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Synoptix Summarizer: A Role and Style Adaptive Text Summarization Tool with Multi-Input Support

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Abstract- Text summarization plays a pivotal role in Natural Language Processing (NLP), enabling efficient distillation of key information from extensive and diverse textual content. This paper introduces Synoptix Summarizer, a modular, customizable summarization tool designed to accommodate multiple input types—including plain text, web URLs, image files, and PDFs—through an integrated and user-friendly interface. The system combines Optical Character Recognition (OCR) via EasyOCR, PDF parsing through PyMuPDF, and a large language model (LLM) accessed through a backend API currently under development. A Gradio-based frontend provides interactive controls that allow users to personalize summaries based on preferred output style (e.g., bullet points, simplified), target reader role (e.g., student, CEO), optional entity focus, and custom prompt instructions. Synoptix Summarizer explores the integration of diverse NLP components into a cohesive summarization pipeline. It emphasizes adaptability, extensibility, and real-world usability, contributing a flexible platform for intelligent content summarization across educational, professional, and everyday use cases.

Keywords- Text Summarization, Natural Language Processing(NLP), Large Language Model(LLMs), Abstractive Summarization, Facebook / Bart-Large-CNN, Optical Character Recognition(OCR), EasyOCR, Gradio Interface, PyMuPDF, Multi-Modal Input, Deep Learning, User-Centric NLP Tools.

I. INTRODUCTION

In today's information-centric environment, users across sectors—academic, legal, corporate, and technical—are frequently overwhelmed by the volume and complexity of textual content. Extracting meaningful insights from such content is both time-consuming and cognitively demanding. Conventional extractive summarization techniques, which select and rearrange existing sentences from source material, often lack coherence, readability, and semantic adaptability. As advancements in Natural Language Processing (NLP) progress, abstractive summarization—where the system generates novel sentences that convey the core ideas of the original—has emerged as a superior alternative for producing human-readable and contextually rich summaries.

Recent developments in transformer-based deep learning models, particularly the advent of pre-trained

Large Language Models (LLMs) such as facebook/bart-large-cnn available via Hugging Face Transformers, have significantly improved the ability to summarize text with fluency and contextual accuracy. These models allow for rephrasing and condensing information while preserving its meaning. However, deploying such models effectively in real-world applications presents challenges such as handling multi-format input (text, images, PDFs), performing text preprocessing, and delivering an accessible and interactive user experience.

This paper introduces Synoptix Summarizer, a modular and user-friendly summarization system that aims to address these challenges. The system supports input from various formats including plain text, image files (e.g., JPG, PNG), and PDF documents. It integrates EasyOCR to extract text from image-based content, PyMuPDF to process multi-page PDF documents, and the facebook/bart-large-cnn model accessed via Hugging Face's pipeline interface to perform abstractive summarization. The frontend is built using Gradio, offering users an intuitive web-based platform to upload inputs and receive personalized summaries. Summaries can be tailored to the reader's context by selecting summary style (e.g., bullet points, simplified) and reader role (e.g., student, CEO), with additional support for custom instructions and entity-focused highlighting.

A core feature of the system is its preprocessing pipeline, which ensures that the input passed to the summarization model is clean, relevant, and well-structured. This step includes OCR text normalization, PDF text segmentation, punctuation correction, and removal of irrelevant characters or symbols. Such preprocessing improves both the quality of the summary and the consistency of results across different content types.

Importantly, the summarization model is accessed via a backend API integration (currently under development), allowing efficient processing without the overhead of maintaining large model weights on the client side. The use of OCR further enhances the system's utility in real-world scenarios involving scanned notes, handwritten content, or multilingual documents. Preliminary testing demonstrates that this hybrid approach outperforms traditional extractive summarization in coherence, readability, and adaptability to different user profiles.

The primary contributions of this paper are as follows:

- Design and implementation of a flexible summarization pipeline supporting input from multiple sources: text, images, URLs, and PDF documents.
- Integration of OCR, PDF parsing, and LLM-based summarization in a unified architecture accessible via Gradio.
- A preprocessing strategy to sanitize and normalize input prior to inference, thereby improving summarization accuracy.
- Practical evaluation of the system using diverse real-world data to assess summarization fluency, contextual relevance, and usability.

The remainder of this paper is organized as follows: Section II discusses related work in NLP-based summarization, OCR, and multimodal content processing. Section III outlines the system architecture, including the preprocessing pipeline and model integration. Section IV presents experimental results, focusing on summarization performance across different input types. Section V concludes the study and outlines future enhancements including multi-language support, offline summarization capabilities, and integration of user feedback for continuous improvement.

By combining OCR-driven extraction, flexible input handling, and LLM-based summarization within an intuitive interface, Synoptix Summarizer aims to provide a scalable and effective solution for diverse real-world summarization needs.

II. RELATED WORKS

Text summarization is a core area of research in Natural Language Processing (NLP), aiming to condense large volumes of text into concise, coherent summaries while preserving the original meaning. Traditionally, extractive summarization has dominated this space, relying on methods that select important sentences directly from the source. Notable algorithms like TextRank and Latent Semantic Analysis (LSA) have demonstrated effectiveness on structured content [1]. However, their inability to generate natural or paraphrased language often results in summaries that lack coherence and contextual flow.

The emergence of deep learning brought significant improvements, particularly in abstractive summarization. Sequence-to-sequence (Seq2Seq) models with attention mechanisms represented a breakthrough by enabling models to generate new phrases and focus selectively on relevant parts of the input text [2]. Despite these gains, challenges such as factual inaccuracies and grammatical inconsistency persisted.

The introduction of transformer architectures, especially encoder-decoder models like BART (Bidirectional and Auto-Regressive Transformers), further advanced the field. BART combines the strengths of both denoising autoencoders and autoregressive decoders, making it highly effective in summarization tasks. The facebook/bart-large-cnn model, a fine-tuned version of BART, has achieved strong results on summarization benchmarks such as CNN/DailyMail, demonstrating fluency, conciseness, and semantic fidelity [3][4].

The proliferation of cloud-accessible APIs and pre-trained models via platforms like Hugging Face has significantly lowered the entry barrier for implementing state-of-the-art summarization models. Developers can now leverage powerful Large Language Models (LLMs) without hosting them locally, thus allowing lightweight systems to integrate advanced summarization capabilities through API endpoints.

Another vital dimension of modern summarization systems is input format diversity. In practical settings, content is not limited to plain text; users often need to summarize data from scanned documents, handwritten notes, or complex PDFs. Optical Character Recognition (OCR) plays a critical role here. While earlier OCR systems like Tesseract provided basic capabilities, deep learning-based tools such as EasyOCR have improved performance, especially on noisy, multilingual, or non-standard input formats [5].

Handling PDF content, which may contain embedded images, non-linear layouts, or mixed-language text, is facilitated by libraries like PyMuPDF. This toolkit enables structured extraction of text from multi-page PDF documents while preserving formatting details. When combined with preprocessing techniques—such as character normalization, whitespace cleanup, and punctuation correction—these tools provide well-structured input to summarization models.

From a usability standpoint, interactive platforms like Gradio have gained popularity for rapidly deploying NLP applications. Gradio supports drag-and-drop interfaces, real-time feedback, and multi-input formats, allowing developers to focus on backend logic while offering users an intuitive front-end experience [6].

Despite these advancements, most academic efforts focus narrowly on either model performance or input preprocessing. Key research gaps still include:

- Lack of unified frameworks that integrate OCR, PDF parsing, and LLM-based summarization.
- Limited benchmarking of summarization performance across multi-format, real-world inputs.
- Minimal exploration of preprocessing pipelines tailored to noisy, informal, or multilingual text inputs.
- Few interactive systems optimized for non-technical users via accessible web interfaces.

This paper addresses these gaps by presenting a modular summarization tool that combines image-based text extraction (via EasyOCR), PDF parsing (via PyMuPDF), and abstractive summarization using facebook/bart-large-cnn through the Hugging Face Transformers pipeline. The entire workflow is wrapped in a web-based Gradio interface. Although the full deployment pipeline is currently under development, initial evaluations demonstrate the potential of such an integrated system in producing coherent, user-adaptive summaries across various content types.

III. COMPARATIVE ANALYSIS

Automatic summarization systems can be evaluated across multiple dimensions, including input type compatibility, summarization method, model accessibility, user customization, and interface usability. While existing models such as BERTSUM, GPT-3-based summarizers, and hybrid pipelines (e.g., Tesseract + LLM) have demonstrated success with text summarization, they often lack integration across diverse file formats and do not provide end-user control over summarization behavior.

The proposed system— Synoptix Summarizer—was designed to address these limitations by offering a modular framework that integrates image, PDF, and text processing, OCR-based extraction, and customization via a user-friendly web interface. This section compares Synoptix Summarizer with several established alternatives to contextualize its contributions and highlight its practical advantages.

Table 1: Comparative Overview of Summarization Systems

2.

Feature / Tool	BERT SUM	GPT-3 Playground	EasyOCR + LLM	Synoptix Summarizer (Proposed)
Input Formats	Text only	Text only	Image + Text	Text, Image, PDF, URL
Summarization Type	Extractive	Abstractive	Abstractive	Abstractive
OCR Integration	No	No	Yes (Basic Tesseract)	Yes (EasyOCR – multilingual)
PDF Support	No	No	Limited (manual)	Yes (via PyMuPDF)
Summary Customization	No	Prompt-based	Limited	Yes (style, role, entity focus)
Interface Type	CLI or code	Web-based	CLI or scripts	Web UI (Gradio)
Deployment Complexity	Medium	Cloud-based	High (manual setup)	Low (lightweight + modular)
Model Hosting	Local	Hosted (OpenAI)	Local / remote	API-based (Hugging Face pipeline)
Language Support (OCR)	N/A	N/A	Limited	80+ Languages (EasyOCR)
Real-world Input Ready	No	Partially	Moderate	High

Key Comparisons and Insights

1. Input Format Flexibility

Synoptix Summarizer uniquely supports multi-modal input, including plain text, scanned images, PDF documents, and web URLs. In contrast, BERTSUM and GPT-3 tools focus exclusively on text-based content. The inclusion of EasyOCR and PyMuPDF allows the system to handle real-world input sources, making it more versatile.

Summarization Capability

3. OCR and PDF Handling

Tools like EasyOCR + GPT pipelines require manual integration and often lack multilingual support. Synoptix Summarizer uses EasyOCR, a deep learning–based OCR system that supports over 80 languages and variable layouts, enhancing text recognition across image files. PyMuPDF integration ensures reliable extraction from multi-page or structured PDFs.

4. Personalization and Customization

Unlike traditional models, Synoptix Summarizer allows users to choose summary styles (e.g., bullet points, ELI5, executive summary), define the reader's role (e.g., student, CEO), and optionally focus on specific named entities. These features offer greater control over how information is summarized and presented—something not typically available in generic summarization tools.

5. Deployment and Usability

Most existing models are built for researchers and developers, with no ready-to-use interface. Gradio integration in Synoptix Summarizer enables an intuitive web-based UI that supports file uploads, URL input, and dropdown customization, making it accessible even for non-technical users. This sets it apart as a practical tool suitable for academic, professional, and educational use.

6. Model Accessibility and Inference

Unlike solutions that require local hosting of large model weights, Synoptix Summarizer interfaces with Hugging Face's hosted model endpoints. This reduces system requirements and makes it suitable for lightweight deployments such as cloud notebooks or low-power environments.

7. Scalability and Adaptability

Thanks to its modular design, Synoptix Summarizer can be easily extended to support more languages, additional file types, or domain-specific tuning. Its flexibility ensures adaptability to evolving summarization needs, making it more future-ready than single-purpose summarizers.

Summary

Overall, the comparative analysis demonstrates that Synoptix Summarizer provides a more holistic and adaptable solution compared to existing summarization systems. By unifying OCR, PDF parsing, and LLM-based summarization into an accessible framework, it bridges a key gap between research-oriented NLP tools and real-world user demands.

IV. PROPOSED WORKS

This section outlines the design vision, foundational motivation, and intended functionalities of the Synoptix Summarizer system. The system is conceptualized as a lightweight, modular summarization tool that integrates multiple open-source technologies to provide real-time, abstractive summaries from varied input formats including plain text, scanned documents, PDFs, and web URLs.

4.1 Problem Statement

Despite the significant progress in automatic summarization technologies, most existing solutions suffer from the following limitations:

- They are typically confined to plain text input and do not support formats such as images or PDFs.
- Summaries generated are often generic and lack customization in tone, structure, or user-specific perspectives.
- Many systems require local deployment of large language models, demanding high-performance hardware.
- Tools that integrate OCR and summarization often involve multiple disconnected components or require programming knowledge to operate.
- There is a lack of intuitive, accessible interfaces for users with limited technical background.
- Existing frameworks rarely address multilingual document handling or noisy real-world inputs (e.g., scanned handwritten notes).

Synoptix Summarizer is proposed to bridge these gaps by offering a single interface that combines multi-modal input processing, OCR integration, PDF parsing, and LLM-based summarization via API access, all wrapped in a simple Gradio-based web interface.

4.2 Objectives

The primary objectives of the proposed system are:

- To build a summarization tool that accepts and processes diverse input types: text, images, PDFs, and web URLs.
- To integrate EasyOCR for accurate text extraction from image-based content, including scanned or handwritten documents.
- To employ PyMuPDF for extracting structured text from multi-page PDF files.
- To leverage the Hugging Face Transformers pipeline for generating abstractive summaries using the facebook/bart-large-cnn model.
- To allow summary customization based on user-selected roles (e.g., Student, CEO) and styles (e.g., Bullet Points, Executive Summary).
- To optionally support named entity–focused summarization (e.g., people, organizations, dates).
- To present all functionalities via an intuitive and responsive web interface built using Gradio.
- To maintain modularity in code design, ensuring future adaptability to multilingual summarization or other file types.

4.3 Proposed Solution Overview

The Synoptix Summarizer tool is designed as an end-to-end pipeline that accepts input in various formats, extracts the relevant text using preprocessing techniques, and then summarizes it using a transformer-based model. The summarized output is displayed interactively through a browser-based UI. The system architecture includes the following core modules:

- Input Handler: Determines the type of user input (text, image, PDF, or URL) and routes it to the appropriate extractor.
- Preprocessing Layer:
  - OCR Engine (EasyOCR) for image and scanned document processing.
  - PDF Parser (PyMuPDF) for extracting content from PDFs.

- URL Fetcher for web article parsing via requests.

● Prompt Builder: Constructs a model-ready summarization prompt using user-specified parameters such as summary style, role, and focus entities.

● Summarizer Module: Connects to the Hugging Face summarization pipeline and uses a pre trained LLM (facebook/bart-large-cnn) to generate concise and human-readable summaries.

● Gradio Interface: Provides interactive frontend elements such as text boxes, dropdowns, and file upload buttons to guide user interaction.

By encapsulating these components within a flexible architecture, the system aims to offer a low-latency, high-utility summarization experience suited for academic, business, and general-purpose applications.

V. METHODOLOGY

The development of Synoptix Summarizer follows a modular and layered approach, enabling flexibility in handling multiple input types and summarizing them effectively through a structured and customizable pipeline. This section outlines the methodology adopted to design and implement the system, including both the software design process and the interaction between its core components.

5.1 Methodological Approach

The system was designed to meet the following methodological goals:

● Modularity: Each component (input handling, text extraction, summarization, UI) is built as an independent, reusable module.

● Input Agnosticism: The system supports diverse formats including plain text, scanned images, PDFs, and online content (URLs).

● Layered Processing: Inputs are processed through a staged pipeline involving extraction, cleanup, formatting, and summarization.

● Customization: Users can select summary tone, target audience, entity focus, and provide their own summarization prompts.

● User Accessibility: The entire system is deployed with an interactive, no-code frontend (Gradio) to support general users.

5.2 System Workflow

The summarization process is divided into the following phases:

1. Input Acquisition:
   - Users can input raw text, upload documents (PDF, TXT, PNG, JPG), or enter a URL pointing to an article.
   - The system detects the input type and forwards it to the relevant extraction module.
2. Preprocessing and Extraction:
   - For PDF files, PyMuPDF is used to extract text content page by page.
   - For images, EasyOCR performs Optical Character Recognition (OCR) to convert visual text into editable strings.
   - For URLs, a requests-based parser downloads and extracts the readable content from the web page.
   - All extracted content is cleaned by removing unwanted whitespace, special characters, and formatting errors.
3. Prompt Preparation:
   - The user can optionally select parameters such as:
     - Summary Style (e.g., Simple Summary, Bullet Points, Executive Summary)
     - Target Role (e.g., Student, CEO, Teacher)
     - Entity Focus (e.g., People, Organizations, Dates)
     - Custom Prompt or Instruction (free-text guidance to personalize output)
   - These options are compiled into a formatted prompt which guides the summarization API in generating relevant summaries.
4. Summarization:
   - The cleaned text and user prompt are passed to the backend summarization engine through an internal or external API.
   - The API uses a pre trained large language model (hosted locally or remotely) to produce the abstractive summary.
   - The model processes a truncated version of the text (limited by token constraints) and returns a concise, well-structured summary.
5. Output Generation:

- The resulting summary is displayed through the Gradio interface.
- Users can read, copy, or refine the summary by modifying the input parameters and re-running the process.

5.3 System Design

Synoptix Summarizer's system design is structured around five major functional layers:

1. User Interface Layer (Gradio):
   - Text input field
   - File upload module
   - URL input field
   - Dropdowns for summary style, role, entity focus
   - Output box to display the summary
2. Input Handler Layer:
   - Detects input type (text, image, PDF, or URL)
   - Routes to the correct preprocessing pipeline
3. Preprocessing Layer:
   - Image files: EasyOCR
   - PDF files: PyMuPDF
   - URL: Web scraper (requests and HTML parser)
   - Text cleaner: whitespace, encoding, punctuation fixers
4. Prompt Builder:
   - Generates structured summarization instructions based on user settings
   - Adds control tags and focus areas
5. Summarization API Engine:
   - Receives cleaned text and prompt
   - Generates abstractive summary using an existing large language model
   - Returns final summary for display
6. Output Renderer:
   - Presents summary via Gradio
   - Allows real-time feedback and iteration

5.4 System Flow Diagram (Descriptive)

User Input → Input Type Detector →
↳ PDF → PyMuPDF → Cleaned Text
↳ Image → EasyOCR → Cleaned Text
↳ URL → Web Scraper → Cleaned Text
↳ Text → (direct) → Cleaned Text
Cleaned Text + Prompt → Summarization API → Final Summary → Gradio UI

This design ensures smooth interoperability between modules, supports expansion to new file types, and allows for external summarization models to be swapped or upgraded as required.

VI. RESULTS

Preliminary testing of Synoptix Summarizer demonstrated its ability to generate coherent, adaptable summaries across diverse input formats, including plain text, PDFs, and images. The system successfully processed scanned documents and multi-page PDFs using integrated OCR (EasyOCR) and PyMuPDF, extracting clean text for summarization. When configured for different user roles (e.g., student or CEO), the abstractive summaries produced by the facebook/bart-large-cnn model via Hugging Face's pipeline exhibited appropriate stylistic variations, such as simplified bullet points for academic use or concise executive briefs. While the current implementation handles standard inputs effectively, limitations were observed with exceptionally long PDFs due to token constraints. The modular design and Gradio interface proved effective for real-world usability, though formal user studies and multilingual support remain areas for future validation.

VII. CONCLUSION AND FUTURE WORKS

This research presents Synoptix Summarizer, a practical, customizable, and multi-modal text summarization system designed to process content from various sources including raw text, images, PDFs, and web links. The system aims to bridge the gap between advanced NLP capabilities and real-world usability by integrating OCR, document parsing, and an abstractive summarization engine into a single modular interface.

Key components such as EasyOCR and PyMuPDF allow users to extract content from unstructured and visually complex formats like scanned documents or multi-page PDFs. A preprocessing pipeline ensures that noisy input is cleaned and formatted before summarization, thereby improving the coherence and relevance of the generated summaries. The inclusion of user-defined preferences—such as target reader role, summary style, entity focus, and custom instructions—enhances the adaptability of the tool to various domains and audiences.

The system prioritizes usability through a Gradio-based interface, offering an accessible and interactive experience for non-technical users. It also maintains a modular backend architecture, enabling easy updates and the integration of future language models or summarization services.

Preliminary evaluations demonstrate that the proposed system performs well in terms of flexibility, relevance, and ease of use. It successfully handles a wide range of input formats and produces summaries that are concise, coherent, and contextually aware.

FUTURE WORKS

While Synoptix Summarizer addresses several limitations of current summarization tools, there remains significant potential for enhancement. Future development directions include:

1. Multilingual Summarization Support:
Expanding both OCR and summarization capabilities to support input and output in multiple languages will increase global usability, particularly for users dealing with non-English content.

2. Domain-Specific Summarization:
Implementing customizable models or prompts tailored to specific fields—such as legal, medical, or academic content—would improve summary relevance and factual alignment in specialized domains.

3. Offline and Edge Deployment:
Enabling offline summarization by packaging pretrained models locally would reduce dependency on internet access and APIs, especially in privacy-sensitive environments or low-connectivity regions.

4. Summarization from Audio and Video:
Incorporating speech-to-text pipelines to support summarization from audio lectures, podcasts, or video captions would extend the system to new modalities.

5. Real-Time Summarization:
Enhancing the system to provide live summarization of streaming content or dynamically updating documents (e.g., live transcripts, meeting minutes) could support fast-paced applications like journalism or education.

6. Feedback Loop and Reinforcement Learning:
Integrating user feedback to evaluate and fine-tune the summary output over time would improve long-term performance and personalization of the system.

7. Mobile and Cross-Platform Compatibility:
Building native mobile or browser extensions could further simplify access, allowing users to summarize content on the go or directly from their web activity.

In summary, Synoptix Summarizer establishes a robust foundation for intelligent, customizable summarization while remaining flexible and accessible. Ongoing improvements in language models, OCR quality, and UI technologies will make it increasingly powerful and adaptable to diverse real-world applications.

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