NLP Tutor

NLP Mini-Project report submitted to Visvesvaraya National Institute of Technology, Nagpur in fulfillment of requirement for the award of the degree of

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by

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Mini Project Report: NLP TutorBot

Introduction

This report provides an in-depth analysis of the NLP TutorBot, an AI-powered tool designed to simplify and optimize interaction with PDF documents. It facilitates querying, extraction, summarization, and contextual responses, enhanced with a user-friendly Streamlit interface and YouTube video suggestions.

Objective

The primary goals of NLP Tutor are:

- Enable querying of user-uploaded PDF content.
- Simplify extraction and summarization of document information.
- Offer an accessible, intuitive interface for enhanced usability.

System Overview

The architecture includes:

- **Input**: PDF uploads processed via Streamlit.
- **Processing**: Text extraction, chunking, embedding, summarization, and RAG-based querying.
- **Output**: Contextual answers and YouTube links displayed in the UI.

Task Ownership

1. Saurabh Sharma – Front End + Testing
2. Sadashiv Nayak A – Backend + Testing

Code Details and Structure

The project is structured with the following Python files, each contributing to its functionality:

- **functions.py**: Contains core logic for PDF processing and conversation.
    - `get_pdf_content`: Extracts text from PDFs using PyPDF2, iterating over pages to build raw text.
    - `get_chunks`: Splits text into 1000-character chunks with 200-character overlap using CharacterTextSplitter.
    - `get_vectorstore`: Generates embeddings with HuggingFaceEmbeddings (all-MiniLM-L6-v2) and stores them in FAISS (Facebook AI – Similarity search uses Nearest neighbor), including error handling for invalid chunks.

    - `conversation_chain`: Implements LangChain's RAG pipeline with a history-aware retriever, using LLaMA3 via Groq API to generate responses, yielding chunks for streaming output.

- **app.py**: Manages the Streamlit UI and backend processing.
    - Initializes Streamlit with custom CSS from `html_template.py` and handles file uploads with `hash_files` for unique identification.
    - `async_process_files`: Processes PDFs asynchronously using threading, updating progress and ETA in session state.
    - `get_youtube_videos`: Fetches top 3 videos using yt-dlp based on user queries.
    - `save_vectorstore_to_disk` and `load_cached_files`: Manages caching with `pickle` in the `cache/` directory.
    - Includes UI elements like chat input, progress bars, and app management buttons (e.g., CLEAR CACHE, RESTART APP).
- **models.py**: Configures the language model.
    - Loads environment variables (e.g., API key) from `config/.env` using `dotenv`.
    - Initializes `ChatGroq` with LLaMA3-70b-8192, setting parameters like temperature (0.7) and max_tokens (8192) for optimal performance.
- **html_template.py**: Defines UI styling and templates.
    - `css`: Styles chat messages with Tailwind-inspired classes, setting background colors and layouts.
    - `ai_template` and `human_template`: HTML templates for bot and user messages, embedding avatar images (e.g., `ai_profile_photo.png` at 120x120 pixels).
    - `hide_st_style`: Hides Streamlit's default menu and footer for a cleaner look.

Architecture Explanation

The NLP Tutor architecture is a sophisticated, RAG-driven system optimized for document interaction:

- **Input Layer**: Streamlit accepts PDF uploads, hashing files with `hash_files` in `app.py` for caching in `cache/`. The UI provides options to load cached sessions or process new files.

- **Preprocessing Layer**: `get_pdf_content` in `functions.py` uses PyPDF2 to extract text, while `get_chunks` splits it into manageable chunks. This layer ensures scalability for large documents.
- **Embedding Layer**: `get_vectorstore` employs HuggingFaceEmbeddings to create vector representations, stored in FAISS for efficient retrieval. Caching with `pickle` allows merging of multiple vectorstores.
- **Summarization Layer**: Although not fully implemented, the design reserves space for facebook/bart-large-cnn to summarize sections, enhancing content overview.
- **Retrieval and QA Layer**: `conversation_chain` leverages LangChain's history-aware retriever to contextualize queries, using RAG to fetch relevant chunks. The LLaMA3-70b-8192 model (via Groq API) generates responses, with deepset/roberta-base-squad2 as a fallback. Optional LangSmith integration tracks quality.
- **Output Layer**: `app.py` renders responses in the Streamlit chat interface using templates from `html_template.py`. `get_youtube_videos` integrates yt-dlp to suggest videos, enhancing educational value.
- **Async Processing**: `async_process_files` uses threading to handle background tasks, updating `st.session_state` with progress and ETA for a responsive user experience.

Workflow

The process flows as follows:

1. Users upload PDFs via Streamlit, triggering `async_process_files`.
2. Text is extracted and chunked, then embedded and stored in FAISS.
3. Queries are processed by `conversation_chain`, retrieving relevant content.
4. Responses are generated and displayed, with YouTube links fetched concurrently.

Features

Key functionalities include:

- **PDF Interaction**: Guides users in querying content.
- **Dynamic Data Querying**: RAG ensures contextual accuracy.
- **User-Friendly Interface**: Streamlit with custom styling offers seamless navigation.

Challenges and Solutions

Development challenges addressed:

- **Challenge**: Long processing times for large PDFs.
- **Solution**: Asynchronous processing with progress tracking.
- **Challenge**: Context accuracy in queries.
- **Solution**: History-aware retriever with RAG.

Technologies Used

The project utilizes:

- **Python**: Core language.
- **LangChain**: Drives RAG and conversational logic.
- **Hugging Face Embeddings and FAISS**: Enables efficient storage and retrieval.
- **Streamlit**: Powers the UI.
- **Groq API and LLaMA3-70b-8192**: Handles high-performance NLP.
- **LangSmith (Optional)**: Evaluates conversation quality.
- **yt-dlp**: Fetches YouTube videos.

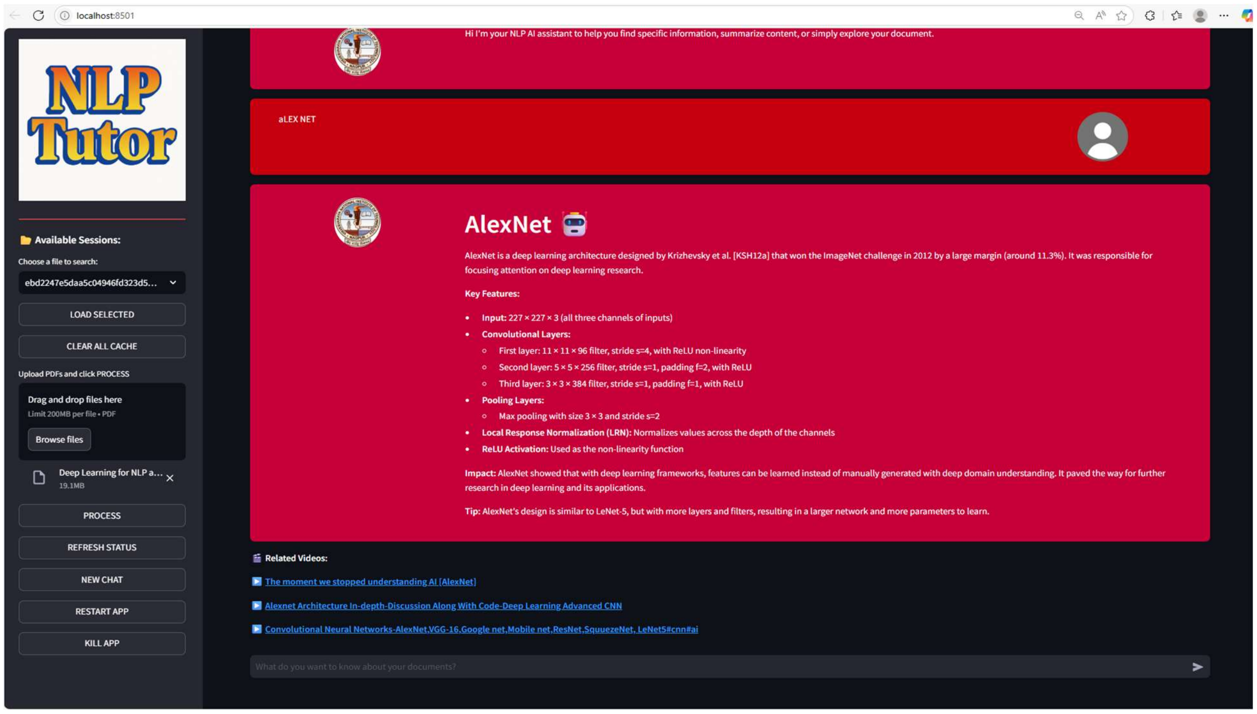
Project Structure

Directory layout:

- `cache/`: Stores vectorstores and processed PDFs.
- `config/`: Holds `.env` for API keys.
- `docs/`: Test PDFs.
- `prints/`: Screenshots.
- `src/`: Source code.
- `README.txt`: Project overview.
- `requirements.txt`: Dependencies.

App Snippet for Output

Sample UI interaction:



Hi I'm your NLP AI assistant to help you find specific information, summarize content, or simply explore your document.

aLEX NET

AlexNet 🤖

AlexNet is a deep learning architecture designed by Krizhevsky et al. [KSH12a] that won the ImageNet challenge in 2012 by a large margin (around 11.3%). It was responsible for focusing attention on deep learning research.

Key Features:

- **Input:** 227 × 227 × 3 (all three channels of inputs)
- **Convolutional Layers:**
  - First layer: 11 × 11 × 96 filter, stride s=4, with ReLU non-linearity
  - Second layer: 5 × 5 × 256 filter, stride s=1, padding f=2, with ReLU
  - Third layer: 3 × 3 × 384 filter, stride s=1, padding f=1, with ReLU
- **Pooling Layers:**
  - Max pooling with size 3 × 3 and stride s=2
- **Local Response Normalization (LRN):** Normalizes values across the depth of the channels
- **ReLU Activation:** Used as the non-linearity function

Impact: AlexNet showed that with deep learning frameworks, features can be learned instead of manually generated with deep domain understanding. It paved the way for further research in deep learning and its applications.

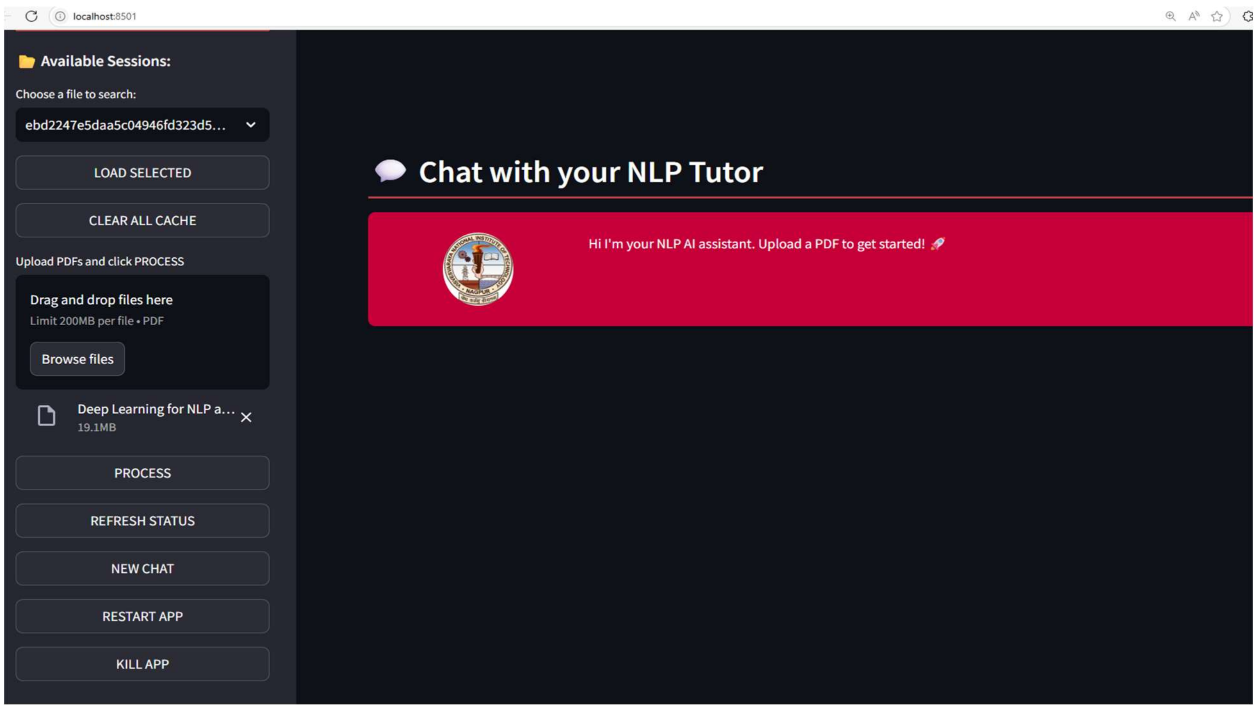
Tip: AlexNet's design is similar to LeNet-5, but with more layers and filters, resulting in a larger network and more parameters to learn.

Related Videos:

▶️ The moment we stopped understanding AI [AlexNet]

▶️ Alexnet Architecture In-depth-Discussion Along With Code-Deep Learning Advanced CNN

▶️ Convolutional Neural Networks-AlexNet,VGG-16,Google net,Mobile net,ResNet,SquuezeNet, LeNet5#cnn#ai



Chat with your NLP Tutor

Hi I'm your NLP AI assistant. Upload a PDF to get started! 🚀

Future Enhancements

Proposed upgrades:

- Multi-language support with Noto Serif fonts.

- Advanced summarization with google/flan-t5-large.
- Cloud deployment for scalability.

Conclusion

NLP TutorBot integrates advanced NLP and RAG(Retrieval Augmented Generation) with a responsive UI, offering a robust platform for document interaction with significant potential for future growth.