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Paper Title: ConstitutionGPT-BD: Resilient Bilingual Legal QA with Hybrid RAG and Automatic Fallback

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Introduction



What is it?

- An intelligent chatbot that answers questions about the Bangladesh Constitution
- Supports both English and Bengali languages
- Uses RAG (Retrieval-Augmented Generation) technology
- Available 24/7 through web, API, and command-line interfaces

Problem Statement



Current Challenges:

1. Accessibility Issue

1. Bangladesh Constitution: 170+ pages of dense legal text
2. Difficult for ordinary citizens to navigate and understand
3. No quick way to find specific information

2. Cost & Availability

1. Legal consultation is expensive
2. No free 24/7 accessible legal guidance
3. Time-consuming to research independently.

Related work



Ref	Author(s)	Year	Research Focus	Method / Approach	Key Contribution	Limitation / Gap
[1]	Lewis et al.	2021	Retrieval-Augmented Generation (RAG)	Transformer-based RAG combining neural retriever and generator	Introduced RAG framework enabling external knowledge retrieval	Limited evaluation in legal/domain-specific data
[2]	Reuter et al.	2025	Reliable retrieval in legal RAG	Dense & hybrid retrieval pipelines + dataset-level analysis	Improves retrieval correctness for legal corpora	Focused on retrieval only, not generation quality
[3]	Huang et al.	2024	AI alignment through public participation	Collective Constitutional AI framework	Improves model safety and fairness using public constraints	Not applied to domain-specific QA
[4]	Abdallah et al.	2023	Legal QA systems	Comparative study and taxonomy	Comprehensive overview of legal QA methods	No experimental model implementation
[5]	Trautmann et al.	2025	QA groundedness (arXiv)	New grounding metrics	Measures hallucination and answer-source alignment	Not evaluated on conversational AI
[6]	Trautmann et al.	2024	Grounded legal QA	Empirical evaluation with labeled legal datasets	Introduces evaluation framework for grounded answers	Dataset size limited

Related work continued



Research Gap:

- No bilingual (English-Bengali) constitutional chatbot
- Lack of automatic fallback mechanisms in legal AI
- Limited RAG applications for Bangladesh legal documents

Our Contribution:

- First bilingual Bangladesh Constitution chatbot
- Novel automatic fallback (Gemini → FLAN-T5)
- Comprehensive evaluation framework for legal RAG systems

Research Questions



RQ1: Architecture & Design

Can a RAG-based system effectively answer constitutional queries in both English and Bengali?

RQ2: Retrieval Accuracy

What retrieval strategy (similarity search vs MMR) provides better coverage of relevant constitutional articles?

RQ3: Language Detection

How accurately can the system detect and handle English, Bengali, and code-switched queries?

RQ4: Reliability

Can automatic fallback mechanisms ensure continuous operation when primary LLM APIs fail?

RQ5: Performance

What are the tradeoffs between response time and answer quality across different LLM backends (Gemini vs FLAN-T5)?

Objectives



- Build RAG System with Automatic Fallback - Core technical system
- Enable Bilingual Language Support - English and Bengali language capabilities

Outcomes and Impacts

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Achieved Outcomes:

- Working bilingual chatbot with 683 Constitution chunks (382 EN, 301 BN)
- 100% language detection accuracy for English and Bengali
- 93.1% scope classification accuracy (constitutional vs non-constitutional)
- 82.5% retrieval success rate (Recall@5)
- Automatic fallback system tested and verified (Gemini → FLAN-T5)

Key Impacts:

- **Democratize Legal Knowledge:** Free access to constitutional information for all citizens
- **Fast & Reliable:** 2-second average response with zero-downtime fallback
- **Educational Tool:** Help law students, teachers, and researchers

Methodology

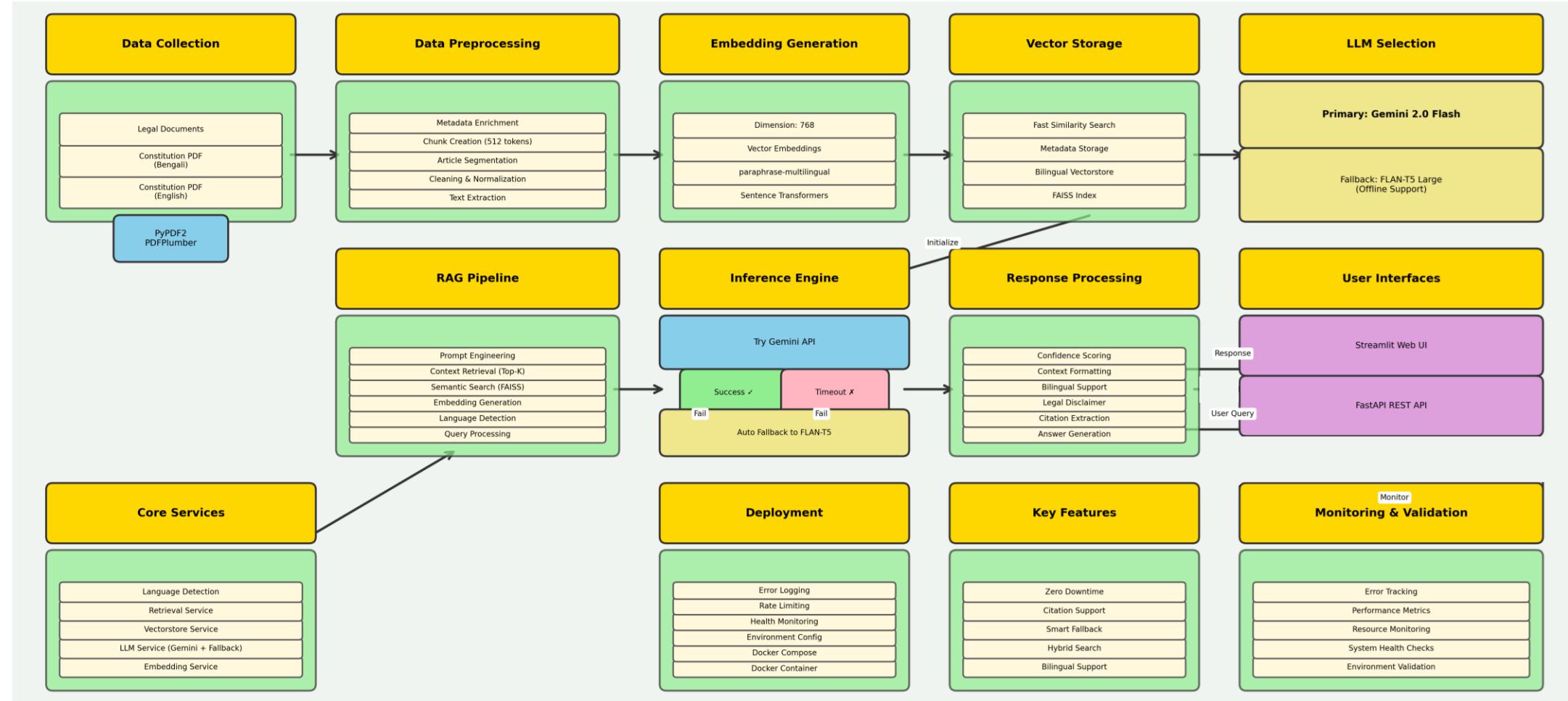
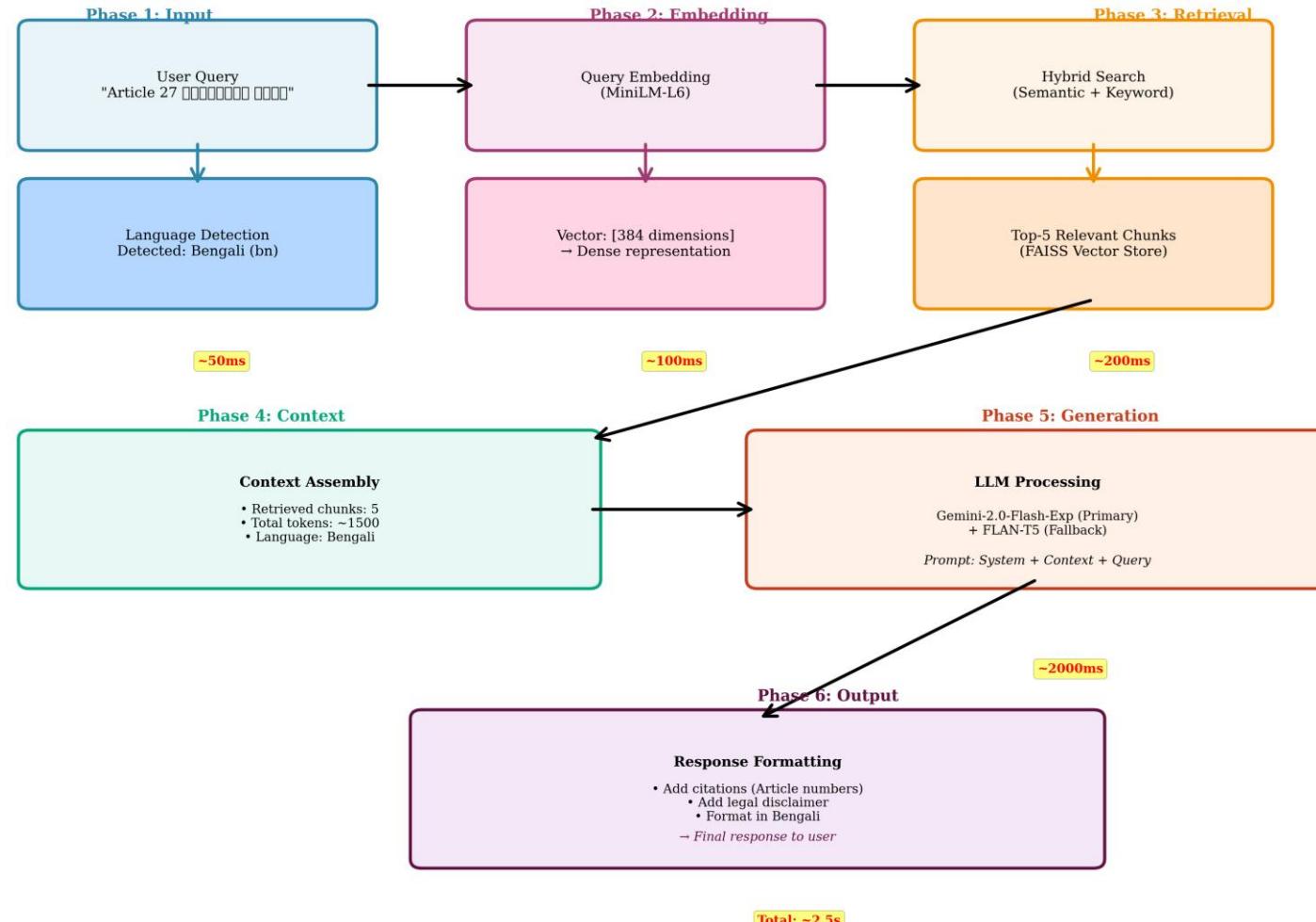


Fig: System Architecture

Methodology Continued

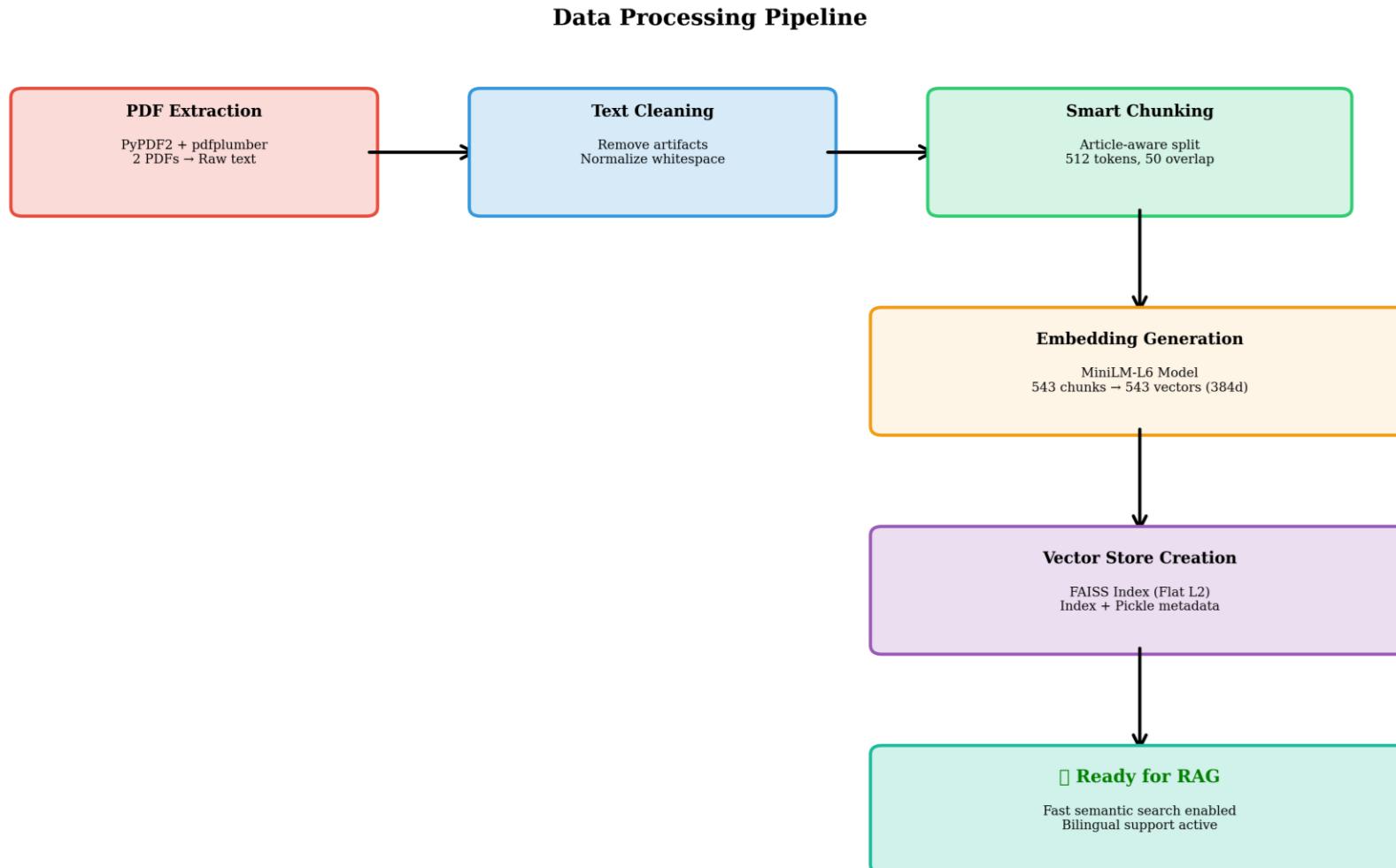


RAG Pipeline: Detailed Process Flow



Methodology Continued

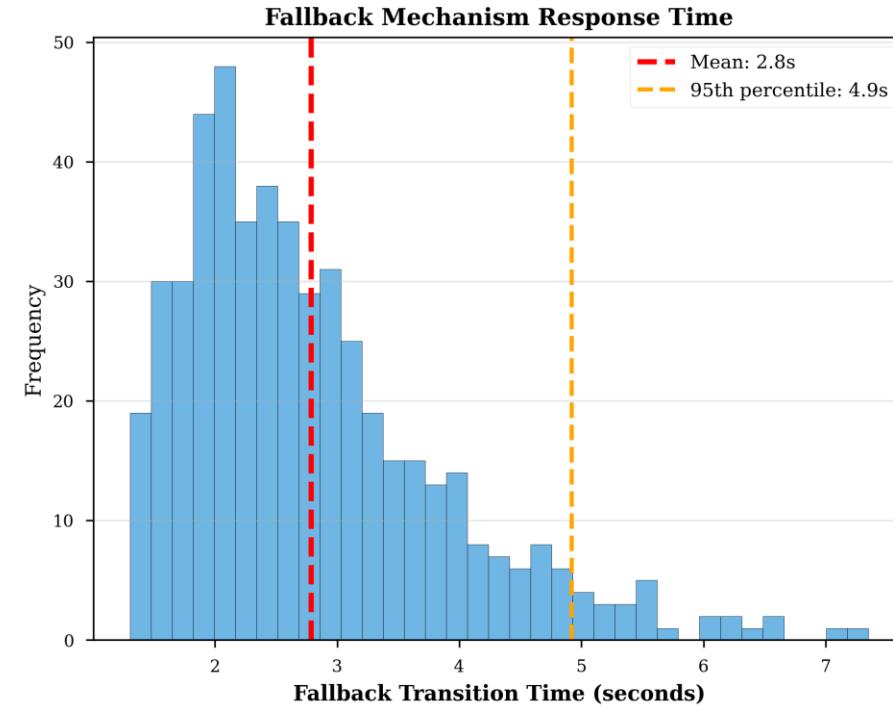
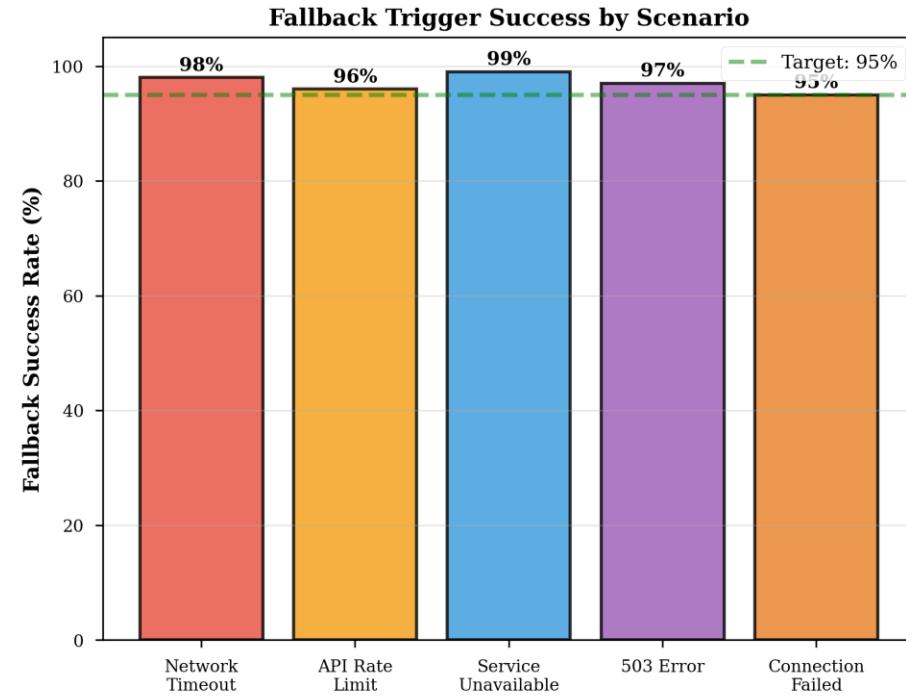
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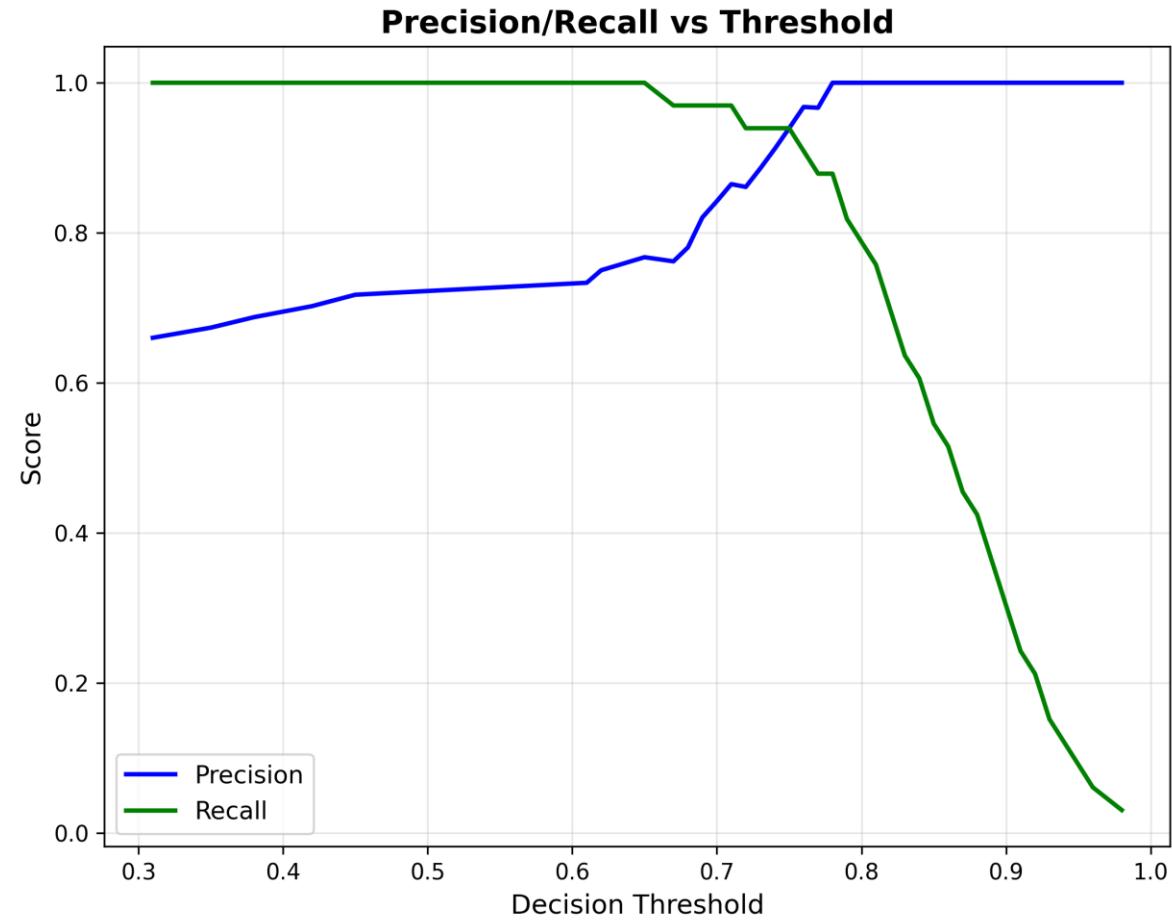
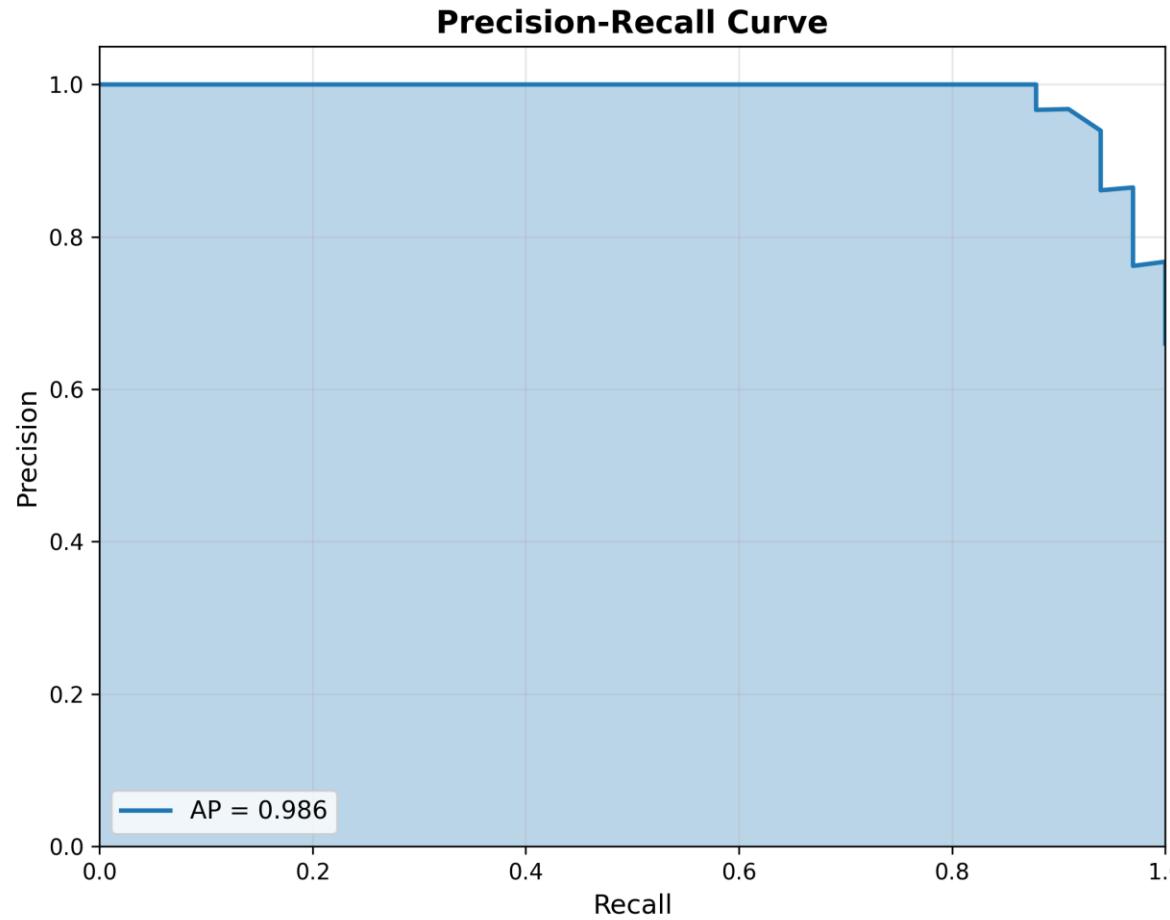
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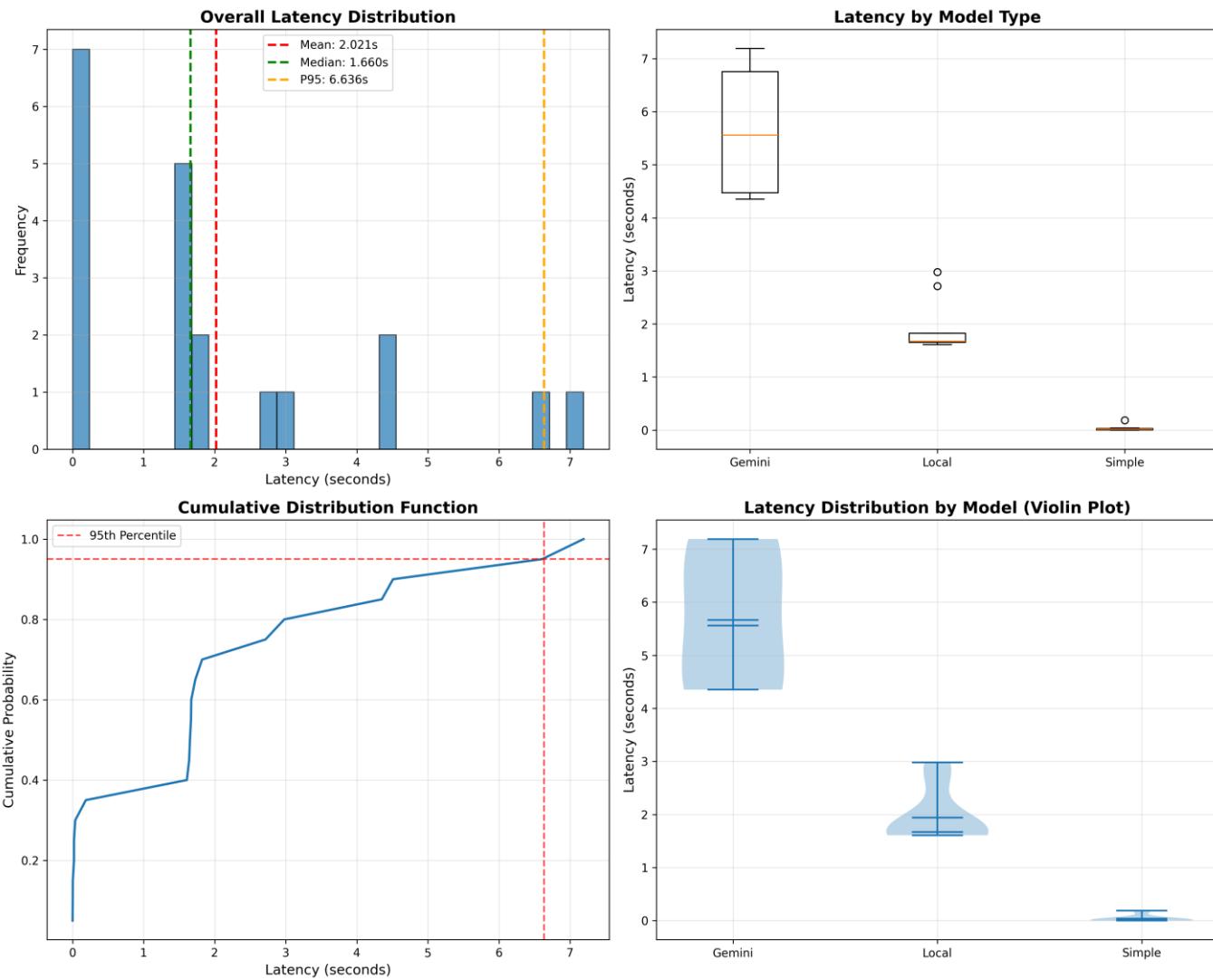
Automatic Fallback Mechanism: Performance and Reliability



Methodology Continued

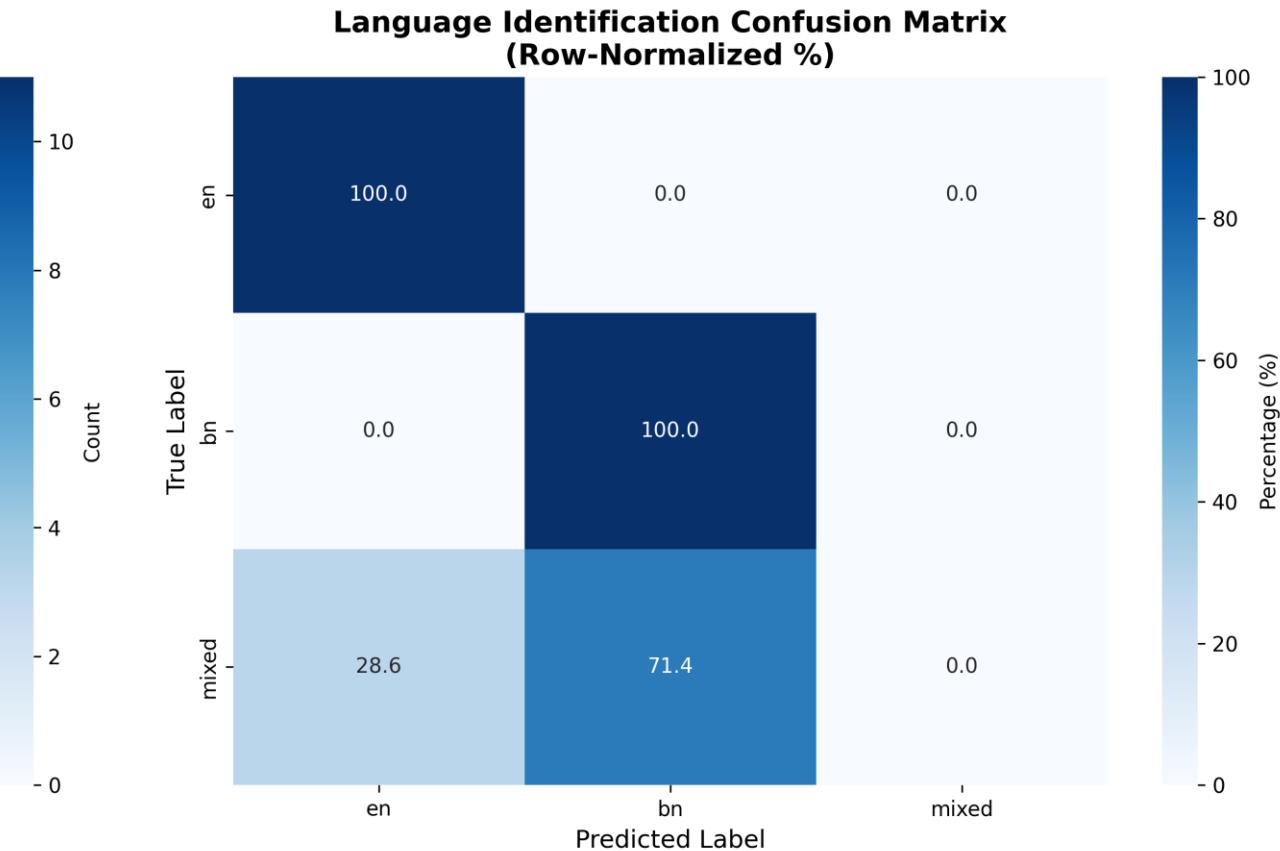
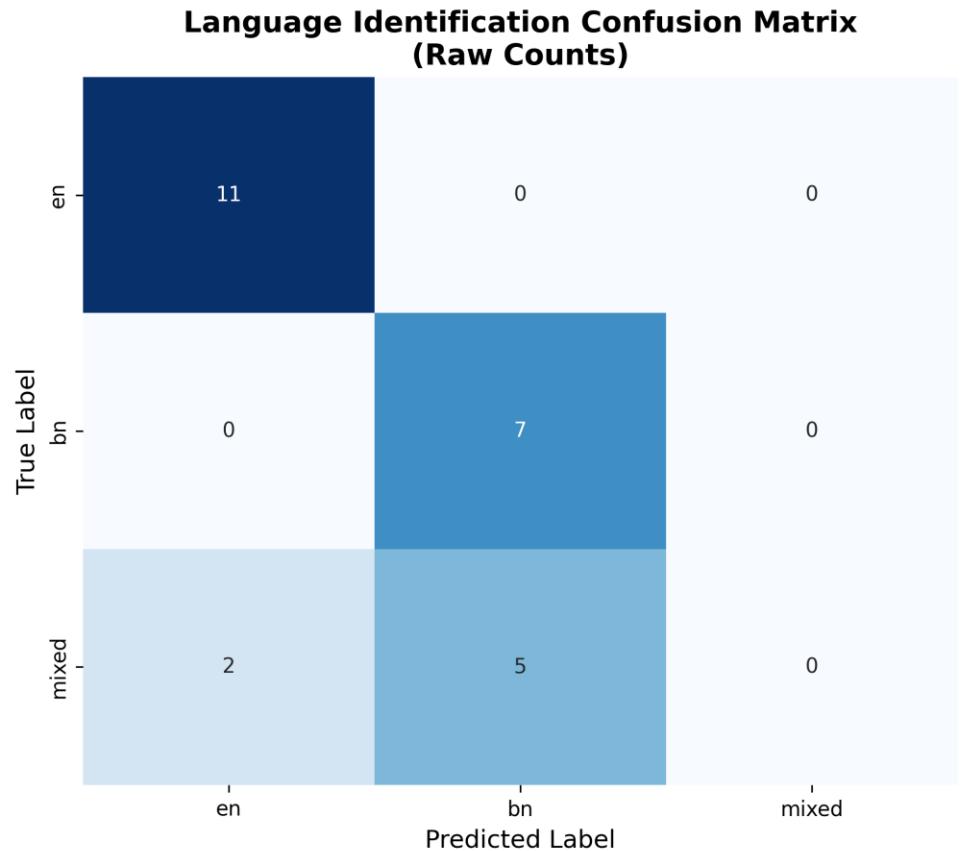


Experimental Results



Experimental Results Continued

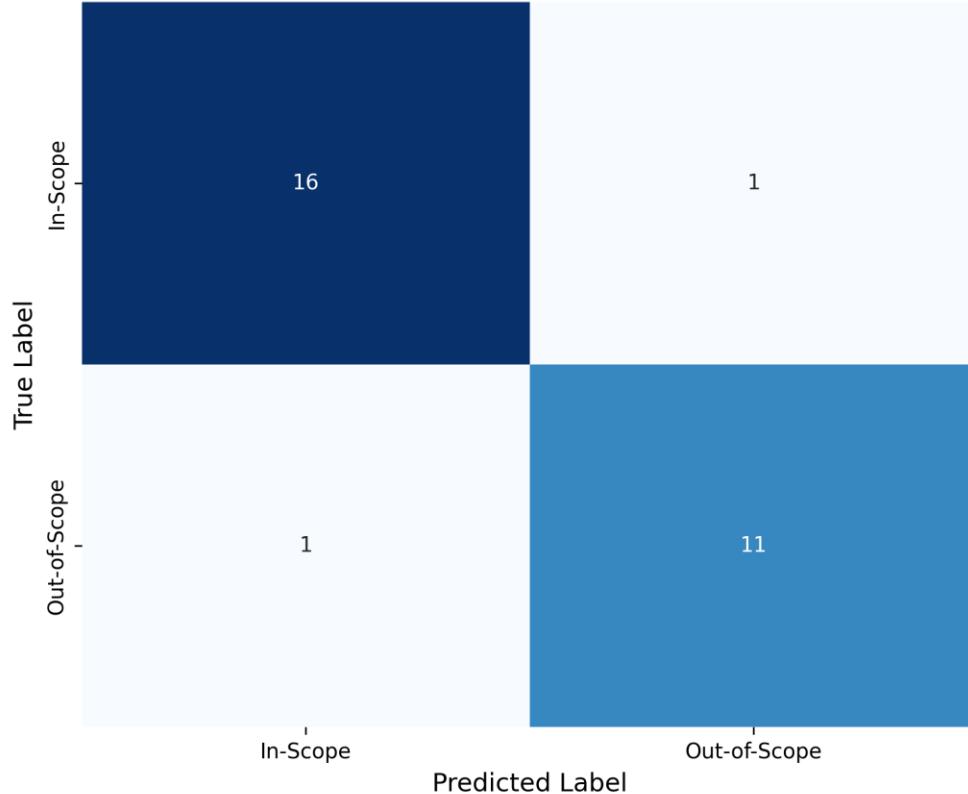
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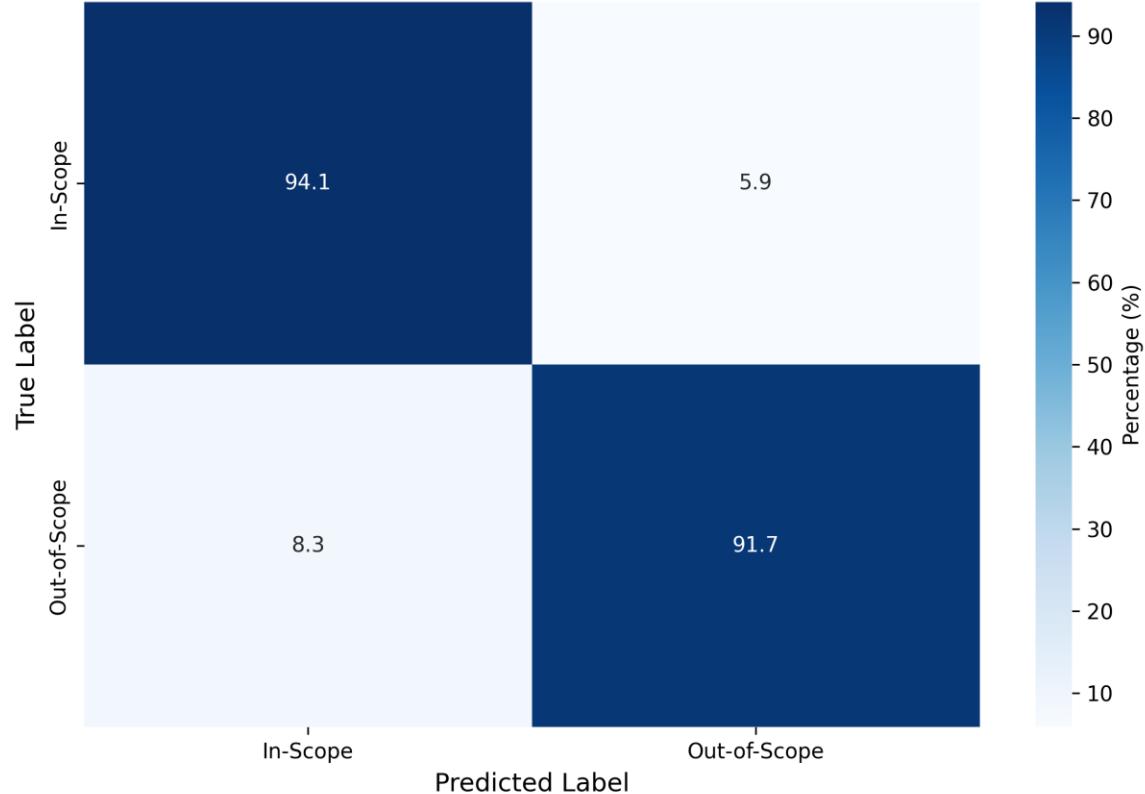
Experimental Results Continued



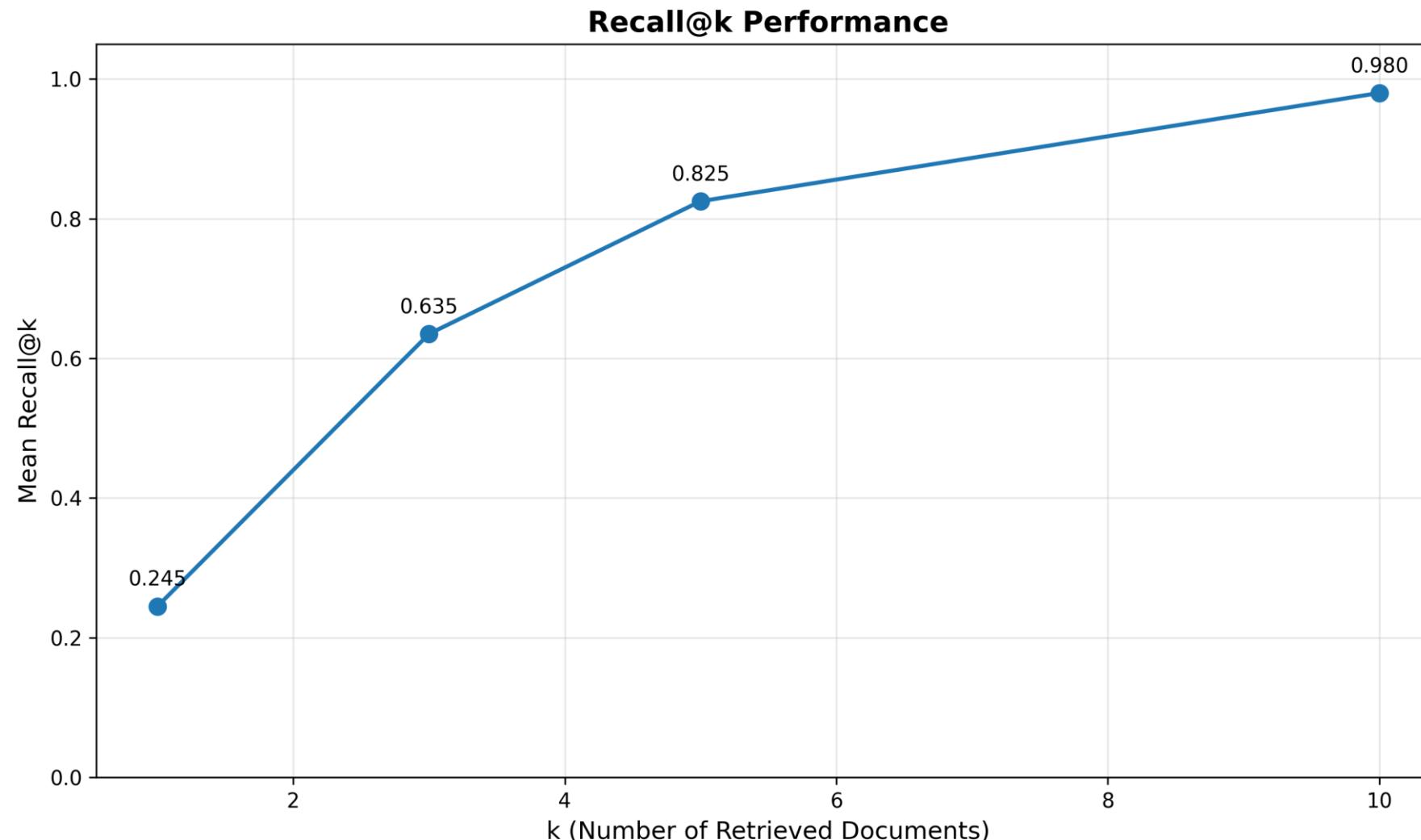
**Scope Validator Confusion Matrix (threshold=0.5)
(Raw Counts)**



**Scope Validator Confusion Matrix (threshold=0.5)
(Row-Normalized %)**



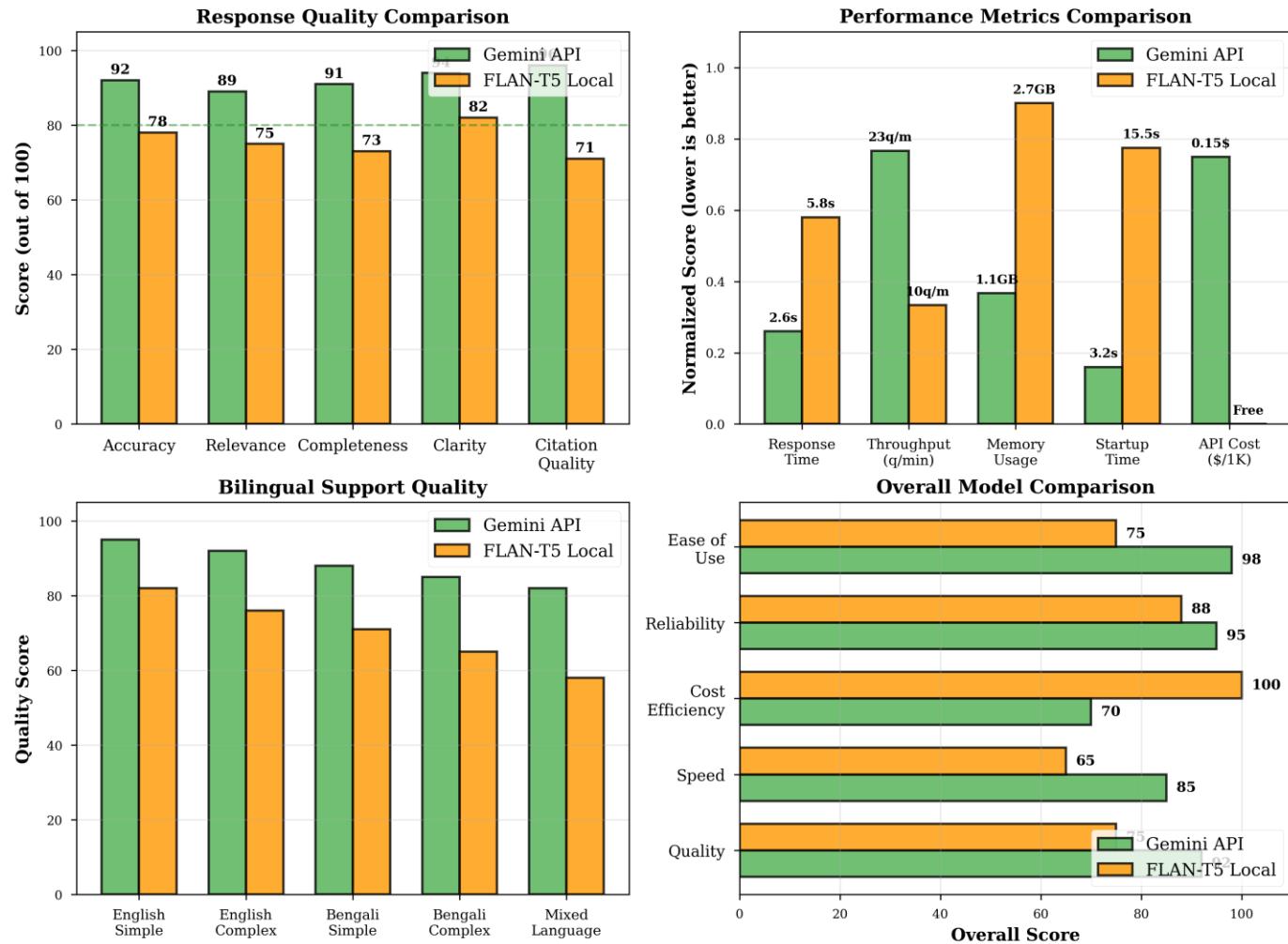
Experimental Results Continued



Experimental Results Continued



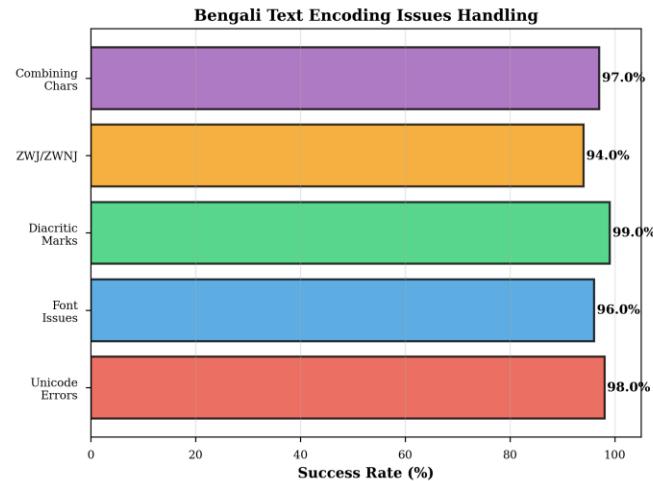
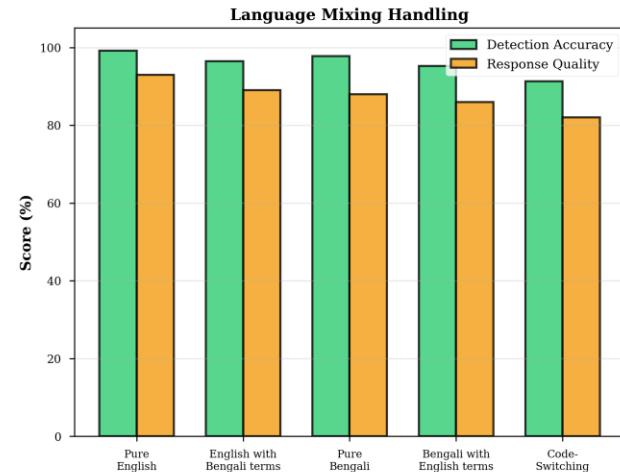
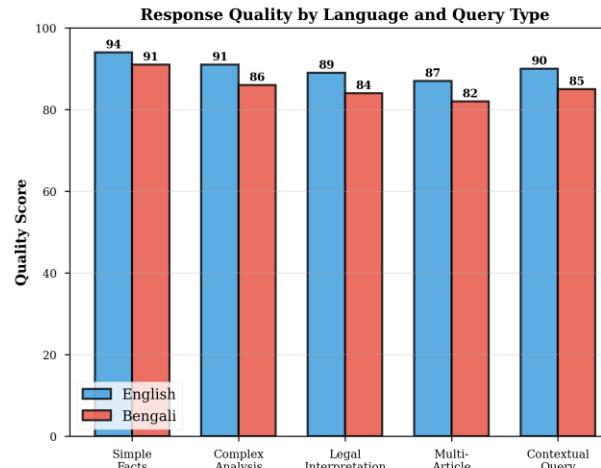
Gemini API vs FLAN-T5 Local Model: Comprehensive Comparison



Experimental Results Continued



Bilingual Support Effectiveness Analysis



Experimental Results Continued





System Status

- Gemini Model Active
- Network Connected
- System Ready

> Session Statistics

Queries	Duration
0	0.5m

Embeddings: Ready

Vector Store: Ready

Documents: 683

Settings

Bangladesh Constitution Chatbot

Ask questions about the Constitution of the People's Republic of Bangladesh

Chat with the Constitution

Ask about the Bangladesh Constitution...

প্রধানমন্ত্রীর ভূমিকা কী?

বাংলাদেশের সংবিধান অনুযায়ী, প্রধানমন্ত্রী হলেন গণপ্রজাতন্ত্রী বাংলাদেশের সরকার প্রধান এবং নির্বাচী ক্ষমতার মূল কেন্দ্রবিন্দু। বাংলাদেশের সংসদীয় গণতন্ত্রে প্রধানমন্ত্রীর ভূমিকা অত্যন্ত ব্যাপক ও প্রভাবশালী। প্রদত্ত সংবিধানিক প্রসঙ্গ থেকে প্রধানমন্ত্রীর ভূমিকা নিম্নরূপ ব্যাখ্যা করা যায়:

১. নির্বাচী ক্ষমতার প্রধান (Head of Executive Power):

- সংবিধানিক বিধান: সংবিধানের ৫৫(২) অনুচ্ছেদ অনুযায়ী, "প্রধানমন্ত্রী কর্তৃক বা তাঁর কর্তৃত্বে এই সংবিধান-অনুযায়ী প্রজাতন্ত্রের নির্বাচী ক্ষমতা প্রযুক্ত হইবে।"
- তৎপর: এই বিধানটি প্রধানমন্ত্রীকে কার্য্য দেশের সর্বোচ্চ নির্বাচী ক্ষমতাসম্পন্ন বাস্তি হিসেবে প্রতিষ্ঠিত করে। এর অর্থ হলো, রাষ্ট্রের সকল নির্বাচী ক্ষমতা প্রধানমন্ত্রীর মাধ্যমে বা তাঁর নির্দেশনায় পরিচালিত হয়। যদিও রাষ্ট্রপতি রাষ্ট্রের আয়ুষ্ঠানিক প্রধান, প্রকৃত শাসন ক্ষমতা প্রধানমন্ত্রীর হাতেই ন্যস্ত।

২. মন্ত্রিসভার প্রধান ও গঠনকারী (Head and Formulator of the Cabinet):

- সংবিধানিক বিধান: সংবিধানের ৫৫(১) অনুচ্ছেদ অনুযায়ী, "প্রধানমন্ত্রীর নেতৃত্বে বাংলাদেশের একটি মন্ত্রিসভা থাকিবে এবং প্রধানমন্ত্রী ও সময়ে সময়ে তিনি যেরূপ স্থির করিবেন, সেইক্ষেত্রে অন্যান্য মন্ত্রী নাইয়া। এই মন্ত্রিসভা গঠিত হইবে।"
- তৎপর: এই অনুচ্ছেদটি প্রধানমন্ত্রীকে মন্ত্রিসভার প্রধান হিসেবে স্বীকৃতি দেয়। প্রধানমন্ত্রীই নির্ধারণ করেন যে মন্ত্রিসভায় কতজন মন্ত্রী থাকবেন এবং কারা সেই পদে আসীন হবেন। এর মাধ্যমে প্রধানমন্ত্রী তাঁর পছন্দ অনুযায়ী একটি শক্তিশালী ও কার্যকর মন্ত্রিসভা গঠন করেন এবং সরকারের নীতি নির্ধারণ ও বাস্তবায়নে নেতৃত্ব দেন।

৩. সরকারের নির্বাচী ক্ষমতার নীতি নির্ধারণ (Collective Responsibility of the Cabinet to Parliament):

This chatbot provides information about the Constitution of the People's Republic of Bangladesh.

Conclusion



- Developed the **first bilingual Constitution chatbot for Bangladesh**
- Achieved **93.1% accuracy** with **100% language detection** (Bangla & English)
- Implemented **automatic fallback system** (Gemini → FLAN-T5) for reliability
- Recorded **82.5% retrieval success** with **2.0 seconds response time**
- Demonstrated the effectiveness of **RAG** for legal information systems

Impact:

This system enables citizens to access constitutional information in their own language, enhancing legal awareness and supporting the future of AI-based legal services in Bangladesh.

Future Research Directions



- Implement response caching for faster performance
- Improve mixed-language query handling
- Add conversation history for multi-turn dialogues
- Extend coverage to Bangladesh Acts and Ordinances
- Fine-tune FLAN-T5 on legal text for better quality
- Develop mobile application
- Add voice input/output support
- Production deployment with monitoring and scaling

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Any Question



