National College of Ireland

Configuration Manual

MSc Research Project
Data Analytics

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Project Submission Sheet
School of Computing

Student Name:	Rutuja bhujbal
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Programme:	Data Analytics
Year:	2023
Module:	MSc Research Project
Supervisor:	Prof. Teerath Kumar Menghwar
Submission Due Date:	14th December 2023
Project Title:	Configuration Manual
Word Count:	751
Page Count:	11

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Configuration Manual

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1 Introduction

The code used to implement the project "Building a question-answering system to extract information from PDF files using BERT transformers" is described in detail in this file, along with the hardware and software requirements.

2 System configuration

Your second section. Change the header and label to something appropriate.

2.1 Hardware

- Processor: AMD Ryzen 5 5500U with Radeon Graphics 2.10 GHz
- 16.0 GB (15.3 GB usable) ,12.7 GB System RAM on Google Colab
- System type: 64-bit operating system, x64-based processor
- Hard Disk Storage: 100GB (Google Drive Storage)

2.2 Software

- Google Colab), Overleaf, Microsoft Excel, Google Scholar
- Browser Engine: Google Chrome/ Microsoft edge.
- Email: Gmail login to access Google Colab .

3 Project Development

3.1 Project management tool

- Google Drive with 100 GB of storage was used for creating a project environment. Domain-specific PDFs used for analysis were stored in separate folders.
- All notebooks were mounted on Google Drive and saved in the Colab Notebooks folder.

3.2 Installed libraries

Libraries required for implementing question-answering systems were installed at the beginning of each notebook. There are a total of six Colab notebooks. Some of the libraries installed were: transformers, Scikit Learn, PyPDF2, genism, pdf Plumber Devlin et al. (2018) Pearce et al. (2021)

```
!pip install pdfplumber          # Python library for extracting information from PDF
!pip install PyPDF2              #library for reading and manipulating PDF files in Python.
!pip install nltk                #library provides tools for tasks such as tokenization, stemming, lemmatization
!pip install -U gensim           # library for topic modeling and document similarity analysis
!pip install accelerate==0.20.3  #library for GPU acceleration in Python
!pip install transformers -U     #library for working with pre-trained models in transformer-based models

import pdfplumber
import re
import gensim
from gensim.parsing.preprocessing import remove_stopwords
from transformers import pipeline
import torch
from transformers import BertTokenizer
from transformers import BertForQuestionAnswering
from sklearn.metrics import f1_score
from sklearn.metrics import f1_score
import re
import pandas as pd
import nltk
```

Figure 1: Libraries installed in Financial Notebook

4 Design Flow

Perform design guidelines mentioned below such as 1) Data understanding 2) data pre-processing 3) Logic implementation for building question-answering system 4) Evaluation of system on Financial, Biomedical, and scientific PDF Dataset Alsentzer et al. (2019) Beltagy et al. (2019)

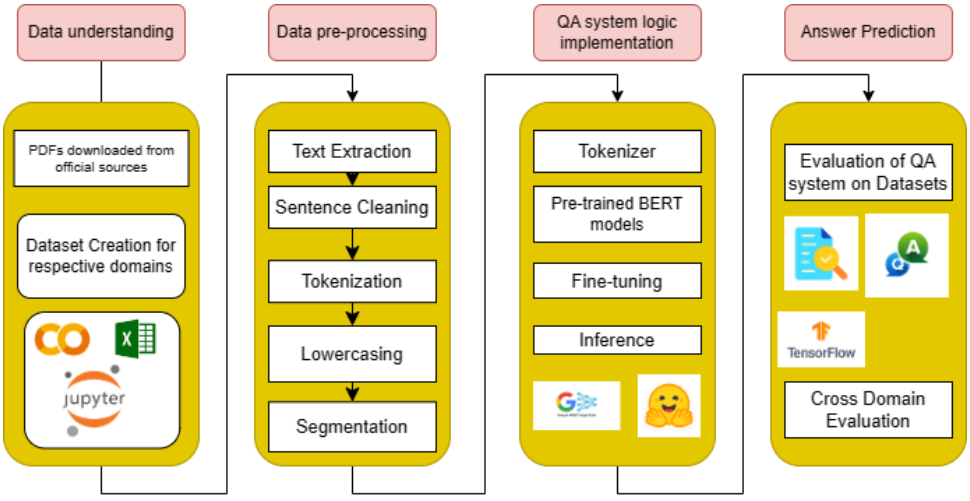


Figure 2: Design flow of building QA system on PDFs

5 Data Collection

PDFs for Financial and Biomedical domains were downloaded from the following sources respectively.

- Amazon's annual reports: Amazon.com Announces Third Quarter Results

- covid Research paper- Biomedical Research COVID-19 Impact Assessment
- For the scientific literature domain research papers used for the literature review of this research were analyzed. Papers were downloaded from Google Scholar.Google Scholar Search

6 Data Pre-processing

This step involves PDF text extraction, text cleaning, tokenization, and segmentation.

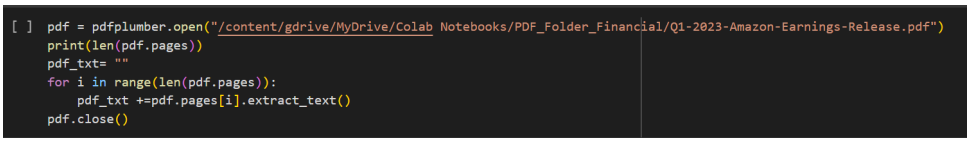


Figure 3: PDF text Extraction

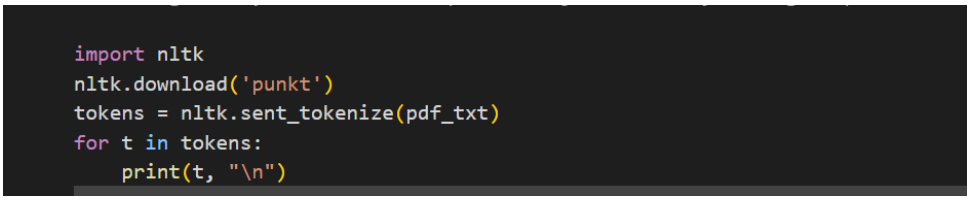


Figure 4: Sentence Tokenization

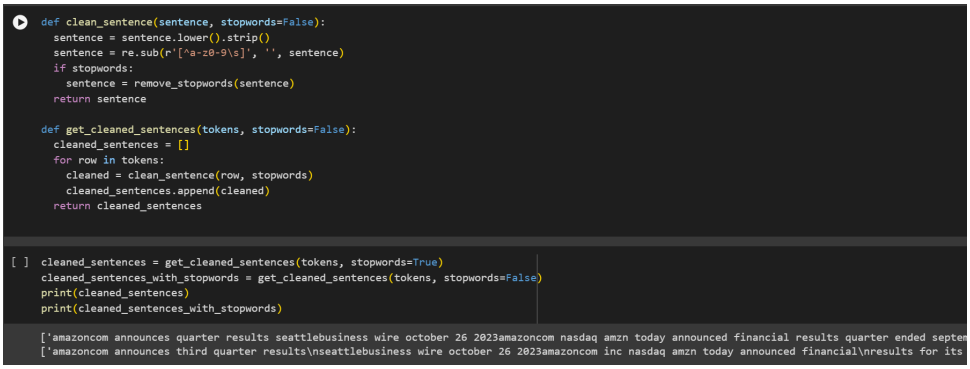


Figure 5: Sentence cleaning

7 Model Implementation Logic

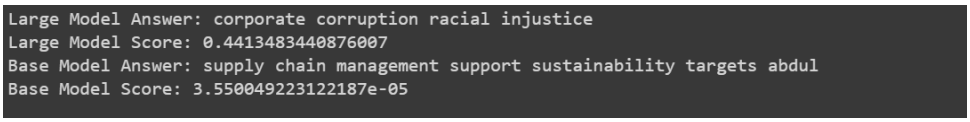
The stepwise model implementation is given below:

7.1 with pipeline library

Implementation of a QA system with a Pipeline library using a pre-trained BERT base and BERT large

```
# Experiment with different models
qa_pipeline_large = pipeline("question-answering", model="bert-large-uncased-whole-word-masking-finetuned-squad")
qa_pipeline_base = pipeline("question-answering", model="bert-base-uncased")

# Assign cleaned sentences to context
context = " ".join(cleaned_sentences)
question = "What is the topic of the document?"

# Get answers from different models
answer_large = qa_pipeline_large(question=question, context=context)
answer_base = qa_pipeline_base(question=question, context=context)

# Print answers and scores
print("Large Model Answer:", answer_large["answer"])
print("Large Model Score:", answer_large["score"])

print("Base Model Answer:", answer_base["answer"])
print("Base Model Score:", answer_base["score"])
```

Figure 6: Implementation of a QA system with a Pipeline



```
Large Model Answer: corporate corruption racial injustice
Large Model Score: 0.4413483440876007
Base Model Answer: supply chain management support sustainability targets abdul
Base Model Score: 3.550049223122187e-05
```

Figure 7: Outputs produced with pipeline library

7.2 with pre-trained BERT function

Implementation of a QA system with a Pipeline library using a pre-trained BERT base and BERT large

```
def answer_question(question, answer_text):
    input_ids = tokenizer.encode(question, answer_text, max_length=512, truncation=True)
    print('Query has {:,} tokens.\n'.format(len(input_ids)))
    sep_index = input_ids.index(tokenizer.sep_token_id)
    num_seg_a = sep_index + 1
    num_seg_b = len(input_ids) - num_seg_a
    segment_ids = [0]*num_seg_a + [1]*num_seg_b
    assert len(segment_ids) == len(input_ids)
    outputs = model(torch.tensor([input_ids]), token_type_ids=torch.tensor([segment_ids]))
    start_index = torch.argmax(outputs.start_logits)
    end_index = torch.argmax(outputs.end_logits)
    all_tokens = tokenizer.convert_ids_to_tokens(input_ids)
    score = float(torch.max(start_index))
    answer_start = torch.argmax(start_index)
    answer_end = torch.argmax(end_index)
    tokens = tokenizer.convert_ids_to_tokens(input_ids)
    answer = tokens[start_index]
    for i in range(start_index + 1, end_index + 1):

        if tokens[i][0:2] == ' ':
            answer += tokens[i][2:]
        else:
            answer += ' ' + tokens[i]
    return answer, score
```

Figure 8: Implementation of a QA system with a BERT large

7.3 With curated Financial dataset

The modified answer_question function is called with the curated dataset to evaluate the F1 score. Refer manual dataset creation step to generate the Financial dataset question-answer pairs.

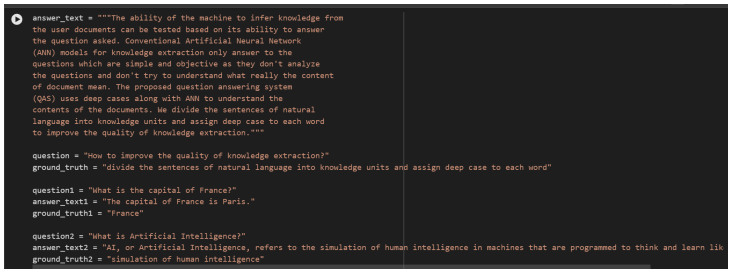


Figure 9: set of of question-answer pairs

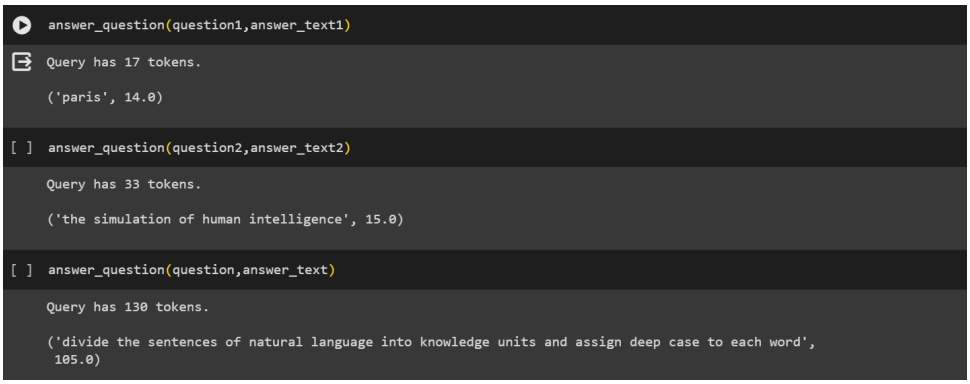


Figure 10: Outputs for set of question-answer pairs

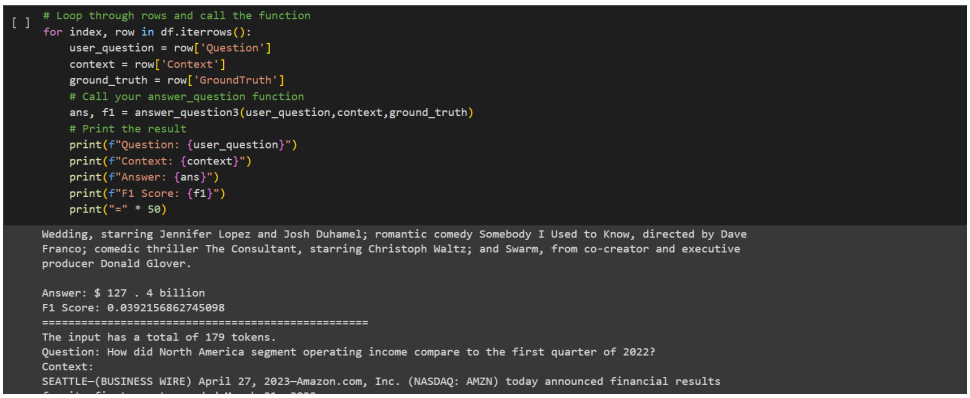
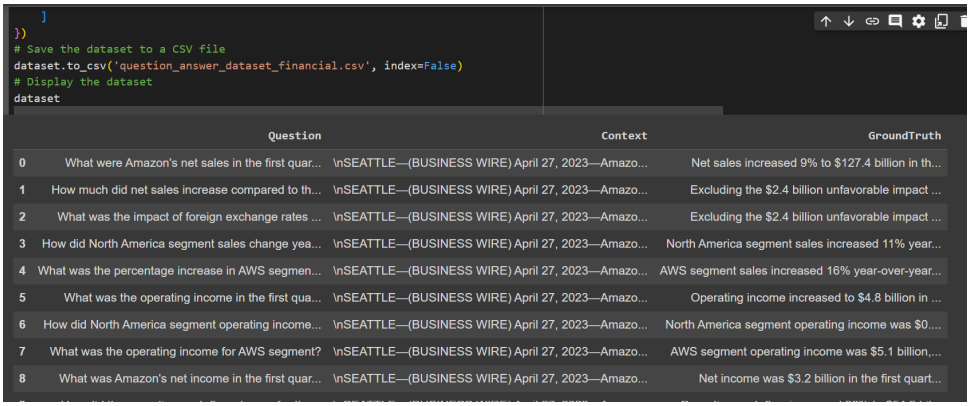


Figure 11: Implementation of QA with curated datset

8 Curated dataset creation

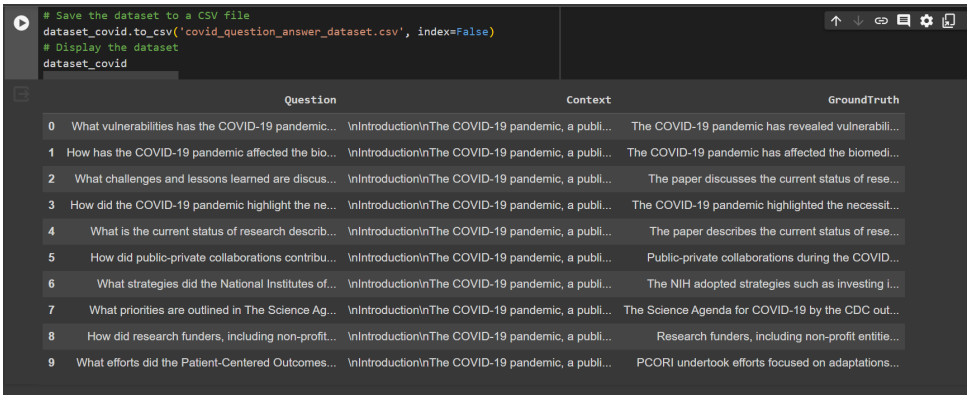
Datasets are created manually for each domain by running the dataset creation notebook.



```
    ]
})
# Save the dataset to a CSV file
dataset.to_csv('question_answer_dataset_financial.csv', index=False)
# Display the dataset
dataset
```

	Question	Context	GroundTruth
0	What were Amazon's net sales in the first quar...	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	Net sales increased 9% to $127.4 billion in th...
1	How much did net sales increase compared to th...	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	Excluding the $2.4 billion unfavorable impact ...
2	What was the impact of foreign exchange rates ...	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	Excluding the $2.4 billion unfavorable impact ...
3	How did North America segment sales change yea...	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	North America segment sales increased 11% year...
4	What was the percentage increase in AWS segmen...	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	AWS segment sales increased 16% year-over-year...
5	What was the operating income in the first qua...	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	Operating income increased to $4.8 billion in ...
6	How did North America segment operating income...	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	North America segment operating income was $0....
7	What was the operating income for AWS segment?	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	AWS segment operating income was $5.1 billion,...
8	What was Amazon's net income in the first quar...	\nSEATTLE—(BUSINESS WIRE) April 27, 2023—Amazo...	Net income was $3.2 billion in the first quart...

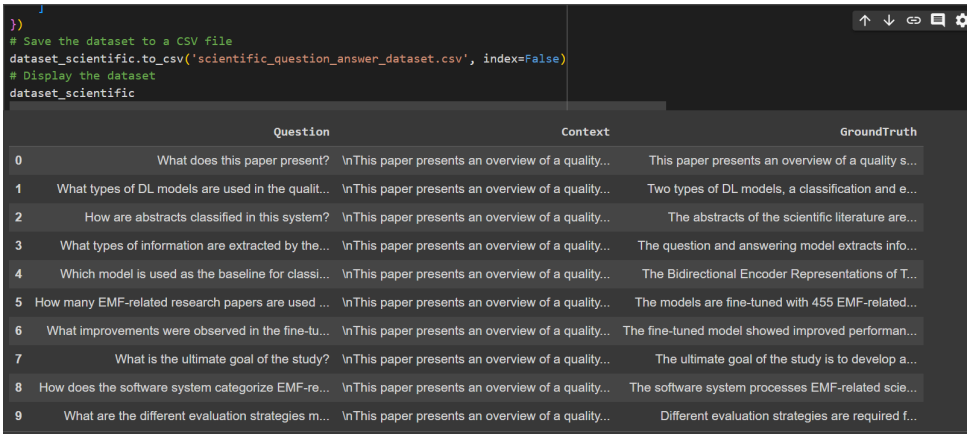
Figure 12: Financial dataset creation



```
# Save the dataset to a CSV file
dataset_covid.to_csv('covid_question_answer_dataset.csv', index=False)
# Display the dataset
dataset_covid
```

	Question	Context	GroundTruth
0	What vulnerabilities has the COVID-19 pandemic...	\nIntroduction\nThe COVID-19 pandemic, a publi...	The COVID-19 pandemic has revealed vulnerabili...
1	How has the COVID-19 pandemic affected the bio...	\nIntroduction\nThe COVID-19 pandemic, a publi...	The COVID-19 pandemic has affected the biomedi...
2	What challenges and lessons learned are discus...	\nIntroduction\nThe COVID-19 pandemic, a publi...	The paper discusses the current status of rese...
3	How did the COVID-19 pandemic highlight the ne...	\nIntroduction\nThe COVID-19 pandemic, a publi...	The COVID-19 pandemic highlighted the necessit...
4	What is the current status of research describ...	\nIntroduction\nThe COVID-19 pandemic, a publi...	The paper describes the current status of rese...
5	How did public-private collaborations contribu...	\nIntroduction\nThe COVID-19 pandemic, a publi...	Public-private collaborations during the COVID...
6	What strategies did the National Institutes of...	\nIntroduction\nThe COVID-19 pandemic, a publi...	The NIH adopted strategies such as investing i...
7	What priorities are outlined in The Science Ag...	\nIntroduction\nThe COVID-19 pandemic, a publi...	The Science Agenda for COVID-19 by the CDC out...
8	How did research funders, including non-profit...	\nIntroduction\nThe COVID-19 pandemic, a publi...	Research funders, including non-profit entitie...
9	What efforts did the Patient-Centered Outcomes...	\nIntroduction\nThe COVID-19 pandemic, a publi...	PCORI undertook efforts focused on adaptations...

Figure 13: Biological dataset creation



```
})
# Save the dataset to a CSV file
dataset_scientific.to_csv('scientific_question_answer_dataset.csv', index=False)
# Display the dataset
dataset_scientific
```

	Question	Context	GroundTruth
0	What does this paper present?	\nThis paper presents an overview of a quality...	This paper presents an overview of a quality s...
1	What types of DL models are used in the qualit...	\nThis paper presents an overview of a quality...	Two types of DL models, a classification and e...
2	How are abstracts classified in this system?	\nThis paper presents an overview of a quality...	The abstracts of the scientific literature are...
3	What types of information are extracted by the...	\nThis paper presents an overview of a quality...	The question and answering model extracts info...
4	Which model is used as the baseline for classi...	\nThis paper presents an overview of a quality...	The Bidirectional Encoder Representations of T...
5	How many EMF-related research papers are used ...	\nThis paper presents an overview of a quality...	The models are fine-tuned with 455 EMF-related...
6	What improvements were observed in the fine-tu...	\nThis paper presents an overview of a quality...	The fine-tuned model showed improved performan...
7	What is the ultimate goal of the study?	\nThis paper presents an overview of a quality...	The ultimate goal of the study is to develop a...
8	How does the software system categorize EMF-re...	\nThis paper presents an overview of a quality...	The software system processes EMF-related scie...
9	What are the different evaluation strategies m...	\nThis paper presents an overview of a quality...	Different evaluation strategies are required f...

Figure 14: Scientific dataset creation

9 Model Fine tuning

This step implements fine-tuning of DistillBERT on the SQAuD dataset where hyper-parameters are set and the model is trained with trainer class. This tuned model is evaluated with a Financial dataset

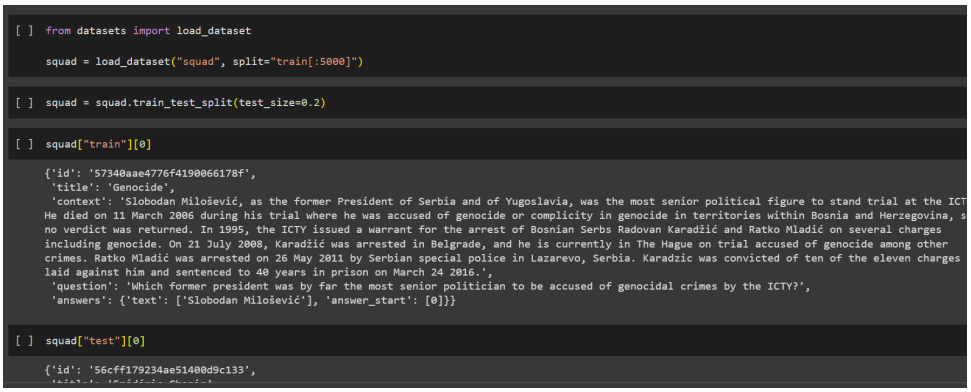


Figure 15: fine tuning with SQAud dataset

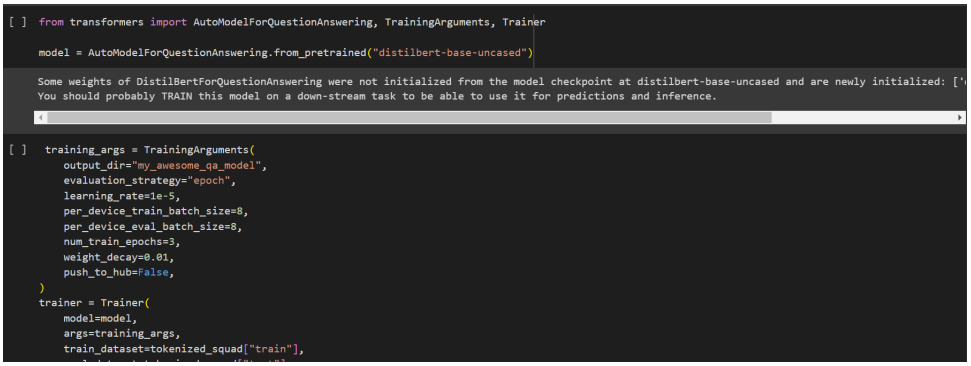


Figure 16: Hyperparameter tuning

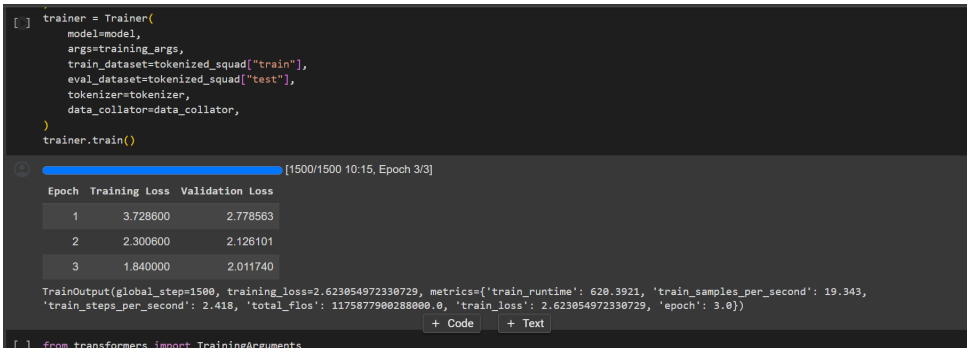


Figure 17: Fine-tuning of DistilBERT calling trainer class

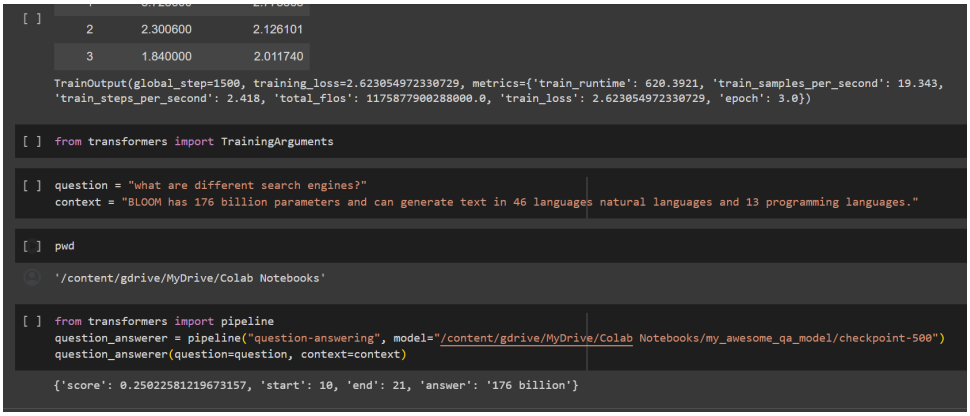


Figure 18: Evaluating financial dataset on fine-tuned model

10 QA system implementation for BioMedical dataset

The BioMedical dataset was implemented using pre-trained bioBERT

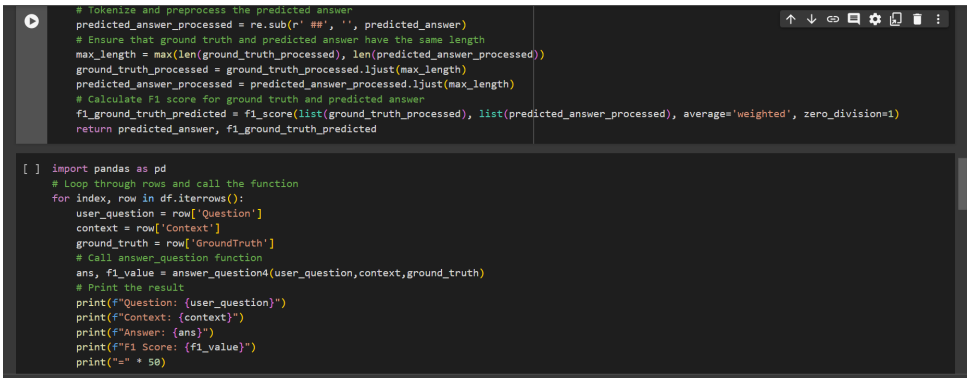


Figure 19: QA system with BioClinical BERT for biomedical dataset

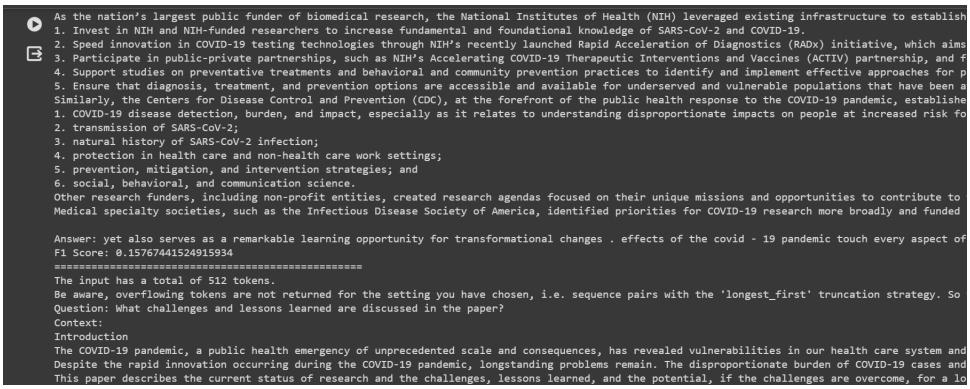


Figure 20: Predicted answers for Bioclinical BERT

11 QA system implementation for Scientific dataset

The Scientific dataset was implemented using pre-trained sciBERT

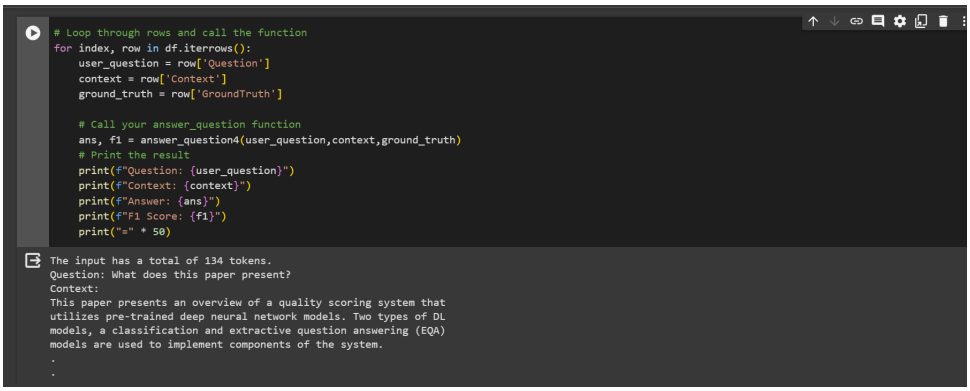


Figure 21: QA system with Scientific BERT for Scientific dataset

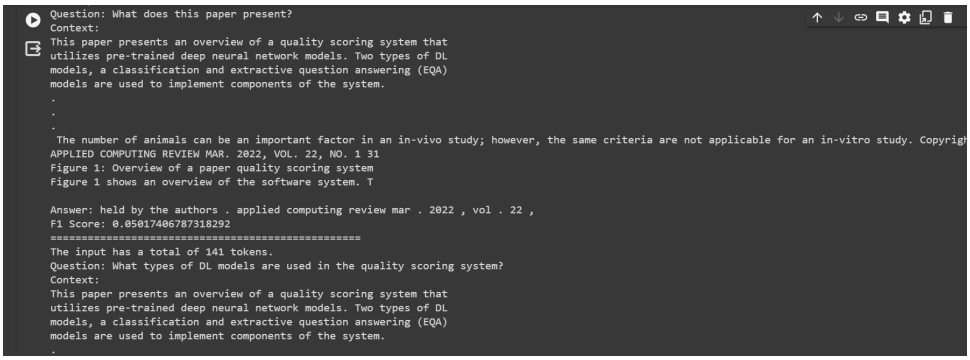


Figure 22: Predicted answers for Scientific BERT

12 Cross domain Evaluation

Biomedical and scientific datasets were evaluated on the BERT large model to check the QA system's generalizability.

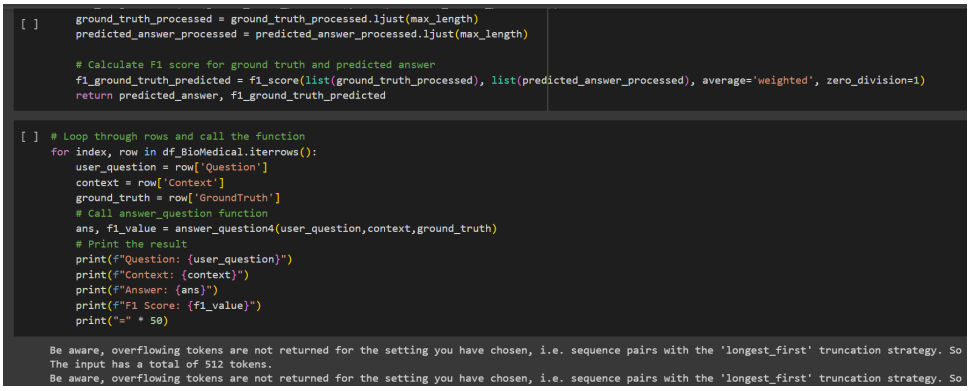


Figure 23: Cross-domain analysis of BiobERT on BERT large

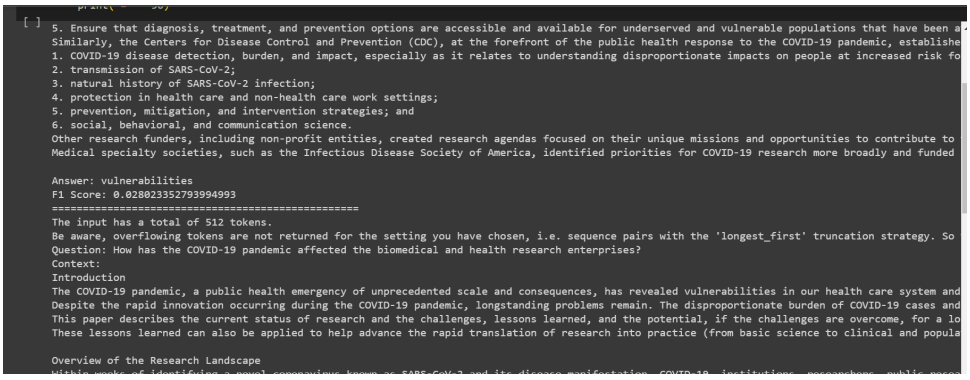


Figure 24: predicted answers for Cross-domain analysis of BiobERT on BERT large

Figure 25: Cross-domain analysis of sciBERT on BERT large

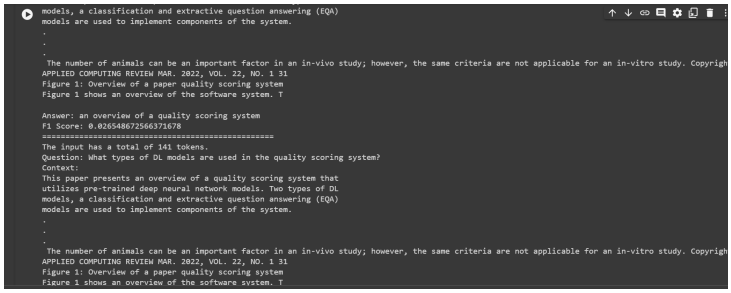


Figure 26: predicted answers for Cross-domain analysis of sciBERT on BERT large

References

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Pearce, K., Zhan, T., Komanduri, A. and Zhan, J. (2021). A comparative study of transformer-based language models on extractive question answering, *arXiv preprint arXiv:2110.03142* .