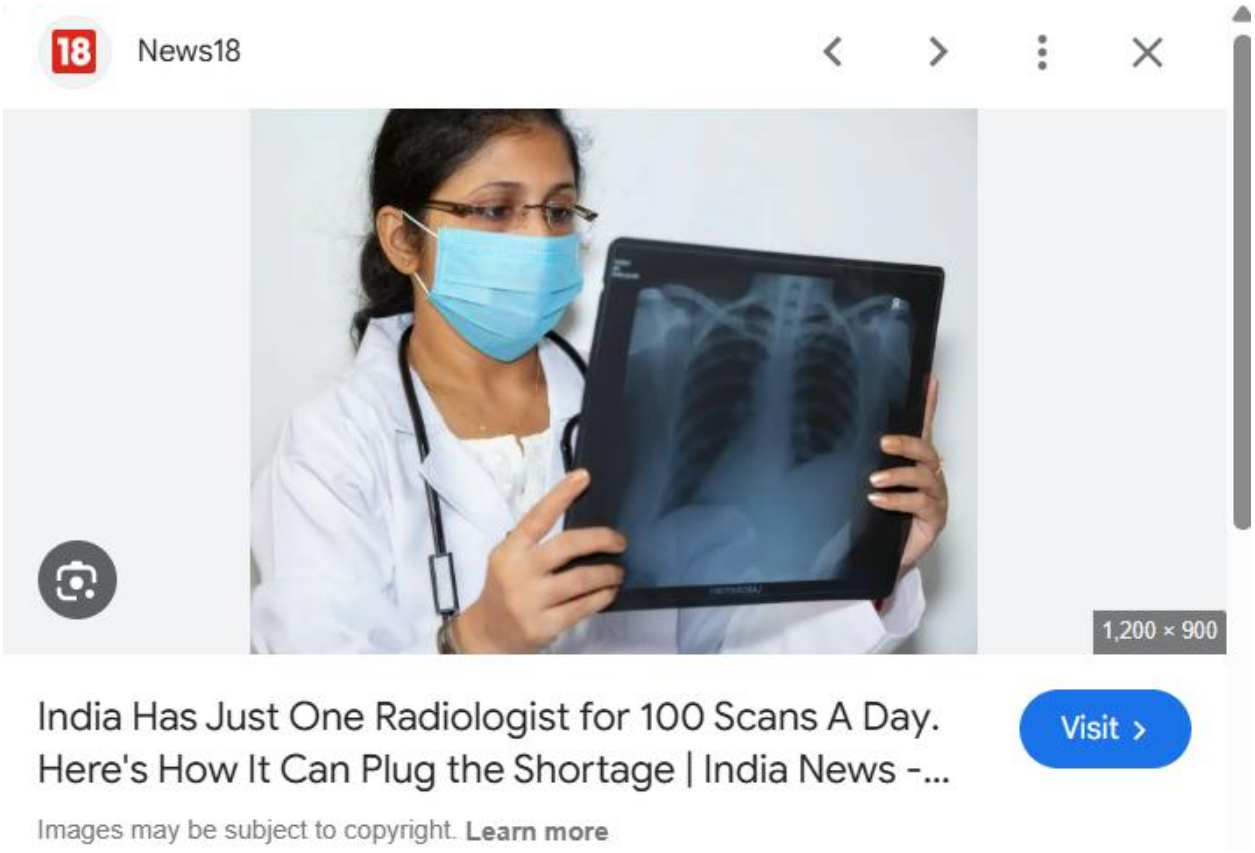
Marwadi University Marwadi Chandarana Group NAAC A+	**Marwadi University** **Faculty of Engineering and Technology** **Department of Information and Communication Technology**	
Subject: Capstone Project (01CT0715)	**System Design And Architecture**	
System Design	**Date: 25/09/2025**	**Enrolment No: 92200133018**

MRI Impression Generation

Introduction

The project focuses on developing an assistive tool that supports doctors as well as radiologists in generating consistent and time-efficient MRI impressions. The system is not meant to replace medical expertise but to act as a supportive layer that reduces repetitive work and ensures accuracy.



Designing such a system requires a modular approach, a carefully selected technology stack, and planning for scalability, so that it can handle large volumes of medical data and adapt to different healthcare settings.

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India Has Just One Radiologist for 100 Scans A Day. Here's How It Can Plug the Shortage

Reported By : Himani Chandna News18.com | Edited By: Apoorva Misra

Last Updated: October 17, 2023, 13:57 IST

With just approximately 20,000 radiologists serving a population of over 1.4 billion, India is confronted with an alarming ratio of one radiologist for every 1,00,000 individuals, far below global healthcare standards

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The shortage of radiologists is exacerbated by the continued increase in both the volume of scans conducted and the number of images per scan. (Shutterstock Image for Representation)

Are you frequently caught in lengthy lin
your ultrasound, MRI, or CT scans? The
time for receiving the comprehensive re
can be quite extensive as well.

You can lay the blame at the scarcity of
radiologists throughout India — a phen
that can be ascribed to multiple factors, ranging from a shortage of training facilities to limited medical seats, increased attrition rates, heavy workloads, burnout and more.

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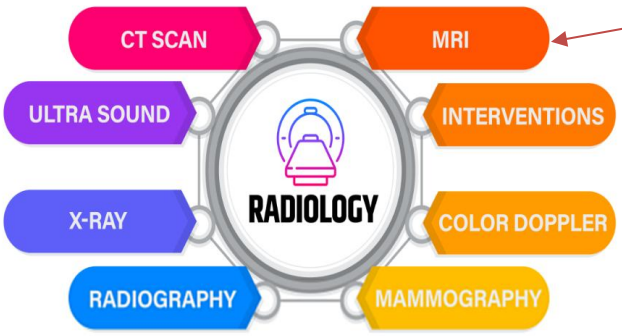

We are working MRI domain

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Modular Design

The assistive tool is organized into several functional modules, each handling a specific part of the workflow. This modularity makes the system easier to maintain, extend, and adapt to different use cases in medical reporting.

1. Input Module (Text / PDF)
    - Users can either paste MRI findings as plain text or upload a PDF report.
    - If a PDF is uploaded, the system extracts the relevant “Findings” section using preprocessing scripts that is unstructured library used for it.
2. Settings & Configuration Module
    - Provides options in the sidebar for adjusting generation parameters such as beam size, minimum impression length, and maximum impression length.
    - This allows radiologists to control the level of detail in the impressions.
3. AI Processing Module
    - The fine-tuned BioBART model generates a draft impression from the findings.
    - The system internally evaluates the draft quality before further refinement.
4. Refinement Module (GPT-Based)
    - GPT takes the draft impression and the original findings as input.
    - It enhances clarity, ensures all significant details are included, and outputs a structured, numbered final impression.
5. Output & Export Module
    - Displays the raw impression (BioBART output) and the enhanced impression (GPT output) in separate tabs.
    - Provides an option to download the final enhanced impression as a text file for record-keeping.

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System Architecture & Workflow

The overall architecture of the proposed system is designed to ensure smooth data flow from input to output, with well-defined processing stages. The workflow can be divided into the following steps:

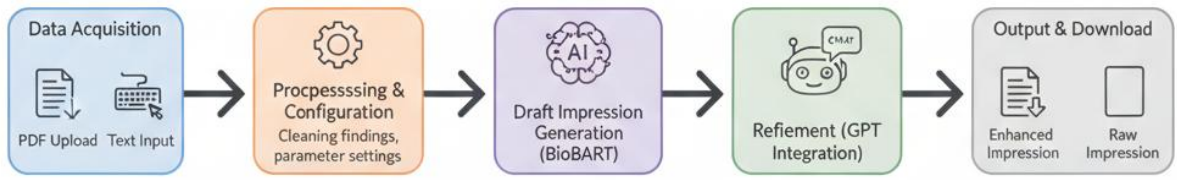
1. **Data Acquisition** :Input can be provided in two ways:
    - **Text Input**: Radiologist pastes MRI findings directly into the interface.
    - **PDF Upload**: A report file is uploaded, and the system extracts relevant content.
2. **Preprocessing & Configuration**
    - Extracted findings are cleaned and formatted.
    - Users can adjust impression generation parameters (beam size, min/max length) through the sidebar.
3. **Draft Impression Generation (BioBART)**
    - The findings are passed to the fine tuned BioBART-based model.
    - The model generates a **draft impression** summarizing the key points.
4. **Refinement (GPT Integration)**
    - GPT model takes the draft impression and original findings.
    - Performs refinement:
    1. Ensures completeness of critical details.
    2. Improves clarity, readability, and professional tone.
    3. Outputs a structured, numbered **enhanced impression**.
5. **Output & Download:** Results are displayed in two tabs:
    - **Raw Impression (BioBART)**
    - **Enhanced Impression (GPT)**
        - Users can download the enhanced impression as a .txt file for clinical or record-keeping purposes.

And so this relates with Ict domain : as we get the information **and then fine tune on llm , biobart encoder decoder , understand the medical terminology** then carefully **extract the**

mri data and fine tune it to solve with the help **of nlp concepts** like **tokenization** etc, the radiology as well as mri problem where one has to spend **more time** to get the **final decision of a scan** , then with the **help of generative-ai ,** we refine the draft impression that we got as it is necessary to check and validate the data before really **giving assistance**.So in this also we learn about **the system templates** that help to get validate the input findings , because one can easily get **summary** from a bart model and this way getting help with open ai apis and google also provides for free , **in gen ai part we can get the proper impression**

- **AI & NLP** (BioBART + GPT) enable automated medical text summarization.
- **PDF parsing** connects unstructured reports to structured impressions.
- **Cloud/Edge Deployable Architecture** as we had deployed on hugging face ,makes it usable in hospitals and clinics.
- **User interface (Streamlit)** ensures accessibility without technical expertise.

Flowchart



Technology Stack

Python in collab using t4 engine – Data preprocessing was done from mimic 4 textual clinical notes https://physionet.org/content/mimic-iv-note/2.2/note/#files-panel, filtering MRI-only notes , and pipeline integration.

- **BioBART (Transformer-based model)** – Domain-specific for biomedical NLP, suitable for medical text summarization.

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Module	Purpose	Technology / Tools	Justification
User Interface	Collect MRI findings via text or PDF upload	Python, Streamlit	Streamlit allows rapid development of an interactive web-based UI for input, settings, and output visualization.
Text Extraction	Extract text from PDF reports	Python, `unstructured.partition.pdf`, `tempfile`, `re`	Handles PDF parsing, temporary file management, and text cleaning for consistent input to the model.
Model Loading & Inference	Generate raw MRI impressions	Python, Transformers (`AutoTokenizer`, `AutoModelForSeq2SeqLM`), PyTorch	Provides a robust NLP pipeline; BioBART model fine-tuned on MRI data ensures domain-specific summarization.
Validation	Check input relevance	Python, AzureOpenAI API	Ensures the text corresponds to MRI findings before processing.
Enhancement	Refine impressions using AI	Python, AzureOpenAI API	GPT-based enhancement improves clarity, accuracy, and clinical readability of raw impressions.
Output Management	Display and download results	Python, Streamlit	Enables users to view raw and enhanced impressions and download them as text files for documentation.

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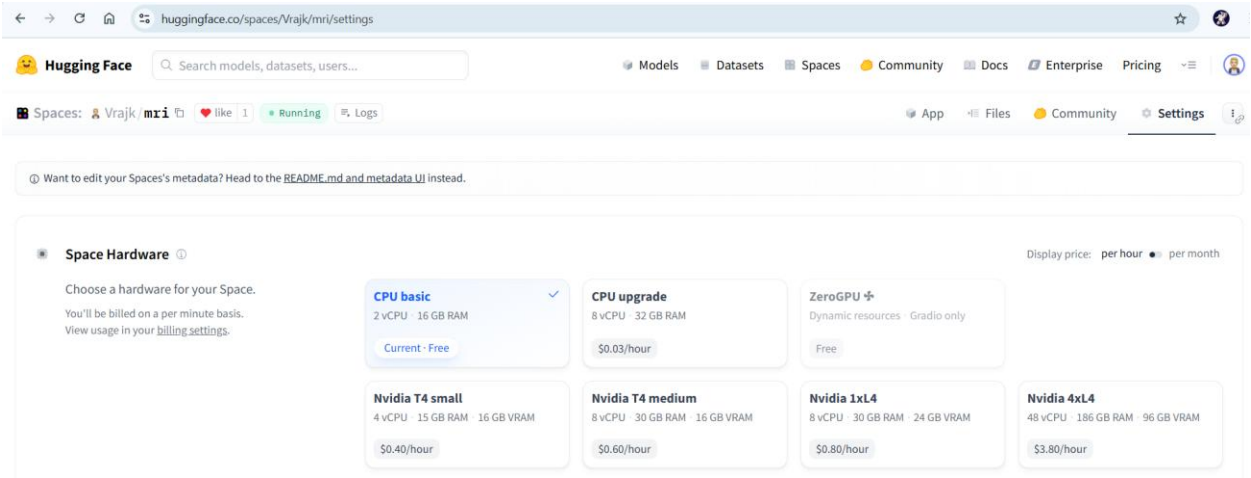
Module	Purpose	Technology / Tools	Justification
Environment & Configuration	Load API keys, environment variables	Python, dotenv, os	Securely manages credentials and configuration for cloud API usage.

Scalability Plan

To ensure the tool can scale across **hospitals and healthcare systems**, we propose:

- **Modular Design** → Each component (data, BioBART, GPT) can be updated or replaced independently as they are already build on local system and deployed on hugging face this is link https://huggingface.co/Vrajk/mri-impressions/tree/main.
- **Cloud-based Deployment** → Running BioBART and GPT inference on cloud GPUs/TPUs ensures handling of **large volumes of reports**.

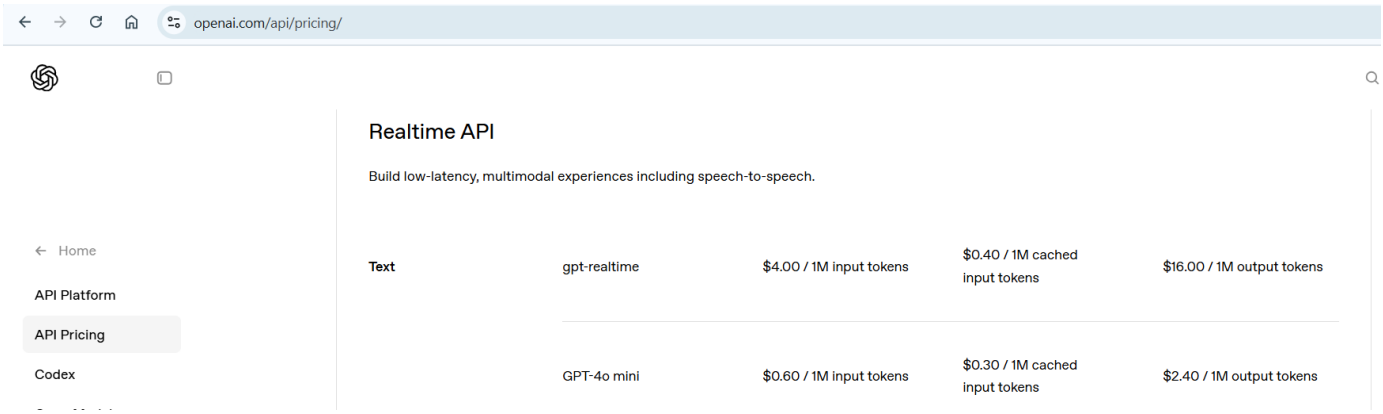


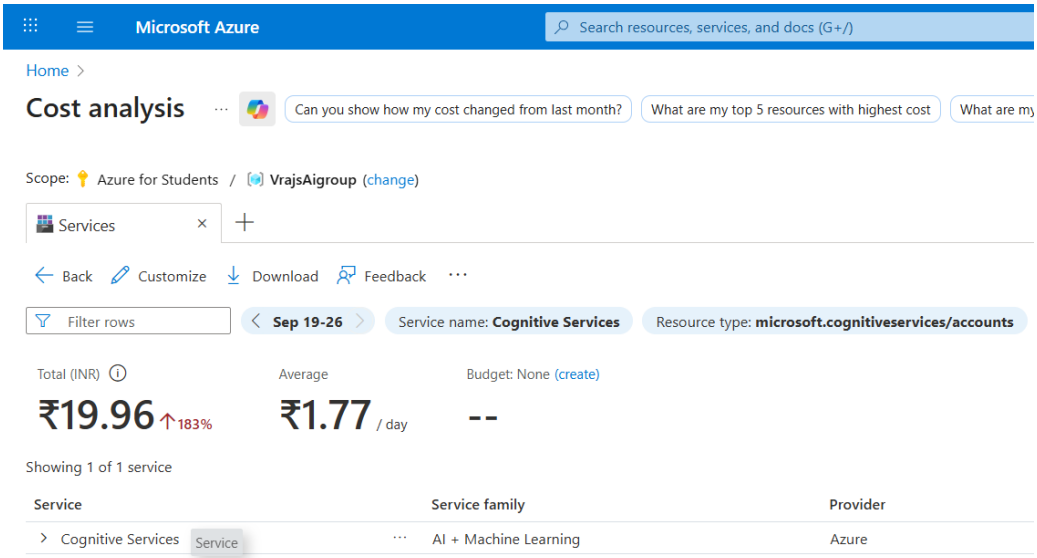
- **Batch Processing** → Enables handling hundreds of MRI reports at once like many users can independently use at once, the local model that has been deployed has no limit but api limit may occur.
- **Bottleneck Handling** →
    - Preprocessing and BioBART inference as well as personal clinic data depending on size may slow with very large datasets.

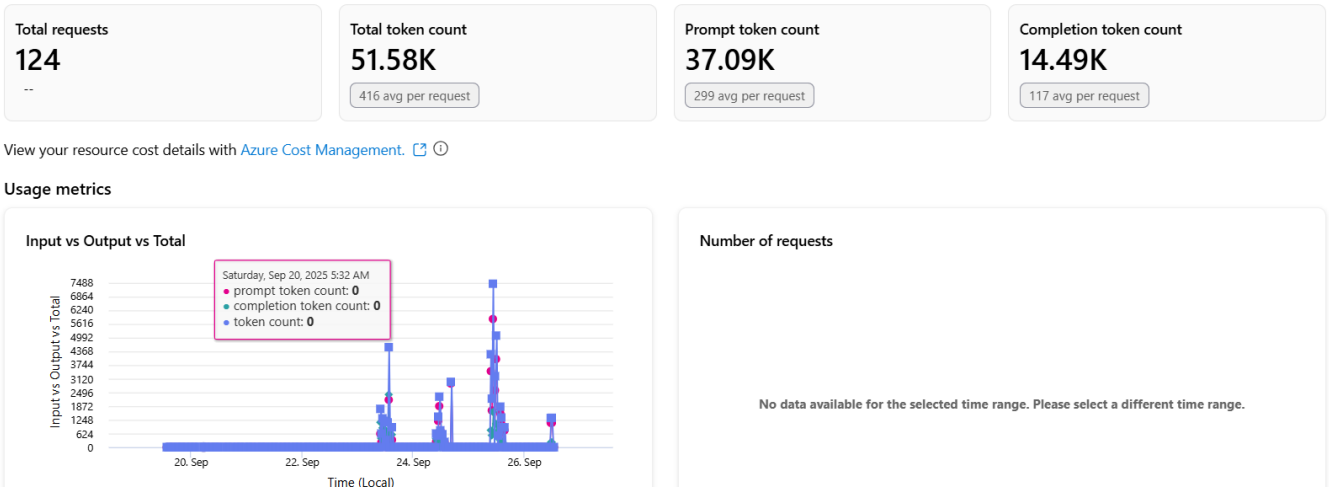
- Solution: implement **parallel processing** and **caching** of frequent pathologies.

Cost vs. Reliability Trade-off →

- GPT calls are more expensive but essential for final validation.
- A hybrid approach: BioBART for bulk draft generation, GPT for selected or complex cases.
- So as you can see that the token used by it is less , as we had till now done impression generation for about 50 to 60 + reports **with gpt 4o model and so there are no issues of pricing and is easily affordable to a personal clinic and hospitals as well.**







Else for students they can rely on free azure resources avail to them , they get $100 to use, and it is easily available till 1 year based on their specific token usage , and also from here they can get many api's of anthropic, as well as grok etc. And also gemini for students version else with limited token one can use.

Sources

1. *Insights into Imaging (2021)* reports that diagnostic radiologists are facing a sharply increasing workload as more complex imaging and higher volume cases arise — many believe that AI will need to help manage this growth. SpringerOpen
2. A systematic review of NLP in radiology reports (BMC, 2021) finds that many models can extract structure or summarize, but often lack integration into workflows, pointing to stakeholders' need for usability and reliability. BioMed Central
3. In *AJNR (2024)* comparing different summarization models, it was shown that although summarization by AI holds promise, current systems do not yet reach full clinical readiness — stakeholders require high accuracy and trust. American Journal of Neuroradiology