TRIBHUVAN UNIVERSITY

Faculty of Computer Science and Information Technology

Edusense Learning AI Agent

Mid defense Project Report

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For the partial fulfillment of Bachelor's degree requirements in Computer Science and Information Technology

<u>To be supervised by</u>:

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Supervisor's Recommendation

It's my earnest recommendation that this specific project entitled "**Edusense Learning AI Agent**" prepared by our genuine students with team members including Rabin Ghalan, Raunak Pyakurel and Shishir Bartaula under my supervision in the partial fulfillment of Bachelor's degree requirements in Computer Science and Information Technology is proposed for the final evaluation.

……………………….

Er. Sonam Yadav, Supervisor

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ABSTRACT

EduSense AI Agent is a web-based platform created to make learning more interactive and effective for students. It allows users to upload study materials such as PDFs, Word files, and images, which are then processed to extract key concepts and organize them into a clear knowledge base. With the help of an AI tutor, students can ask questions directly from their documents and receive simple, explanations anytime, making study sessions more efficient and engaging. In addition to question-answering, EduSense AI Agent provides visual tools like knowledge graphs that help learners understand complex topics more easily. The platform is designed with a focus on user-friendly design, data security, and continuous improvement based on user feedback. By combining AI tutoring, document analysis, and knowledge visualization, EduSense AI Agent aims to become a dependable companion that supports students in their everyday learning journey.

LIST OF FIGURES

Chapter 1: Introduction

1.1 Introduction

Education is rapidly changing with the advancement of digital technologies and artificial intelligence. Traditional learning methods are often limited in providing personalized guidance, and many students face challenges in understanding complex topics or managing substantial amounts of study material. In this context, there is a growing demand for smart educational tools that can make learning more interactive, accessible, and effective. AI-powered systems can support students by analyzing their study materials, answering questions in simple ways, and helping them visualize knowledge for better understanding.

To address this need, our team developed EduSense Agent, a web-based platform designed to manage resource and chat with RAG agent. The system allows users to upload study materials in formats such as PDF, Word, or images, which are then processed to extract key concepts and build an organized knowledge base. Students can interact with the RAG Agent to receive personalized explanations and use tools like knowledge graphs to explore complex topics visually. With a focus on ease of use, data security, and continuous improvement through feedback, EduSense Agent aims to provide a reliable and modern solution that supports students in their learning journey.

1.2 Problem Statement

In today's digital learning environment, students often face challenges in accessing reliable study resources, managing their learning materials securely, and receiving timely academic support. Existing platforms are either too generalized, lacking subject-specific focus, or fail to integrate advanced technologies. As a result, learners spend excessive time searching for relevant notes, clarifications, and conceptual understanding, which reduces study efficiency and negatively impacts learning outcomes. There is a pressing need for a comprehensive platform that bridges technological innovation with effective learning practices, ensuring secure resource management, quick access to key concepts.

1.3 Objective

- To function as a bridge between technological innovation and effective learning outcomes.
- To provide students with a secure platform for uploading and managing their study materials.
- To deliver personalized tutoring through AI-powered question answering and explanations.
- To help learners save valuable study time by offering quick access to key concepts and visual learning tools.

1.4 Scope and Limitations

1.4.1 Scope

In the context of modern education, digital learning platforms are gaining wide importance as students increasingly rely on technology to study, revise, and manage their materials. EduSense AI Agent has a broad scope in providing intelligent document analysis, interactive question answering, and knowledge visualization features. The platform allows users to upload study materials in different formats such as PDFs, Word documents, and images, which are then processed to extract key concepts. Students also have access to an AI Agent that offers personalized explanations through chat, while visual tools like knowledge graphs help in better understanding of complex topics. Additionally, the platform emphasizes secure user authentication, easy profile management, and continuous improvement based on feedback, ensuring a reliable and engaging learning experience.

1.4.2 Limitations

It is important to recognize the limitations that may affect the project in the future. One notable challenge is ensuring consistent performance across different devices and browsers, as variations in operating systems and screen sizes may impact usability. Another limitation is the dependency on internet connectivity, since EduSense AI Agent requires online access for processing documents and generating responses, which may restrict its use in areas with poor connectivity. Additionally, the platform currently supports only limited file formats and languages, which may not cover all learners'

needs. Addressing these limitations will require system optimization, support for more languages and formats, and possible offline features in the future.

1.5   Development Methodology

1.5.1   Agile Development Methodology

Agile is an iterative and flexible software development methodology where the project is divided into smaller cycles called sprints. Each sprint focuses on delivering a working feature, followed by review and feedback, which helps in continuous improvement. Unlike the linear and rigid approach of the Waterfall model, Agile emphasizes adaptability, teamwork, and quick responses to changing requirements. It is suitable for our project due to:

- Continuous Feedback

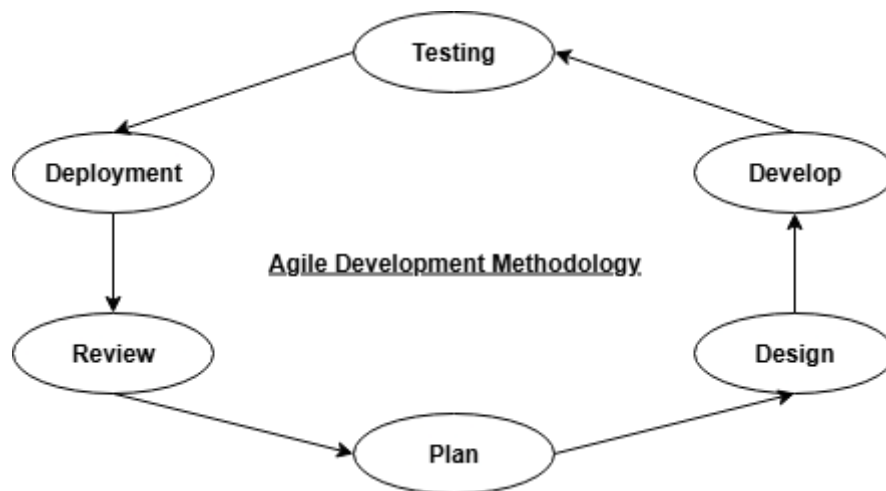- Faster Delivery of Features

- Flexibility to Adapt Changes

Figure 1.5.1 Agile Methodology

The first step in any project is to select a suitable development model. For EduSense AI Agent, our team adopted the Agile Development Model because of its ability to manage evolving requirements in educational technology. The process begins with gathering requirements such as document upload, AI chats, and knowledge visualization features. These requirements are then broken down into user stories and planned into sprints. Each sprint involves designing, implementing, and evaluating a small part of the system. For example, the file upload module, the AI question-answer

system, or the mind map visualization. After each sprint, feedback is collected, and improvements are made before moving to the next cycle. This iterative process allows us to continuously refine EduSense AI Agent, ensure user satisfaction, and quickly address issues, leading to a more reliable and user-friendly platform.

1.6 Report Organization

The brief overview and fundamentals of the project are being summarized in the context of introduction, objectives, problem statement and development methodology. In the next chapter, there will be fundamental theories, literature reviews, algorithms used to include the analysis of similar projects and the research done by other researchers.

Chapter 2: Background Research and Literature Review

1.7 Background Research

Education has continuously evolved with the integration of technology, moving from traditional classrooms to digital learning platforms. The introduction of e-learning systems in the late 20th century provided students with greater flexibility and accessibility to knowledge. Today, modern approaches such as Learning Management Systems (LMS), AI-powered tutoring, and adaptive learning models are reshaping the way students' study and interact with educational content.

AI in education is being widely adopted to support personalized learning, intelligent content analysis, and interactive assistance. Current trends include the use of AI tutors, automated grading systems, knowledge visualization tools, and multilingual support to reach diverse learners. However, challenges such as data privacy, system reliability, and the need for quality learning materials remain key concerns in the development of AI-driven educational applications.

1.8 Literature Review

Recent research highlights the transformative potential of artificial intelligence in education, particularly using AI tutors. Baillifard et al. [1] conducted a case study demonstrating how an AI-powered tutor can implement core learning principles such as spaced repetition and personalized retrieval practice. Their findings suggest that students who engage with AI-driven tutoring systems achieve significantly better academic outcomes compared to peers without such support. This underscores the role of AI in enhancing personalization and learning efficiency.

Beyond personalization, the usability of e-learning platforms depends heavily on their user interface and user experience design. Miya and Govender [2] emphasized in their review that well-designed UX/UI not only improves student engagement but also contributes directly to better learning effectiveness. Their work highlights the necessity of aligning technical innovations with intuitive and learner-friendly design practices.

In addition, Hasani et al. [3] investigated user-centered design (UCD) approaches in e-learning platforms, concluding that projects which actively involve users during the design process, through techniques like prototyping and iterative testing, achieve superior usability outcomes. This evidence reinforces the importance of designing platforms that adapt to learners' needs rather than forcing learners to adapt to rigid systems.

Taken together, these studies indicate that effective AI-supported education requires not only advanced tutoring models but also careful attention to usability and user-centered design. Platforms such as EduSense AI Agent, which integrate AI, secure document management, and visual knowledge tools, are positioned to bridge the gap between technological innovation and effective learning outcomes.

Chapter 3: System Analysis

1.9   System Analysis

1.9.1   Requirement Analysis

EduSense AI Agent, being an AI-powered tutoring platform, requires a set of robust features to ensure accurate knowledge processing, interactive learning, and secure user access. The system must allow users (students) to upload study materials in formats such as PDF, Word, or images, which will then be processed to extract key concepts and build a structured knowledge base. A conversational AI tutor will allow users to ask questions, get personalized explanations, and visualize topics through mind maps and knowledge graphs. Additionally, the platform should maintain data security, provide role-based access (admin and users), and ensure a user-friendly interface.

1.9.2   Functional Requirements

i.   **User Registration and Authentication**
     The system must allow users to register with unique credentials and log in securely.

ii. **Material Upload and Processing**
     Users should be able to upload study materials in formats such as PDF, Word, and images. The system must process these files, extract text, and generate a knowledge base from the content.

iii. **AI Interaction through Chat**
     The system must provide an AI-driven chat interface where students can ask questions and receive contextual, simplified explanations based on their uploaded materials.

iv. **Knowledge Visualization**
     The platform should generate mind maps, knowledge graphs, and other visual tools to help students understand complex topics in a structured manner.

v.   **Content Navigation**

Users must be able to search uploaded content and navigate through key concepts or topics easily.

1.9.3   Non-Functional Requirements

i.   **Performance**

The system must be able to process and extract information from study materials in real-time or with minimal delay.

ii.   **Scalability**

EduSense AI Agent should support many simultaneous users and manage large files without performance degradation.

iii.   **Usability**

The platform must provide an intuitive and user-friendly interface that ensures ease of navigation for students of all levels.

iv.   **Security**

Uploaded materials and user credentials must be encrypted to ensure data privacy and integrity. Multifactor authentication should be implemented for additional security.

v.   **Reliability**

The system must be universally available with minimal downtime, ensuring students can rely on it for their studies.

1.9.4   Software Requirements

i.   **Client Side**

On the client side, the focus is on designing a responsive and interactive user interface for students to interact with the AI tutor. This includes implementing navigation, chat functionalities, and visualization tools like knowledge graphs and mind maps. The client application is built using **React.js**, which ensures smooth rendering and responsiveness across devices.

Minimum Requirements (Client Side):

- Device: Desktop, Laptop, or Smartphone with modern browser support
- Internet Connection: Stable connection

- Browser Compatibility: Google Chrome (latest), Firefox, Microsoft Edge, Safari

ii. Server Side

On the server side, the backend is built using Node.js, Express.js with Langchain and Langgraph providing APIs for user management, file handling, and communication with the RAG Agent. MongoDB is used to store user credentials, study materials metadata, and knowledge graphs. Uploaded materials (PDF, Word, images) are processed and forwarded to LLM for intelligent tutoring responses.

Minimum Requirements (Server Side):

- Backend Framework: Node.js with Express.js
- Database: MongoDB
- Hosting: Cloud server (Vercel)
- AI Processing: RAG with Langchain and Langgraph
- API Integration: REST API calls between client and server

1.10 Feasibility Analysis

Feasibility Analysis is the decisive analysis of the project to understand and determine the potential risks and suitable environment. Through the analysis, the decision must be taken whether a proposed project is viable and worth pursuing. For the initiation of the project, the following feasibility study must be considered:

1.10.1 Technical Feasibility

EduSense AI Agent is developed using the MERN stack with Langchain for RAG integration, making it compatible across modern devices and browsers. React.js ensures a smooth interface, while Node.js, Express.js, and MongoDB provide secure and scalable backend support. With authentication and reliable API communication, the system can efficiently manage file uploads, AI responses, and visualizations, proving its technical feasibility.

1.10.2 Operational Feasibility

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EduSense AI Agent is easy to operate, allowing students to upload study materials, interact with the AI through Chat, and explore visual learning tools. The project milestones were managed effectively, and the platform complements existing study practices without disruption. Its simplicity and usefulness confirm its operational feasibility.

1.10.3 Economic Feasibility

EduSense AI Agent is cost-effective as it relies on open-source technologies like MongoDB, React.js, Node.js, and Express.js reducing development expenses. The main cost involves hosting, and minimal server resources. Compared to traditional tutoring services, the platform offers a scalable and affordable solution, making it economically feasible for both developers and users.

1.10.4 Schedule Feasibility

The objective is to determine whether the project can be completed within the specified time frame. We are required to assess the realistic time required for each phase of the project. And there will surely arise the internal as well as the external factors that may impact on the project timeline. So, multiple dependencies for the project's completion must be there.
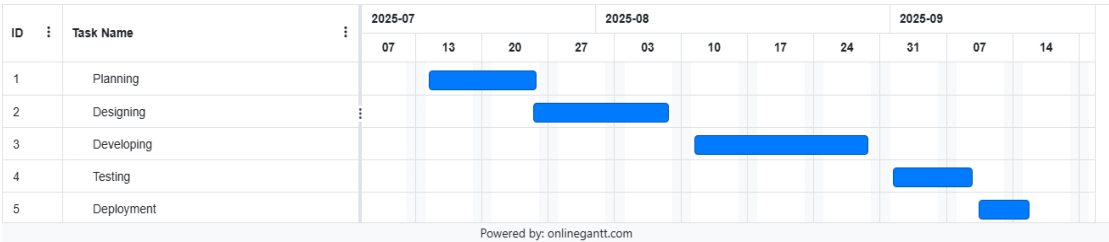
Figure 3.2.4 Gantt Chart

Chapter 4: System Design

System design phase is the crucial stage in the web application development lifecycle. During this phase, the overall architecture and structure of the application are planned in detail. We as a design team must address the components and modules with functional as well as non-functional requirements of the application. Additionally, the design phase involves defining the data models, outlining system workflows and data protection mechanisms.

1.11 Architectural Design

In the architectural design of the EduSense AI web application, client–server communication is based on structured requests and responses. The React.js frontend sends requests to the backend server for tasks such as uploading study materials, managing user authentication, and retrieving AI-generated responses. The Node.js + Express.js backend processes these requests, communicates with the MongoDB database for storing user data and study material information, and interacts with the RAG Agent for AI-powered explanations and Structured LLM for knowledge visualization. The system follows a three-tier architecture: the React.js client as the presentation layer, the Node.js/Express.js backend with Langchain and Langgraph as the application layer, and MongoDB for operational database and vector database.
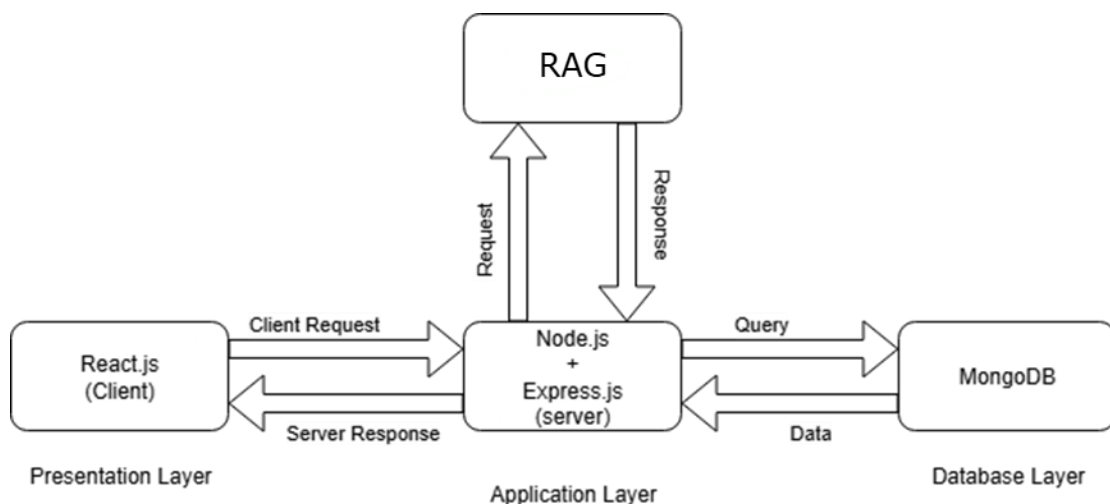
Figure 4.1.   Architectural Design
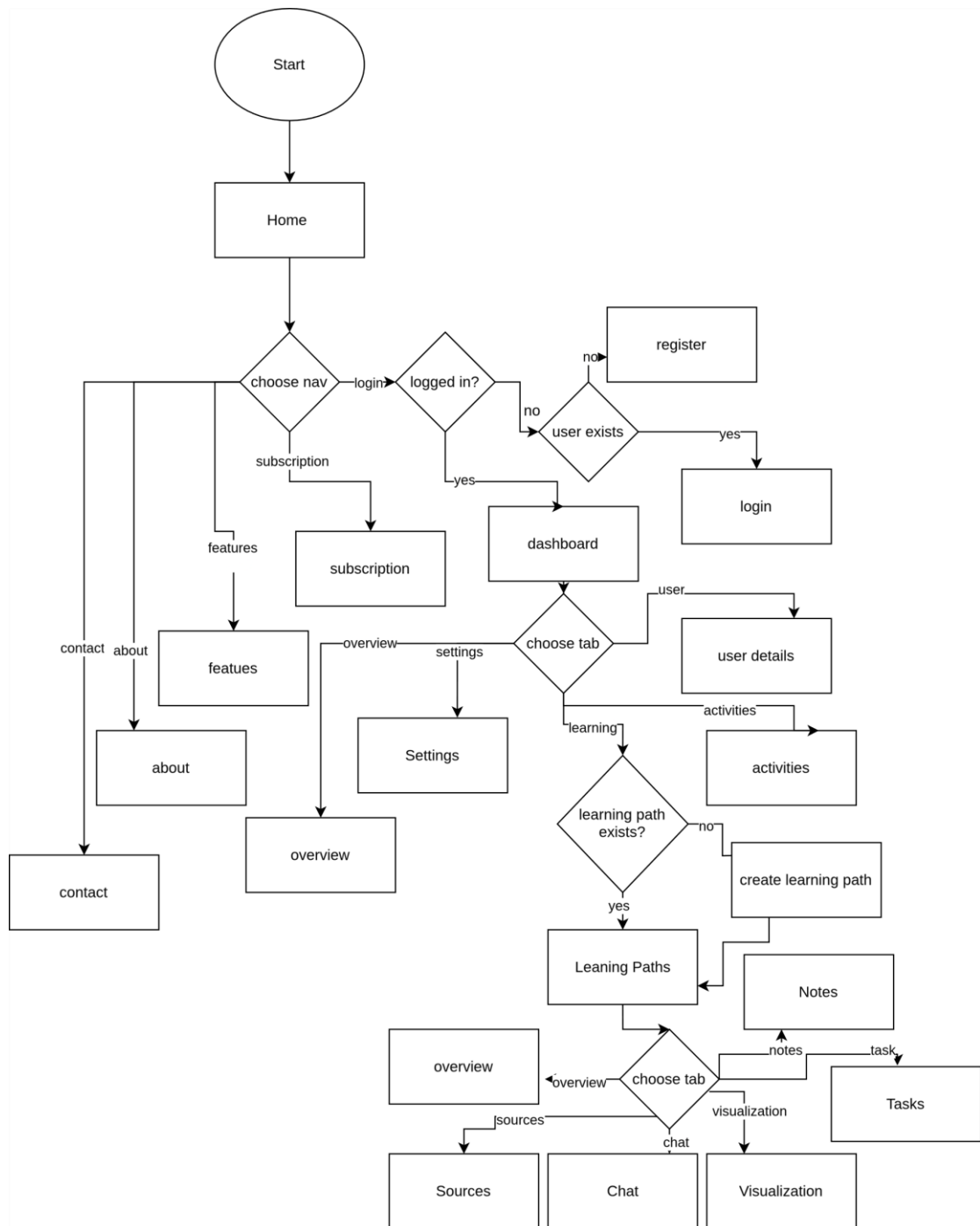
1.12 Project Flowchart

Figure 4.2 Flowchart
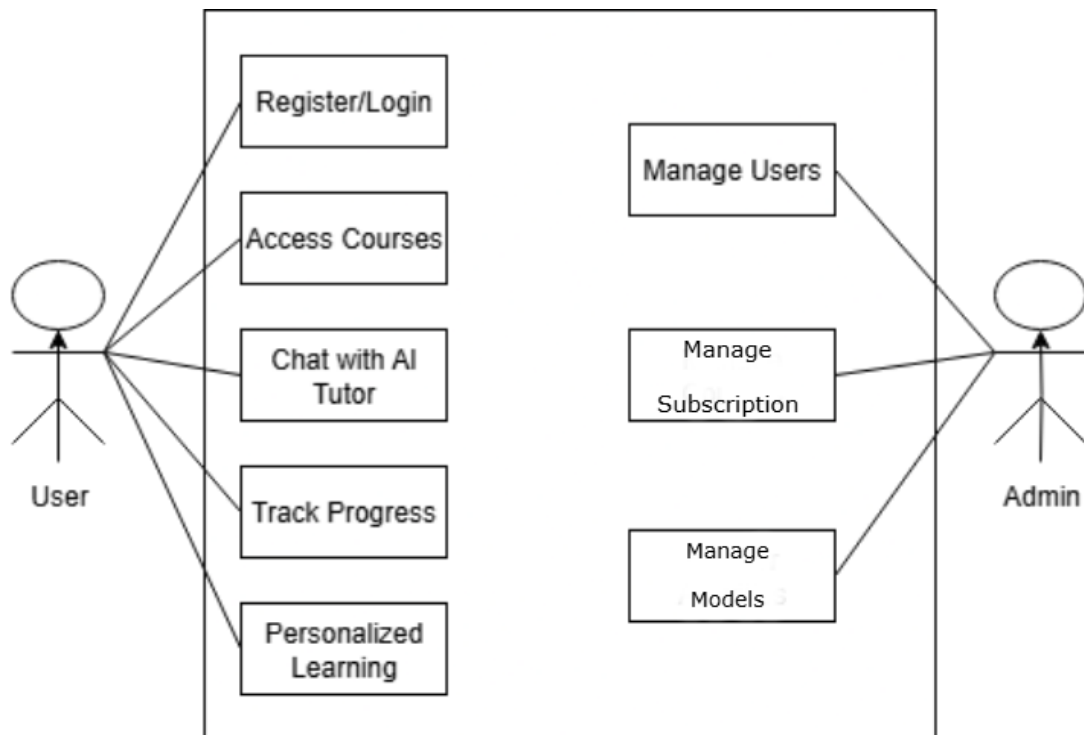
1.13 Use Case Diagram

Figure 4.3   Use Case Diagram

The Use Case Diagram for Edusense highlights the key functionalities available to the user. The user can register/login, access courses, chat with AI tutor, track progress, etc. and the admin can manage users, courses and monitor activities.
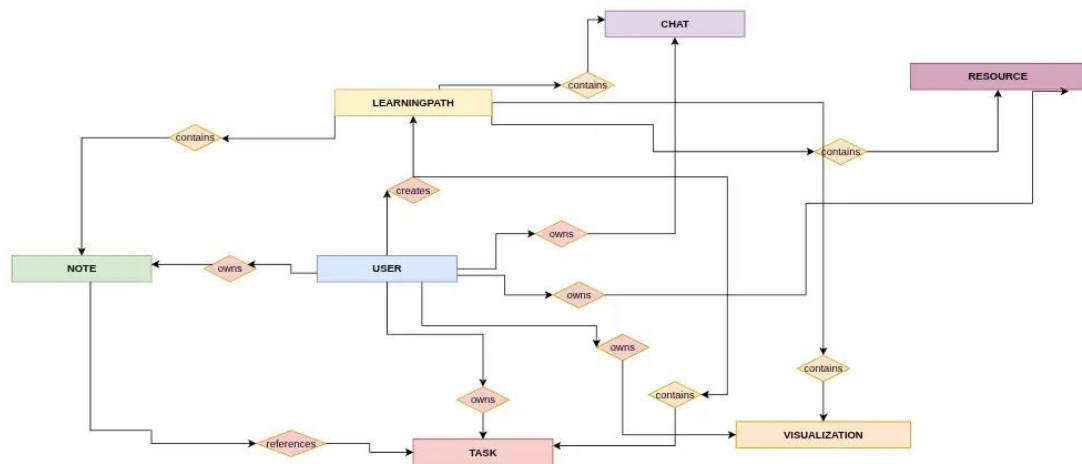
1.14 ER Diagram

Figure 4.4   ER Diagram

This image is an Entity- Relationship Diagram for Edusense which shows the relation between different entities of the system.

1.15 Algorithm Details

i.   Document Embedding

Document embedding is the process of converting text (a document, paragraph, or sentence) into a dense vector representation (numerical array).

The vector captures the semantic meaning of the text so that similar documents are close in vector space.

How It Works

1. Load the documents
2. Split the documents into chunks for generating vectors with overlapping for context
3. Use a pre-trained embedding model (e.g., OpenAI embeddings, Sentence-BERT) and Convert each chunk into a vector.
4. Store vectors in a vector database (e.g., Pinecone, FAISS, Weaviate).
5. At query time, convert the user query into a vector and find the most similar documents by measuring cosine similarity or dot product.

Example

Suppose you have documents:

1. "The Eiffel Tower is in Paris."
2. "The Great Wall is in China."
3. "The Colosseum is in Rome."

Query: "Where is the Eiffel Tower?"

- The query is embedded into a vector.
- The system finds the most similar document vector → retrieves doc (1).

ii.   RAG (Retrieval – Augmented Generation)

RAG is a technique that combines:

- Retrieval (fetching relevant documents from a knowledge base)

- Generation (using a Large Language Model to produce an answer)

It improves factual accuracy and domain-specific responses by grounding LLMs with external knowledge.

How It Works

1. **Embed and Store:** Convert documents into embeddings and store in a vector DB.
2. **Retrieve:** At query time, embed the question and retrieve top-k similar documents.
3. **Augment:** Pass the retrieved documents along with the user query into LLM.
4. **Generate:** The LLM produces a response using both the retrieved context and its own knowledge.

Example

- **Knowledge base:** Wikipedia articles.
- **Query:** "Explain the history of the Eiffel Tower."

  - System retrieves the most relevant docs about Eiffel Tower.
  - LLM reads both the query and retrieved context.
  - Output: "The Eiffel Tower, constructed in 1889 for the Paris Exposition, was designed by Gustave Eiffel..."

Chapter 5: Research and Discussion

1.16 Output Related Discussion

In an AI-powered educational web application like EduSense AI, outputs focus on delivering personalized learning support and interactive study tools. These outputs primarily revolve around processing uploaded materials, providing intelligent responses, and enabling students to explore concepts more effectively. The platform provides clear and accessible outputs such as:

- **Processed Study Material**: uploaded documents are analyzed, and key concepts are extracted.
- **AI Responses**: students receive simplified, personalized explanations through the chat interface.
- **Knowledge Visualization**: mind maps and knowledge graphs are generated to help understand complex topics.
- **User Dashboard:** students can manage their uploaded materials, view past interactions, and track progress.

These outputs ensure that students not only receive accurate answers but also gain a structured and engaging way to study, enhancing overall learning efficiency.

1.17 Work Completed

Here, we outline the functionalities that have been successfully implemented and completed during the development of EduSense AI:

- User Signup/Login with authentication
- Landing screen and responsive frontend layout.
- File upload feature for study materials (PDF, Word, Images)
- Chat interface and visualizations
- Interface for Notes and Tasks
- Knowledge extraction from uploaded materials through RAG
- User dashboard for managing uploaded materials and tracking progress.

1.18 Remaining Tasks of the project

- Testing of the project to be done in future.

- After testing, the project is to be deployed.

- Admin Dashboard needs refactoring.

Chapter 6: Expected Outcome

1.19 Outcomes

The goal of EduSense AI is to enhance learning experience and provide personalized educational support. Evaluating outcomes helps measure the success and effectiveness of the project. Key outcomes of the EduSense AI project include:

- **Enhanced Learning** - provides explanations and knowledge visualization.

- **Scalability** - capable of handling multiple users and large study materials simultaneously.

- **User-Friendly Interface** - simple and intuitive design for smooth navigation.

- **Time Efficiency** - reduces study time by highlighting key concepts and providing instant AI responses.

- **Innovative Learning Tool** - differentiates from traditional and existing digital learning platforms.

1.20 Future Recommendations

From the developer's perspective, EduSense AI has scope for enhancement to improve functionality and user experience. Future recommendations include:

- **Multilingual Support** - allows AI tutors to manage multiple languages for diverse learners.
- **Improved User Interface** - enhance dashboard and visualization tools for better usability.
- **Advanced AI Features** - integrate more sophisticated AI models for deeper explanations and adaptive learning.
- **Mobile Application** - develop a mobile version for offline access and on-the-go learning.
- **User Feedback System** - collect and analyze feedback to continuously improve AI responses.
- **Integration with Learning Management Systems (LMS)** - support schools and institutions for formal education.

References

[1] M. G. P. B. L. C. S. M. A. Baillifard, "Implementing Learning Principles with a Personal AI Tutor: A Case Study," arXiv, 2023.

[2] D. I. S. K. R. R. S. L. M. Hasani, "User-Centered Design of e-Learning User Interfaces: A Survey of the Practices," in *2020 3rd International Conference on Computer and Informatics Engineering (IC2IE 2020)*, 2020.

[3] I. G. T. K. Miya, "UX/UI design of online learning platforms and their impact on learning: A review," *International Journal of Research in Business and Social Science (IJRBS),* 2022.

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APPENDICES

Learning Path

Overview

Visualization

Login/Signup Page