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How to create your own Question-Answering system easily with python

How to create a QA System on your own (private) data with cdQA-suite

The history of Machine Comprehension (MC) has its origins along with the birth of first concepts in Artificial Intelligence (AI). The brilliant Allan Turing proposed in his famous article "Computing Machinery and Intelligence" what is now called the Turing test as a criterion of intelligence. Almost 70 years later, Question Answering (QA), a sub-domain of MC, is still one of the most difficult tasks in AI.

However, since last year, the field of Natural Language Processing (NLP) has experienced a fast evolution thanks to the development in Deep Learning research and the advent of Transfer Learning techniques. Powerful pre-trained NLP models such as OpenAI-GPT, ELMo, BERT and XLNet have been made available by the best researchers of the domain.

With such progress, several improved systems and applications to NLP tasks are expected to come out. One of such systems is the cdQA-suite, a package developed by some colleagues and me in a partnership between Telecom ParisTech, a French engineering school, and BNP Paribas Personal Finance, a European leader in financing for individuals.

Open-domain QA vs. closed-domain QA

When we think about QA systems we should be aware of two different kinds of systems: **open-domain QA** (ODQA) systems and **closed-domain QA** (CDQA)

systems.

Open-domain systems deal with questions about nearly anything, and can only rely on general ontologies and world knowledge. One example of such a system is DrQA, an ODQA developed by Facebook Research that uses a large base of articles from Wikipedia as its source of knowledge. As these documents are related to several different topics and subjects we can understand why this system is considered an ODQA.

On the other hand, closed-domain systems deal with questions under a specific domain (for example, medicine or automotive maintenance), and can exploit domain-specific knowledge by using a model that is fitted to a unique-domain database. The cdQA-suite was built to enable anyone who wants to build a closed-domain QA system easily.

cdQA-suite

cdQA

An End-To-End Closed Domain Question Answering System. - cdQA

github.com

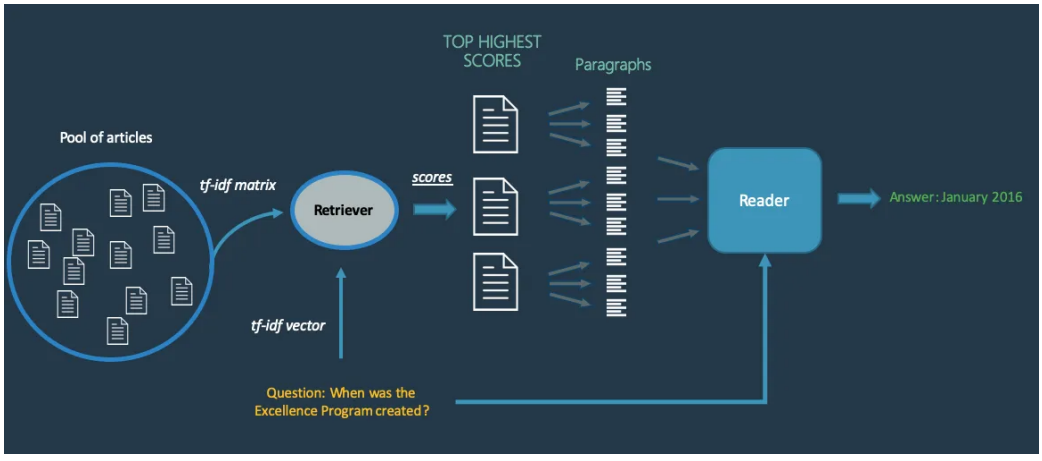
The cdQA-suite is comprised of three blocks:

- cdQA: an easy-to-use python package to implement a QA pipeline
- cdQA-annotator: a tool built to facilitate the annotation of question-answering datasets for model evaluation and fine-tuning
- cdQA-ui: a user-interface that can be coupled to any website and can be connected to the back-end system.

I will explain how each module works and how you can use it to build your QA system on your own data.

cdQA

The cdQA architecture is based on two main components: the **Retriever** and the **Reader**. You can see below a schema of the system mechanism.



Mechanism of cdQA pipeline

When a question is sent to the system, the Retriever selects a list of documents in the database that are the most likely to contain the answer. It is based on the same retriever of DrQA, which creates TF-IDF features based on uni-grams and bi-grams and compute the cosine similarity between the question sentence and each document of the database.

After selecting the most probable documents, the system divides each document into paragraphs and send them with the question to the Reader, which is basically a pre-trained Deep Learning model. The model used was the Pytorch version of the well known NLP model BERT, which was made available by HuggingFace. Then, the Reader outputs the most probable answer it can find in each paragraph. After the Reader, there is a final layer in the system that compares the answers by using an internal score function and outputs the most likely one according to the scores.

Using the cdQA python package

Before starting using the package, let's install it. You can install it using `pip` or clone the repository from source. For this tutorial I will also download the BNP Paribas' dataset (a dataset with articles extracted from their public news webpage).

```
# Installing cdQA package with pip
pip install cdqa

# From source
git clone https://github.com/cdqa-suite/cdQA.git &&
cd cdQA &&
pip install .
```

Now, you can open a jupyter notebook and follow the steps below to see how cdQA works:

```python
import pandas as pd
from ast import literal_eval

from cdqa.utils.filters import filter_paragraphs
from cdqa.utils.download import download_model, download_bnpp_data
from cdqa.pipeline.cdqa_sklearn import QAPipeline

# Download data and models
download_bnpp_data(dir='./data/bnpp_newsroom_v1.1/')
download_model(model='bert-squad_1.1', dir='./models')

# Loading data and filtering / preprocessing the documents
df = pd.read_csv('data/bnpp_newsroom_v1.1/bnpp_newsroom-v1.1.csv', converters={'paragrap
df = filter_paragraphs(df)

# Loading QAPipeline with CPU version of BERT Reader pretrained on SQuAD 1.1
cdqa_pipeline = QAPipeline(reader='models/bert_qa_vCPU-sklearn.joblib')

# Fitting the retriever to the list of documents in the dataframe
cdqa_pipeline.fit_retriever(X=df)

# Sending a question to the pipeline and getting prediction
query = 'Since when does the Excellence Program of BNP Paribas exist?'
prediction = cdqa_pipeline.predict(X=query)

print('query: {}\n'.format(query))
print('answer: {}\n'.format(prediction[0]))
print('title: {}\n'.format(prediction[1]))
print('paragraph: {}\n'.format(prediction[2]))
```

tutorial-cdqa.py hosted with ❤️ by GitHub view raw

You should have something like the following as output:

```
query: Since when does the Excellence Program of BNP Paribas exist?

answer: January 2016

title: BNP Paribas' commitment to universities and schools

paragraph: Since January 2016, BNP Paribas has offered an Excellence Program targeting new Master's level graduates
(BAC+5) who show high potential. The aid program lasts 18 months and comprises three assignments of six months each.
It serves as a strong career accelerator that enables participants to access high-level management positions at a fas
ter rate. The program allows participants to discover the BNP Paribas Group and its various entities in France and ab
road, build an internal and external network by working on different assignments and receive personalized assistance
from a mentor and coaching firm at every step along the way.
```

The output of a QAPipeline prediction

You can notice that the system not only outputs an answer, but also **the paragraph where the answer was found and the title of the document / article.**

In the snippet above, the preprocessing / filtering steps were needed to transform the BNP Paribas dataframe to the following structure:

title	paragraphs
The Article Title	[Paragraph 1 of Article, ... , Paragraph N of Article]

Structure of the Dataframe that should be sent to cdQA pipeline

If you use your own dataset, please be sure that your dataframe has such structure.

When using the CPU version of the model, each prediction takes between 10 and 20 seconds to be done. This moderate execution time is due to the BERT Reader, which is a very large deep learning model (~110M parameters). If you have a GPU, you can use directly the GPU version of the model `models/bert_qa_vGPU-sklearn.joblib`. These pre-trained models are also available on the releases page of cdQA github: https://github.com/cdqa-suite/cdQA/releases

Training / Fine-tuning the reader

You can also improve the performance of the pre-trained Reader, which was pre-trained on SQuAD 1.1 dataset. If you have an annotated dataset (that can be generated by the help of the cdQA-annotator) in the same format as SQuAD dataset you can fine-tune the reader on it:

```
# Put the path to your json file in SQuAD format here
path_to_data = './data/SQuAD_1.1/train-v1.1.json'

cdqa_pipeline.fit_reader(path_to_data)
```

Please be aware that such fine-tuning should be performed using GPU as the BERT model is too large to be trained with CPU.

You can also check out other ways to do the same steps on the official tutorials: https://github.com/cdqa-suite/cdQA/tree/master/examples

cdQA-annotator

In order to facilitate the data annotation, the team has built a web-based application, the cdQA-annotator.

In order to use it, you should have your dataset transformed to a JSON file with SQuAD-like format:

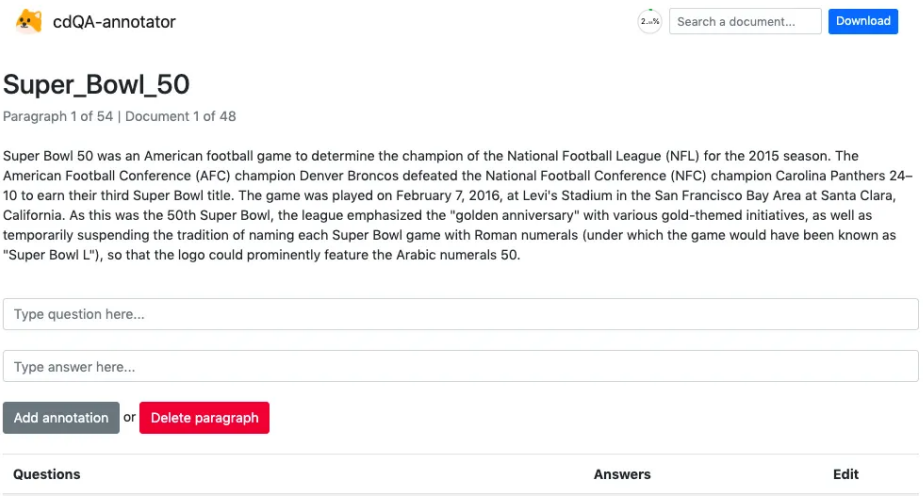
```
from cdqa.utils.converters import df2squad

# Converting dataframe to SQuAD format
json_data = df2squad(df=df, squad_version='v1.1', output_dir='.',
filename='dataset-name.json')
```

Now you can install the annotator and run it:

```
# Clone the repo
git clone https://github.com/cdqa-suite/cdQA-annotator
```

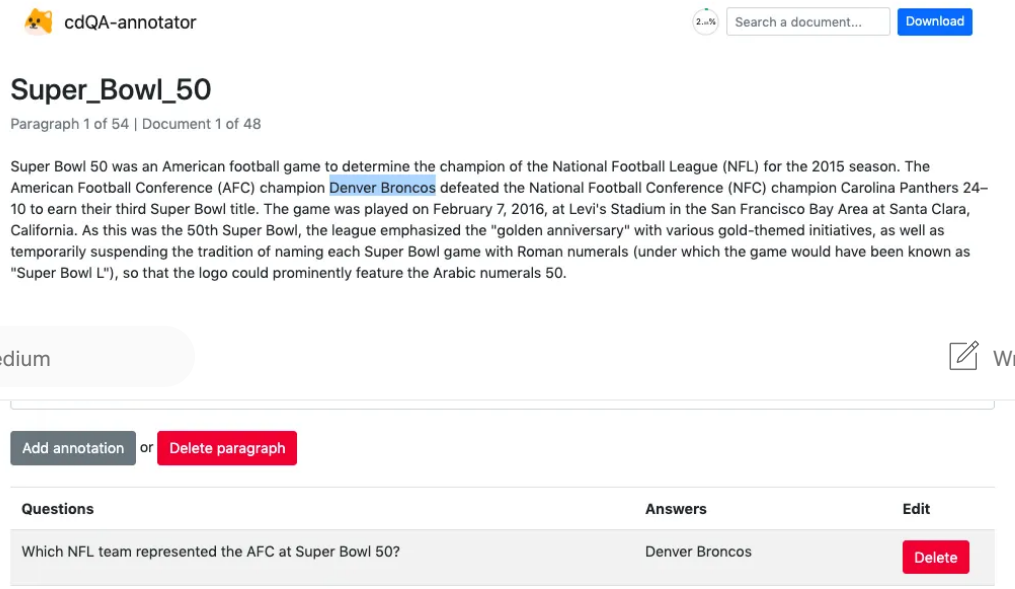
```
# Install dependencies
cd cdQA-annotator
npm install

# Start development server
cd src
vue serve
```

Now you can go to http://localhost:8080/ and after loading your JSON file you will see something like this:



cdQA-annotator interface

To start annotating question-answer pairs you just need to write a question, highlight the answer with the mouse cursor (the answer will be written automatically), and then click on `Add annotation`:



Annotating question-answer pairs with cdQA-annotator

After the annotation, you can download it and use it to fine-tune the BERT Reader on your own data as explained in the previous section.

cdQA-ui

The team also has provided a web-based user interface to couple with cdQA. In this section, I will describe how you can use de UI linked to the back-end of `cdQA`.

First, you have to deploy a `cdQA` REST API by executing on your shell (be sure you run it on `cdQA` folder):

```
export dataset_path=path-to-dataset.csv
export reader_path=path-to-reader-model

FLASK_APP=api.py flask run -h 0.0.0.0
```

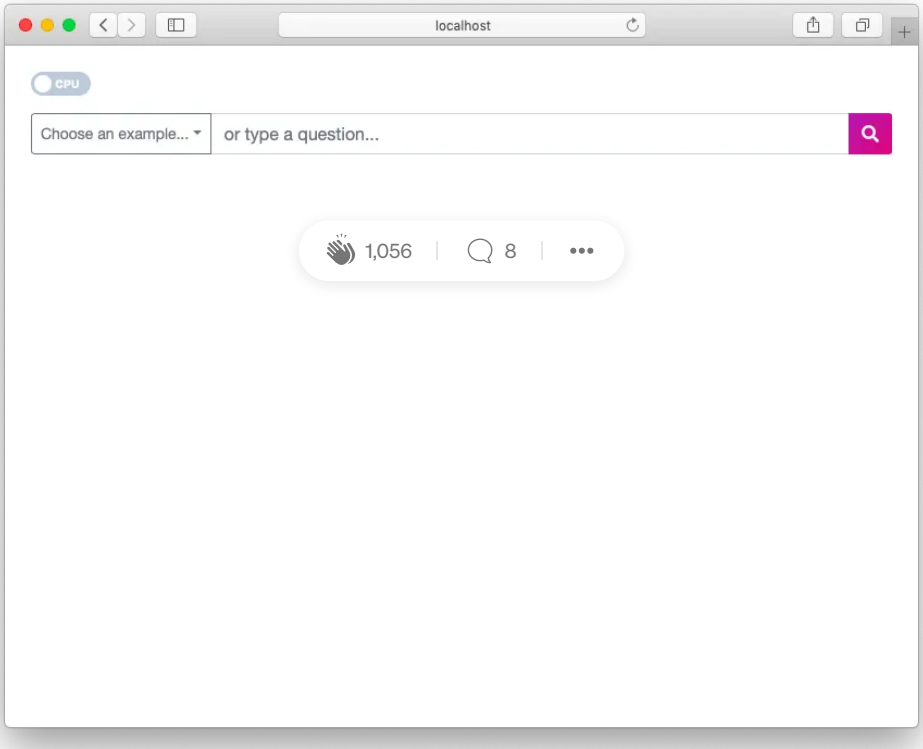
Second, you should proceed to the installation of the cdQA-ui package:

```
git clone https://github.com/cdqa-suite/cdQA-ui &&
cd cdQA-ui &&
npm install
```

Then, you start the develpoment server:

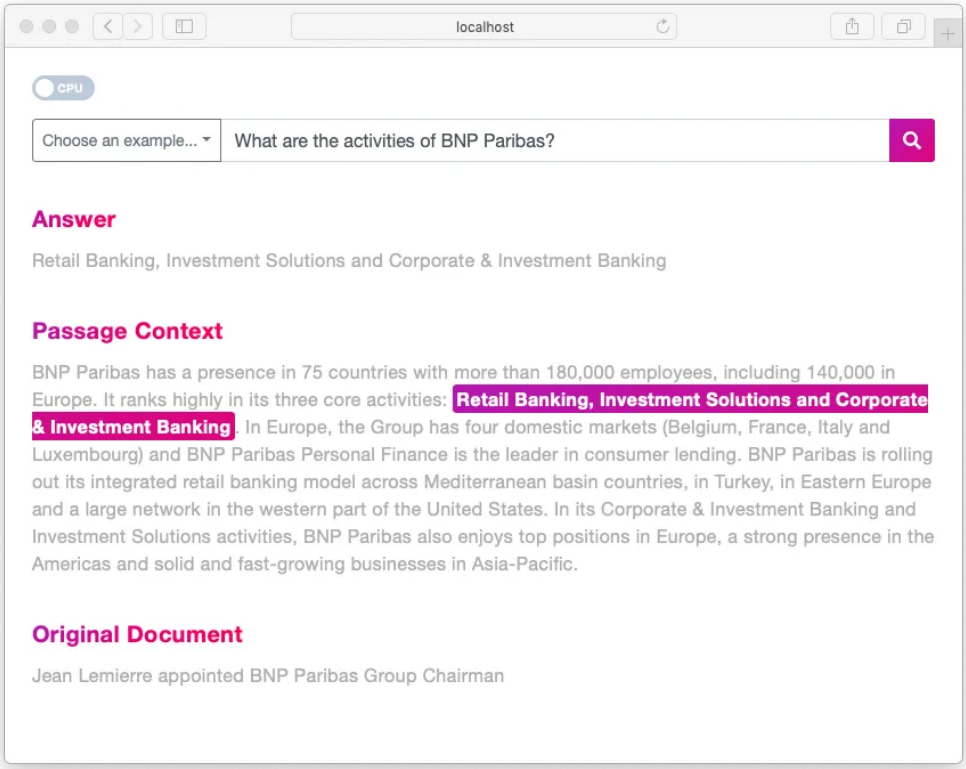
```
npm run serve
```

You can now access the web application on http://localhost:8080/. You will see something like the figure below:



Web application of cdQA-ui

As the application is well connected to the back-end, via the REST API, you can ask a question and the application will display an answer, the passage context where the answer was found and the title of the article:



Demonstration of the web application running

Inserting the interface in a web-site

If you want to couple the interface on your website you just need do the following imports in your Vue app:

```
import Vue from 'vue'
import CdqaUI from 'cdqa-ui'

Vue.use(CdqaUI)
```

```
import Vue from 'vue'
import BootstrapVue from "bootstrap-vue"

Vue.use(BootstrapVue)

import "bootstrap/dist/css/bootstrap.css"
import "bootstrap-vue/dist/bootstrap-vue.css"
```

Then you insert the cdQA interface component:

```
1  <CdqaUI api_endpoint_cpu="http://localhost:5000/api" :queries_examples="['What is Artific
2  </CdqaUI>
```

cdqa-ui.html hosted with ❤ by GitHub view raw

Demo

You can also check out a demo of the application on the official website: https://cdqa-suite.github.io/cdQA-website/#demo

. . .

Conclusion

In this article, I presented `cdQA-suite`, a software suite for the deployment of an end-to-end Closed Domain Question Answering System.

If you are interested in learning more about the project, feel free to check out the official GitHub repository: https://github.com/cdqa-suite. Do not hesitate to star and to follow the repositories if you liked the project and consider it valuable for you and your applications.

We recently released the version 1.0.2 of the `cdQA` package, which is performant and shows very promising results. However, there is still headroom for improvement. If you wish to contribute to the project and help with such improvements, you can take a look at our current issues: https://github.com/cdqa-suite/cdQA/issues. Feel free to choose one and to do a Pull Request :).

Cheers!

Sources:

- cdQA-suite repositories on GitHub: https://github.com/cdqa-suite
- official BERT version from Google: https://github.com/google-research/bert
- Pytorch version of BERT by HuggingFace: https://github.com/huggingface/pytorch-pretrained-BERT
- SQuAD dataset: https://rajpurkar.github.io/SQuAD-explorer/
- DrQA by Facebook Research: https://github.com/facebookresearch/DrQA/
- DeepPavlov, a library that has an Open-Domain QA system: https://medium.com/deeppavlov/open-domain-question-answering-with-deeppavlov-c665d2ee4d65
- OpenAI GPT: https://openai.com/blog/better-language-models/
- ELMo: https://allennlp.org/elmo
- XLNet: https://arxiv.org/abs/1906.08237

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