IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Neurolearn AI: Generative Learning Platform For Intelligent Educational Video Summarization And Assessment

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Abstract: Traditional e-learning platforms lack real-time personalization and engagement, leading to passive consumption and reduced retention. NeuroLearn AI proposes an AI-driven educational framework that transforms educational videos into structured learning artifacts using technologies such as Gemini API, LangChain, and Retrieval-Augmented Generation (RAG). The platform automatically extracts YouTube video transcripts and generates summaries, quizzes, flashcards, and personalized learning paths. A built-in progress tracker and adaptive assessments further ensure consistent student engagement. Designed to be scalable, accessible, and inclusive, the system demonstrates high learner satisfaction and improved retention, redefining how students engage with educational content.

Index Terms - Video Summarization, Personalized Learning, AI-Powered Flashcards

I. INTRODUCTION

Education is evolving rapidly, yet students still face challenges like scattered content, lack of personalization, and low engagement. Platforms like YouTube offer vast academic content, but passive consumption leads to poor retention and motivation. Traditional e-learning tools are fragmented, offering isolated quizzes or notes without adaptability or accessibility.

NeuroLearn AI addresses this gap by transforming educational videos into structured learning through transcript summarization, personalized quizzes, and flashcards. By integrating emotional engagement, inclusivity, and adaptive feedback, it offers a smart, scalable, and interactive learning experience for all.

1.1 Motivation

Education is vital for growth, yet many students face fragmented, unstructured learning experiences. Platforms like YouTube offer abundant content, but learners often struggle with retention, motivation, and overload. Traditional e-learning lacks adaptability and real-time feedback. Marginalized groups, including visually impaired learners, remain underserved. Emerging AI technologies now make it possible to build inclusive, personalized, and engaging learning systems that turn passive video consumption into active learning.

1.2 Problem Statement

Current e-learning platforms often lack deep personalization, emotional engagement, and real-time adaptability. Students are left without structured study paths, tailored feedback, or AI-driven content recommendations. Most systems either deliver content passively or offer generic, context-free assessments. NeuroLearn AI addresses this gap by extracting knowledge from educational videos and generating personalized quizzes and flashcards. By incorporating explainable AI, the system ensures transparency and scalability, offering learners an interactive and reliable digital learning companion.

II. LITERATURE SURVEY

Researchers have extensively explored the application of Artificial Intelligence and Generative AI in enhancing digital learning experiences. Studies on intelligent tutoring systems, adaptive e-learning models, and AI-driven content generation highlight the potential of these technologies in improving personalization, engagement, and learner retention. Despite significant progress, current approaches face challenges such as limited real-time adaptability, lack of multimodal content understanding, and insufficient inclusivity for diverse learners. Moreover, many existing systems focus on static textual materials and fail to utilize the vast pool of educational video data available online. There remains a strong need for scalable, automated solutions capable of transforming unstructured video content into personalized, interactive, and explainable learning resources.

Key reviewed works include:

- **Meghana Puvvadi et al. (2025, IEEE ICISS):** This paper explores the application of Generative AI for building personalized learning systems. The authors demonstrate how transformer-based models and natural language generation enhance adaptive content delivery, quiz formulation, and student engagement. The study integrates ethical AI and Explainable AI (XAI) principles to ensure transparency and inclusivity in learning models. Experimental results show improvements in learner motivation and completion rates across AI-integrated learning platforms. However, this approach focuses primarily on generative text learning rather than video transcript-based content generation and multimodal assessment. The research establishes a strong foundation for integrating AI into education but remains limited to text-driven frameworks, indicating the need for incorporating multimodal inputs such as video and audio data to create richer and more context-aware learning experiences.
- **Xin Wang (2025, IEEE EESPE):** The author proposed an AI-powered personalized learning platform based on cross-border e-commerce education using NLP, ML, and knowledge graphs. Employing the CIPP evaluation model, the research analyzes system performance in terms of learning outcome, adaptability, and interactivity. The platform uses an intelligent feedback loop to adjust content based on user progress and learning style. The study emphasizes real-time analytics and learner profiling to improve personalized education quality. However, its domain-specific application limits generalization. NeuroLearn addresses this by extending personalization to video-based content and adaptive generative study modules for a broader learning spectrum.
- **Lyazzat Zhaidakbayeva et al. (2024, IEEE ICAI):** This research provides a comprehensive review of AI learning models aimed at developing next-generation e-learning platforms. The paper highlights the use of deep learning, data analytics, and machine learning for adaptive learning and student engagement optimization. It identifies challenges in scalability, feedback loops, and real-time adaptation, which hinder widespread adoption of AI-driven systems. The study emphasizes personalization through data mining but lacks an automated generative content mechanism. NeuroLearn bridges this gap by integrating retrieval-augmented generation (RAG) and large language models (LLMs) to transform unstructured video transcripts into structured learning material.
- **Dominik Bernd Oliver Bösl et al. (2024, IEEE ITHET):** This study presents APOLLO, an AI-based lifelong learning companion designed to optimize personal and professional growth. The system helps learners manage, organize, and enhance their lifelong educational journeys by providing tailored course recommendations and adaptive learning pathways. The platform leverages AI to map user skill profiles and suggest personalized training programs across disciplines. It highlights accessibility and scalability in lifelong education. However, it focuses on structured formal learning rather than automated generative video-based learning as implemented in NeuroLearn. Additionally, APOLLO lacks real-time adaptability and multimodal integration, which limits its ability to handle diverse content formats. NeuroLearn overcomes these limitations by automating transcript analysis, summarization, and self-assessment generation, offering a more dynamic and inclusive framework.
- **Hrishikesh D. J. et al. (2024, IEEE ICCPCT):** The paper introduces Skillify, an AI-powered Learning Management System (LMS) built using Generative AI to enhance student engagement through real-time interaction. The system employs Spring Boot and AI-driven content recommendation models to create personalized assessments and text-to-speech-enabled lessons. This study demonstrates how AI integration can simplify content creation and automate feedback for learners. While Skillify focuses on adaptive assessments and AI-powered course delivery, it lacks multimodal transcript summarization and generative study materials, which form the foundation of NeuroLearn's design. Furthermore, Skillify's structure remains limited to pre-defined content modules, while NeuroLearn provides automated content generation from raw video data. This makes NeuroLearn more flexible, learner-centered, and scalable for diverse educational environments.

- **S. P. Wavre et al. (2025, IEEE IATMSI):** This paper applies Edward de Bono's "Six Thinking Hats" model to AI-based learning systems to foster creativity and self-reflection in learners. The study emphasizes emotional intelligence and engagement by aligning cognitive models with AI-driven learning pathways. It highlights how emotional engagement enhances individual participation and retention within online platforms. The paper demonstrates a psychological framework for AI-based personalization but does not integrate generative video summarization or autonomous flashcard and quiz creation—key features of NeuroLearn AI. Moreover, the framework focuses mainly on emotional aspects rather than knowledge structuring or concept reinforcement. NeuroLearn bridges this gap by combining emotional engagement with automated content generation, creating a more holistic and adaptive learning ecosystem.

From this review, it is evident that prior research has advanced personalization and automation in e-learning but often overlooked real-time adaptability, multimodal content generation, and accessibility for diverse learners. The proposed system aims to bridge these gaps by transforming unstructured educational videos into structured, interactive, and inclusive learning experiences.

III. PROPOSED SYSTEM AND METHODOLOGY

3.1 System Architecture

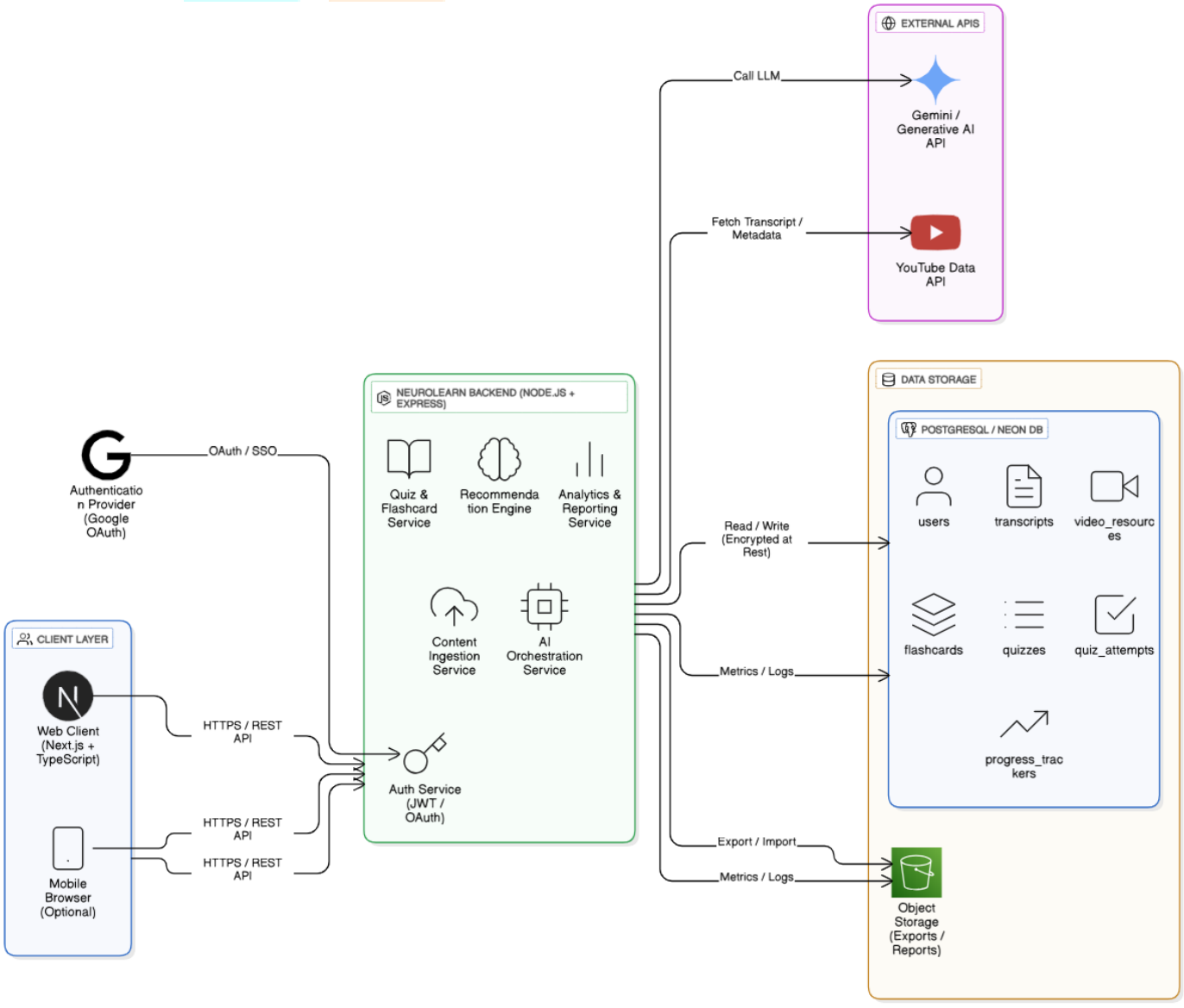

Fig. 1: NeuroLearn AI System Architecture

The system consists of three major stakeholders:

- **Students:** Students are the core users of the NeuroLearn AI platform. They interact through the web or mobile interface by providing YouTube video links, which the system automatically processes to generate structured study materials such as summaries, quizzes, and flashcards. The platform monitors learning behavior, quiz performance, and engagement levels in real time to recommend personalized study paths. Students receive adaptive feedback and progress reports through the dashboard, helping them improve retention and understanding over time. Furthermore, accessibility features like text-to-speech and AI-driven explanations support diverse learning styles and ensure inclusiveness for all learners.
- **Administrators:** Administrators are responsible for managing and maintaining the entire NeuroLearn ecosystem. Their duties include monitoring backend services, managing user authentication through Google OAuth, handling API key configurations for Gemini AI and YouTube, and ensuring database stability. They oversee the flow of data between modules—transcript extraction, AI processing, and analytics—to maintain accuracy and system reliability. Administrators also manage user records, storage security, and compliance with data protection standards like GDPR and FERPA. Through dedicated monitoring dashboards, they track system performance, error logs, and API usage metrics to ensure smooth and uninterrupted functioning of the platform.
- **Auditors:** The AI Services layer acts as the cognitive engine of NeuroLearn AI. It integrates the Gemini API, LangChain, and Retrieval-Augmented Generation (RAG) mechanisms to transform unstructured video transcripts into coherent summaries, quizzes, and flashcards. The system also uses a recommendation engine that personalizes content based on learners' quiz accuracy, engagement history, and time spent on topics. This backend operates asynchronously with caching and fallback logic to ensure real-time response even during high API load. It continuously evolves through data-driven insights, creating a dynamic, adaptive, and context-aware learning experience that bridges the gap between raw educational content and intelligent, interactive learning outcomes.

3.2 Methodology

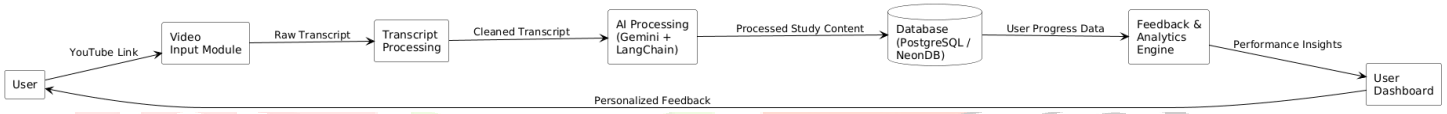

Fig. 2: Data Flow Diagram

- **Data Ingestion:** The system accepts YouTube video links from users and retrieves transcripts automatically using the YouTube Data API.
- **Transcript Processing:** Extracted transcripts are cleaned and structured for better readability and AI analysis.
- **AI Processing:** The Gemini API and LangChain framework generate concise summaries, flashcards, and quizzes from processed transcripts.
- **Database Management:** All processed learning content and user progress data are securely stored in a PostgreSQL/NeonDB database.
- **Feedback and Analytics:** User interactions, quiz scores, and learning patterns are analyzed to generate performance insights and adaptive recommendations.
- **Personalized Dashboard:** Learners receive tailored feedback and progress summaries through an interactive dashboard for continual improvement.

3.3 State-Machine Diagram:

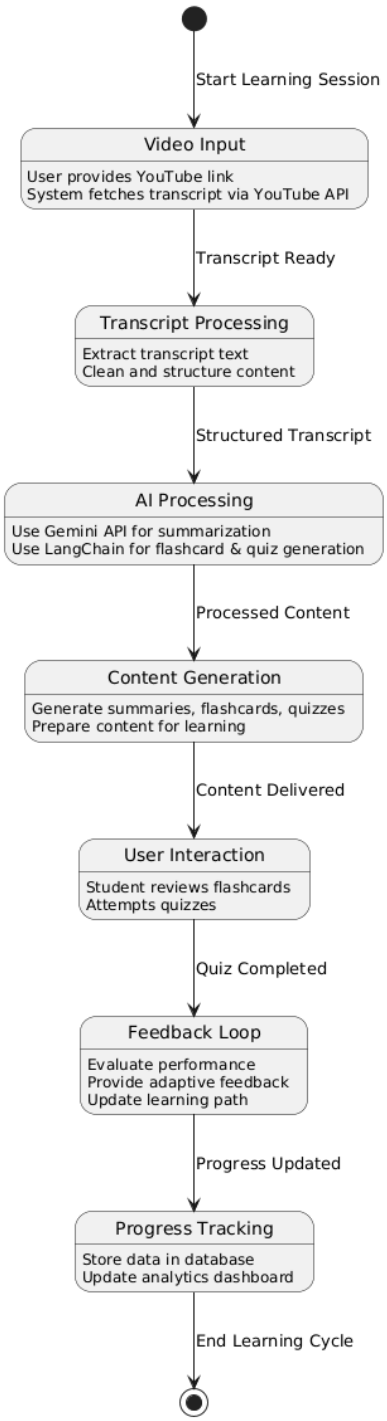

Fig. 3: State Machine Diagram

Roles and Functions of the System:

- **Video Input:** This state initiates the learning session, where the user provides a YouTube video link. The system fetches the transcript using the YouTube API for further processing.

- **Transcript Processing:** In this state, the system extracts, cleans, and structures the transcript text to prepare it for AI-based summarization and learning material generation.

- **AI Processing:** The AI module uses the Gemini API for content summarization and LangChain for generating quizzes and flashcards. This ensures structured, context-aware learning resources.

- **Content Generation:** Here, the processed content is transformed into summarized notes, flashcards, and quizzes. The learning materials are then made available for the student to review.

- **User Interaction:** Students engage with the generated content by reviewing flashcards and attempting quizzes. This step allows for active participation and reinforcement of key topics.

- **Feedback Loop:** Based on student quiz results, the system evaluates performance and provides adaptive feedback. It helps refine learning paths to match individual progress levels.

- **Progress Tracking:** The final stage stores updated data in the database and refreshes the analytics dashboard. It records learner activity, quiz performance, and overall improvement to complete the learning cycle.

3.3 Minimum Viable Product:

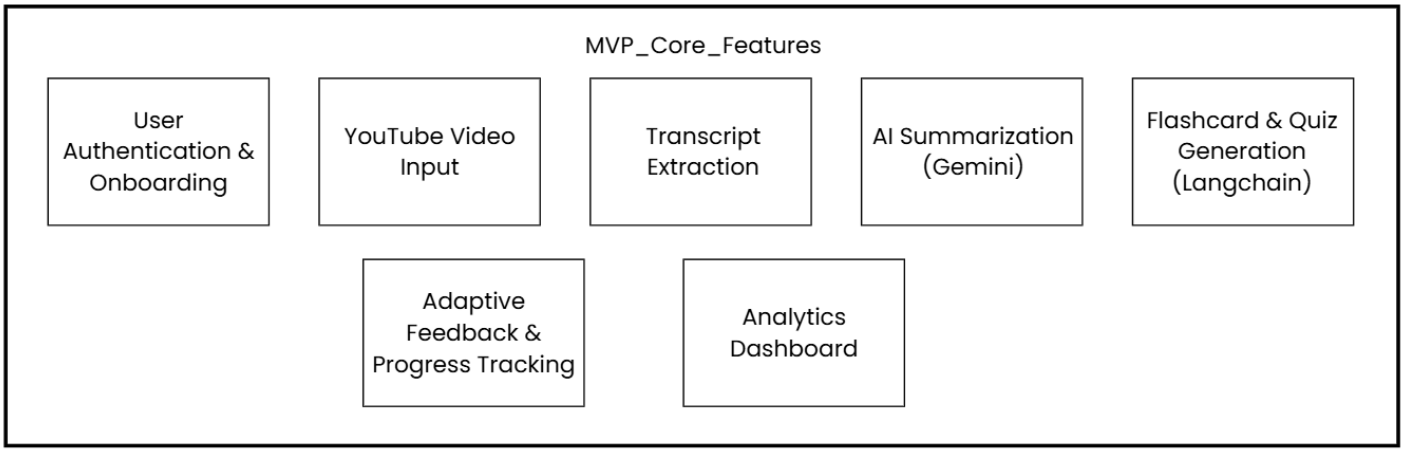

Fig. 4: MVP Diagram

Key functionalities include:

- **User Authentication & Onboarding:** Ensures secure access and profile creation for every learner, enabling a personalized experience. It stores user preferences, learning goals, and historical data to tailor study paths and content recommendations.
- **YouTube Video Input:** Allows users to input educational video links for AI-based content generation. This module connects with the YouTube API to automatically fetch transcripts, metadata, and captions required for processing.
- **Transcript Extraction:** Automatically extracts and cleans transcripts from uploaded videos to prepare structured text. It segments long transcripts into logical sections for easier summarization and quiz generation.
- **AI Summarization (Gemini):** Utilizes the Gemini API to create concise, context-aware summaries from extracted transcripts. This ensures learners focus on key points, improving comprehension and retention efficiency.
- **Flashcard & Quiz Generation (LangChain):** Employs LangChain for transforming summarized content into interactive flashcards and quizzes.
- **User Interaction & Quiz Attempt:** Allows learners to interact with AI-generated content and test their understanding through quizzes. The system records performance data to improve subsequent learning recommendations.
- **Adaptive Feedback & Progress Tracking:** Monitors user engagement and quiz scores to deliver personalized feedback in real-time. It adjusts learning material difficulty and content delivery pace based on individual progress.
- **Analytics Dashboard & Recommendations:** Displays user progress, activity statistics, and learning insights through visual analytics. It provides AI-based recommendations to guide learners toward continuous improvement.

3.4 Component Diagram:

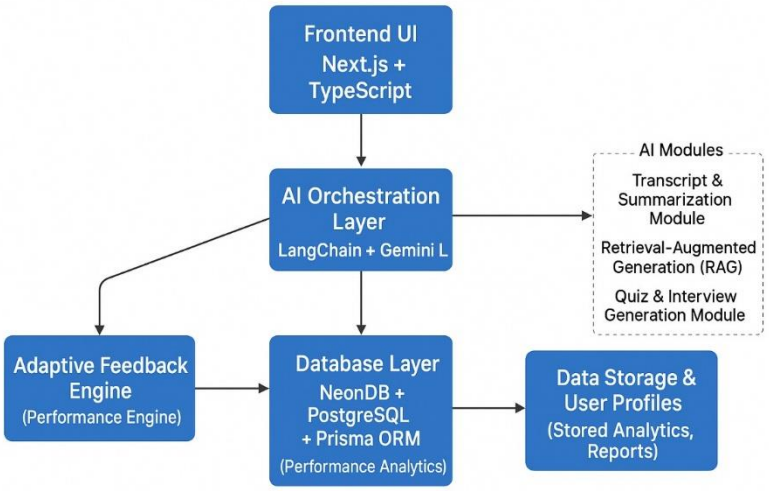

Fig. 5: Component Architecture

Unit Overview:

- **Frontend UI (React.js):** The user-facing layer that enables learners to interact with the system. Built with Next.js and TypeScript, it manages video inputs, quizzes, and analytics through a responsive web interface and communicates with backend APIs.
- **AI Orchestration Layer (LangChain + Gemini API):** The core intelligence module coordinating data flow between AI models. LangChain handles prompt chaining and context retrieval, while Gemini API performs summarization, quiz generation, and other language tasks.
- **Database Layer (NeonDB + PostgreSQL + Prisma ORM):** Stores structured data such as user profiles, transcripts, quiz results, and progress metrics. Prisma ORM ensures smooth database interaction with NeonDB and PostgreSQL for reliable and scalable storage.
- **Adaptive Feedback Engine (Performance Engine):** Analyzes user progress and quiz outcomes to generate personalized feedback. It dynamically adjusts recommendations and learning paths to enhance user engagement and performance.
- **Data Storage & User Profiles (Reports and Analytics):** Handles storage of reports, analytics summaries, and performance logs. It enables progress tracking and generates visual insights for learners and administrators.
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IV. COMPARISON WITH EXISTING SYSTEMS

Traditional e-learning and content delivery systems often rely on static materials, manual quiz creation, and limited personalization. They lack automation in transcript generation, adaptive assessment, and real-time learner feedback.

By contrast, **NeuroLearn AI offers:**

- Automated transcript extraction and summarization from educational videos using YouTube and Gemini APIs.
- Intelligent quizzes and flashcard generation powered by LangChain for personalized learning.
- Adaptive feedback and progress tracking based on learner analytics.
- Seamless content organization and retrieval through AI-driven knowledge structuring
- Improved accessibility through AI-generated study content.

This combination directly addresses the gaps found in existing systems.

V. APPLICATIONS

- **Educational Institutions:** Assist schools, colleges, and universities in automating lecture summarization, quiz creation, and personalized learning content generation using AI-driven tools for students and faculty.

- **E-Learning Platforms:** Integrate with platforms such as Coursera, Udemy, or institutional LMS systems to automatically convert video lectures into structured learning materials, enhancing student engagement.

- **Corporate Training Programs:** Enable companies to develop AI-based employee upskilling modules that adapt to learner progress and generate assessments automatically, ensuring continuous professional development.

- **Research and Academia:** Support research scholars by transforming recorded presentations or webinars into concise transcripts, notes, and flashcards for efficient review and knowledge retention.

- **Accessibility and Inclusive Learning:** Provide adaptive study content for differently-abled learners through AI-powered video transcription, summarization, and speech-to-text support.

VI. CONCLUSION

NeuroLearn AI demonstrates how generative artificial intelligence can revolutionize personalized education by automating transcript processing, content generation, and adaptive assessment. Through the integration of Gemini API, LangChain, and YouTube data extraction, the system efficiently transforms raw video lectures into structured, interactive learning materials. It enhances accessibility, engagement, and retention by tailoring study experiences to individual learner needs.

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