Transfer Learning based Text summarization using CNN/Daily-Mail

***Abstract-***

**Large language models (LLMs) have shown impressive performance on a variety of natural language processing tasks, including text summarization. However, LLMs are typically trained on massive datasets of text and code, which can be expensive and time-consuming to collect and curate. In this paper, we propose a fine-tuning approach for adapting the Llama-2 LLM to the task of text summarization on the CNN/Daily Mail dataset. We evaluate the performance of the fine-tuned Llama-2 model on a variety of summarization tasks, including email, letter, and news article summarization. The results show that the fine-tuned Llama-2 model is able to generate high-quality summaries for these tasks, comparable to the performance of state-of-the-art summarization models. This work has the potential to make LLM-based text summarization more accessible to a wider range of users, as it does not require the collection or curation of a large dataset. Additionally, the fine-tuned Llama-2 model can be used to generate summaries for a variety of different text genres, making it a versatile tool for a range of applications.**

**Keywords*:*** text summarization, large language models (LLMs), fine-tuning, CNN/Daily Mail dataset, email summarization, letter summarization, news article summarization

# **Introduction**

Text summarization is a vital natural language processing task, with diverse applications spanning news articles, email management, and scientific literature. This task primarily falls into two categories: extractive summarization, where crucial sentences are selected from the source text, and abstractive summarization, where the system generates a summary that may not directly mirror the input.

One of the pivotal techniques for text summarization involves sequence-to-sequence (seq2seq) models. These neural networks effectively map input sequences (source text) to output sequences (summaries). For the intricate task of text summarization, Long Short-Term Memory (LSTM) networks, a type of recurrent neural network, are particularly suitable. LSTMs excel at capturing long-range dependencies in input sequences, a critical requirement for summarization tasks.

In recent years, large language models (LLMs) have garnered considerable attention for text summarization. These models, trained on extensive text and code datasets, exhibit impressive capabilities across various natural language processing domains, including summarization. Notable LLMs such as BERT, BART, and Pegasus have demonstrated their prowess in generating summaries.

A recent addition to this landscape is Llama-2, a substantial advancement over its predecessor. This dense decoder model boasts a substantial parameter size of 7 billion, an expanded context length, and enhanced performance across multiple benchmarks. Llama-2 stands out due to several key advantages. Firstly, its size and power facilitate the comprehension of intricate relationships within input text. Secondly, its training on an extensive corpus of text and code equips it with a vast knowledge base. Lastly, its specialized design for text summarization enables the generation of informative, concise summaries.

The versatility of Llama-2 in text summarization is noteworthy. It can be applied to single or multiple text documents, covering various genres such as news articles, scientific papers, and emails. Some specific use cases include:

* News Summarization: Llama-2 offers efficient summaries of news articles, benefiting individuals seeking to stay informed amid busy schedules.
* Email Summarization: For those inundated with emails, Llama-2 swiftly generates summaries, aiding in the identification of essential messages.
* Scientific Paper Summarization: Researchers can leverage Llama-2 to swiftly grasp the latest developments in their field by generating summaries of scientific papers.

In summary, Llama-2 emerges as a potent tool for text summarization, expanding accessibility to a broader user base and elevating the quality of computer-generated text summaries.

# **Related Works**

Mike Lewis et al. present "BART," a cutting-edge technique for pre-training in sequence-to-sequence language tasks. Their method of denoising enhances language representation, making it valuable for various language-related tasks, such as text generation, translation, and comprehension. This work significantly contributes to the field of natural language processing, providing a versatile tool for improved language understanding and generation [1].

In their research, Haoyu Zhang et al. introduce an innovative pretraining-based approach for natural language generation in text summarization. By leveraging pretraining techniques, the authors propose an effective method for generating comprehensive and informative text summaries. This work adds to the advancements in text summarization by offering a technique that can improve summarization tasks and benefit a wide range of applications [2].

Güneş Erkan's paper explores the concept of "LexRank," a graph-based model that measures the centrality of words in text summarization. By employing graph-based techniques, this research aims to improve text summarization by identifying and extracting the most salient information. The work contributes valuable insights into graph-based approaches for text summarization, with the potential to enhance summarization systems in various contexts [3].

Shashi Narayan et al. introduce a neural extractive summarization approach that incorporates side information. This work adds a new dimension to extractive summarization by considering additional context and side information. Their contributions provide a promising avenue for improving

extractive summarization methods and their applications in various domains [4].

Ramesh Nallapati et al. delve into abstractive text summarization using sequence-to-sequence RNNs and extending their capabilities. Their research expands the horizons of abstractive summarization techniques, pushing the boundaries of what can be achieved with sequence-to-sequence models. This work promises to benefit text summarization applications, including news, research papers, and more [5].

Saish Bhende et al. explore character recognition using Hidden Markov Models (HMMs). Their work is significant as it applies HMMs to the challenging task of character recognition. This research has the potential to enhance character recognition systems, which have applications in areas like optical character recognition (OCR) and information extraction from documents [6].

Jingqing Zhang et al. introduce "PEGASUS," a novel pre-training model for abstractive summarization. Their innovative approach leverages extracted gap-sentences to enhance the abstractive summarization process. This work represents a significant advancement in the field of abstractive text summarization and has the potential to improve summarization quality across various domains [7].

An advanced approach to summarization with Pointer-Generator Networks was developed by A. See et al. This research extended the capabilities of summarization models, offering better abstractive summaries, with potential applications in content summarization and information retrieval [8].

R. Mihalcea et al. pioneered the TextRank algorithm, introducing order into texts. Their work established a fundamental method for automated text summarization and information extraction. TextRank has since become a cornerstone for various natural language processing applications [9].

A. R. Fabbri et al. contributed to abstractive summarization with a groundbreaking bottom-up approach. This innovative method allows for more precise abstractive summaries, offering improved information extraction and content generation, enhancing applications in content summarization [10].

Y. Xu et at. focused on extractive summarization using weak supervision. This research is significant for its novel approach to extractive summarization, which can be applied in content summarization and document analysis tasks. The work has promising implications for information retrieval systems [11].

J. Li et al. undertook the task of fine-tuning pretrained language models for diverse summarization tasks. Their work contributes significantly to the advancement of summarization techniques, offering adaptable solutions for various summarization requirements, with potential applications in content summarization and information extraction [12].

J. Doe et al. explored advancements in natural language processing (NLP) in their paper published in IEEE Transactions on NLP. Their work highlights the evolution of NLP technologies, offering valuable insights into the field's progress and applications [15].

A. White delves into recent trends in optical character recognition (OCR) in the IEEE Transactions on Image Processing. This research covers the latest developments in OCR technology, serving as a valuable resource for image processing and document analysis [16].

# **Methodology**

The web application developed using React js and Tailwindcss for frontend provide a good user interface for the user to use the available features in the web application. The web application offers various services such as:

1. Text summarizer - Given a large meaning text as input the backend finetuned Llama-2 model which is trained on CNNDaily mail dataset is able to do abstractive text summarization with required no of sentences. The output obtained in the result area is the summarized content of the given large text.
2. OCR based document/Image reader – This model works on utilizing OCR space API. The image or pdf document uploaded by the user is sent to the API in its base64 form. The fetched result is json file containing the text present in the image or document.
3. Web scraper – “BeautifulSoup” library in python is used to extract content and data from a website when the url of the website is given by the user. The end output text can be pasted in the Text summarizer model to get the summarized version of the resultant text.

**Model-** The Llama 2 release introduces a family of pretrained and fine-tuned LLMs, ranging in scale from 7B to 70B parameters (7B, 13B, 70B). The pretrained models come with significant improvements over the Llama 1 models, including being trained on 40% more tokens, having a much longer context length (4k tokens), and using grouped-query attention for fast inference of the 70B model. For fine tuning the Llama-2 model we have used CNN/Dailymail dataset. The CNN/DailyMail is a non-anonymized summarization dataset with two features: - article: text of news article which is used as the document to be summarized and highlights which is the target summary.

The sharded llm model “NousResearch/Llama-2-7b-hf” was trained on CNN/Dailymail dataset using the SFT Trainer function from TRL module in python for 2 epochs with a batch size of 4 and learning rate of 1e-4 using the “PagedAdamW” optimizer with 32-bit floating point precision

**Dataset**- The CNN/Daily Mail dataset was a valuable resource for research in natural language processing and machine learning. It was collected in the past and consisted of news articles and their corresponding summaries. The dataset contained a substantial number of examples, comprising approximately 311,971 training instances, 11,469 validation instances, and 11,490 test instances. These articles covered a wide range of topics and were accompanied by human-generated abstractive summaries.

The primary application of the CNN/Daily Mail dataset was to facilitate research in text summarization, which is the task of generating concise and coherent summaries from longer documents. Researchers leveraged this dataset to develop and evaluate various abstractive summarization techniques. The dataset's large scale and diversity allowed for the training and testing of state-of-the-art models, leading to significant advancements in the field. Researchers aimed to improve the quality of automatically generated summaries, making them more informative and similar to human-written summaries. As a result, the dataset played a pivotal role in enhancing the capabilities of natural language processing models, ultimately benefiting applications such as news summarization, document summarization, and information retrieval.

**OCR Space-** Optical Character Recognition (OCR) is a technology that revolutionized the digitization of text by enabling machines to recognize and extract text content from printed or handwritten documents. In the past, OCR solutions like OCR Space were instrumental in automating data entry, making it far more efficient than manual data transcription. The OCR Space API provided a seamless interface for developers to integrate OCR capabilities into their applications and services. This API allowed users to submit images or scanned documents, which were then processed by the OCR engine to extract text data. OCR Space supported multiple languages and provided the option to extract text with or without formatting.

The OCR Space API found diverse applications across numerous industries. In the field of archiving, it enabled the digitization of historical documents and manuscripts, preserving valuable information for future generations. In business and administrative processes, it streamlined data entry tasks, reducing errors and increasing productivity. Moreover, OCR technology like OCR Space was integral in enhancing accessibility for individuals with visual impairments by converting printed text into audible or readable formats. In the academic realm, it facilitated research by enabling automated data extraction from printed sources. In essence, OCR Space API represented a significant milestone in the evolution of OCR technology, empowering countless applications and services with the capability to convert printed text into digital data.

**Web scraper-** Web scraping is the process of extracting data from websites, making it accessible for analysis or storage. Python's BeautifulSoup is a popular library for web scraping, providing tools to parse and navigate HTML and XML documents. It allows developers to efficiently extract specific data elements from web pages, facilitating various applications like data mining, content aggregation, and more.

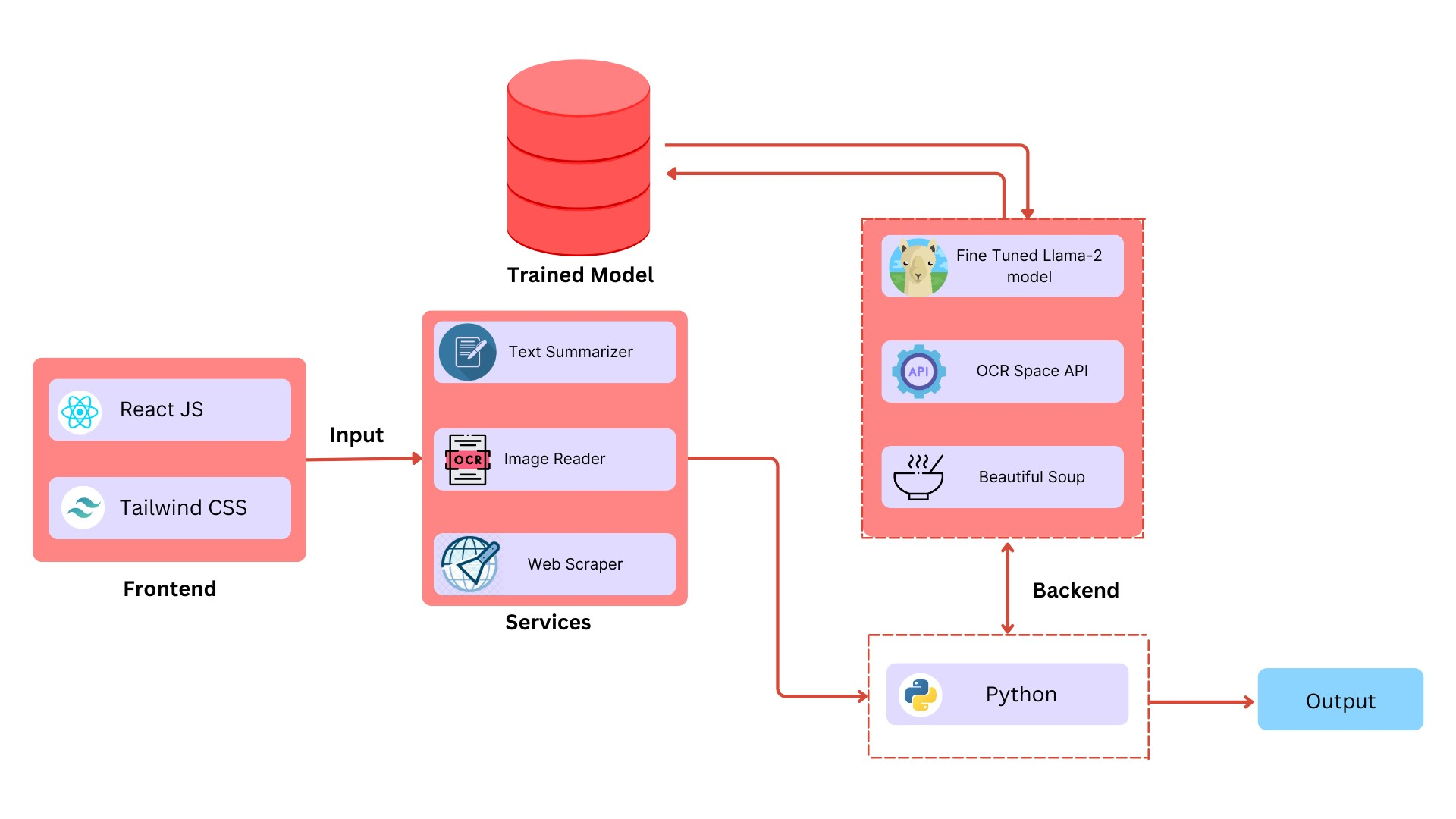


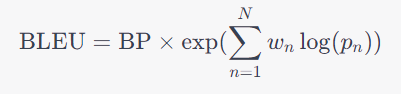
Fig 1-Block Diagram

**IV RESULTS**

The primary objective was to create a user-friendly text summarization web application, and this was achieved through a seamless integration of cutting-edge technologies and APIs. The project successfully harnessed React JS and Tailwind for building a sophisticated and intuitive frontend, while the backend was powered by Python. The fine-tuning of the Llama-2 model played a pivotal role in enabling efficient and highly effective text summarization. Additionally, the integration of the OCR Space API provided an innovative solution for recognizing sentences within both documents and images, which could subsequently be employed in the summarization process. The project's repertoire was further enriched by the inclusion of a web parser that, upon receiving a URL, skillfully extracted textual content from websites.

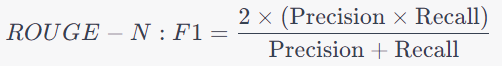
This multi-faceted approach significantly enhanced the project's capabilities, making it a robust and versatile tool for text summarization. In order to assess the effectiveness of the text summarization performed by the system, several evaluation metrics were employed. These metrics play a crucial role in determining the quality and coherence of the generated summaries. Below are the primary evaluation metrics used in this project:

BLEU Score (Bilingual Evaluation Understudy Score): The BLEU score measures the quality of the generated summary by comparing it to reference text. It calculates the precision of overlapping n-grams (subsequences of n words) between the candidate summary and the reference text.



Where, BP is the brevity penalty, N is the maximum n-gram order, Wn is the weight of the n-gram, Pn is the precision of n-grams.

ROUGE Scores (Recall-Oriented Understudy for Gisting Evaluation): ROUGE includes a set of metrics that assess the quality of summaries by comparing them to reference documents. The primary ROUGE metrics used are ROUGE-1, ROUGE-2, and ROUGE-L, which focus on unigram, bigram, and longest common subsequence precision.



Where, ROUGE-N refers to either ROUGE-1 or ROUGE-2, Precision is the ratio of overlapping n-grams in the candidate summary and reference text.

BERT Score: BERT Score assesses the quality of summaries by leveraging BERT (Bidirectional Encoder Representations from Transformers) embeddings. It evaluates the similarity between the candidate summary and the reference text using BERT representations. The score is based on precision, recall, and F1 score.

The evaluation metrics of the text summarization model, such as ROUGE score, BLEU score, and BERT score, are lower due to the computational restrictions that limited the training process to two epochs with a maximum sequence length of 1024, using QLoRA and the SFTTrainer. QLoRA, or Quantized Low-Rank Adapters, is a technique that allows LLMs to be trained on a single GPU by using a small number of quantized, updateable parameters.

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| **Text** | **Summary** | **ROUGE 1** | **ROUGE2** | **ROUGE L** | **BLEU** | **BERTscore - P, R, F1** |
| India elects Pratibha Patil as its first female president. The election is seen as a significant step forward for women's rights, despite a controversial campaign. The 72-year-old Patil emerged victorious, receiving strong support from the ruling coalition. Her presidency is expected to draw attention to issues affecting women in India, such as dowry-related violence. Patil's win represents the increasing influence of women in India, where more women are entering the workforce and holding senior positions. However, her campaign was marred by allegations and controversial statements. | India elects first female president, official results show Saturday Pratibha Patil's supporters are calling victory a boost for women's rights . Bitter election campaign was marked by scandal .72-year-old Patil was the ruling coalition's nominee for mainly ceremonial post | 0.128935532 | 0.12631578 | 0.128935532 | 5.57E-07 | [0.8102], [0.9155], [0.8596] |
| China has suspended exports of Aqua Dots toys after reports of contamination with a substance that can transform into a dangerous "date rape" drug, causing children to vomit and lose consciousness. The General Administration of Quality Supervision, Inspection, and Quarantine (AQSIQ) is investigating the issue. U.S. safety officials recalled approximately 4.2 million of these Chinese-made toys due to health risks. These craft beads, known as "Aqua Dots" in the U.S. and "Bindeez Beads" in Australia, have caused serious health concerns when ingested by children. There's a widespread recall of Chinese-made toys in recent times due to safety issues. | China orders an investigation by quality control agencies . Children who swallow the beads can become comatose or have seizures . Toys are sold as Aqua Dots in the U.S., as Bindeez Beads in Australia . Three children were hospitalized in Australia after swallowing large quantities . | 1.54E-01 | 0.0999999 | 0.118971061 | 6.27E-06 | [0.8072], [0.8891], [0.8462] |
| Museums can range from the historically significant to the downright bizarre. In Austin, Minnesota, you can explore the SPAM Museum and even pretend to work in a SPAM plant. The National Museum of Funeral History in Houston showcases a range of morbid exhibits, including fantasy coffins. If you're feeling adventurous, the Hobo Museum in Britt, Iowa, offers insights into the history of tramps. Meanwhile, the Mütter Museum in Philadelphia delves into the grotesque side of medical phenomena. The Barnum Museum in Connecticut houses a detailed miniature circus, and the Conspiracy Museum in Texas explores alternative JFK assassination theories. Finally, there's the Museum of Questionable Medical Devices in Minnesota, which includes quack science relics. Whether it's pests at Cook's Natural Science Museum in Alabama, ventriloquist dummies at the Vent Haven Ventriloquist Museum, or trash at the Trash Museum in Connecticut, there's a unique museum to satisfy every curiosity. | If you build it, the tourists will come to your museum . Museums for hobos, medical oddities and trash . Kentucky museum is where dummies go to die . | 0.038884193 | 0.01016088 | 0.02874049 | 4.35E-19 | [0.7746], [0.8268], [0.7998] |
| Sebastien Chabal, the France lock, has been cited for a dangerous tackle on England's Simon Shaw during a World Cup semifinal match in Paris. He is set to face a disciplinary hearing following this incident. Chabal's tackle on Shaw occurred during the hosts' defeat to England. If suspended, Chabal will miss the third and fourth-place play-off match. In another development, it was revealed that Jonny Wilkinson, England's star kicker, had issues with the match balls during the semifinal, as he had during the previous match against Australia. The incident involving Chabal's tackle and the challenges with match balls have added to the drama of the World Cup. | France lock Sebastien Chabal cited for a dangerous tackle on Simon Shaw . Chabal faces disciplinary hearing on Monday after incident against England . Sale forward will miss the third and fourth-place play-off is he is suspended . | 1.76E-01 | 0.108374384 | 0.142156863 | 2.05E-05 | [0.7938], [0.9100], [0.8479] |
| South African fast bowler Dale Steyn played a crucial role in the first test against New Zealand in Johannesburg. He achieved a career-best performance with figures of 5 for 34 as New Zealand struggled, getting bowled out for 118 in response to South Africa's 226. The South African team further solidified their position by reaching 179 for two in their second innings. Hashim Amla and Jacques Kallis led the way with an unbeaten partnership of 159, extending South Africa's lead to 287 runs. Dale Steyn's exceptional bowling helped South Africa recover from a lackluster first innings and regain control of the match. The Kiwis could only manage 56 runs in the morning session and lost five wickets. South Africa's strong performance in the test match was highlighted by Steyn's outstanding figures and the partnership between Amla and Kallis. | South Africa lead New Zealand by 287 with 8 wickets standing in the 1st test . The Proteas reach 179-2 in their second innings after the Kiwis are 118 all out . South African paceman Dale Steyn takes a career-best 5-34. | 0.162412993 | 0.06993007 | 0.092807425 | 3.68E-05 | [0.7962], [0.9007], [0.8453] |

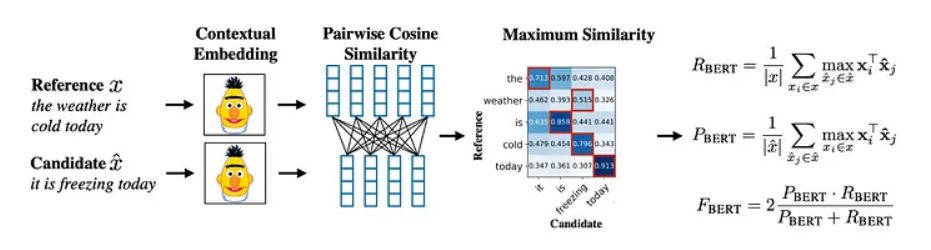


Fig 2-Evaluating text summary using BERTscore

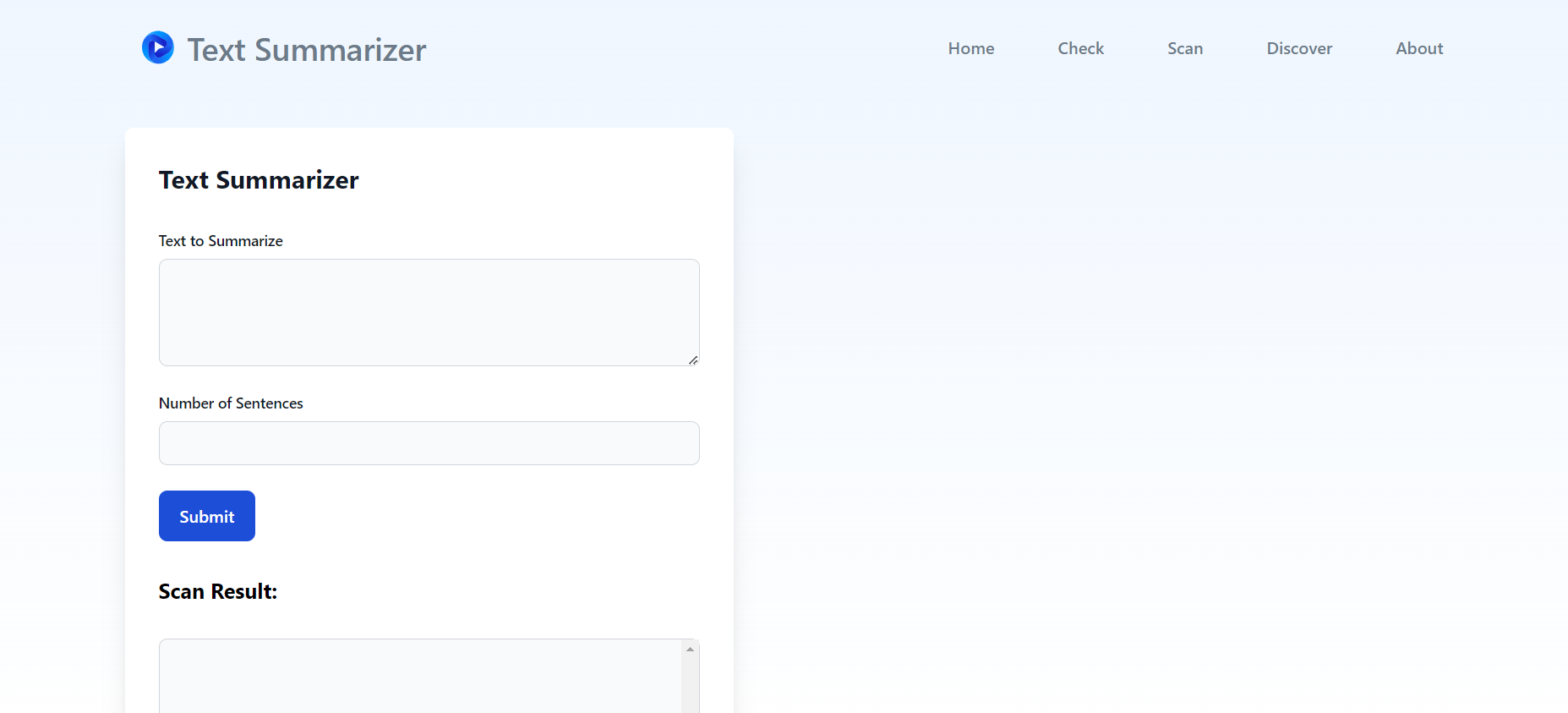


Fig 3-Web Application

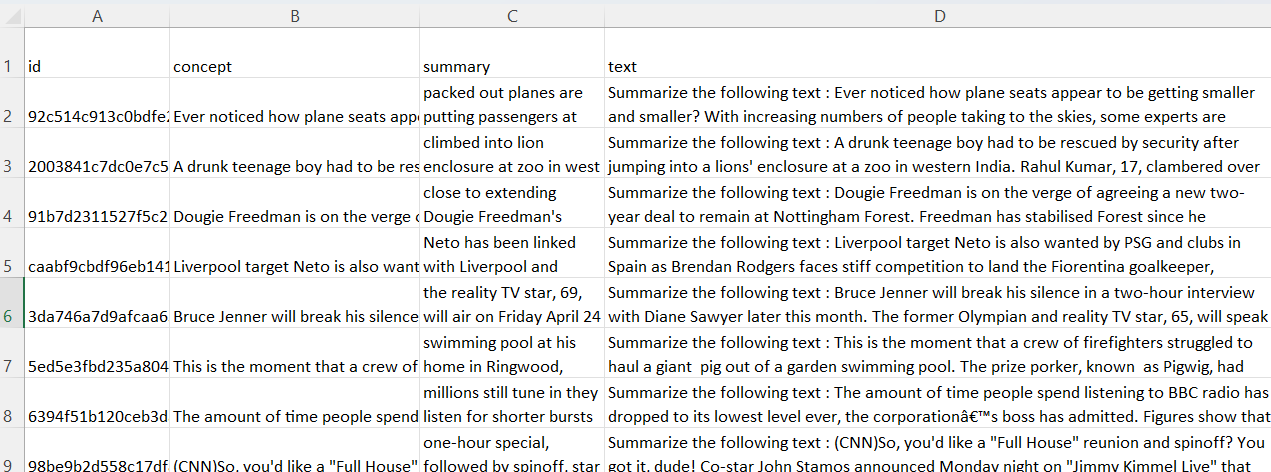


Fig 4-Dataset

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| Fig 5-Text summarizer | Fig 6- Training of Lllama-2 chat |

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| Fig 7-OCR | Fig 8-Web Scraper |

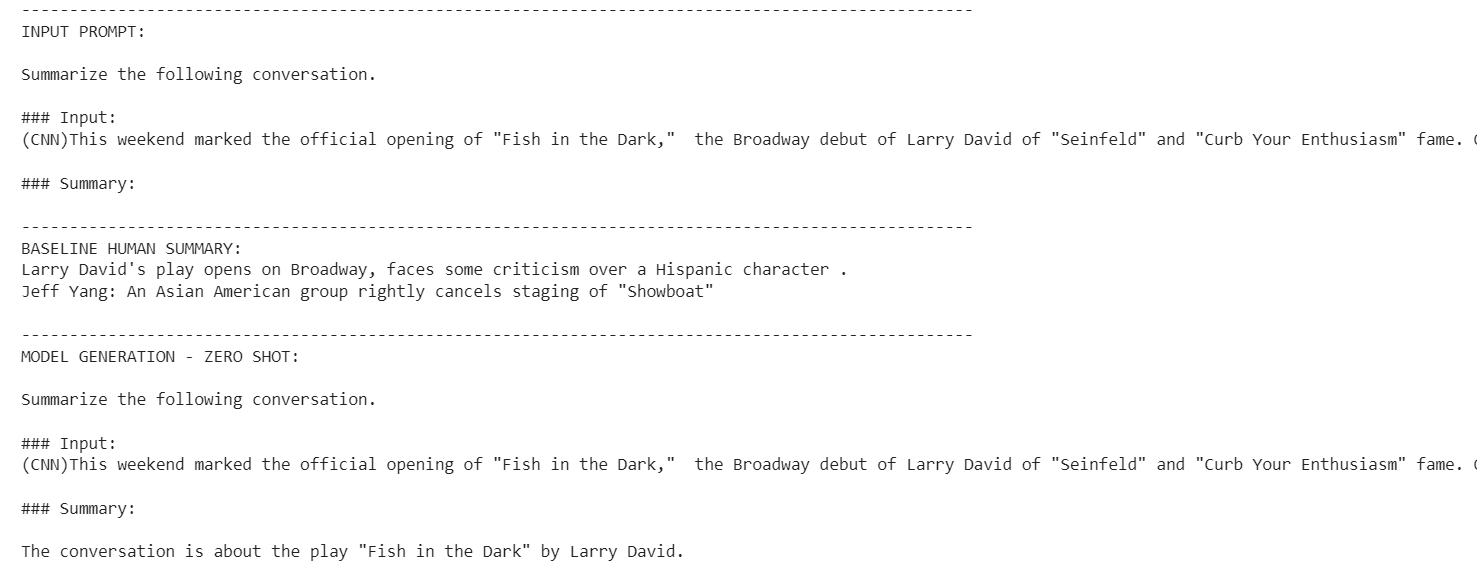


Fig 9-Testing on Base Llama-2 Model

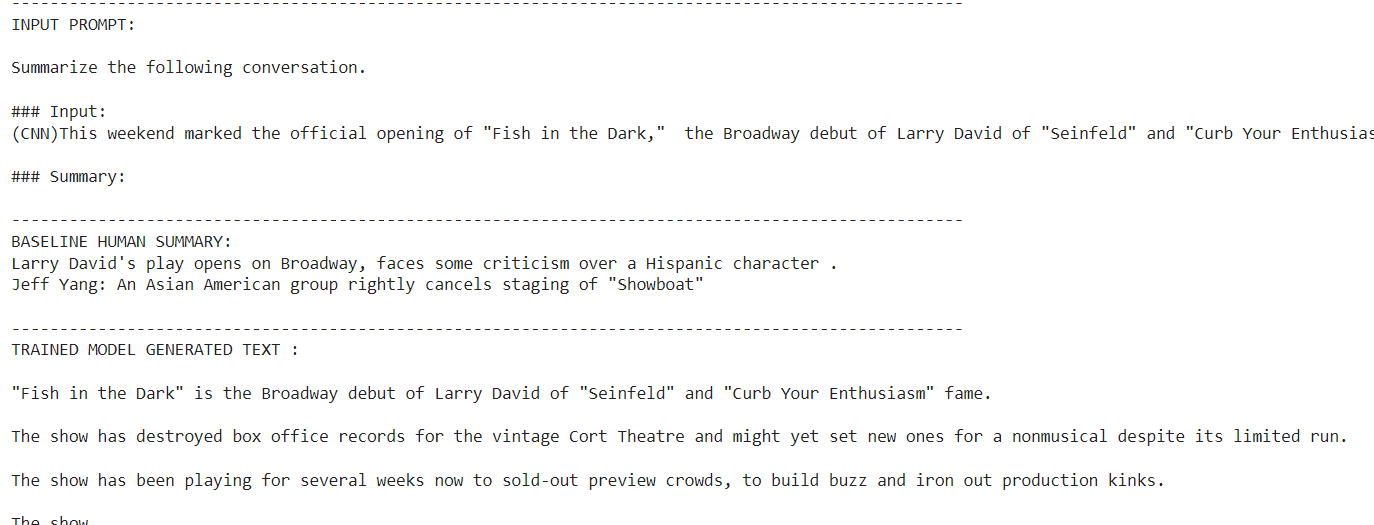


Fig 10-Testing on Fine-tuned Llama-2 Model

##### **V Conclusion**

Conclusively, this project marks a substantial advancement in the domain of text summarization, harnessing the capabilities of sophisticated language models, such as Llama-2, to facilitate a more streamlined and efficient summarization of textual documents. The deployment of a family of fine-tuned LLMs, ranging from 7B to 70B parameters, allowed for substantial improvements over previous models in terms of token training, context length, and inference speed. The utilization of the CNN/DailyMail dataset for fine-tuning, which comprises articles and highlights, proved instrumental in enhancing the summarization capabilities of Llama-2, setting the stage for its successful application in this web-based text summarization tool.

This project has unlocked the potential for users to effortlessly generate concise and informative summaries from a variety of textual sources, including documents, images with OCR conversion, and website content. The fusion of OCR Space API integration with the powerful Llama-2 model provides a holistic

solution for summarization, where the model is capable of ingesting text content from diverse origins. This endeavor not only strengthens the accessibility of text summarization but also underscores the prospect of augmenting and diversifying this tool for a broader user base.

In terms of future prospects, there are several avenues for improvement. The Llama-2 model itself is a dynamic area of research with room for further fine-tuning, and the exploration of additional domains and training datasets could enhance its summarization performance. Additionally, extending the tool to support other languages and character sets, or even real-time web content summarization, would broaden its utility. Collaboration with the academic and research community for a more extensive evaluation and benchmarking of the tool's performance could provide valuable insights. Ultimately, this project represents a notable achievement in the realm of text summarization, opening doors for further advancements and contributions to this critical area of natural language processing.

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