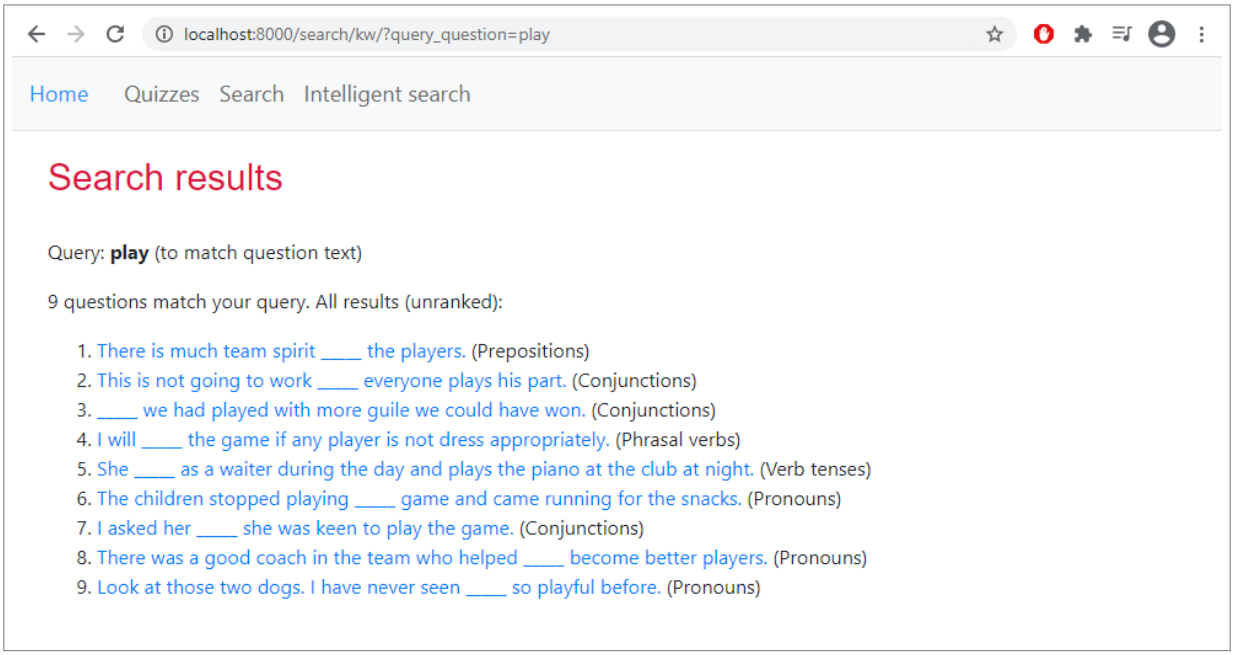
5.5.2 Search Page

Now that the database is fully populated, we will be able to use these three search features on the **Search** page. The system will return grammar questions from the table `appsearch_modelquestionbank`:

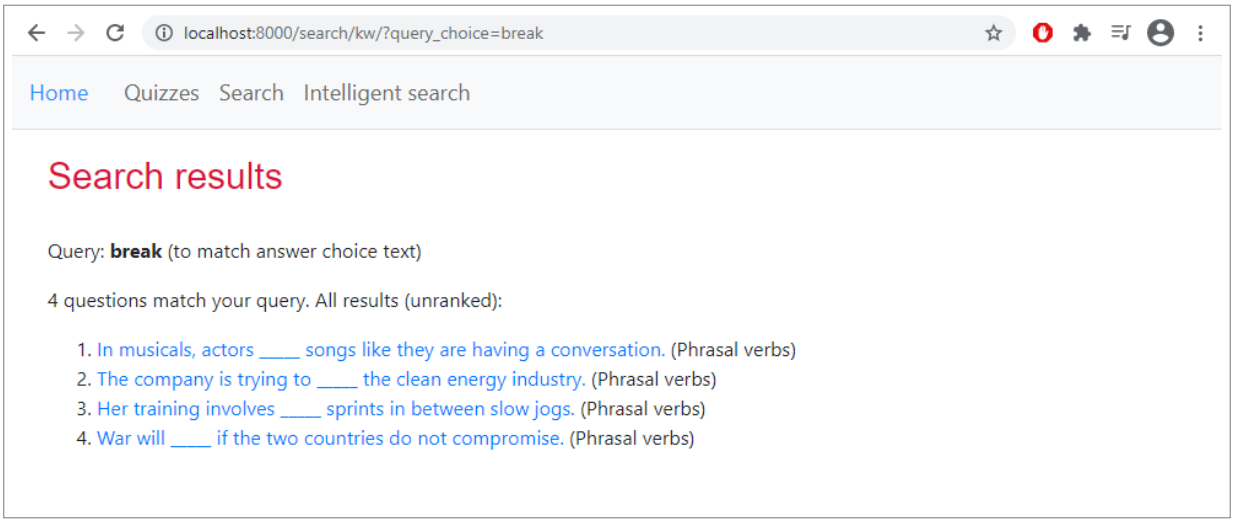
- **Search by topic**



- **Search by question text**



- **Search by answer choice text**



In the next chapter, we will set up the Solr server and upload data to the Solr server so that the Solr search features will work. Then we will set up Learning To Rank so that the intelligent Solr search features will work.

Chapter 6

Solr Search

6.1 Solr Version and Documentation

We will use Solr 7.7.3. However, if you wish to use Haystack, Solr 6.6.6 is officially the latest version that Haystack 2.8.1 supports. We will not use Haystack, as I will explain in Section 6.5. Solr documentation archives are at:

https://lucene.apache.org/solr/guide/

The glossary is useful for understanding the components of Solr:

https://lucene.apache.org/solr/guide/7_7/solr-glossary.html

6.2 Java Runtime Environment

The only requirement for running Solr is Java Runtime Environment (JRE) version 1.8 or later (https://lucene.apache.org/solr/guide/7_7/solr-system-requirements.html). Download and install JRE from:

https://www.java.com/en/download/.

Check that the installation is successful:

```
PS C:\> java -version
java version "1.8.0_271"
Java(TM) SE Runtime Environment (build 1.8.0_271-b09)
Java HotSpot(TM) 64-Bit Server VM (build 25.271-b09, mixed mode)
```

6.3 Code

Copy the following files from the repository directory:

- `/grammar/setup_solr_upload_data.ipynb`
- `/grammar/setup_solr_upload_feature.ipynb`
- `/grammar/setup_solr_upload_model.ipynb`
- `/grammar/solr.py`

6.4 Solr Server

6.4.1 Solr Node

We will now set up a Solr server, also called a *Solr node*. This is a three-step process. We download the ZIP file of the required version of Solr, decompress the file to extract the Solr directory, and start the server from the Solr directory. First, download `solr-7.7.3.zip` from:

https://archive.apache.org/dist/lucene/solr/7.7.3/

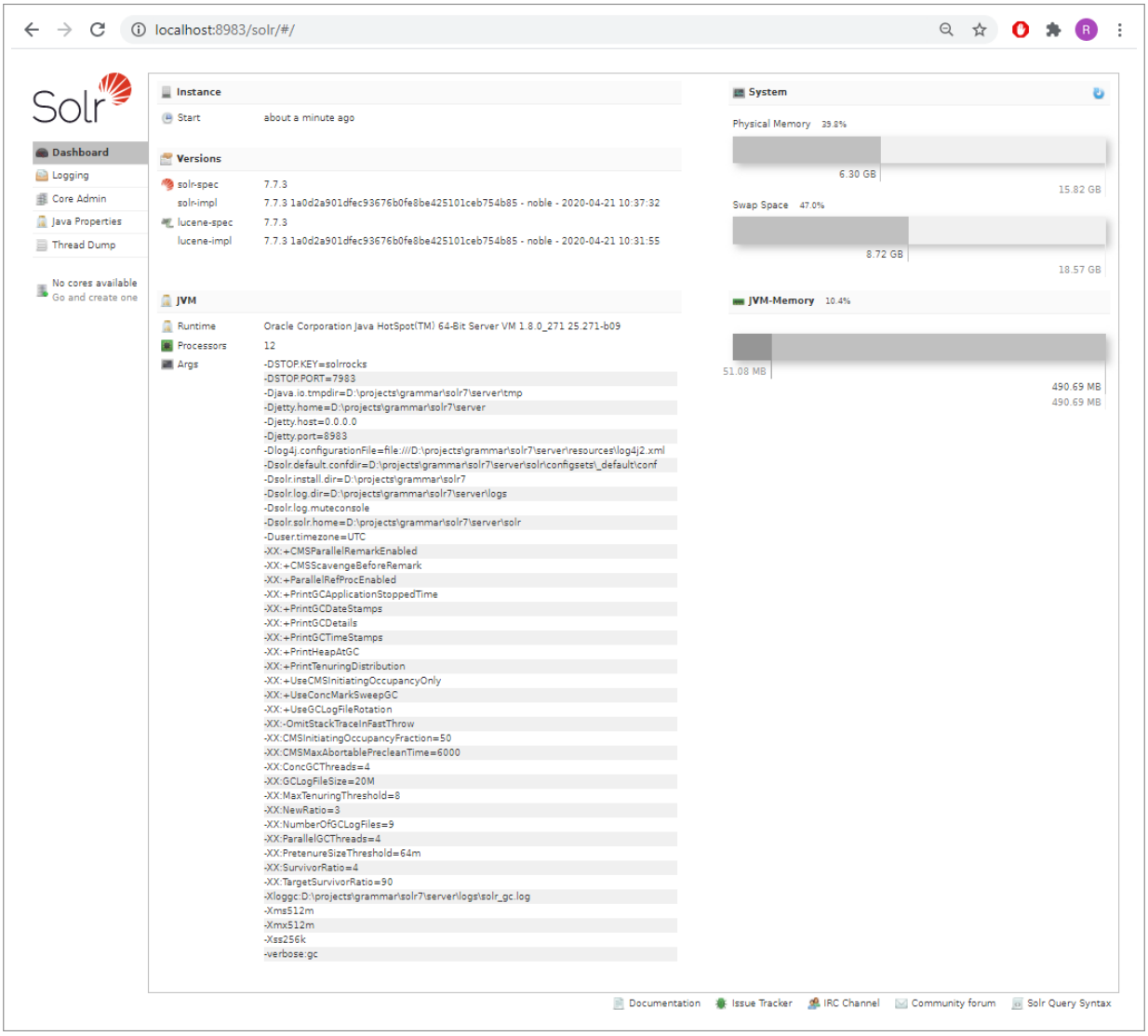
The ZIP file contains a single directory named `solr-7.7.3`. Move this directory to the project directory. At this point, it would be good to explore the Solr file system. The location that we will need to access most is `solr-7.7.3/server/solr`. When we create a new *core*, a directory for the core will be created there. Let's rename the Solr directory to `solr7`. In Windows PowerShell, start the Solr server:

```
PS D:\grammar\solr7> bin/solr start
Waiting up to 30 to see Solr running on port 8983
Started Solr server on port 8983. Happy searching!
```

Other than `start`, other Solr commands are `stop`, `restart`, and `status`. The following shows the output of `status` if a Solr node is running:

```
PS D:\grammar\solr7> bin/solr status

Found Solr process 5424 running on port 8983
{
  "solr_home":"D:\\projects\\grammar\\solr7\\server\\solr",
  "version":"7.7.3 1a0d2a901dfec93676b0fe8be425101ceb754b85 - noble - 2020-04-21 10:37:32",
  "startTime":"2021-01-27T22:23:12.354Z",
  "uptime":"0 days, 0 hours, 28 minutes, 6 seconds",
  "memory":"40.7 MB (%8.3) of 490.7 MB"}
```

We will see the Solr Administration User Interface (Solr Admin UI) at `http://localhost:8983/`:

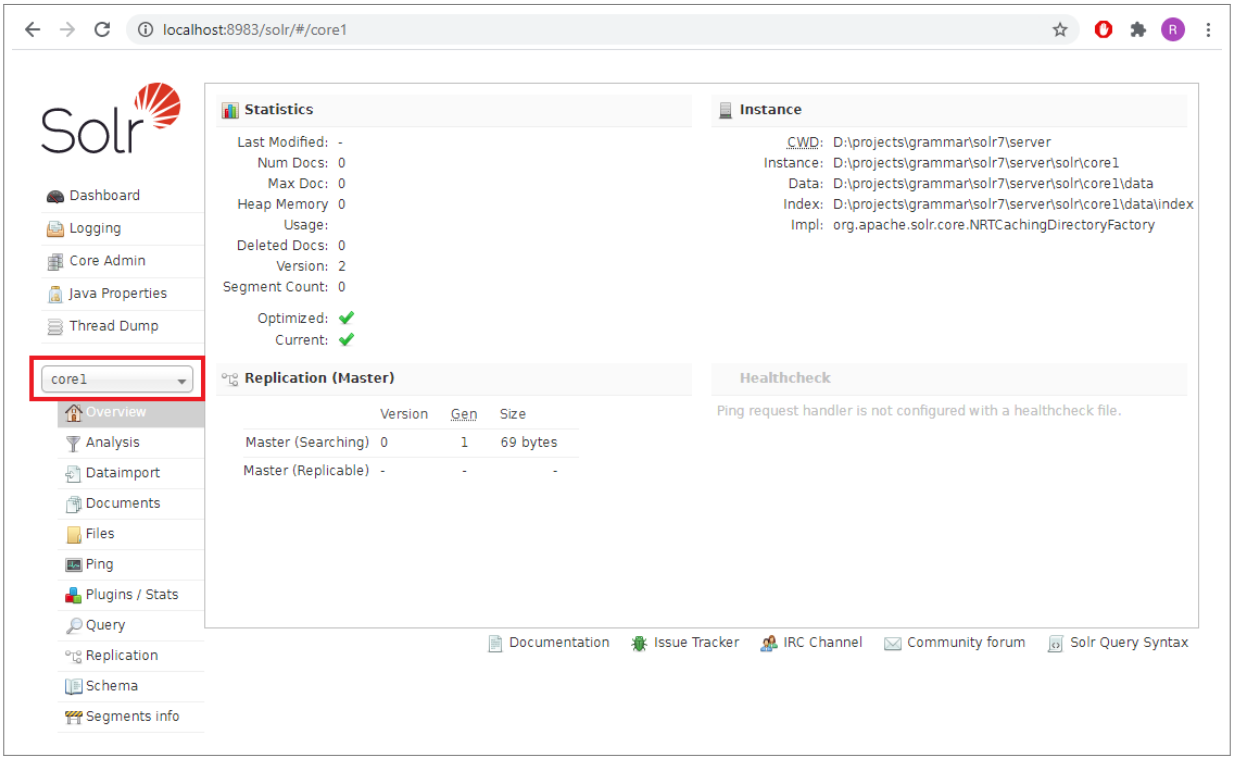


6.4.2 Creating a Core

A *Solr instance*, representing a logical index, is called a *core*. We can create and run multiple cores in a single Solr node. Let's create a core named `core1`:

```
PS D:\grammar\solr7> bin/solr create -c core1
WARNING: Using _default configset with data driven schema functionality.
NOT RECOMMENDED for production use.
To turn off: bin\solr config -c core1 -p 8983 -action set-user-property
-property update.autoCreateFields -value false

Created new core 'core1'
```

Refresh the Solr Admin UI and we will now be able to select the newly created core:



6.4.3 Deleting a Core

To delete an existing core:

```
PS D:\grammar\solr7> bin/solr delete -c core_name
```

6.4.4 Core Directory

It is important to be familiar with the files in the directory created for the core:

```
solr7/
    server/
        solr/
            core1/
                conf/
                    lang/
                        ...
                    managed-schema
                    params.json
                    protwords.txt
                    solrconfig.xml
                    stopwords.txt
                    synonyms.txt
                data/
                    index/
                        segments_1
                        write.lock
                    snapshot_metadata/
                    tlog/
                core.properties
```

The two most important files are `solrconfig.xml` and `manage-schema.xml`. We need to add information to `solrconfig.xml` when we set up Learning To Rank. `manage-schema.xml` is generally left untouched unless we wish to customize the search behavior.

`managed-schema.xml` defines the data *fields* and *field types*, which will determine the search behavior. When we upload data to this core, Solr will index the data and update `managed-schema.xml` with new fields. Solr will also guess the field type for each new field created. We should check the field type for each field and modify it if necessary.

6.5 Uploading Data to Solr

6.5.1 Uploading Methods

We need to upload data to the Solr server in order to do a Solr search. Solr will then index the data. There are two ways to upload data to Solr:

- **Method 1:** From the database to Solr by Haystack's API
- **Method 2:** From a CSV file to Solr by Solr's REST API

While I was learning to use the Solr REST API, I experimented with Haystack. Haystack provides the API to upload data to Solr from a database in Django, by adding some scripts to the Django setup and some code to the scripts `/config/settings.py` and `/config/urls.py`.

The process might appear easier compared to writing Python code to upload data from a CSV file (our code is in `setup_solr_upload_data.ipynb`). However, I found the Haystack process to be a black box. Whenever there was an error, I could not be sure which part of the process I did wrongly. The flexibility and clarity of using Solr's API is easier in the long run.

Nevertheless, Haystack is an option worth exploring, because it also supports **Elasticsearch** and other search software. For more details, refer to the documentation:

https://django-haystack.readthedocs.io/en/master/

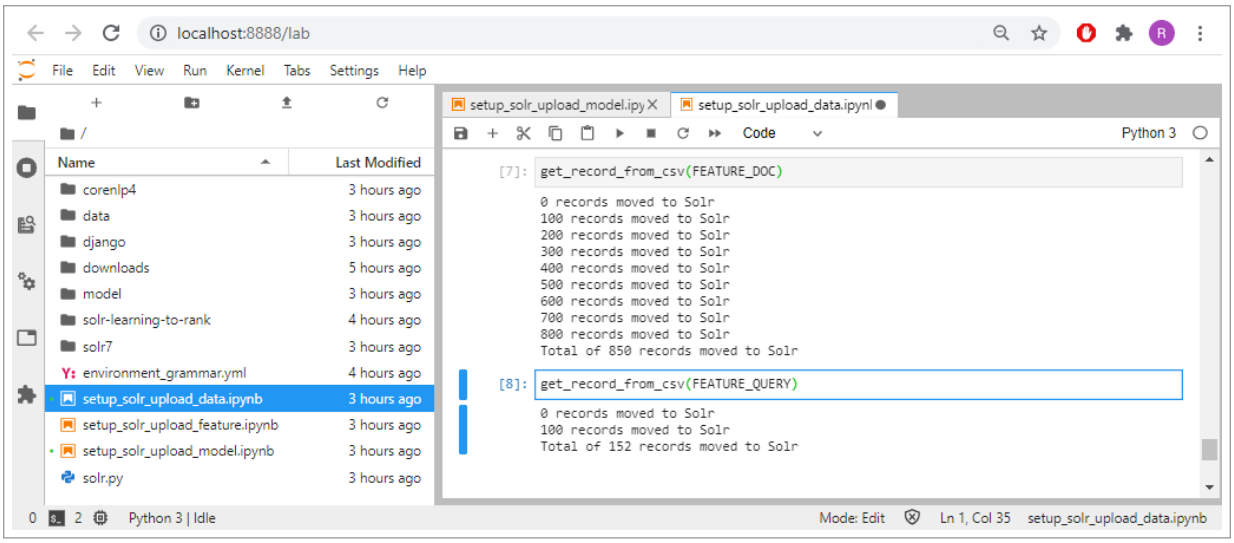
6.5.2 Uploading Data by Solr's REST API

We will upload data to Solr by Solr's REST API, because the data in the database is not what we need for intelligent Solr search. For the 1002 raw grammar questions in the question bank (see Section 5.4.2), we need to extract features and upload the features data to Solr. Copy the following directory from the repository directory:

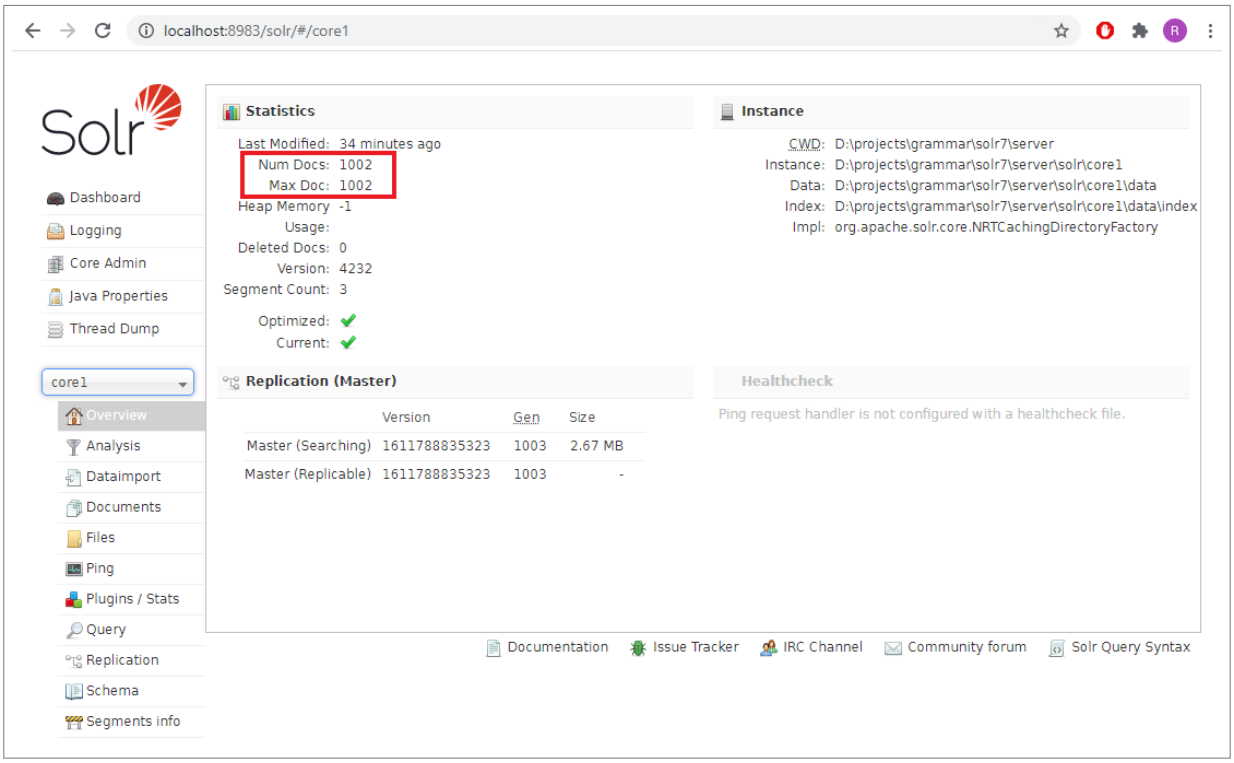
- `/grammar/data/feature`

This directory contains the datasets `feature_doc.csv` and `feature_query.csv`.

To upload data to Solr, open `setup_solr_upload_data.ipynb` and run it.



When all 1002 records are uploaded (it will take a while), check the Solr Admin UI. We will now see 1002 documents in `core1`:



6.6 Deleting Data From Solr

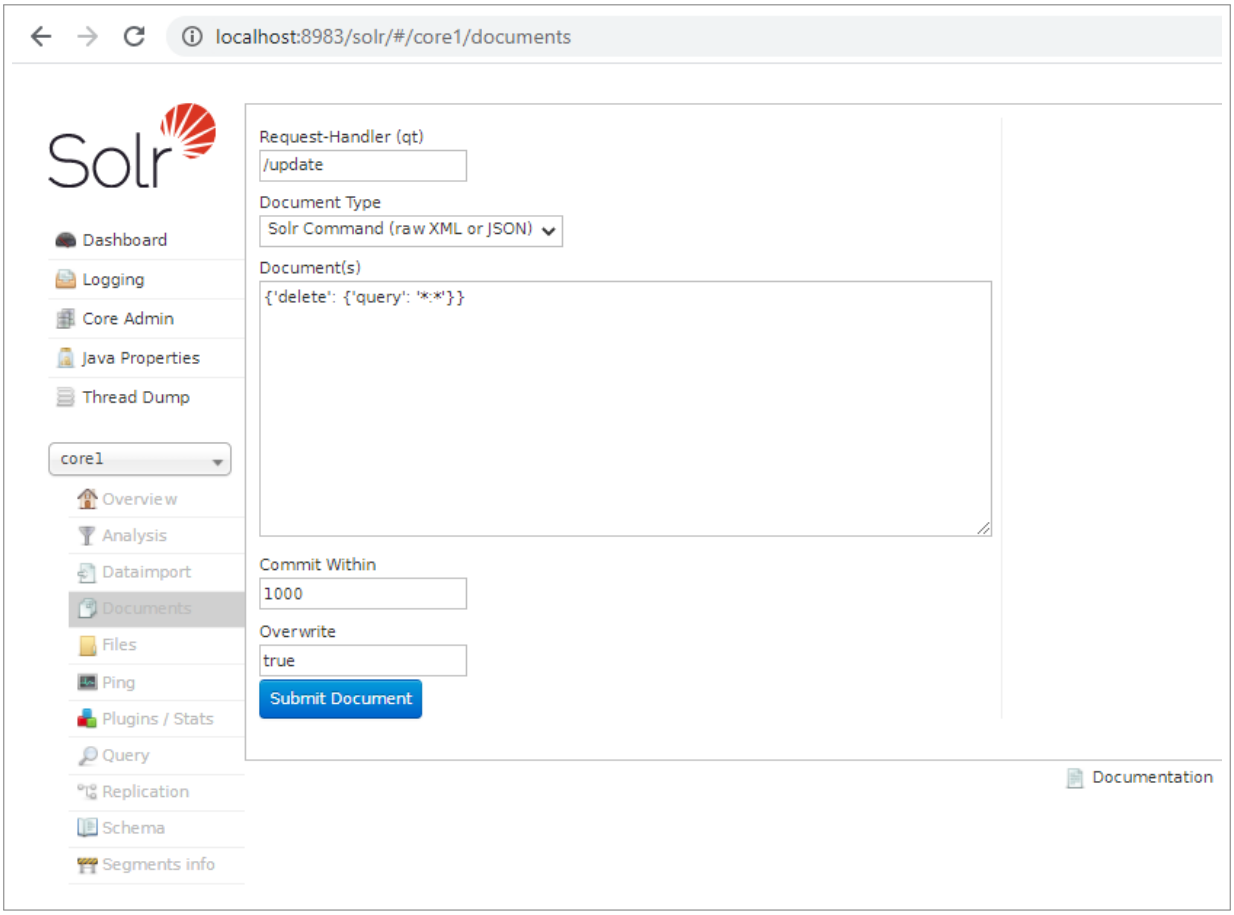
We can delete data in Solr from the Solr Admin UI. To delete all data, on the **Documents** interface, select the **Document Type** `Solr Command (raw XML or JSON)` and enter the XML command:

```
<delete><query>*:*</query></delete>
```

or the JSON command:

```
{'delete': {'query': '*:*'}}
```

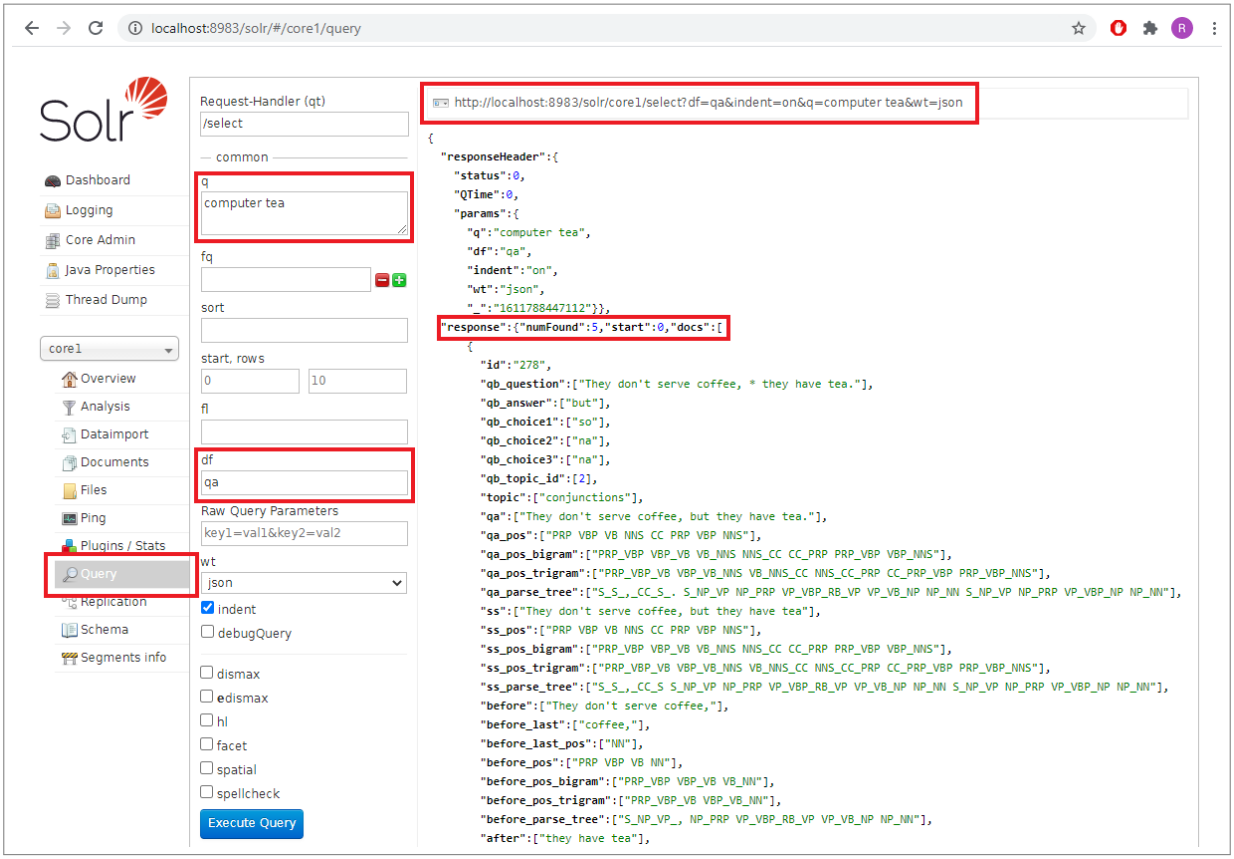
Click **Submit Document** to delete all data:



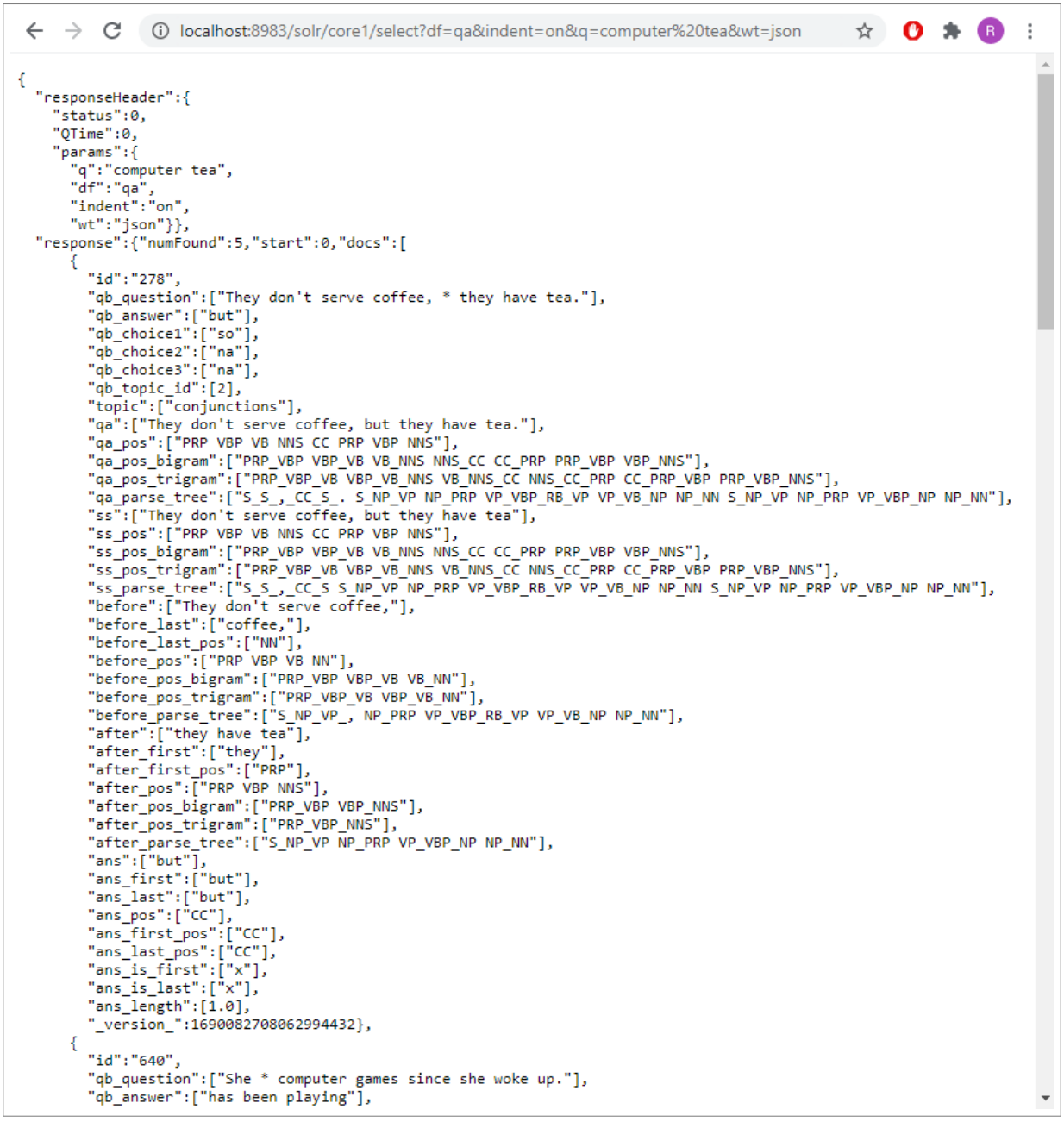
6.7 Solr Search

6.7.1 Solr Admin UI

After data is uploaded to Solr, we can search for documents in the Solr Admin UI. The data in each document is organized into 40 fields. In the screenshot below, the query is “computer tea”. We specify the default field (`df`) as `qa`, so that Solr knows which field to match the query with. Solr returns five documents matching the query. In other words, at least one of the words in the query (”computer” or ”tea”) is found in the field `qa` in each of the five documents:



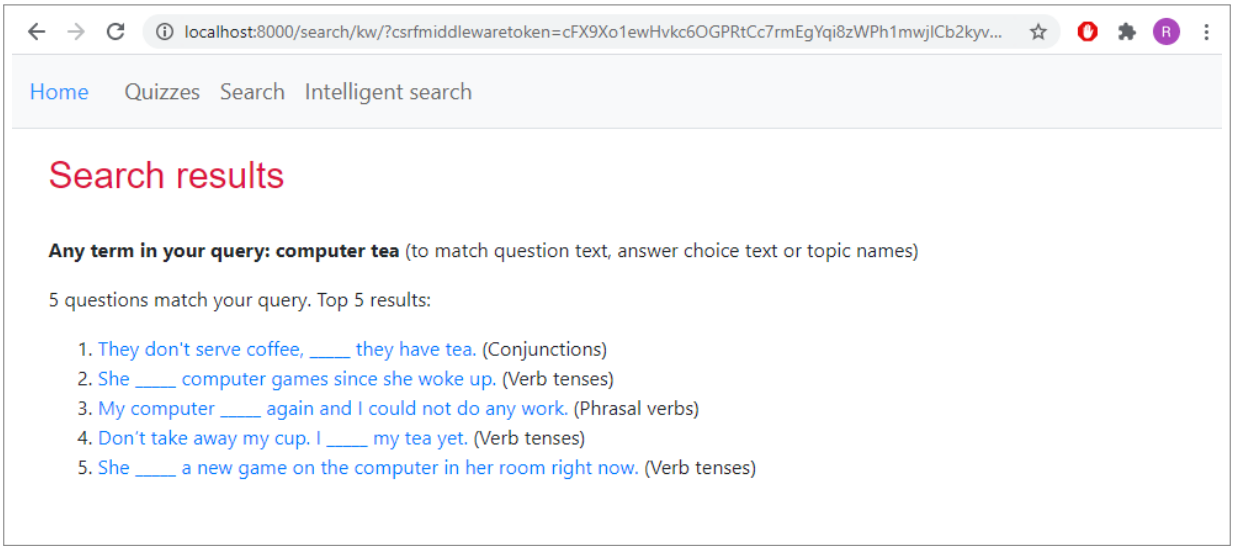
At the top of the query interface on the previous page, the query is given as a URL. Click on this URL and we will see the results on a web page:




```
{
  "responseHeader":{
    "status":0,
    "QTime":0,
    "params":{
      "q":"computer tea",
      "df":"qa",
      "indent":"on",
      "wt":"json"}},
  "response":{"numFound":5,"start":0,"docs":[
      {
        "id":"278",
        "qb_question":["They don't serve coffee, * they have tea."],
        "qb_answer":["but"],
        "qb_choice1":["so"],
        "qb_choice2":["na"],
        "qb_choice3":["na"],
        "qb_topic_id":[2],
        "topic":["conjunctions"],
        "qa":["They don't serve coffee, but they have tea."],
        "qa_pos":["PRP VBP VB NNS CC PRP VBP NNS"],
        "qa_pos_bigram":["PRP_VBP VBP_VB VB_NNS NNS_CC CC_PRP PRP_VBP VBP_NNS"],
        "qa_pos_trigram":["PRP_VBP_VB VBP_VB_NNS VB_NNS_CC NNS_CC_PRP CC_PRP_VBP PRP_VBP_NNS"],
        "qa_parse_tree":["S_S_,_CC_S_. S_NP_VP NP_PRP VP_VBP_RB_VP VP_VB_NP NP_NN S_NP_VP NP_PRP VP_VBP_NP NP_NN"],
        "ss":["They don't serve coffee, but they have tea"],
        "ss_pos":["PRP VBP VB NNS CC PRP VBP NNS"],
        "ss_pos_bigram":["PRP_VBP VBP_VB VB_NNS NNS_CC CC_PRP PRP_VBP VBP_NNS"],
        "ss_pos_trigram":["PRP_VBP_VB VBP_VB_NNS VB_NNS_CC NNS_CC_PRP CC_PRP_VBP PRP_VBP_NNS"],
        "ss_parse_tree":["S_S_,_CC_S S_NP_VP NP_PRP VP_VBP_RB_VP VP_VB_NP NP_NN S_NP_VP NP_PRP VP_VBP_NP NP_NN"],
        "before":["They don't serve coffee,"],
        "before_last":["coffee,"],
        "before_last_pos":["NN"],
        "before_pos":["PRP VBP VB NN"],
        "before_pos_bigram":["PRP_VBP VBP_VB VB_NN"],
        "before_pos_trigram":["PRP_VBP_VB VBP_VB_NN"],
        "before_parse_tree":["S_NP_VP_, NP_PRP VP_VBP_RB_VP VP_VB_NP NP_NN"],
        "after":["they have tea"],
        "after_first":["they"],
        "after_first_pos":["PRP"],
        "after_pos":["PRP VBP NNS"],
        "after_pos_bigram":["PRP_VBP VBP_NNS"],
        "after_pos_trigram":["PRP_VBP_NNS"],
        "after_parse_tree":["S_NP_VP NP_PRP VP_VBP_NP NP_NN"],
        "ans":["but"],
        "ans_first":["but"],
        "ans_last":["but"],
        "ans_pos":["CC"],
        "ans_first_pos":["CC"],
        "ans_last_pos":["CC"],
        "ans_is_first":["x"],
        "ans_is_last":["x"],
        "ans_length":[1.0],
        "_version_":1690082708062994432},
      {
        "id":"640",
        "qb_question":["She * computer games since she woke up."],
        "qb_answer":["has been playing"],
```

6.7.2 Website

On the **Search** page, do a Solr search. The query "computer tea" will return the same five documents in the same ranking order:



Chapter 7

Intelligent Solr Search

7.1 Learning To Rank Plugin

To enable Learning To Rank (LTR) for `core1`, we need to add the following configuration information to the file `solrconfig.xml` in `solr7/server/solr/core1/conf`:

- the library `solr-ltr-7.7.3.jar`, located in `solr7/dist/`
- the Learning To Rank *query parser* named `ltr`
- the *feature values cache* named `QUERY_DOC_FV`
- the *transformer* named `features`

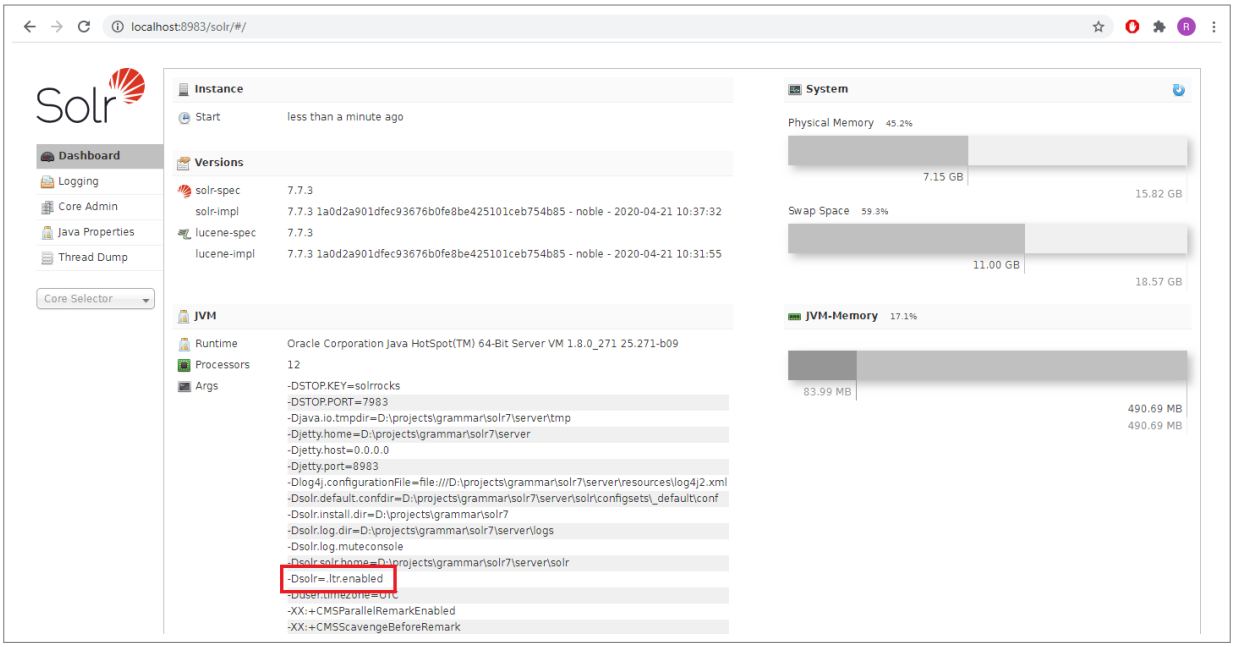
Put the following code before `</config>` at the end of `solrconfig.xml`:

```
<lib dir="${solr.install.dir:../../../..}/dist/" regex="solr-ltr-\d.*\.jar" />

<queryParser name="ltr" class="org.apache.solr.ltr.search.LTRQParserPlugin"/>

<cache name="QUERY_DOC_FV"
       class="solr.search.LRUCache"
       size="4096"
       initialSize="2048"
       autowarmCount="4096"
       regenerator="solr.search.NoOpRegenerator" />

<transformer name="features"
  class="org.apache.solr.ltr.response.transform.LTRFeatureLoggerTransformerFactory">
    <str name="fvCacheName">QUERY_DOC_FV</str>
</transformer>
```

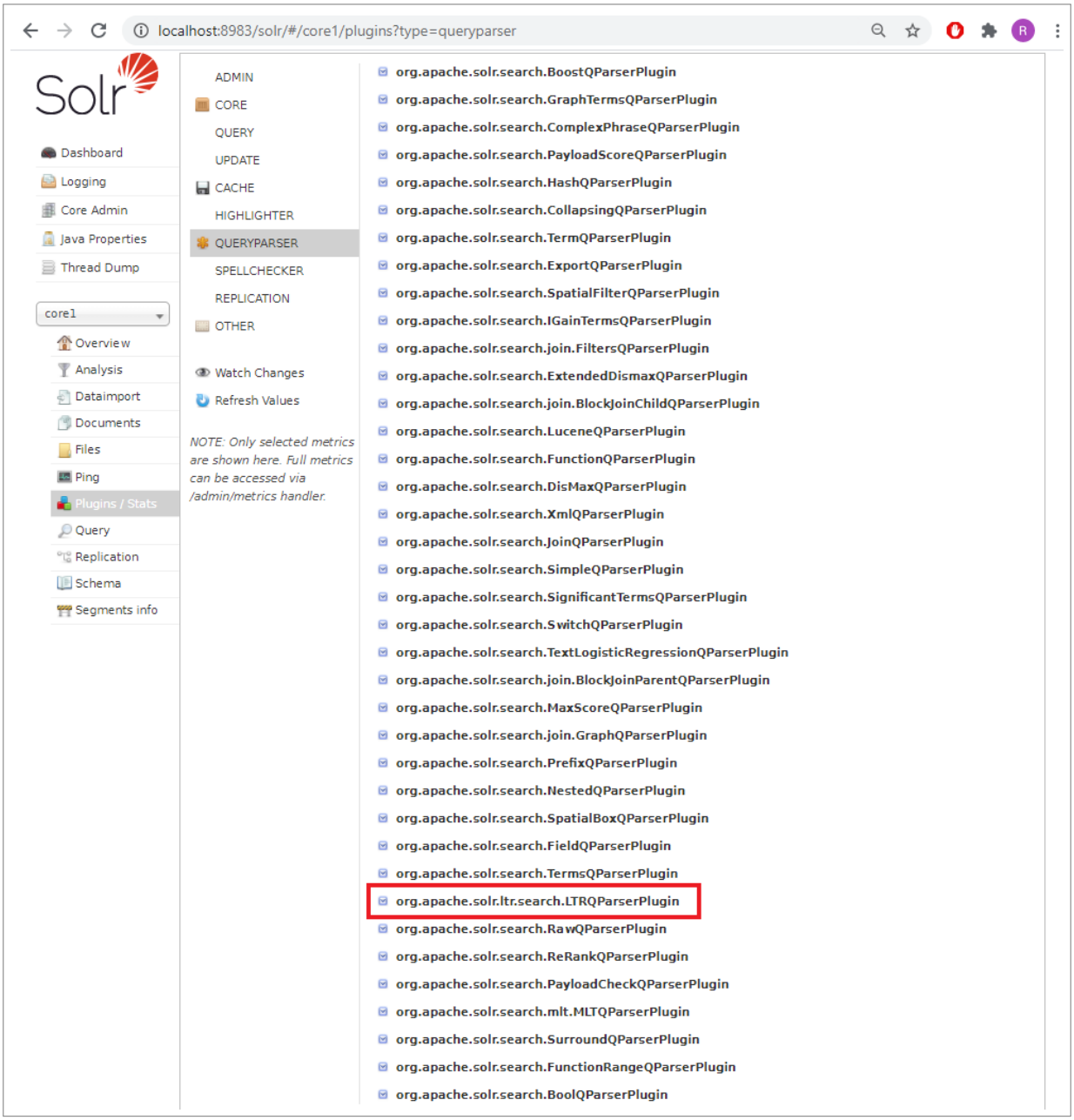
Restart Solr with LTR enabled:

```
PS D:\grammar\solr7> bin/solr restart -Dsolr.ltr.enabled -p 8983
Stopping Solr process 19952 running on port 8983

Waiting for 0 seconds, press a key to continue ...
Waiting up to 30 to see Solr running on port 8983
Started Solr server on port 8983. Happy searching!
```

Refresh the Solr Admin UI. The Dashboard will show that LTR is now enabled:



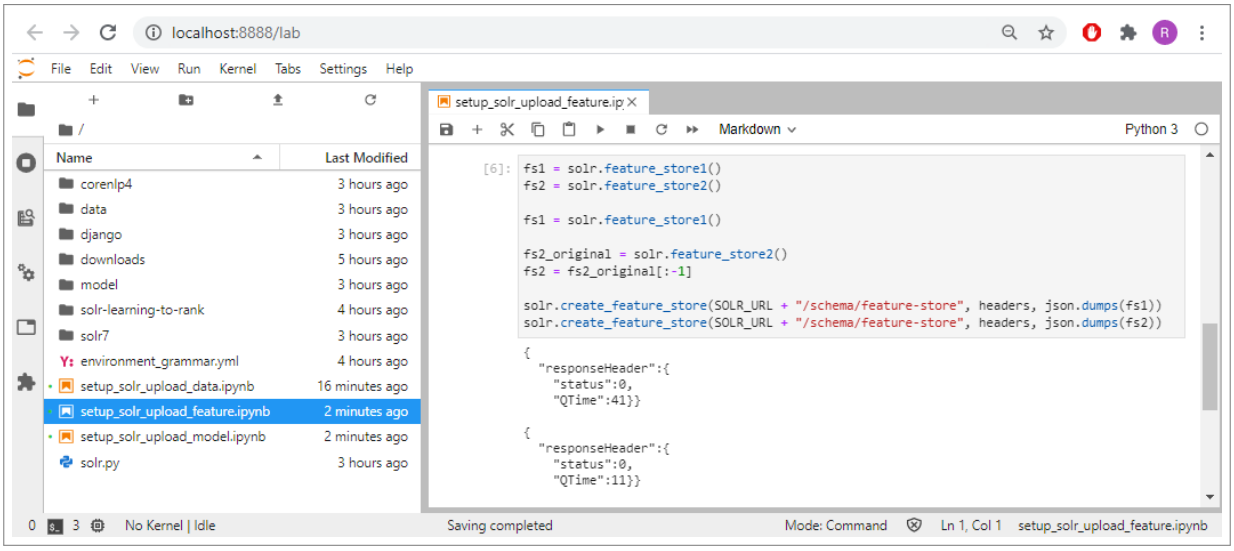
In the list of *query parser plugins* for `core1`, we will see the LTR plugin:



7.2 Feature Store and Model Store

7.2.1 Uploading Features

First, we upload the feature definitions for all features to Solr. To upload feature definitions to Solr, open `setup_solr_upload_feature.ipynb` and run it:



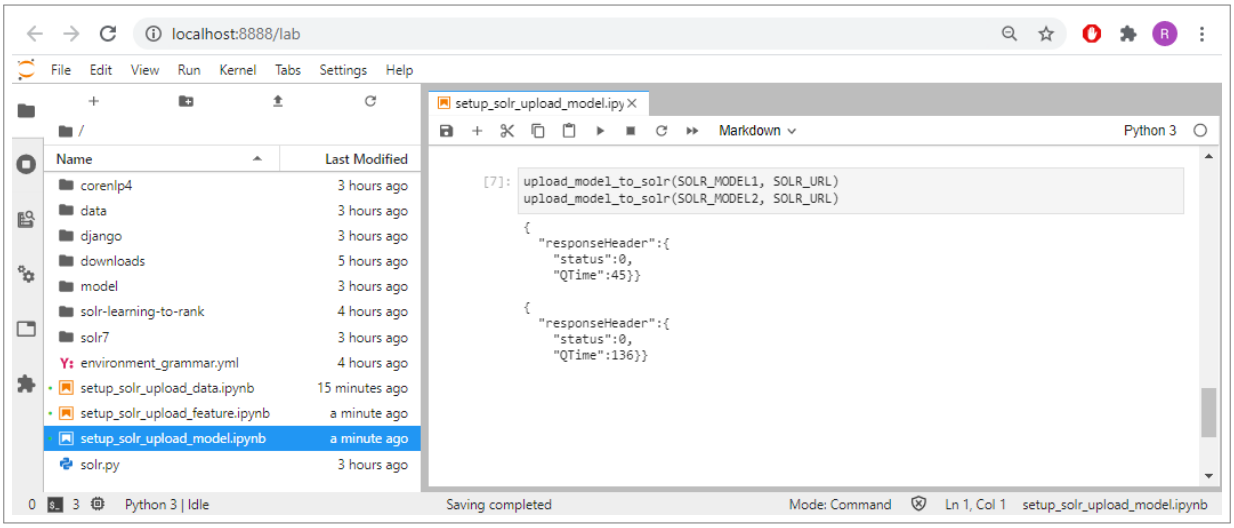
Solr will create the JSON file `_schema_feature-store.json` to store the feature definitions.

7.2.2 Uploading Models

Next, we upload the trained models to Solr. Copy the following models from the repository directory:

- `/grammar/model/model1.json`
- `/grammar/model/model2.json`

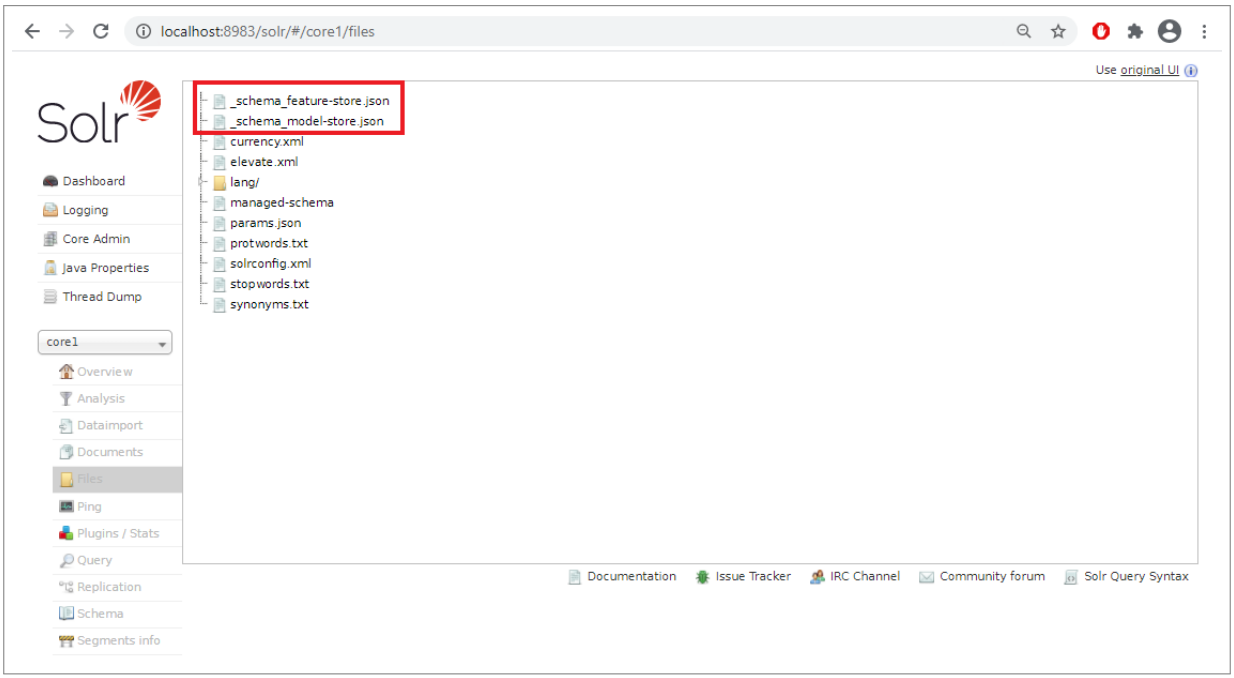
We upload Model 1 and Model 2 in JSON format to Solr. Open `setup_solr_upload_model.ipynb` and run it:



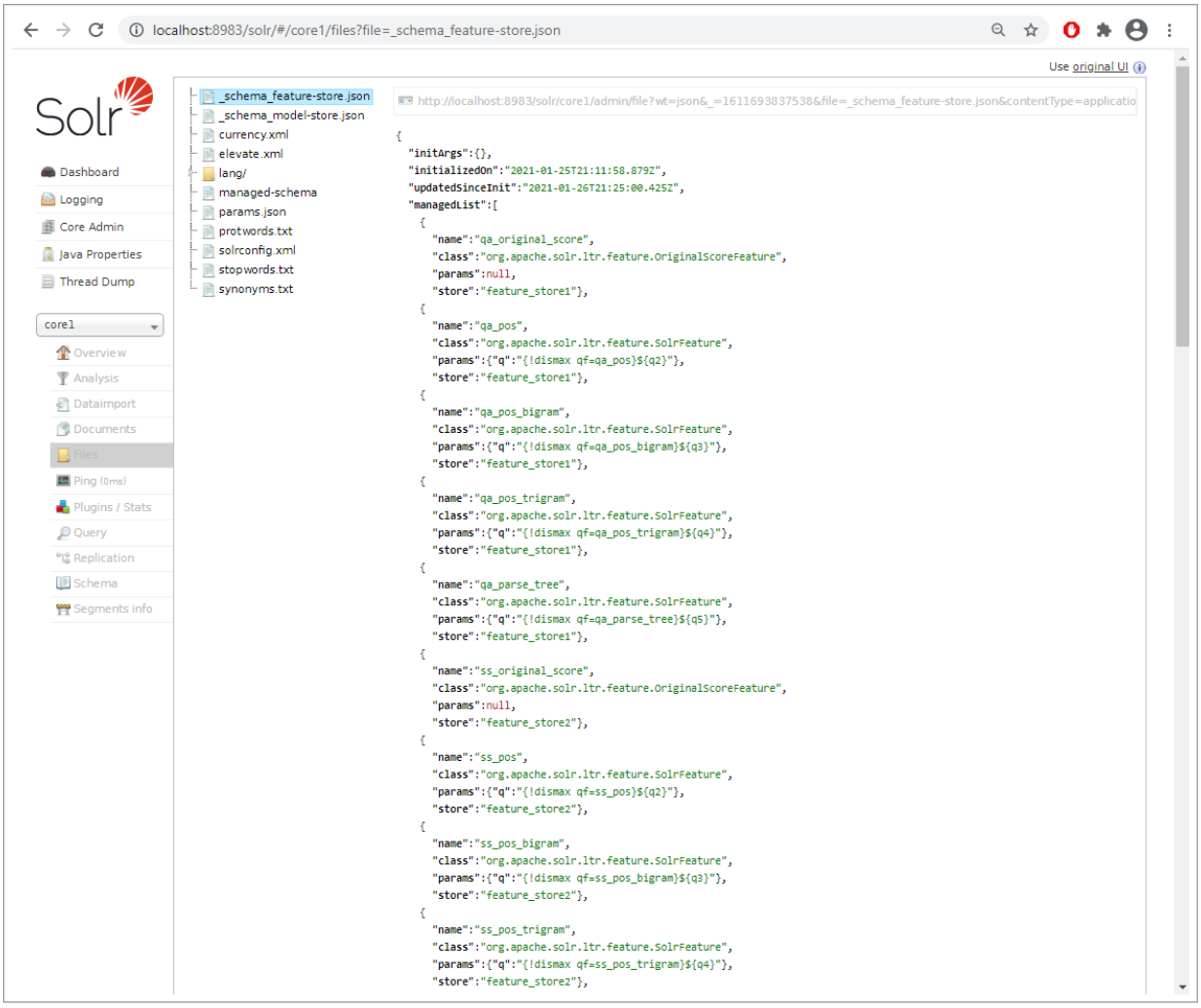
Solr will create the JSON file `_schema_model-store.json` to store the information uploaded.

7.2.3 Solr Admin UI

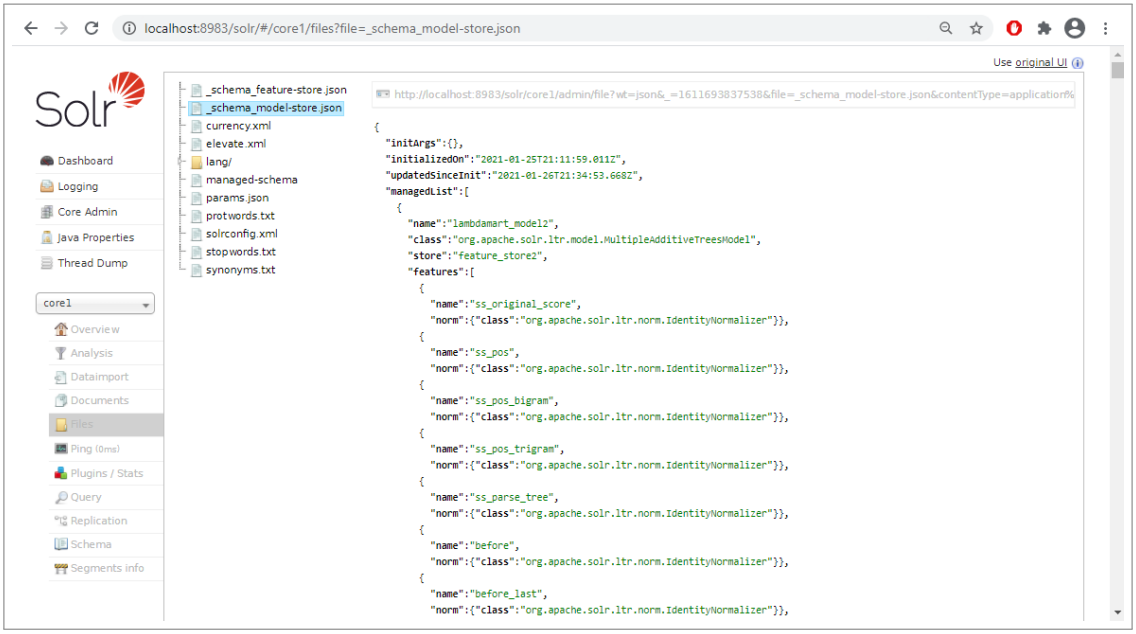
In Solr Admin UI, go to the **Files** interface. We will see the two JSON files created by Solr:

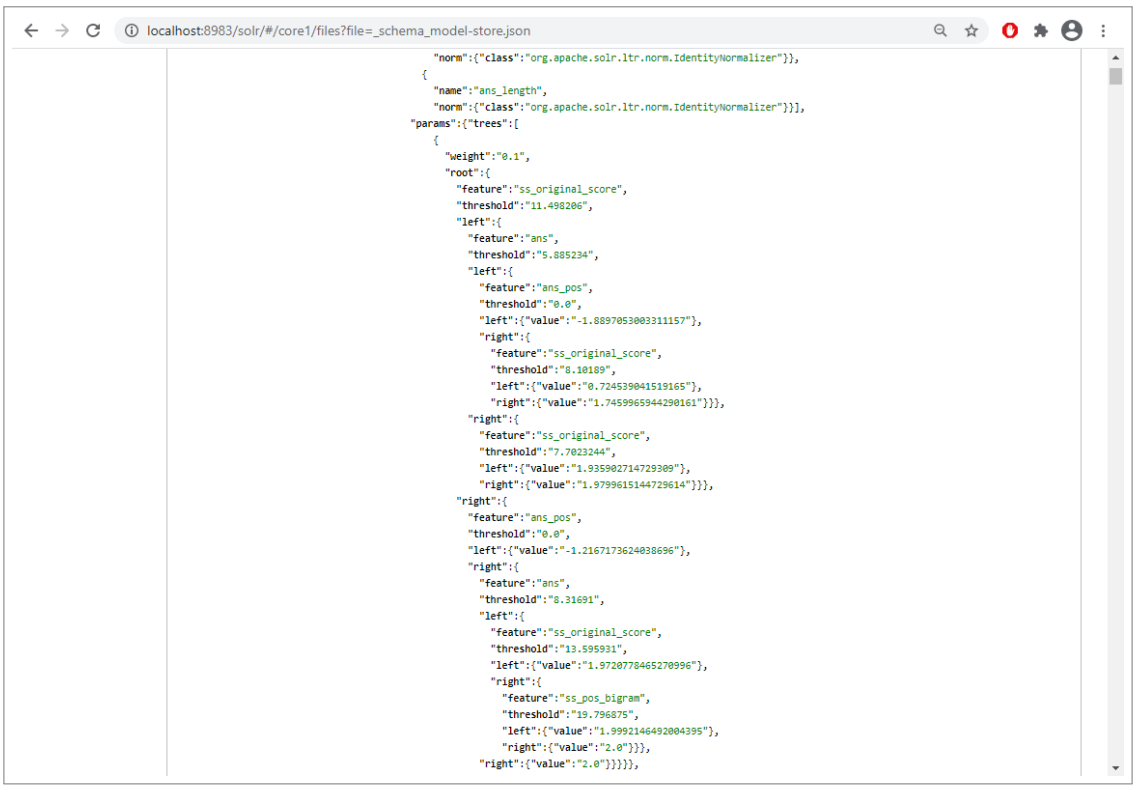


Click on each file to see its contents. In `_schema_feature-store.json`, the variable `managedList` is a list of feature definitions. Each feature is stored in either `feature_store1` (Model 1 features) or `feature_store2` (Model 2 features):



In `_schema_model-store.json`, the variable `managedList` is a list of models. The screenshot below shows the information stored for Model 2: the model name (`lambdamart_model2`), the model class, the feature store name, the list of features, and the LambdaMART model.





7.3 Stanford CoreNLP

The last thing that we need to set up before we can do intelligent Solr search is the Stanford CoreNLP server. CoreNLP is used to extract grammar production rules from sentences. Download CoreNLP (`stanford-corenlp-latest-4.2.0.zip`) from:

https://stanfordnlp.github.io/CoreNLP/

The ZIP file contains one directory. Move it to the project directory and rename it `corenlp4`. To start the server, the basic command is:

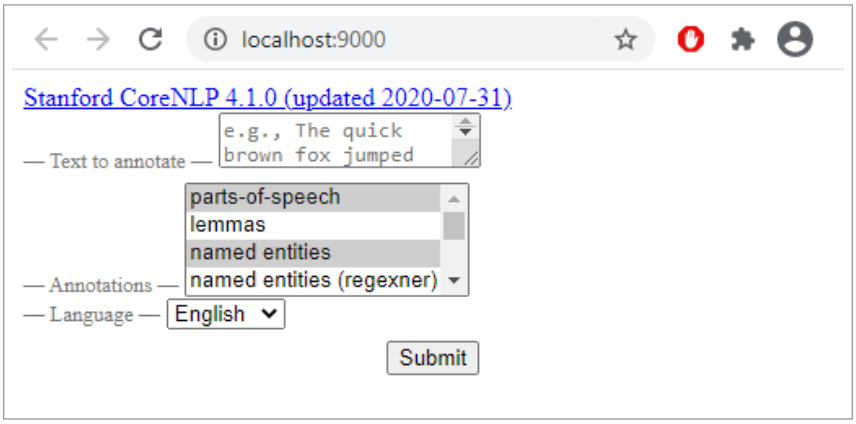
```
PS D:\grammar\corenlp4> java -mx4g -cp "*" edu.stanford.nlp.pipeline.StanfordCoreNLPServer
-timeout 15000
[main] INFO CoreNLP - --- StanfordCoreNLPServer#main() called ---
[main] INFO CoreNLP - Server default properties:
                        (Note: unspecified annotator properties are English defaults)
                        inputFormat = text
                        outputFormat = json
                        prettyPrint = false
[main] INFO CoreNLP - Threads: 12
[main] INFO CoreNLP - Starting server...
[main] INFO CoreNLP - StanfordCoreNLPServer listening at /0:0:0:0:0:0:0:0:9000
```

An equivalent command, in which all *annotators* are specified, is:

```
PS D:\grammar\corenlp4> java -mx4g -cp "*"
edu.stanford.nlp.pipeline.StanfordCoreNLPServer -preload
tokenize,ssplit,pos,lemma,ner,parse,depparse
-port 9000 -timeout 15000
```

The wildcard `"*"` (it must be in quotes) after `-cp` loads all JAR files in the current directory. If the server is running, the CoreNLP page will be loaded at http://localhost:9000:

If you are not connected to the internet, the CoreNLP page will not be styled:



The method to shut down the server is described in CoreNLP's documentation:

https://stanfordnlp.github.io/CoreNLP/corenlp-server.html#stopping-the-server

To shut down the server, we pass the shutdown key in the command `wget`. In Windows 10, the key can be obtained as follows:

```
PS C:\> cat /Users/ronko/AppData/Local/Temp/corenlp.shutdown
18fbitvsk05312p26tt04tdd47
```

The command to shut down the server is:

```
wget "localhost:9000/shutdown?key=18fbitvsk05312p26tt04tdd47" -O -
```

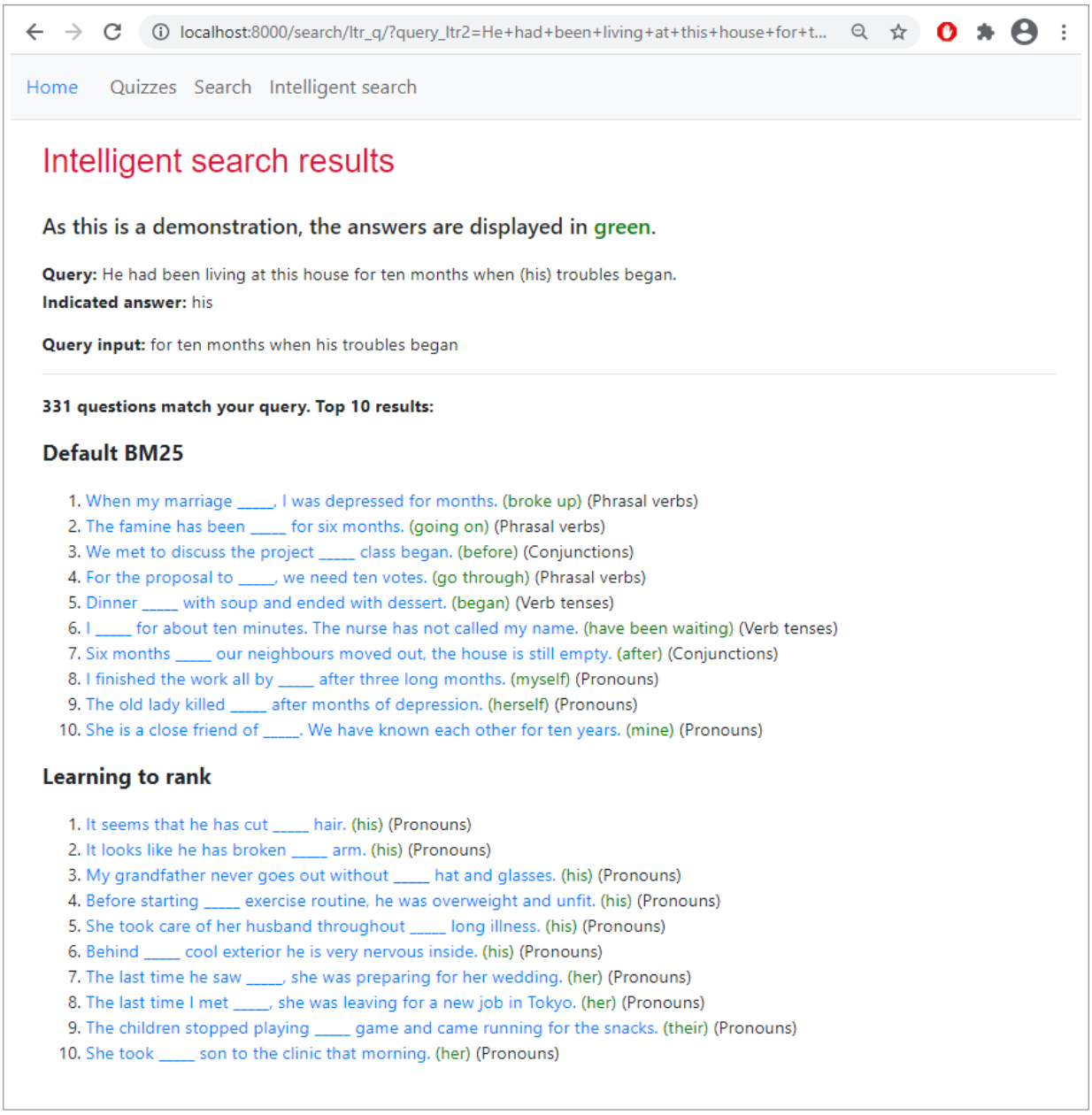
However, we can easily shut down the server by closing the command line interface in which we started the server.

7.4 Intelligent Search

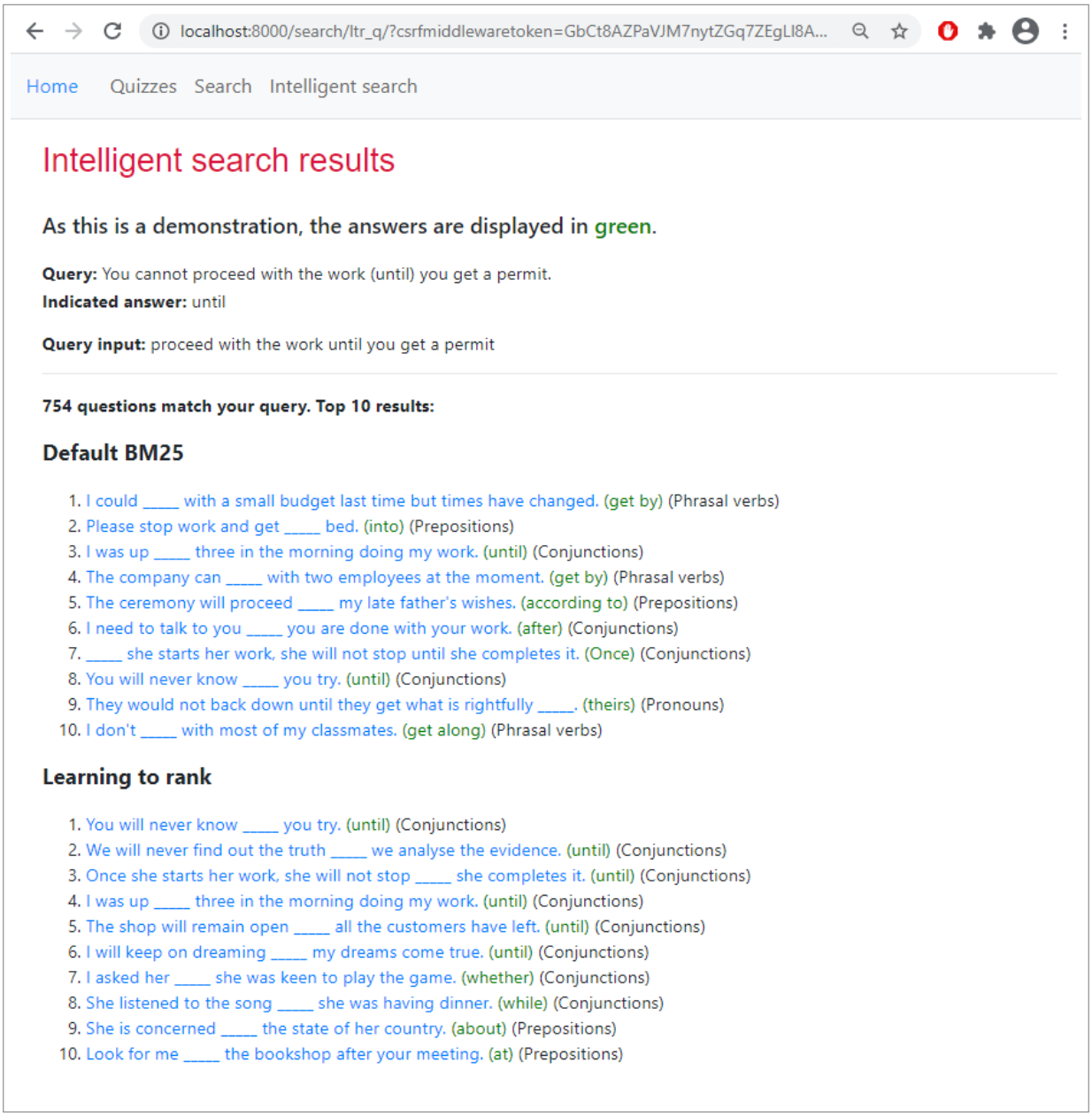
7.4.1 Intelligent Search Page

Now that everything is set up, we can send queries on the website:

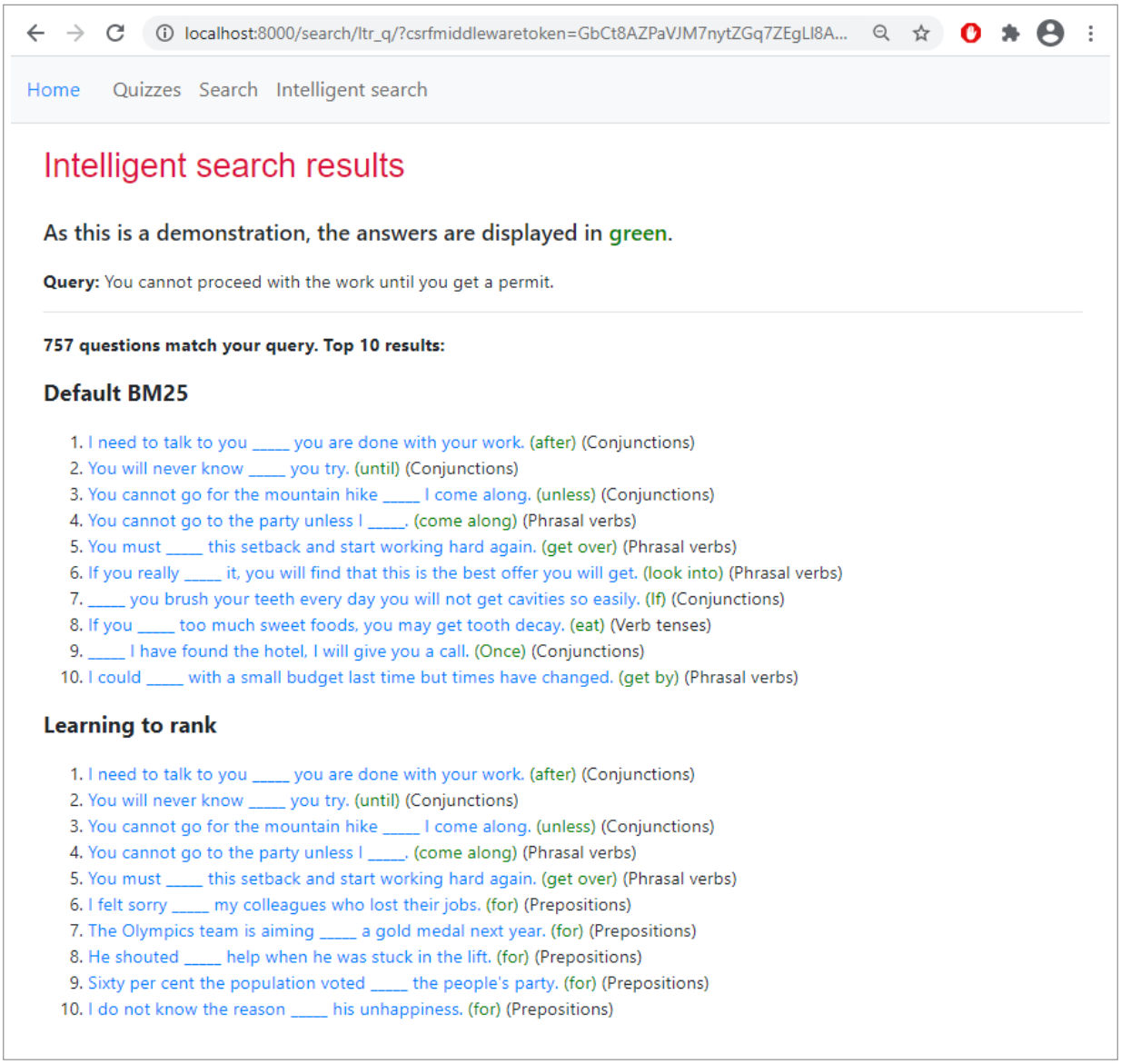
- **Sample queries**



- **Answer indicated**

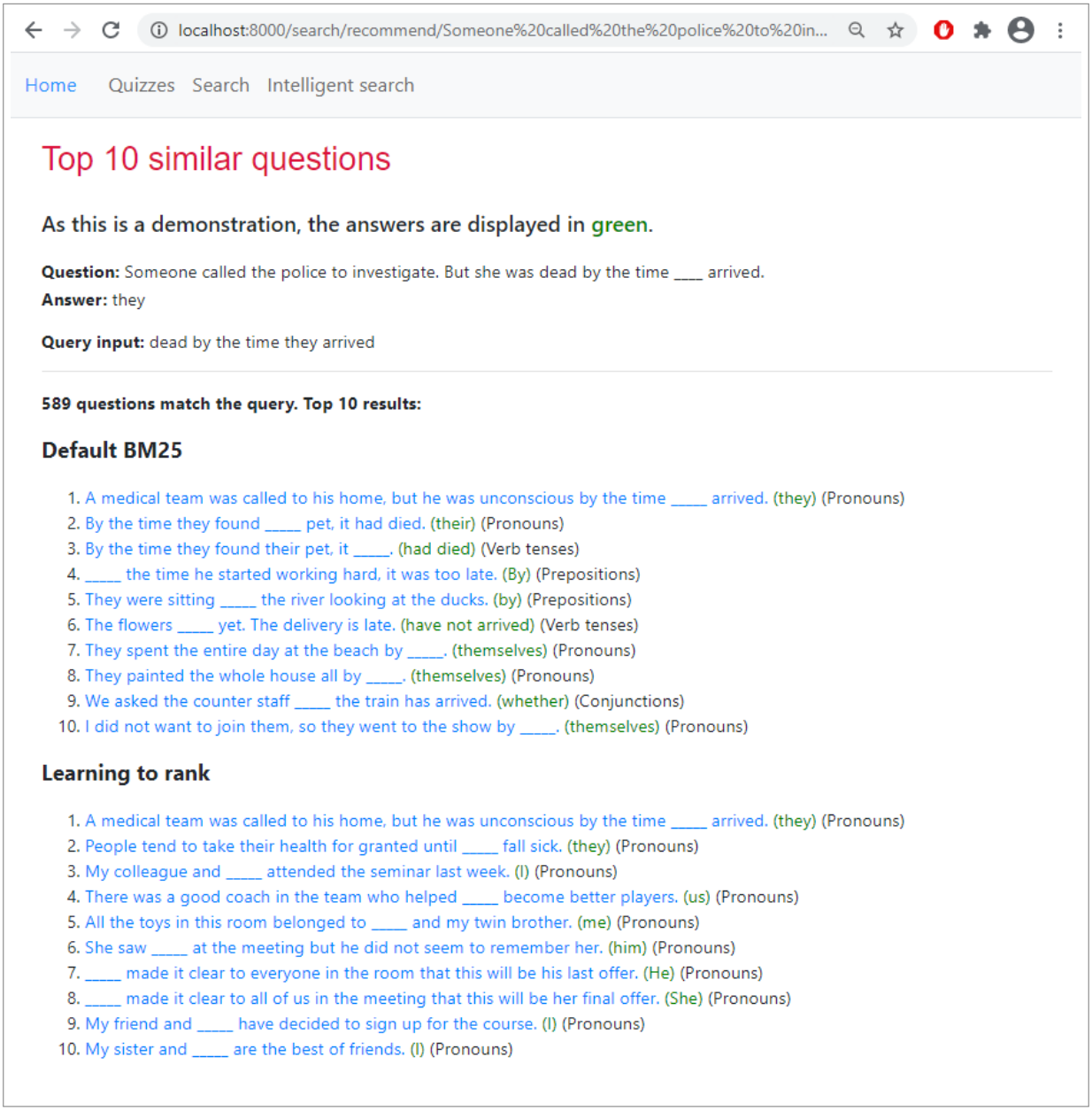


- **Answer not indicated**



7.4.2 Quizzes Page

Test the quiz feature **More questions like this**:



Chapter 8

Summary of Setup Process

We have completed the setup using the raw datasets, feature datasets, model datasets, and the trained models. The following is a step-by-step summary of the setup process described in the preceding six chapters:

1. **Project Requirements and Virtual Environment**
    - Download Solr, CoreNLP, RankLib, and Apache Commons Mathematics.
    - Download and install Java Runtime Environment and DB Browser.
    - Download and install Miniconda.
    - Set up the virtual environment.
    - Install the required libraries in the virtual environment.
    - Create the project file system.
    - Download the project repository from GitHub.
2. **Django Setup on Development Server**
    - Set up the default Django website (`http://localhost:8000`).
    - Set up the Django admin site (`http://localhost:8000/admin`).
    - Create the directories for templates and static files.

3. **Grammar Practice Website**

   - Add the three applications `apppage`, `appquiz`, and `appsearch` to `settings.py`.
   - Add the application `crispy_forms` to `settings.py`.
   - Add the paths for the three apps to `urls.py`.
   - Copy the source files (templates, CSS) and directories for the three applications from the repository directory.
   - Run the development server and check that the grammar website home page loads (http://localhost:8000/grammar).

4. **Quizzes and Database Search**

   - Copy the raw data directory from the repository directory.
   - Create the database tables for `appquiz` and `appsearch`.
   - Create data (for topics and quiz numbers) in database tables using the Django admin site.
   - Import data (for quiz questions and question bank questions) from CSV files (`rawdata_quiz.csv`, `rawdata_doc.csv`, `rawdata_query.csv`) to database tables using **DB Browser**.
   - Check that the quiz and basic search features work on the website.

5. **Solr Search**

   - Set up a Solr node (http://localhost:8983).
   - Create a core in the Solr node.
   - Upload features data to Solr from CSV files (`feature_doc.csv`, `feature_query.csv`).
   - Check that Solr search works on the website.

6. **Intelligent Solr Search**

   - Add LTR plugin configuration information to `solrconfig.xml`.
   - Upload the feature definitions to Solr.
   - Upload the two LambdaMART models to Solr.
   - Run Stanford CoreNLP (http://localhost:9000) using the command:

     ```
     java -mx4g -cp "*" edu.stanford.nlp.pipeline.StanfordCoreNLPServer -timeout 15000
     ```

   - Check that intelligent Solr search works and the **More questions like this** feature works in quizzes.

Chapter 9

Creating Model Datasets

I will now describe the process of creating the model datasets (training, validation, testing) from the raw data (in `/grammar/data/raw`), and the building of the LambdaMART models. Copy the following the Jupyter Notebooks from the repository directory and run them in the following order:

- `/grammar/1_extract_feature.ipynb`
  This notebook extracts features from the raw datasets in `/grammar/data/raw/` and creates the feature datasets in `/grammar/data/feature`.
- `/grammar/setup_solr_upload_data.ipynb`
  Upload the features data in `feature_doc.csv` and `feature_query.csv` to Solr. This is the same as what we did in Section 6.5.2.
- `/grammar/2_solr_upload_feature.ipynb`
  This notebook uploads the feature definitions to Solr. This is slightly different from what we did in Section 7.2.1, which excluded the feature `qb_topic_id`. `qb_topic_id` is only used for creating the datasets; it is not a feature in the ranking models.
- `/grammar/3_solr_upload_linear_model.ipynb`
  This notebook uploads two *linear models* (one for each ranking model) used by Solr to extract feature values (which are the weights in each linear model) for all the features.

- `/grammar/4_create_model_dataset.ipynb`

  This notebook creates the training, validation and testing datasets for Model 1 and Model 2.

  A sample of the Model 1 dataset `model1_train.txt` is shown below:

```
1 qid:851 1:19.991014 2:4.0605597 3:11.197081 4:16.45244 5:8.824474 # docid:851
1 qid:851 1:10.315361 2:3.538503 3:6.289652 4:4.206999 5:4.2085648 # docid:554
1 qid:851 1:9.662352 2:3.5659604 3:5.561839 4:4.520902 5:4.8901253 # docid:236
```

  A sample of the Model 2 dataset `model2_train.txt` is shown below:

```
3 qid:851 1:19.452402 2:4.8407536 3:11.618433 4:15.950744 5:9.296059 6:11.506929
7:1.0 8:1.0 9:5.9961243 10:8.067158 11:5.6357236 12:9.641943 13:6.9352627 14:1.0
15:1.0 16:1.4760072 17:1.5126191 18:0.0 19:1.9578518 20:4.6139307 21:1.0 22:1.0
23:1.0 24:1.0 25:1.0 26:1.0 27:1.0 28:1.0 # docid:851
0 qid:851 1:10.547468 2:4.3035083 3:6.9204445 4:4.260151 5:5.3723674 6:2.2685385
7:0.0 8:0.0 9:0.6976033 10:0.0 11:0.0 12:0.6431802 13:5.4170594 14:1.0
15:1.0 16:1.1525129 17:1.0870409 18:0.0 19:1.3429569 20:0.0 21:0.0 22:0.0
23:0.0 24:0.0 25:0.0 26:0.0 27:0.0 28:0.0 # docid:554
0 qid:851 1:9.775789 2:4.3051305 3:4.950946 4:0.0 5:4.6064773 6:1.4456632
7:0.0 8:0.0 9:2.5833564 10:2.4382665 11:0.0 12:1.4965961 13:0.0 14:0.0
15:0.0 16:0.0 17:0.0 18:0.0 19:0.0 20:0.0 21:0.0 22:0.0
23:1.0 24:1.0 25:1.0 26:0.0 27:0.0 28:1.0 # docid:236
```

- `/grammar/5_create_baseline_dataset.ipynb`

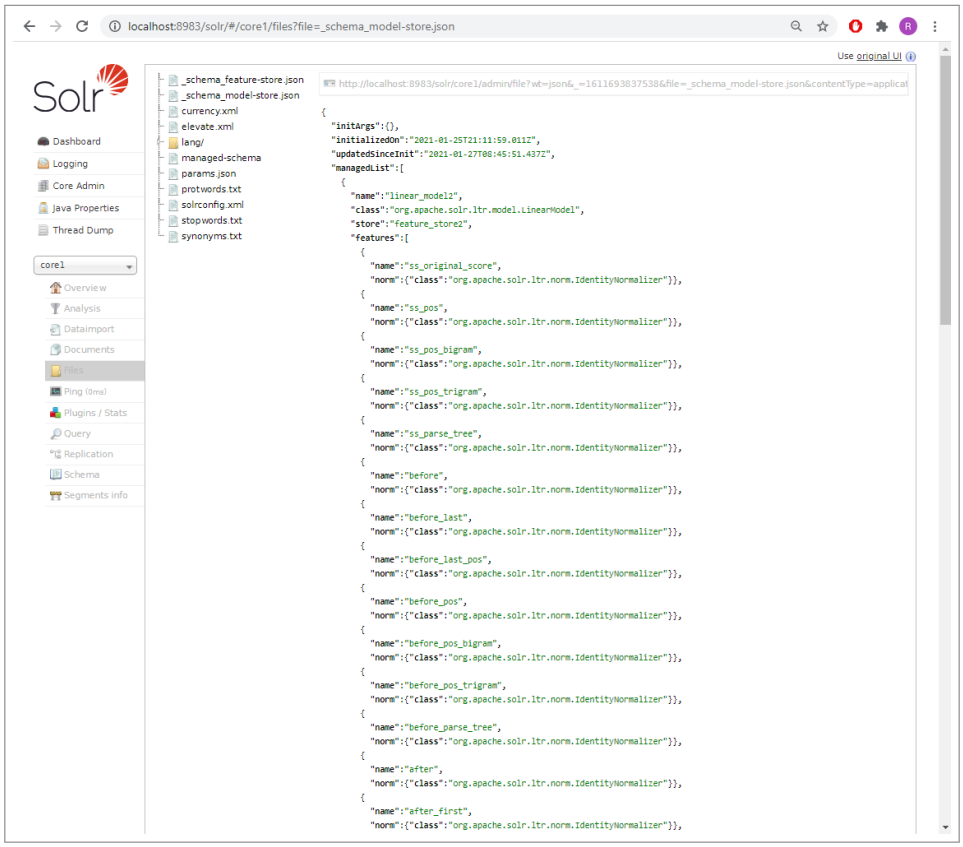
  This notebook creates the training, validation and testing datasets for Baseline Model 1 and Baseline Model 2. A sample of the Baseline Model 1 dataset `baseline_model1_train.txt` is shown below:

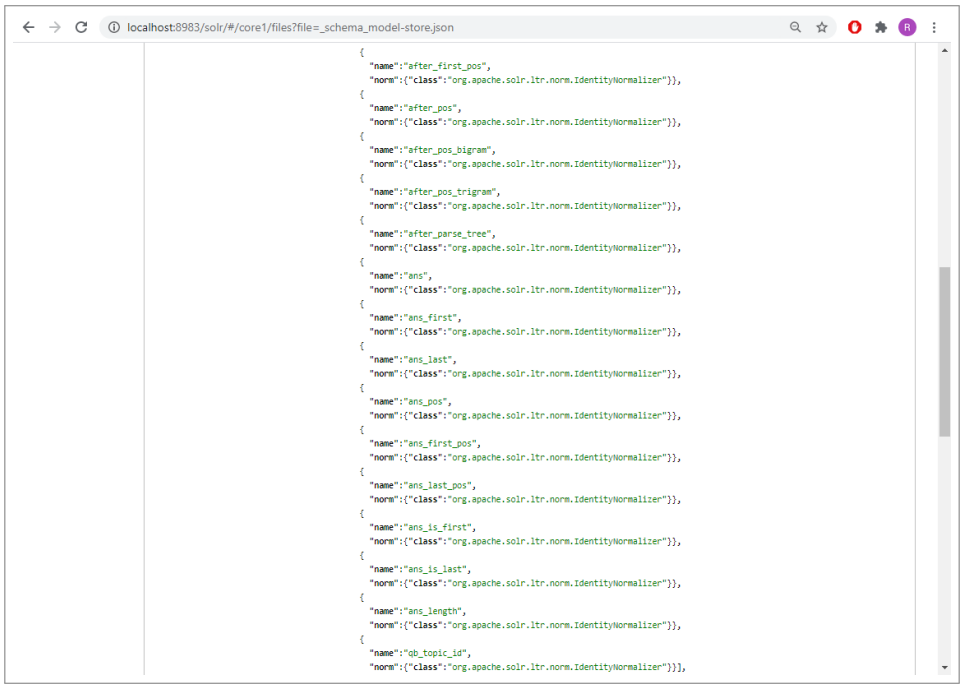
```
1 qid:851 1:19.991014 # docid:851
1 qid:851 1:10.315361 # docid:554
1 qid:851 1:9.662352 # docid:236
```

  A sample of the Baseline Model 2 dataset `baseline_model2_train.txt` is shown below:

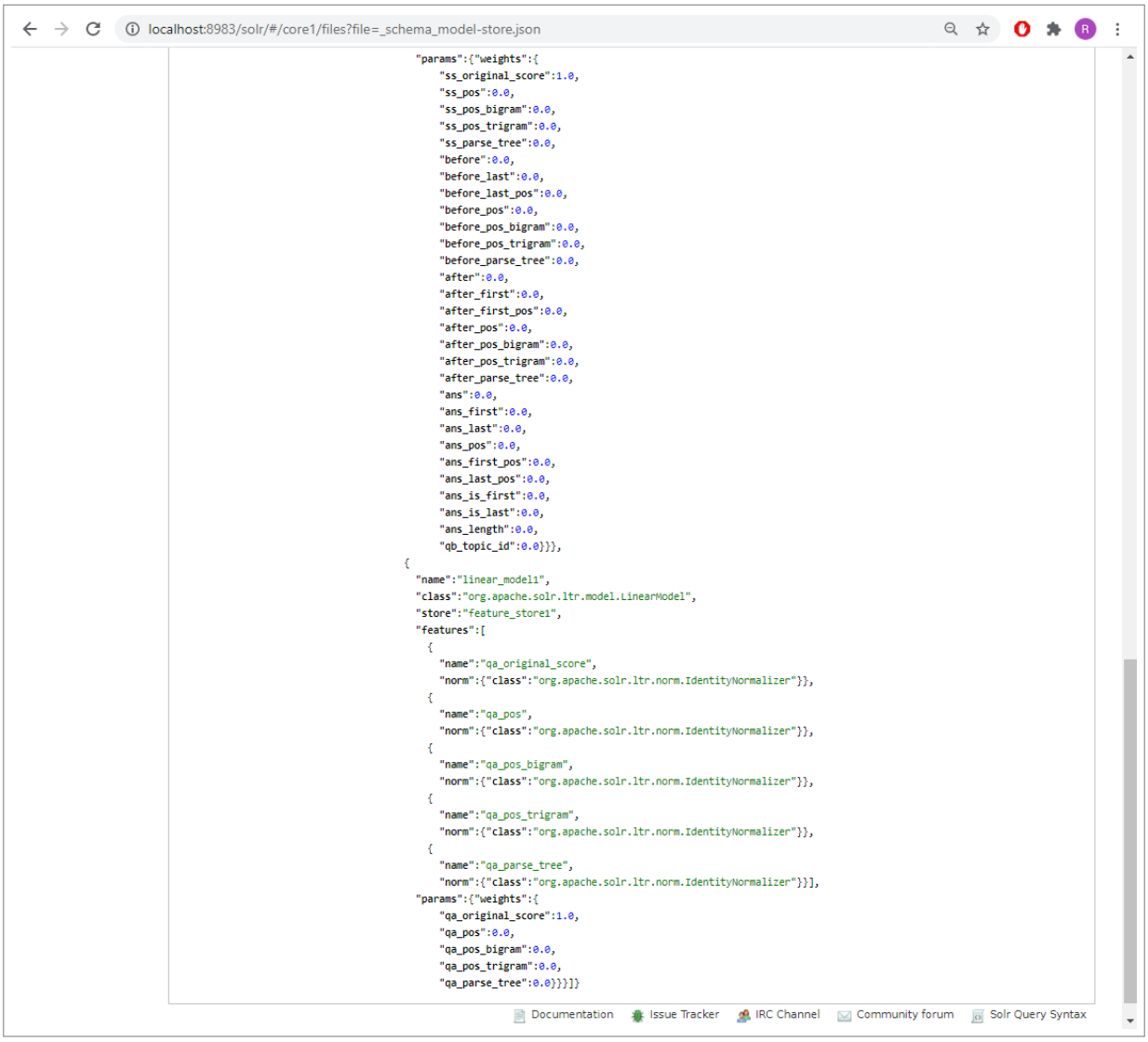
```
3 qid:851 1:19.452402 # docid:851
0 qid:851 1:10.547468 # docid:554
0 qid:851 1:9.775789 # docid:236
```

Linear model for Model 2:





Linear model for Model 1:



Chapter 10

Building and Testing the Models

10.1 RankLib

After the model datasets are created, we use them to build the models. We use the LambdaMART algorithm in the LTR library **RankLib**:

https://sourceforge.net/p/lemur/wiki/RankLib/

Download `RankLib-2.15.jar` from the following website and save it in `/grammar/ranklib2`:

https://sourceforge.net/projects/lemur/files/lemur/RankLib-2.15/

To train, validate and test a model, run the following command:

```
PS D:\grammar\ranklib2> java -jar RankLib-2.15.jar
-train ../path/train.txt
-test ../path/test.txt
-validate ../path/validate.txt
-ranker 6
-metric2t NDCG@10
-metric2T NDCG@10
-save ../path/model.txt
```

`ranker 6` refers to LambdaMART.

`metric2t <metric>` refers to the metric to optimize on the training data.

`metric2T <metric>` refers to the metric to evaluate on the test data. If not specified, it will use the same metric as `metric2t <metric>`.

Supported metrics are: `MAP`, `NDCG@k`, `DCG@k`, `P@k`, `RR@k`, `ERR@k`. The default metric is `ERR@10`.

10.2 Model Statistics

RankLib generates model statistics. First, download the Apache Commons Mathematics library `commons-math3-3.5.jar` from:

http://commons.apache.org/proper/commons-math/

Save this file in the `/grammar/ranklib2` and run the following command in Windows command prompt:

```
D:\grammar\ranklib2> java -cp RankLib-2.15.jar;commons-math3-3.5.jar
ciir.umass.edu.features.FeatureManager -feature_stats model_name.txt
```

For Model 1, trained using the metric `MAP`, we will see the following output:

```
Algorithm : LambdaMART

Feature frequencies :
        Feature[1] :     291
        Feature[2] :     232
        Feature[3] :     226
        Feature[4] :     385
        Feature[5] :     261

Total Features Used: 5

Min frequency    :    226.00
Max frequency    :    385.00
Median frequency :    261.00
Avg frequency    :    279.00
Variance         :   4180.50
STD              :     64.66
```

10.3 Converting Models to JSON

The tree models from RankLib are in text format. We need to convert them to JSON before uploading them to Solr. Copy the following notebook from the repository directory and run it:

`/grammar/6_convert_model_json.ipynb`

This notebook converts the models from text format to XML format and then to JSON format.

10.4 Uploading Models and Testing with Queries

The final step is to upload the full models and baseline models for Model 1 and Model 2 to Solr. Then we test the models with queries. To upload the four models, copy the following notebook from the repository directory and run it:

`/grammar/7_solr_upload_model.ipynb`

We select a random query and send it to Solr:

`/grammar/8_solr_send_query.ipynb`