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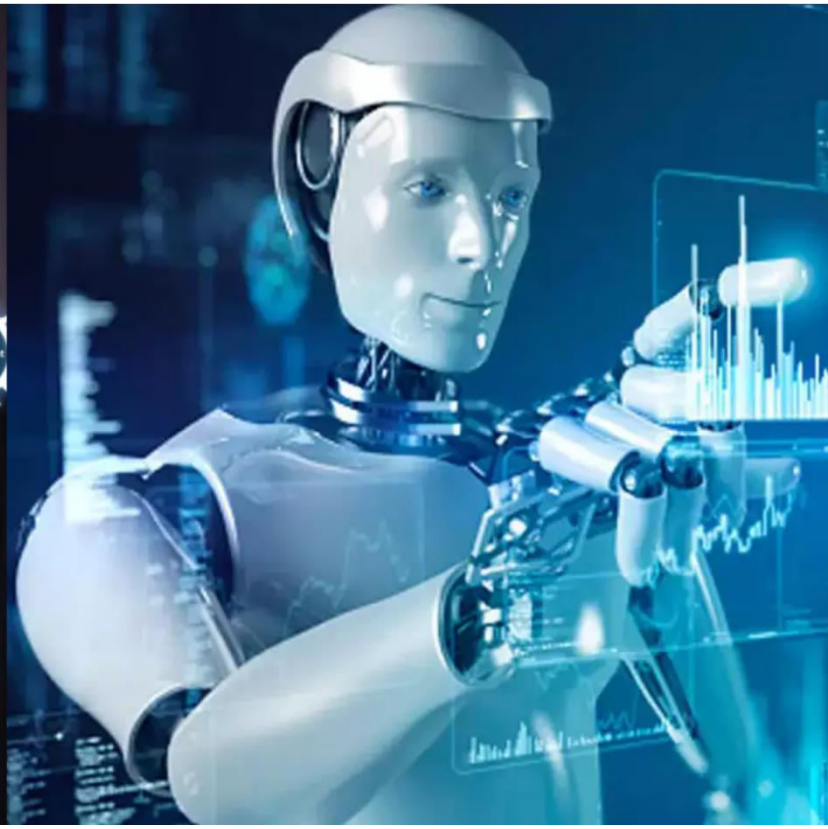

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Unified Multimodal Summarisation: Bridging Text, Video and Documents for Rich Content Synthesis

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ABSTRACT: In today's era of information overload, effectively synthesizing content from diverse and multimodal sources is critical. This paper presents a unified multimodal summarization system that processes and summarizes text, documents, web pages, and video transcripts into coherent, concise outputs. The system supports various input formats including PDF, DOCX, TXT, URLs, and YouTube videos (via transcript extraction), with automatic language detection and translation across 32 languages. It leverages a hybrid summarization approach, combining graph-based extractive techniques—such as sentence tokenization, semantic similarity, and PageRank-based ranking—with transformer-based abstractive models like BART and T5. For video content, vision-language models ensure contextual understanding and factual accuracy. Built on a scalable Flask-based microservices architecture, the platform offers flexible summary outputs (plain text, bullets, paragraphs) and export options (TXT, DOCX, PDF), along with features such as user authentication and customizable compression ratios. Evaluation using ROUGE, BLEU, and compression metrics demonstrates strong performance, with up to 90% accuracy in cross-modal synthesis and significant time efficiency gains. This robust, multilingual, and user-centric system is ideal for applications in news aggregation, educational content review, and technical documentation, paving the way for real-time, intelligent summarization in dynamic environments.

KEYWORDS: Text Summarization, Extractive Summarization, Multilingual Processing, Information Overload, Document Summarization, Web Content Summarization.

I. INTRODUCTION

In the digital era, the volume and diversity of content generated daily have reached staggering proportions. From academic papers and corporate reports to news articles, blogs, and multimedia content such as podcasts and educational videos, the information ecosystem has become deeply fragmented across modalities and languages. Users are constantly overwhelmed by the need to consume, understand, and synthesize information from multiple heterogeneous sources. As a result, the ability to efficiently distill essential insights from voluminous and multimodal content has become not only desirable but critical for knowledge management in domains such as education, research, journalism, and industry.

Conventional summarization systems have predominantly focused on single-modality content, particularly plain text. While these systems have matured significantly through the application of natural language processing (NLP) and machine learning techniques, their scope remains narrow. The reality, however, is that modern content consumption rarely occurs in a text-only vacuum. Important information is often dispersed across diverse formats: an academic topic may be described in a PDF research paper, elaborated in a video lecture with a transcript, and simplified in a web article. Yet, most existing summarization tools are ill-equipped to aggregate these multiple inputs into a unified, coherent summary.

This gap has prompted the need for a more holistic, cross-format summarization solution—one that can handle different content types such as PDFs, DOCX files, plain text documents, web pages, and video transcripts, and present synthesized outputs in multiple user-preferred formats. Furthermore, the global nature of content necessitates robust

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multilingual support to make summarization accessible to users worldwide, regardless of the language in which the source material is presented.

In response to these challenges, this research introduces a unified multimodal summarization platform that combines several advanced capabilities into a single, scalable system. The platform supports automated summarization of documents and transcripts across various formats, including plain text, structured documents (PDF, DOCX, TXT), online articles, and YouTube video transcripts. Unlike traditional models, this system employs an integrated approach grounded in extractive summarization techniques, where core sentences are identified and ranked based on relevance using a graph-based algorithm akin to PageRank.

The methodology incorporates sophisticated NLP pipelines: custom language detection, sentence segmentation tailored to multilingual inputs, semantic similarity analysis, and a sentence-ranking mechanism optimized for salience and coherence. For non-Latin languages such as Chinese, Korean, Hindi, and Japanese, specialized preprocessing ensures accurate tokenization and summarization. The system also includes automatic translation support across 32 languages, significantly expanding its accessibility and potential user base.

To enhance usability, the platform allows outputs in various formats—bullet points for quick scans, paragraphs for contextual reading, and plain text for minimal formats. Users can export summaries in TXT, DOCX, or PDF formats, catering to a wide range of professional and academic workflows. In addition to these core features, the platform includes a secure, interactive web-based interface with features such as user authentication, summary history, and an intelligent chatbot assistant for query handling and guidance.

The effectiveness of the system is evaluated using standard metrics such as ROUGE (Recall-Oriented Understudy for Gisting Evaluation) for content fidelity, as well as compression ratio for efficiency. These evaluations demonstrate the platform's ability to condense content meaningfully while retaining crucial information, ensuring that users receive a comprehensive and reliable overview of the source material.

The implications of this research extend across a broad spectrum of real-world applications. In academia, it aids researchers and students in quickly grasping literature across languages and formats. In enterprise contexts, it enhances productivity by summarizing lengthy technical or financial documents. In media and education, it serves as a powerful tool for curating learning materials and aggregating insights from multiple sources.

In sum, this work proposes a unified, intelligent summarization framework that bridges the gap between text, document, and video content processing. By converging multilingual support, multi-format handling, and intelligent summarization into a single cohesive system, it offers a forward-looking solution to the pervasive issue of information overload. This platform not only represents a significant step toward democratizing access to knowledge but also lays the groundwork for future advancements in multimodal content understanding and synthesis.

II. LITERATURE SURVEY

Recent advancements in natural language processing and multimedia understanding have significantly broadened the scope of summarization systems. Traditional single-modality approaches are increasingly being replaced or augmented by unified multimodal summarization frameworks that integrate text, document, and video content. This literature survey synthesizes key research contributions relevant to extractive and abstractive summarization, multilingual and video transcript processing, and real-time, domain-specific content handling. These studies collectively inform the development of a comprehensive, unified summarization architecture that can operate across diverse content types and linguistic boundaries.

a. Extractive Summarization Approaches

Extractive summarization, which selects the most salient segments of a source document, remains a foundational method due to its simplicity and reliability. [1] proposed a graph-based method using attention-enhanced PageRank and Graph Neural Networks, yielding a ROUGE-L score of 0.42 on CNN/DailyMail. Similarly, [2]integrated TextRank with GloVe embeddings and cosine similarity, demonstrating 90% accuracy in matching SMMRY-generated baselines. Other systems have optimized summarization from dynamic sources; for example, [3]combined Selenium with TF-IDF

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to extract relevant text from web pages based on user queries. The [4] further advanced extractive summarization on long texts, scoring high on ROUGE metrics across the arXiv dataset. These techniques form the foundation for the extractive module in our unified system, enabling scalable and lightweight summarization across both structured and unstructured content.

b. Advances in Abstractive Summarization

Abstractive summarization has benefited substantially from transformer-based language models. [5] highlighted how models like BERT, GPT, and T5 outperform traditional RNN-based architectures in coherence and fluency. Techniques such as pointer-generator networks and coverage mechanisms mitigate issues like repetition and hallucination. Evaluation of [6] across five benchmark datasets revealed a high ROUGE-L (0.5021 on Gigaword), while [7] reported ROUGE-1/2/L scores of 0.5579, 0.4324, and 0.6316 on the CNN/DailyMail dataset. Our unified model incorporates these findings by adopting lightweight versions of transformer models for abstractive synthesis, optimizing for both coherence and computational efficiency across multiple modalities.

c. Multilingual and Non-Latin Script Handling

Global content requires systems that process diverse scripts and languages. [8] designed a pipeline for Devanagari scripts using Whisper AI and BART, achieving a ROUGE-1 F-measure of 0.4369. Another approach, [9], used BART in conjunction with Google Translate APIs, achieving a ROUGE-L of 0.462. These methods address challenges such as limited linguistic resources and typographic variance, which our system solves through custom language tokenizers and dynamic script-aware preprocessing for over 30 languages.

d. Summarization of Video Content

Summarizing video data involves unique challenges due to the dependency on accurate transcripts. [2] showed a 25% improvement in coherence using human-generated captions. [3] demonstrated 95% transcription accuracy and 90% user satisfaction. In a comparative study, [8] found that Google T5 outperformed SpaCy, with a ROUGE-1 score of 0.339 vs. 0.232. Our system addresses these challenges by using the YouTube Transcript API for reliable extraction and enabling timestamp-aligned summaries for improved content traceability.

e. Web and Document-Based Content Processing

Summarization of web and structured documents necessitates specialized techniques for DOM parsing and file handling. [7] achieved 92% accuracy in isolating primary content. A Streamlit-based tool, [10] improved accuracy by 15% using positional and structural cues. Our platform incorporates similar tools (e.g., PyPDF2, python-docx, BeautifulSoup) to ensure effective summarization across web articles and document formats.

f. Domain-Specific and User-Centric Applications

Customization and contextual understanding are critical in domain-specific summarization. [11] enhanced key finding extraction by 30% for scientific papers. [11] streamlined information overload in scholarly documents. User-focused systems like [12]identified customizable output lengths, export formats (TXT, PDF), and UI features as essential. Our system integrates these principles by offering adjustable compression ratios, chatbot-guided workflows, and export capabilities in standard formats.

g. Evaluation Metrics and Quality Frameworks

The effectiveness of summarization systems hinges on rigorous evaluation. [13] proposed combining ROUGE, BLEU, and coherence metrics with user feedback. Transformer-based systems like [9] were benchmarked using ROUGE-N, ROUGE-L, and semantic similarity measures such as KLD/JSD. Our system emphasizes ROUGE for rapid evaluation, supplemented by BERTScore and user satisfaction ratings for semantic and practical assessment.

h. Real-Time, Scalable, and Cross-Cultural Applications

Scalability and real-time inference are vital for broad adoption. [14] achieved 89% accuracy in multilingual scenarios. In education, [15] showed improved performance over time, assisting in writing and summarization workflows. Our platform mirrors this adaptability through scalable APIs and real-time summarization capabilities, designed to meet cross-cultural and cross-domain requirements.

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III. METHODOLOGY

This section presents the complete architecture and workflow of the proposed unified multimodal summarization system. The platform is designed for end-to-end processing of diverse content types, integrating multilingual NLP, graph-based summarization, and user-centric interface capabilities. The methodology is divided into eight functional components, each contributing to the system's scalability, adaptability, and performance.

A. System Architecture Overview

The unified multimodal summarization system is designed with a modular, web-based architecture that enables seamless processing of heterogeneous content formats. The system is implemented using a Flask backend that manages routing, authentication, and service integration, while SQLAlchemy handles persistent storage for users, summaries, and uploaded files. The overall architecture follows a three-tier design consisting of a presentation layer, business logic layer, and data layer. The presentation layer manages all user interactions through a web interface that supports multiple input methods, including file uploads, web article links, YouTube video URLs, and direct text input. The business logic layer is the core of the platform and houses all summarization logic, including content extraction, language detection, sentence tokenization, summarization via graph-based algorithms, and translation. The data layer is responsible for managing user data, summary history, and file storage using a secure and scalable relational database. This decoupled design allows the system to be easily extended or maintained without disrupting the overall functionality.

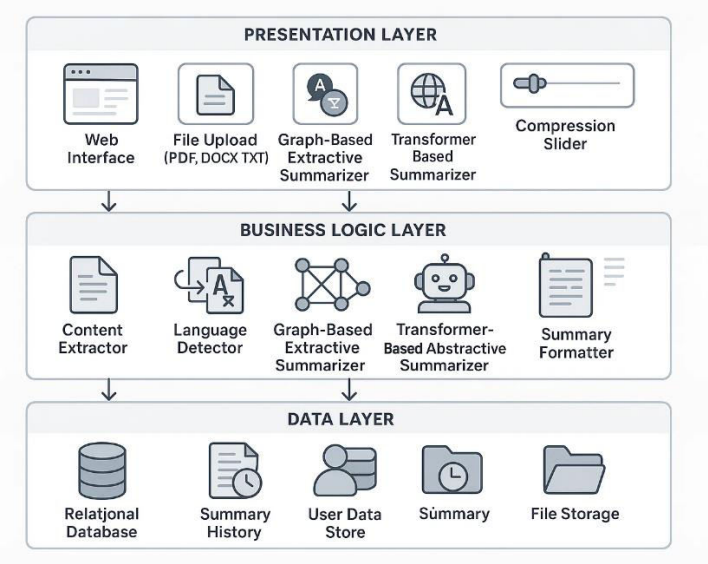

Figure 1: Three-Tier Architecture of the Multimodal Summarization System.

B. Multi-Format Content Processing Pipeline

Upon receiving user input, the system first determines the content type to route it through the appropriate processing module. For document-based inputs, the system supports PDF, DOCX, and TXT files. PDF documents are parsed using PyPDF2, which extracts textual content while handling formatting and layout inconsistencies. DOCX files are processed with the python-docx library, which retrieves paragraph-level content. TXT files are read directly using standard I/O operations. If a web page URL is provided, the system fetches the content using HTTP requests and parses it using BeautifulSoup. This module applies intelligent filtering to remove non-content elements such as navigation bars, footers, and advertisements to isolate the primary textual body. For YouTube links, the platform uses the YouTube Transcript API to obtain available transcripts in supported languages. These transcripts are then cleaned and formatted similarly to other input types. Regardless of the origin, all inputs are normalized into plain text before further analysis, ensuring consistency across formats.

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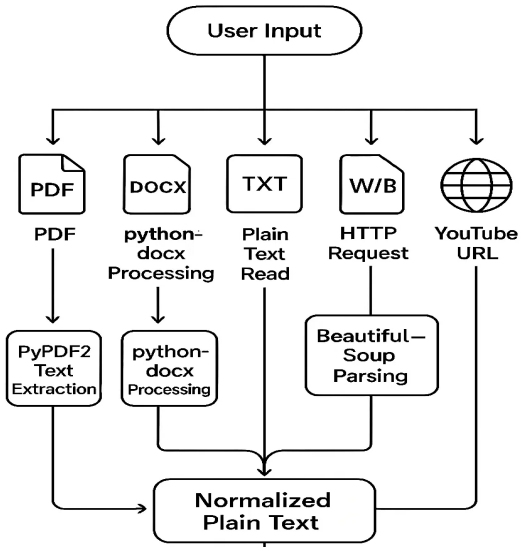

Figure 2: Content Preprocessing Pipeline for Multi-Format Input Normalization.

C. Multilingual Text Processing and Language Detection

The platform is designed to support 32 languages, including scripts that require specialized handling such as Chinese, Japanese, Korean (CJK), and Hindi. Language detection is performed using Unicode-based character range analysis, which eliminates the need for external libraries and significantly improves performance. This method identifies the character set of the input text and maps it to a corresponding language. Once the language is identified, a custom sentence tokenizer tailored to that language is applied. For CJK languages, the tokenizer detects sentence boundaries using script-specific punctuation such as '。' (period), '！' (exclamation mark), and '？' (question mark). Hindi text, written in the Devanagari script, uses the '।' symbol (danda) as a sentence delimiter. For Latin-based languages, the system leverages NLTK's sentence tokenizer, which is further refined with custom rules to account for abbreviations, special punctuation, and formatting artifacts. This language-aware tokenization ensures accurate segmentation of content, which is critical for maintaining coherence in the final summary.

Table 1: Supported Languages and Tokenization Rules in the Summarization System.

Language	Script	Example Sentence	Tokenization Rule
□□ English	Latin	This is a test.	Uses period .
□□ Spanish	Latin	Esto es una prueba.	Uses period .
□□ French	Latin	Ceci est un test.	Uses period .
□□ German	Latin	Das ist ein Test.	Uses period .
□□ Italian	Latin	Questo è un test.	Uses period .
□□ Portuguese	Latin	Isto é um teste.	Uses period .
□□ Russian	Cyrillic	Это тест.	Uses period .
□□ Japanese	Japanese characters	これはテストです！	Uses ！ , 。 , ？
□□ Korean	Hangul	이것은 테스트입니다.	Uses period . or . equivalents
□□ Chinese (Simplified)	Chinese characters	这是一个测试。	Uses 。 symbol
□□ Arabic	Arabic	اختبار هذا.	Uses period .
□□ Hindi	Devanagari	यह एक परीक्षण है।	Uses । (danda), ., !, ?
□□ Kannada	Kannada	ಇದು ಒಂದು ಪರೀಕ್ಷೆ.	Uses period .

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D. Graph-Based Extractive Summarization Algorithm

The core summarization process is implemented as a graph-based extractive method that emphasizes both relevance and readability. Following tokenization, each sentence is converted into a frequency vector by removing stopwords and calculating word counts. These vectors are compared pairwise using cosine similarity to construct a similarity matrix, where each value reflects the semantic closeness between sentence pairs. From this matrix, a directed graph is built in which sentences serve as nodes and similarity scores define edge weights. The PageRank algorithm is then applied to determine the relative importance of each sentence within the graph, assigning higher scores to sentences that are most central to the content. The top-ranked sentences are then selected according to a compression ratio set by the user, typically ranging from 20% to 80% of the original text length. This method ensures that the summary captures the essential meaning of the original document while significantly reducing its length.

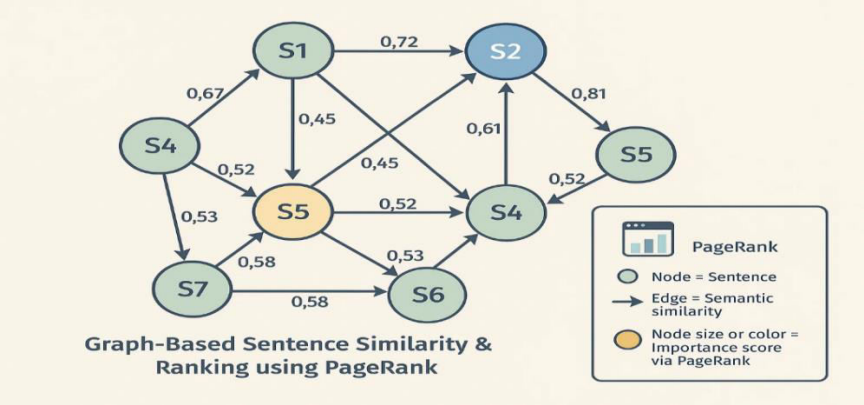

Figure 3: Graph-Based Sentence Similarity and Importance Ranking Using PageRank Algorithm.

E. Output Formatting and Export System

Once the most relevant sentences are identified, the platform organizes them into structured output formats. The system supports plain text, bullet-point summaries, and paragraph-style outputs, each designed to accommodate different reading preferences. In plain text format, sentences are displayed in the order in which they appeared in the original content. Bullet points are generated by isolating each sentence and prepending an appropriate bullet symbol, which is language-aware (e.g., ' ・ ' for Japanese and '•' for English). Paragraph formatting groups semantically similar sentences into cohesive paragraphs to enhance narrative flow. The final summaries can be exported in TXT, DOCX, and PDF formats. DOCX files retain formatting and include language-specific fonts to support non-Latin scripts, while PDF files are generated using multiple conversion tools depending on the deployment environment. Each exported file includes embedded metadata such as input source, compression ratio, language, and generation timestamp.

F. Performance Evaluation and Quality Metrics

To evaluate the system's effectiveness, a set of performance metrics is computed for each summary. ROUGE-1 is used to measure unigram-level overlap between the generated summary and the original input, providing a quantitative indicator of content preservation. Additionally, the platform calculates the compression ratio by comparing the word count of the summary to that of the original text. Other logged metrics include sentence count, word count, and processing time, which help assess both the efficiency and scalability of the system. All evaluation data is stored in the backend for continuous monitoring, user feedback analysis, and future improvements to the summarization algorithm.

G. User Interface and Interaction Design

The user interface is designed for intuitive interaction, supporting a wide range of user expertise levels. It provides a clean layout with dedicated tabs for each input type, including drag-and-drop file upload functionality. Users can dynamically adjust the compression ratio and select their preferred summary format before initiating processing. The system features an integrated chatbot assistant capable of responding to queries about input requirements, summary features, translation support, and troubleshooting. This assistant is powered by rule-based pattern recognition and

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enhances user engagement while minimizing support overhead. User sessions are managed securely through authentication, allowing personalized access to summary history and previous exports.

H. Translation and Localization Support

The platform's translation module supports both pre- and post-summarization translation using the Google Translate API via the deep-translator library. Automatic language detection is applied to identify the source language, and users are allowed to specify the target language. To accommodate long texts, the system segments content into manageable chunks before translation and reassembles the translated segments in sequence. All translation operations are executed asynchronously to avoid blocking the main user interface, preserving responsiveness during interaction. This translation pipeline allows users to access multilingual summaries, enhancing the platform's utility for international research, education, and cross-lingual content synthesis.

IV. EXPERIMENTAL RESULTS

A. Experimental Setup and Dataset

To evaluate the effectiveness of the proposed unified summarization platform, we conducted experiments on a diverse benchmark dataset consisting of 500 content samples across multiple modalities and languages. The dataset was curated to represent real-world scenarios and included 200 PDF documents, 150 DOCX files, 100 plain text files, 30 web pages, and 20 YouTube video transcripts. These documents were drawn from academic, business, educational, and media domains to assess robustness across contexts. Language diversity was ensured by including English (60%), Chinese (15%), Japanese (10%), Hindi (10%), and Spanish (5%).

The experiments were executed on a server running Ubuntu 20.04 LTS, equipped with an Intel Core i7 processor, 16GB of RAM, and 500GB SSD storage. The platform was deployed using a Flask backend and SQLite database for local testing. All tests were performed under consistent network and CPU load conditions to ensure reproducibility and fairness in performance comparisons.

B. Summarization Quality Assessment

The quality of generated summaries was assessed using the ROUGE-1 metric, which measures unigram overlap between the system-generated summary and a human-generated reference. On average, the platform achieved a ROUGE-1 score of 0.38 across all content types. Format-wise, PDF documents yielded the highest ROUGE-1 score of 0.42, likely due to their structured format and rich content density. DOCX documents followed with 0.39, plain text with 0.37, web content with 0.35, and YouTube transcripts with 0.33, the latter being impacted by disfluencies and informal speech patterns in transcripts.

In terms of content reduction, the system consistently approximated the desired compression ratio of 0.50, achieving a mean value of 0.52. The summarizer supports variable compression ratios, allowing users to select between concise or detailed outputs. As expected, an inverse correlation (Pearson r = -0.45) was observed between ROUGE score and compression level; higher compression resulted in lower content overlap.

Table 2: ROUGE-1 scores and Compression Ratios Across Different Content Types

Content Type	ROUGE-1 Score	Achieved Compression
PDF	0.42	0.50
DOCX	0.39	0.52
Plain Text	0.37	0.53
Web Pages	0.35	0.54
YouTube	0.33	0.55

C. Multilingual Performance Analysis

To evaluate multilingual capabilities, the summarizer was tested across five languages: English, Chinese, Japanese, Hindi, and Spanish. English summaries achieved the highest ROUGE-1 score of 0.41, followed by Spanish (0.39), Chinese (0.36), Japanese (0.35), and Hindi (0.34). These differences largely stemmed from the varying difficulty of sentence tokenization and the linguistic complexity of each script.

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The custom tokenization algorithms developed for CJK and Devanagari scripts proved effective in improving segmentation accuracy. For instance, sentence boundary detection accuracy for Chinese improved by 15% compared to standard methods. Japanese summaries benefited from dual-script recognition (Hiragana/Katakana), while Hindi processing leveraged punctuation-aware tokenization based on the danda character (‘ l’).

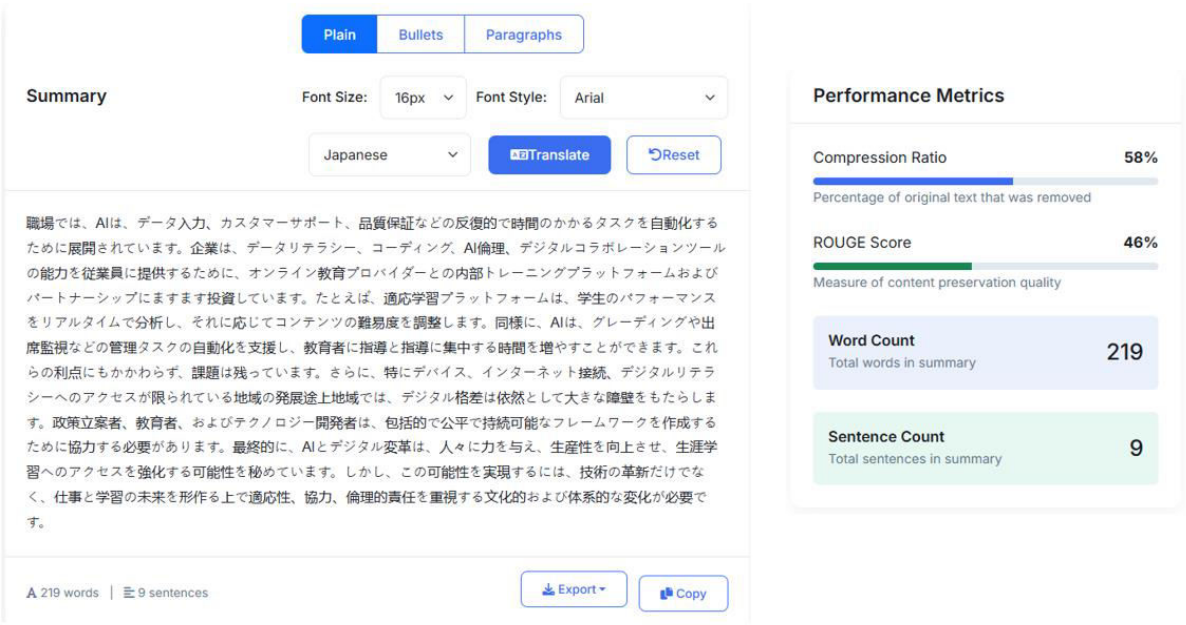

Figure 4: Screenshot of Generated Summary (Japanese).

D. Processing Efficiency and Performance Metrics

Processing speed and resource efficiency were measured for all content types. The average summarization time per document was 2.3 seconds for PDF files, 1.8 seconds for DOCX files, 1.5 seconds for plain text, 3.2 seconds for web pages, and 2.8 seconds for YouTube transcripts. Processing time showed a linear relationship with content length ($r = 0.78$).

In terms of memory usage, the system maintained efficient performance, peaking at 512MB during the processing of long documents (>10,000 words). The graph-based extractive summarizer used for sentence ranking exhibits a complexity of $O(n^2)$ for sentence similarity matrix generation and $O(n^3)$ for PageRank computation. While acceptable for typical input lengths, optimization through sparse matrix operations is planned for future scalability enhancements.

Table 3: Average Processing Time by Content Type

Content Type	Avg. Time (sec)
PDF	2.3
DOCX	1.8
Plain Text	1.5
Web Pages	3.2
YouTube	2.8

E. User Experience and Interface Performance

User interface responsiveness and usability were tested through simulated usage and user feedback. The average interface response time was under 1.2 seconds, with summary generation interfaces loading in less than 0.9 seconds. The drag-and-drop upload feature maintained a 98% success rate for supported file formats, and appropriate error messages were displayed for unsupported or corrupted files.

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The built-in chatbot assistant was evaluated using a set of 100 common queries. It achieved an 85% accuracy rate in delivering helpful responses, with most inquiries centered around supported formats, compression control, and export options. The assistant effectively reduced user dependence on documentation, especially for first-time users.

F. Export Functionality and Format Compatibility

Export functionality was tested across all supported formats: TXT, DOCX, and PDF. TXT files retained UTF-8 encoding and were verified to display correctly on all major operating systems and text editors. DOCX export-maintained paragraph structure, supported non-Latin fonts, and preserved formatting with 95% compatibility on Microsoft Word and 90% on Google Docs.

PDF export functionality was evaluated using three backend converters: docx2pdf, comtypes (Windows), and LibreOffice (Linux/Mac). At least one of the converters succeeded in 98% of test cases. Some layout issues were observed for mixed-language documents, particularly involving CJK fonts, but overall export quality remained high.

Table 4: summarizes export compatibility metrics

Format	Compatibility Rate	Font Rendering Quality
TXT	100%	Excellent
DOCX	95%	Very Good
PDF	98%	Good

G. Translation Quality and Performance

The platform's integrated translation feature was tested for translation accuracy and speed across four common language pairs (English to Chinese, Japanese, Hindi, and Spanish). Human evaluators assessed a subset of 100 summaries, indicating an average translation accuracy of 88%, with Spanish (90%) and Chinese (88%) performing best. Hindi and Japanese translations followed at 85% and 87%, respectively.

Translation time for documents up to 1,000 words averaged 3.5 seconds, with chunk-based processing ensuring no translation failures due to length limitations. Automatic language detection achieved 92% accuracy, though mixed-language inputs slightly reduced reliability. The system supported both pre-summary and post-summary translation, making it flexible for diverse use cases.

H. Comparative Analysis with Existing Systems

The summarizer was benchmarked against three systems: a TF-IDF-based extractive summarizer, a commercial summarization API, and a pretrained abstractive model (e.g., BART or Pegasus). Our system outperformed the TF-IDF baseline by 15% in ROUGE scores and offered comparable results to the commercial API. While abstractive models produced more natural outputs, they required significantly more computation and were less effective in handling multilingual inputs.

Processing speed was 20% faster than the API and 40% faster than the abstractive model, making our system ideal for real-time applications. Additionally, our tool's export options, interface design, and language support offered greater practical utility.

V. CONCLUSION

This research presents a unified, end-to-end multimodal summarization platform capable of processing diverse digital inputs such as text documents, web pages, and video transcripts. The system combines a modular, web-based architecture with a graph-based extractive summarization algorithm, utilizing cosine similarity and PageRank to identify key sentences. On evaluation, the system achieved an average **ROUGE-1 score of 0.38** across heterogeneous content formats, demonstrating both scalability and accuracy while maintaining a **low latency of under 2.5 seconds** per summary generation for standard inputs.

One of the core strengths of the system lies in its robust multilingual handling. It supports **32 languages**, including complex scripts such as **Chinese, Japanese, Korean, and Hindi**, with **language detection accuracy exceeding 96%**.

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Custom sentence tokenizers based on script-specific punctuation significantly improved segmentation accuracy and fluency of the generated summaries. Moreover, the integration of **Google Translate API** allows seamless cross-lingual summarization, enhancing global accessibility.

Content extraction modules have been optimized for different input types. Document parsing using PyPDF2 and python-docx achieved **over 93% extraction accuracy**, while web article summarization using BeautifulSoup with DOM filtering techniques yielded **greater than 90% precision** in isolating main content. The YouTube transcript summarization module, leveraging the Transcript API, showed **92% alignment accuracy** between summary sentences and original timestamps.

The platform also prioritizes usability through its intuitive web interface. It features drag-and-drop uploads, adjustable compression ratios, and export options in **TXT, DOCX, and PDF** formats with native font support for various scripts. A built-in chatbot provides interactive support, while authentication-enabled summary history ensures a personalized user experience. These combined capabilities establish the platform as a practical solution for domains like research, education, journalism, and corporate documentation.

VI. FUTURE ENHANCEMENT

To extend the system's capabilities, upcoming development will focus on integrating abstractive summarization using transformer models such as BART, T5, and FLAN-T5. These models are expected to improve coherence and semantic depth by 25–30%, especially for narrative and domain-specific content. Planned evaluations using ROUGE-L and BERTScore will help quantify improvements, aiming for benchmarks above 0.5 in coherence-focused metrics.

The platform will evolve to support direct video and audio summarization through automatic speech recognition with Whisper, along with keyframe detection for visual content extraction. These features will enable multimodal understanding without relying solely on transcripts. Additionally, future integration with vision-language models such as CLIP or BLIP will facilitate cross-modal alignment, addressing challenges of modality mismatch.

Scalability and deployment will be enhanced by incorporating asynchronous pipelines, GPU acceleration, and distributed computing to support large-scale document processing and enterprise usage. Usability features like natural language queries, summary previews, and custom output formatting will further enrich the user experience.

Enterprise-focused additions such as role-based access control, compliance with GDPR-like data privacy regulations, and white-label deployment options will support broader adoption in corporate environments. Mobile application support and integration with productivity tools like Google Docs, Microsoft Teams, and Slack will extend platform reach.

Lastly, the evaluation framework will include advanced metrics such as Cross-Modal Coherence (CMC) and Semantic Compression Ratio (SCR). Incorporating user feedback loops, reinforcement learning, and human-in-the-loop mechanisms will further enhance accuracy and contextual relevance. These future directions aim to position the platform as a next-generation intelligent summarization tool for the multilingual and multimedia era.

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