National College of Ireland

Exploring Advanced AI Capabilities for Project Management

MSc Research Project
Programme Name

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MSc Project Submission Sheet

School of Computing

Student Name: ……. Disha Agrawal…..

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Exploring Advanced AI Capabilities for Project Management

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Abstract

This report developed ProManage, a virtual project management assistant chatbot by leveraging OpenAI's GPT-3.5 model to enhance project outcomes via enhanced decision-making, task automation, predictive analytics, and Natural Language Processing. It is smartly designed to process complex project data including timelines, chats, emails, MOM, team deployed, client information, project progress and more. This could assist project managers in optimizing resources, tracking milestones and budget allocation. Implemented as a web-based chatbot, ProManage is user-friendly with NLP at its core functionality. Comprehensive evaluation of the chatbot shows that it has a 96% accuracy and can handle complex queries across a wide range of industries. The report concludes by discussing the implications of AI for Project Management and how it presents a promising future.

Keywords- Project Management, Natural Language Processing, Chatbot, Contextual Learning, Virtual Assistant

1 Introduction

Artificial Intelligence has made its way into every industry, and one thing that is common across all industries is Project Management. AI holds great potential for not only simplifying complex tasks within project management, but also improving outcomes and efficiency for the project. Conventional methods for project management often consist of manual tasks. information silos, and most importantly, human biases, which cost companies in terms of inefficiencies, budget overruns, and delays (Al-Mashari, M., & Zairi, M., 2022). AI presents a solution to these problems as it can equip project managers with advanced predictive capabilities, data-driven risk management, communication platforms, resource allocation, budget management, and more. As AI becomes more and more prevalent, it is also expected to raise the efficiency and efficacy of project management. The way projects are planned, executed and monitored might be completely transformed by the implementation of AI technology (Alshaikhi & Khayyat, 2021).

However, on conducting a thorough analysis of the existing AI solutions and literature, we found that applications currently in use are capable of assisting the project managers only partially. For example, automating repetitive tasks, task management, basic reporting, and so on. However, they are more rule-based and lack advanced capabilities such as predictive risk analytics and mitigation, natural language processing, budget forecasting, handling complex project management queries, historical data utilization, and more. Identifying this gap in

existing work, we formulated the following research question- **How can one leverage advanced AI capabilities for Project Management?**

This led us to develop ProManage, a Gen-AI powered virtual project management assistant that has the following capabilities.

- Contextual Learning Engine: Going beyond ordinary data analysis, ProManage can analyze the unique context for each project by processing all project data including timelines, emails, project summary, team dynamics, and more. It processes task dependency data to help project managers identify the most efficient path for completion.

- Advanced Risk Analytics and Mitigation: ProManage learns from historical project insights and current trends to analyse and mitigate obstacles for the ongoing project. So, in addition to predicting risks, it can also suggest mitigation strategies.

- Handling Complex Queries: ProManage excels at handling complex queries as opposed to rule-based chatbots that work on fixed algorithms and workflows. From resource allocation and budget monitoring to keeping daily track of milestones, ProManage can handle all kinds of queries. It can work according to the users' choice of management methodology, be it, Agile or Waterfall, and suggest the Critical Path for each project.

- Natural Language Processing and Sentiment Analysis: ProManage can perform sentiment analysis on the emails, MOM data, and chat histories to suggest possible course of action and insights related to team dynamics. This can help Project Managers better assign tasks and identify the strengths and weaknesses of the team.

- User-friendliness: ProManage is deployed as a chatbot on a website interface which clearly lists the steps for using the tool. The Project Managers can treat it as a friendly assistant who can answer all the project-related questions once they've uploaded their project data.

ProManage was systematically developed using OpenAI's GPT 3.5 model as its core. A comprehensive dataset describing the project details was first generated and was structured into json format for simplicity. We wrote the code using Python as the programming language for fine-tuning the model. The front-end and UI was generated using Gradio, one of Python's open-source libraries, and was integrated with the website developed through Carrd.co. ProManage was thoroughly tested for accuracy and versatility so as to ensure that it could handle complex project queries, give real-time updates and assist project managers with their day-to-day tasks, leaving them more time for strategic decision-making. It was found that ProManage was 96% accurate, 4% owing to AI models being prone to hallucinations. This is one of the limitations of the chatbot; the information provided by the chatbot must always be cross-verified and overviewed by a human expert. The second limitation is that it can take input in only json file format as the program is designed to read only json files.

The rest of the report is organized into Related Work, Research Methodology, Design Specification, Implementation, Evaluation, Results and Discussion, and finally, Conclusion and Future Scope. The Literature Review is an analysis of the existing work on AI in Project

Management; it seeks to highlight current findings and how this project can fill in the gaps. Following that, Research Methodology explains in detail how the chatbot is developed, outlining each step and its significance. Implementation, as the name suggests, explains the outcomes of the project and all the products developed. Evaluation of the project helps us gauge the efficiency of the chatbot and analyse if it works as per expectations. Following that, we discuss the results of evaluation and explain their significance in context to the research question. To conclude, we discuss the limitations and future scope of AI in Project Management.

2 Related Work

AI holds great potential for increasing productivity and reducing errors in project management, especially int the field of IT due to availability of extensive datasets. AI can facilitate smoother management through predictive analytics and by removing redundant information (Victor, 2023). AI ensure efficiency and accuracy when it comes to creating project networks and plans as it can process huge amounts of data at once and connect all dots. It also offers potential for automating routine tasks, thus saving project managers time and improving task accuracy. Data-driven insights can guide the decision-making process for managers, enabling them to make informed choices (Munirm, M. 2019). Chatbots have the ability to offer personalized solutions across a wide range of project contexts (Missonier and Asgari, 2019).

One of the critical tasks is resource allocation, that is, assigning tasks to team members in accordance with their availability and workload. To organize this, AI algorithms can analyse and process previous project data to learn about each members' expertise and working style to make recommendations for the current project. This results in improved efficiency and reduces chances of delay (Moeeni et al., 2018). A project may be prone to several risk factors that could hamper the budget and schedule of the project. Analysis of large volumes of data via Deep Learning can help warn project managers of risks early in the lifecycle, thus saving an enormous amount of time and resources (Tiao et al., 2019). Along with resource allocation, another critical factor that affects project success is the order of task execution. Conventional practices have little room for flexibility as they are based on static schedules which are tedious to update and do not reflect real-time data. This AI algorithms, on the other hand, can dynamically update schedules to reflect real-time progress. This ensures that the most efficient path to completion is taken and delays are detected quickly (Hartmann & Basten, 2017). Talking of cost estimation, traditional practices utilize historical averages, resulting in inaccurate estimates. Researchers explain how ML models identify patterns and forecast accurate cost estimates, thus resulting in greater financial control (Alaghband & Fischer, 2018). A successful project relies on seamless collaboration between its team members. AI chatbots can play a pivotal role in promoting teamwork by providing common working spaces. Chatbot technology has the potential to automate task delegation, answer common queries and provide updates. This can free up the manager's time for more important and strategic tasks (Pardede & Wijaya, 2019).

Shoushtari et al. (2023) built a deep learning model that predicted risk for building projects, The model was able to effectively spot risks through the early stages itself. Thus, this enabled the project team to cut down on risk-related costs by 15% (Shoushtari et al., 2023a). Another study shows how the application of AI algorithms in manufacturing projects assisted with dynamic scheduling. The AI-powered solution reduced scheduling errors by 30%, increasing project predictability and on-time delivery rates (Rezvanjou et al., 2023). Another study highlights the advantage of AI tools over conventional methodologies for a construction project. The report presents a contrast between the two through cost-estimation difference. Conventional techniques estimated the cost of the project with an accuracy of only 85% in contrast to 92% for AI model generated estimates. A more accurate cost estimate ensures better project outcomes and lower budgetary constraints (Auth et al., 2021). Another important research investigated the application of chatbots for improving communication amongst employees. It was seen that there was a 10% decrease in delays owing to communication and a massive 25% improvement in member engagement (Shoushtari et al., 2024).

While AI presents promising outcomes in the future, existing work in Project Management mostly centers around rule-based platforms and lacks depth when it comes to complex functionalities. Though existing AI can perform well with clearly stated rules and datasets, the field of contextual learning and proactive risk mitigation still has room for exploration. Learning each project's context and unique details requires advanced AI capabilities.

3 Research Methodology

ProManage is a virtual PM assistant chatbot that can help project managers with advanced tasks based on the project details provided by them. Let's take a closer look at how to achieve the above-mentioned outcomes. The following methodology was used for the development of this chatbot.

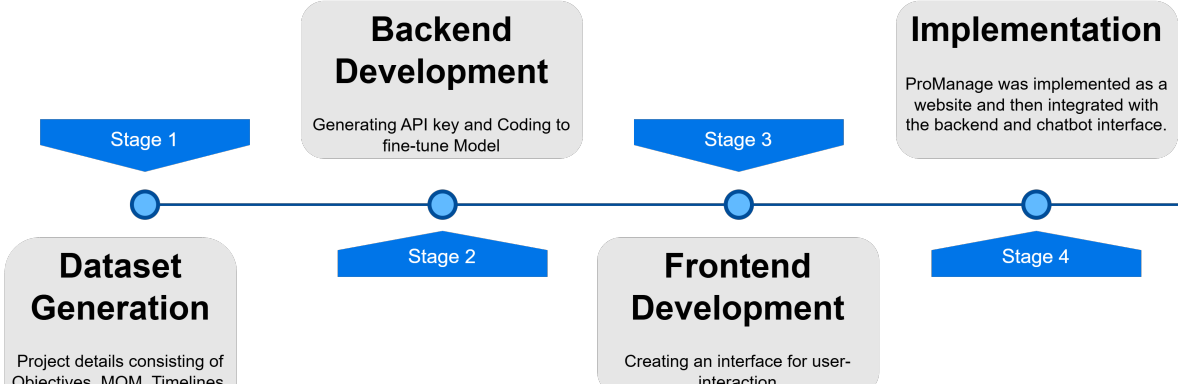

Fig 1: Research Methodology

3.1 Dataset Generation: A hypothetical dataset describing detailed project information was generated in json format. This dataset consists of the following details-

- Project Overview: Aim, budget, client, timeline, deliverables planned, and more.
- Tasks: The tasks involved, along with their due dates, status and interdependencies.
- Resources: Information of the employees deployed on the project, their skills and qualifications and their existing workloads.
- Milestones: Task timelines and key milestones.
- Historical project data: Insights from similar projects in the past and learnings for risk analytics and mitigation.
- Minutes of Meeting: Meeting summaries, and email history for Sentiment Analysis and complex queries.

3.2 Backend Development: The Backend of the chatbot is based on OpenAI's GPT 3.5 model (Large Language Model). To utilize that, we generated an API key on OpenAI's platform. This secret key helps accessing the OpenAI's LLM model when presented with a query from the user. We used Google Colab for programming in Python. The generated dataset was loaded into the Python environment using import command and json library. After installing and importing OpenAI, the API key was then securely integrated into the code. Further, we defined a function called 'chatbot()' to help users query the LLM model and the following prompt was used to instruct the model- "You are a virtual project management assistant. Analyzing the given project information for a website redesign project, you have to answer project managers' questions:"

```
import openai

# Load the Ope
openai.api_key = 'sk-proj-f5BLRrrqnmGQ0oscjNGIT3BlbkFJiEUUNtzbHWFhwJ4BqL4q'

def ask_chatbot(question, project_data):
    # Convert project_data to a string format (optional: simplify or summarize if needed)
    project_data_str = json.dumps(project_data, indent=2)

    # Define the messages
    messages = [
        {"role": "system", "content": "You are a virtual project management assistant. Analyzing the given project information for a website rede
        {"role": "system", "content": project_data_str},
        {"role": "user", "content": question}
    ]

    # Call the OpenAI API
    response = openai.ChatCompletion.create(
        model="gpt-3.5-turbo",
        messages=messages,
        max_tokens=512
    )
```

Fig 2: Backend Development

3.3 Frontend Development: The chatbot's frontend was developed using Gradio, which is an open-source library of Python. It is the smart way to create customizable UIs for ML models and other such applications. This was then hosted onto HuggingFace spaces, which an open-source platform that can be utilized to deploy pre-trained NLP models, free of charge.

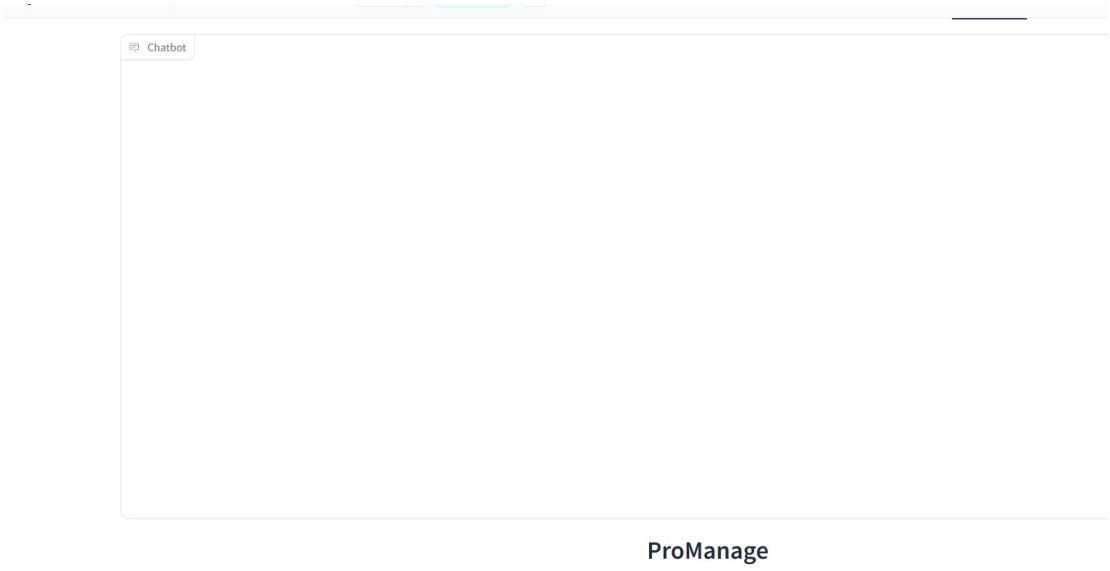

Fig 3: Chatbot Interface

3.4 Implementation: The entire product, ProManage, was implemented as a website hosted on carrd.co for users to access. The website links to the chatbot interface we developed in the previous step, alongside providing a proper documentation of the steps that users can follow to get maximum benefit out of the chatbot. This also lists the capabilities of ProManage, helping users identify their needs and make efficient use of ProManage. This is further elaborated in the Implementation section of the report.

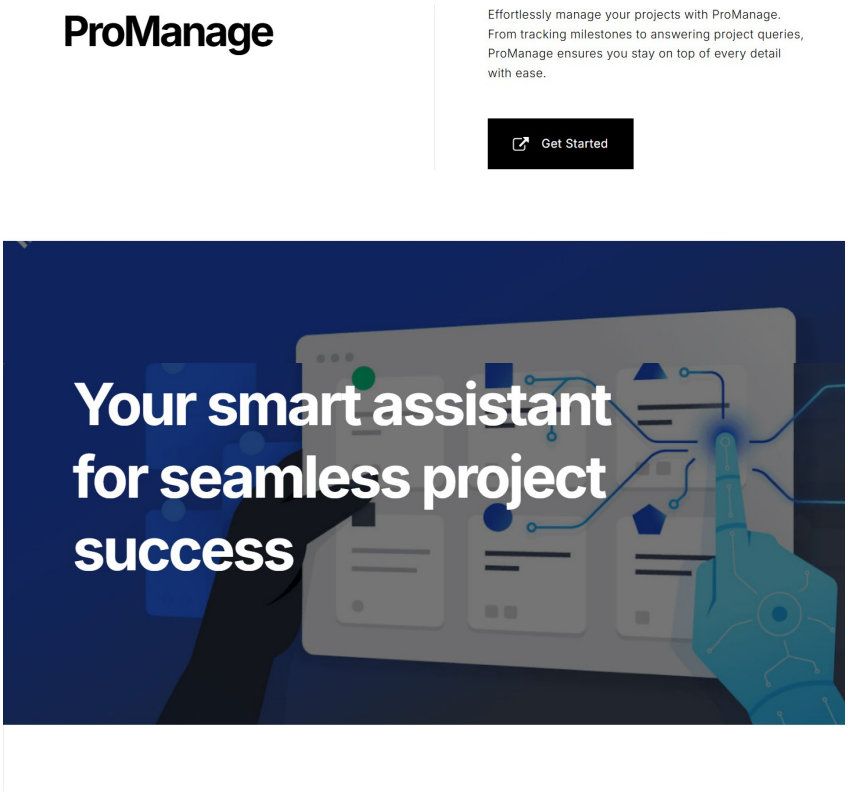

Fig 4: Webpage

3.5 Results and Evaluation: Finally, the product is tested for accuracy and versatility. The chatbot is presented with a variety of questions to test its accuracy. Further, the chatbot is tested with different kinds of projects and is again checked for accuracy for each of them. The performance of the chatbot is gauged in terms of percent responses achieved correctly. This is further elaborated in the Results and Evaluation section of the report.

4 Design Specification

ProManage is meticulously designed to optimize the Project Management experience for users. It combines the capabilities of OpenAI's powerful LLM Model (GPT 3.5) with the interactive website interface. This section of the report describes the design aspects of the project, including system architecture and key components and technologies utilized.

The design of ProManage is basically a client-server model for efficient data processing and user-friendliness.

Client-side: The model's web interface is embedded into a Carrd.co website. Carrd allows for easy-to-use customizable website templates that can be used to design webpages in minutes. It also helps generate mobile-friendly webpages so that users can manage projects on the go. This website is the point of contact for users where they can access the chatbot through a link. The webpage also links to a documentation that describes the steps for using the chatbot in detail. The chatbot opens in a different window and has a separate interface that is developed using Gradio. Gradio is an open-source library in Python that helps us develop a simple interface for the chatbot. It acts as the link between backend and front end, relaying queries from the users to the LLM model and responses from the backend to the users.

Backend or Server-side: The chatbot opens in a different window, hosted on the HuggingFace spaces platform. HuggingFace spaces allows developers to host their files on a single platform and utilize pre-trained NLP models for free. The backend was mainly implemented using Python as the programming language, and OpenAI API for the LLM model. This setup allows for flexibility and simplicity, allowing us to seamlessly integrate NLP capabilities into PM workflows. The Project data, compiled into Json file format, allows for easy querying and reduced processing time as compared to any other file format.

The following diagram summarizes the components of ProManage.

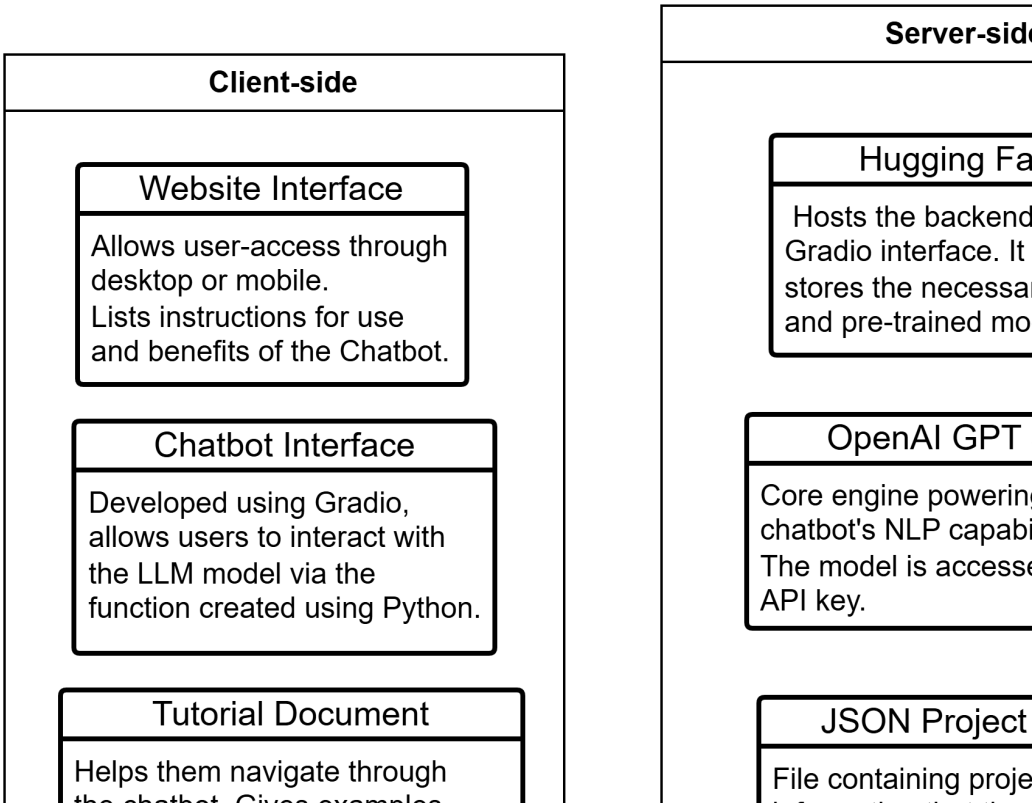

Fig 5: Design Specifications

User-interaction Flow

Step 1: User goes to the website- ProManage (pmvirtualassistant.carrd.co)
Step 2: User clicks on the "Get Started" button, which links to the chatbot window at Project Manager - a HuggingFace spaces Space by Dishaa. Alternatively, if the users find themselves confused, they can click on "How do I use ProManage?" button at the bottom of the page. This brings them to the tutorial document.
Step 3: User clicks on "Upload File" button at the bottom of the screen to upload their file, ensuring it is in Json format.
Step 4: The Json file goes to the Backend hosted on HuggingFace spaces; Gradio relays the project data HuggingFace spaces which in turn sends it to GPT for processing.
Step 5: When the user inputs a prompt into the chat box, Gradio again sends this query to the backend. The LLM model processes this using the uploaded Json file as reference.
Step 6: The model generates a response after parsing the query and this information is relayed back by the same pathway.

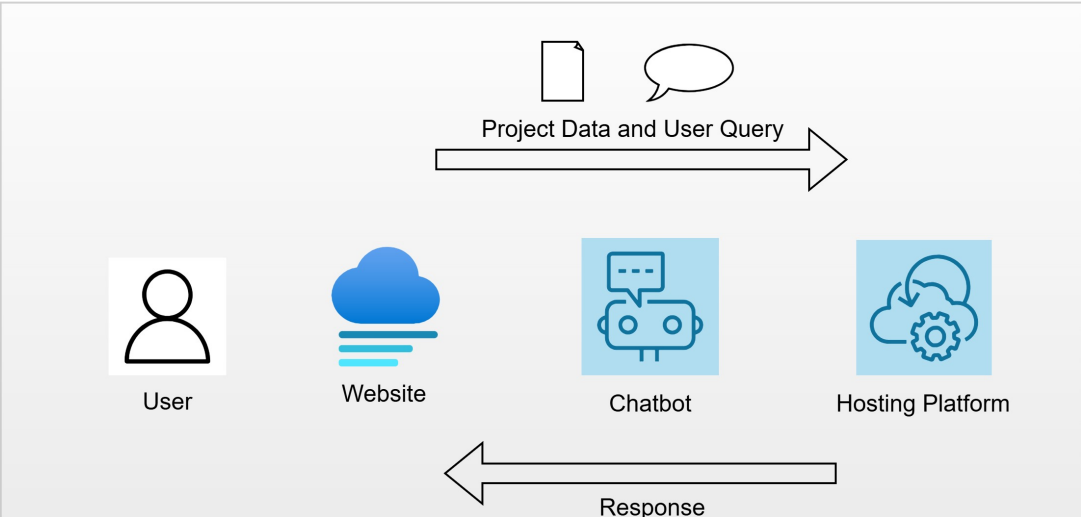

Fig 6: User Interaction Flow

5 Implementation

The final implementation of the above-mentioned design resulted in a fully-functional Project Management VA, ProManage, seamlessly integrated into a web-based interface. Listed below are the outputs generated-

- Developed Code: The system was programmed using Python with libraries installed and imported for file upload (Json), LLM integration (OpenAI), and managing user-interaction (Gradio). The GPT model was fine-tuned using appropriate instructions and the prompt as mentioned in the design methodology.
- Frontend: Gradio was used to develop the UI, which was then integrated into a Carrd.co website to offer a simple and intuitive platform for interaction. Project Managers can easily use this platform to streamline their work.

The figures below explain the implementation of the design clearly.

Users' first point of contact is the webpage- [ProManage (pmvirtualassistant.carrd.co)]

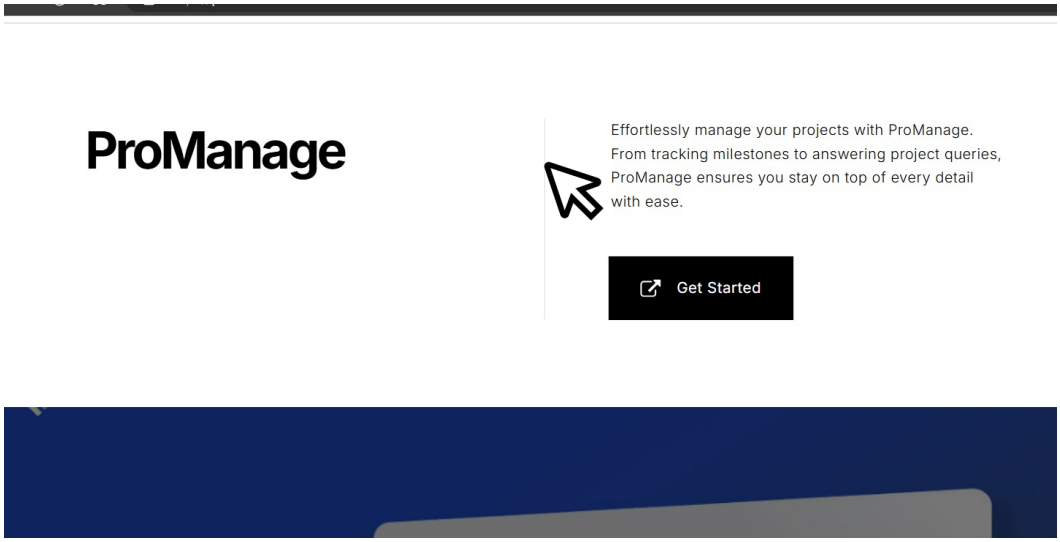

Fig 7: First POC

An action button “Get Started” is provided to help users navigate to the chatbot interface.

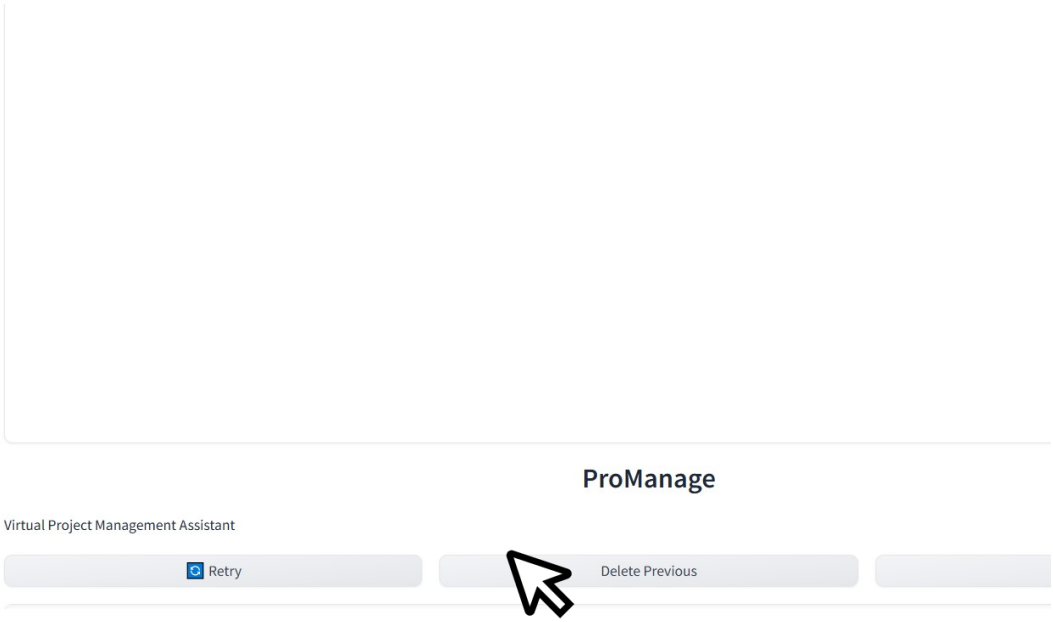

Fig 8: File Upload

Users can upload their Project Data file (Json format), which is then relayed to the backend as is visible from the code given below.

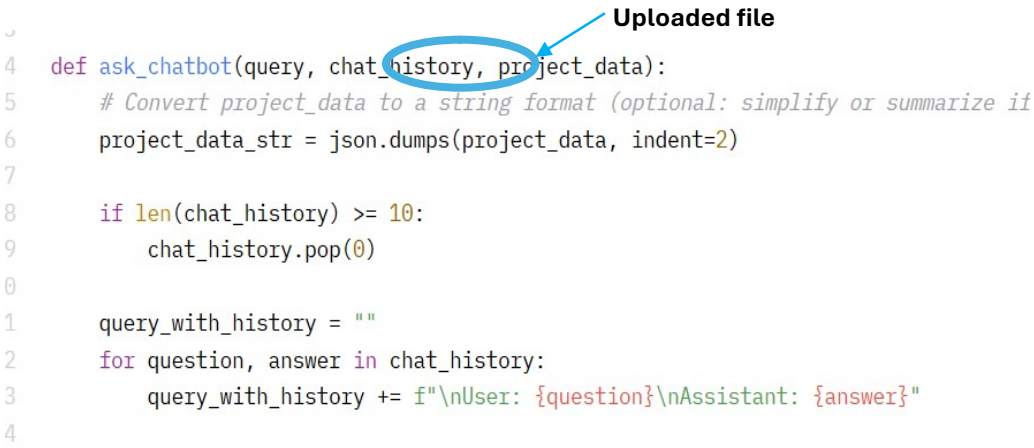

Fig 9: File uploaded on the Backend

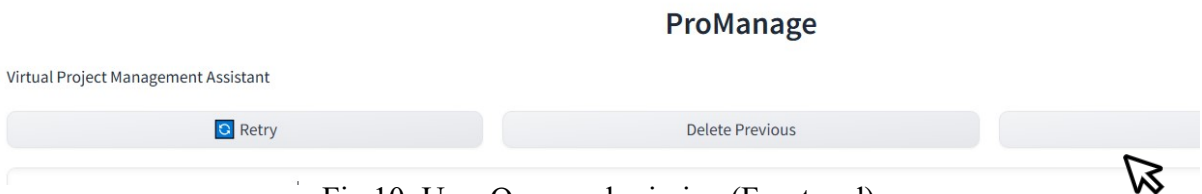

Fig 10: User Query submission (Front end)

```python
api_key = os.getenv("api_key")

# Load the OpenAI API key
openai.api_key = api_key

project_data = {}

def ask_chatbot(query, chat_history, project_data):
    # Convert project_data to a string format (optional: simplify or summarize if needed)
    project_data_str = json.dumps(project_data, indent=2)

    if len(chat_history) >= 10:
        chat_history.pop(0)

    query_with_history = ""
    for question, answer in chat_history:
        query_with_history += f"\nUser: {question}\nAssistant: {answer}"

    query_with_history += f"\nUser: {query}"


    # Define the messages
    messages = [
        {"role": "system", "content": "You are a virtual project management assistant. \
                                       Analyzing the given project information for a website redesign project, you have to answer project ma
        {"role": "system", "content": project_data_str},
        {"role": "user", "content": query_with_history}
    ]

    # Call the OpenAI API
    response = openai.ChatCompletion.create(
        model="gpt-3.5-turbo",
        messages=messages,
```

User Query

Fig 11: User Query submission (Backend)

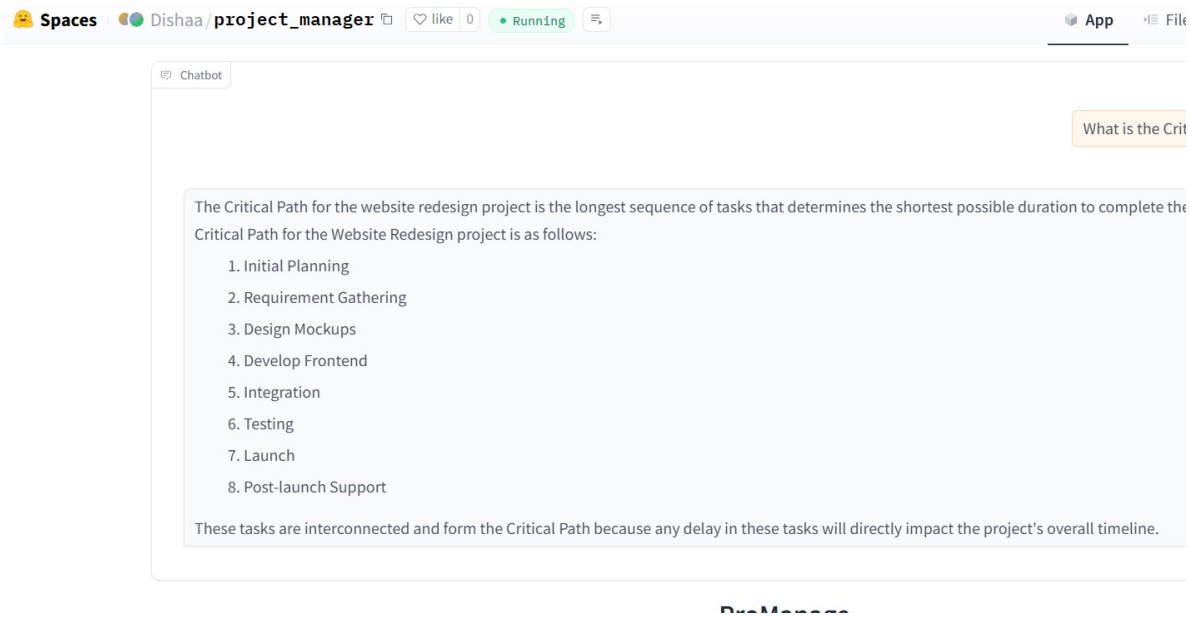

Fig 12: Chatbot response

6 Evaluation

The chatbot was subject to thorough testing to ensure its reliability and versatility using the following methods. A comprehensive dataset of 72 questions spanning across 4 hypothetical projects was generated and the chatbot's response was benchmarked against the correct/expected answers. These questions encompassed various aspects of the project details, such as start and end dates, project manager, budget, main objectives, milestones, team members, stakeholders, and deliverables.

6.1 Experiment 1- Accuracy test

This test helps gauge the chatbot's efficiency and effectiveness in retrieving accurate information, highlighting areas needing improvement in its contextual understanding capabilities. Out of 72 in total, the chatbot answered 69 questions correctly, therefore, achieving an overall accuracy of 96%.

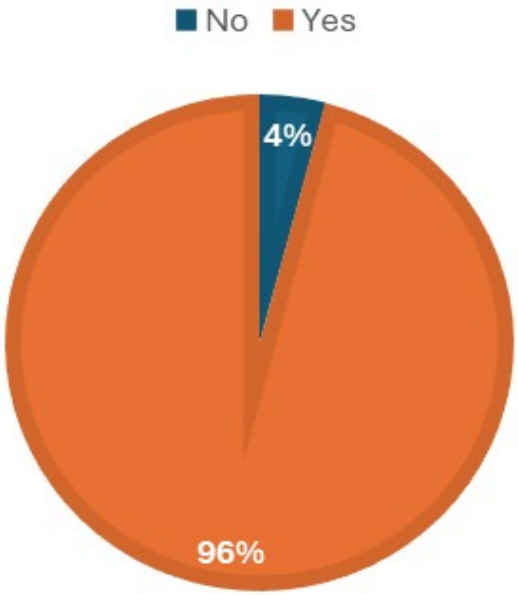

Fig 13: Accuracy Test

Matches (Yes/No)	Count of Matches	Percentage of Total
No	3	4%
Yes	69	96%

Table 1: Accuracy Test

6.2 Experiment 2- Versatility test

The versatility test is designed to assess the chatbot's usability across a variety of projects, through scenario-based and cross-domain testing. For this, multiple project datasets, including a Mobile App Development project, a Software Upgrade project, and a Summer Marketing Campaign, were uploaded to the chatbot interface, one by one. The chatbot was then prompted with standardized questions tailored to each project. ProManage's responses were evaluated in terms of accuracy and relevance and compared with the expected/correct response according to the respective datasets. This test measures adaptability for handling diverse projects and contexts. The Project Management chatbot was subject to 18 questions for each of the projects, with 6 of each easy, moderate and complex queries, and the following results were obtained. The chatbot's average accuracy was 96%.

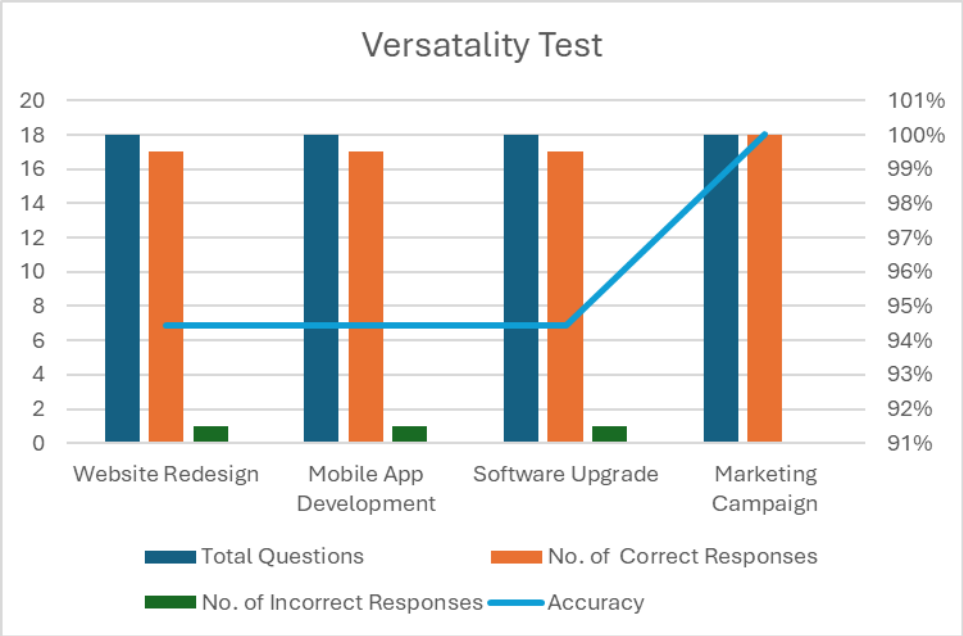

Fig 14: Versatility Test

Project Name	Total Questions	No. of Correct Responses	No. of Incorrect Responses	Accuracy
Website Redesign	18	17	1	94%
Mobile App Development	18	17	1	94%
Software Upgrade	18	17	1	94%
Marketing Campaign	18	18	0	100%

Table 2: Versatility test

6.3 Experiment 3- Response Time Analysis

This test is to assess the time taken by the chatbot to generate response to simple, moderate and complex queries. This is to ensure a high quality of user-experience and to fine-tune the chatbot to generate faster responses. The chatbot is subject to a variety of questions, ranging from simple to complex. The benchmark response time for simple queries was less than 1 second, 2 seconds for moderate and 3 seconds for complex queries. For each of these queries, the chatbot's response time is logged and a graph is plotted. The results indicate an overall quick response timing, with just 5% of the times exceeding expected time limits, always for the complex queries which require elaborate reports to be generated.

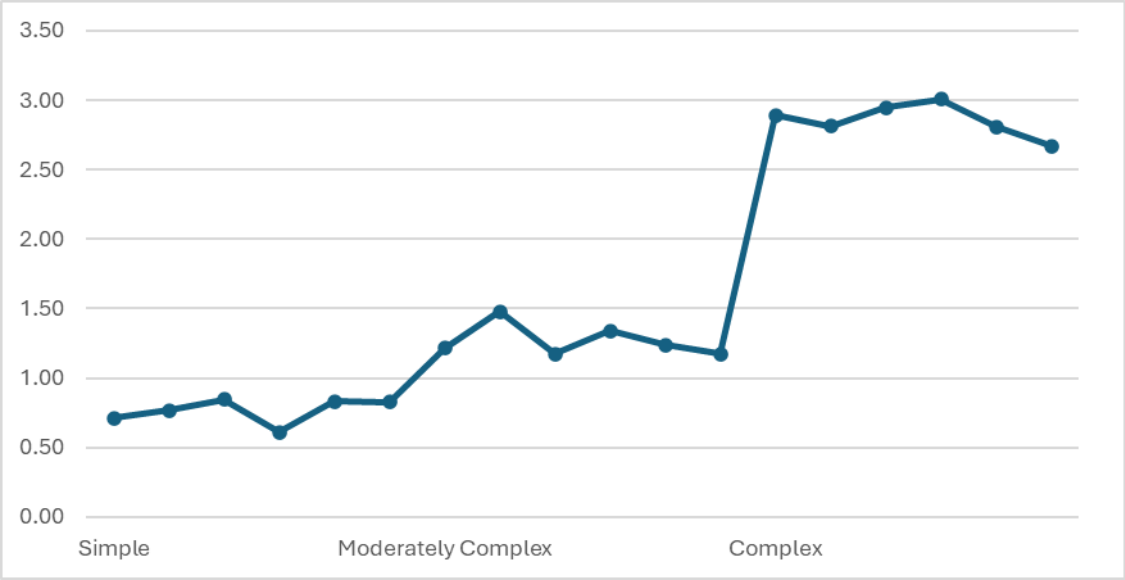

Fig 15: Response Time Analysis

6.4 Error Analysis and Manual Review

Incorrect and irrelevant responses were identified and manually reviewed to analyse the cause for such inconsistencies, if they were due to model limitations, human error, or simply data issues. It was found that the chatbot answered incorrectly 3 out f 72 responses, summary of which is given below.

Project	No. of Incorrect responses	Reason
Website redesign	1	Insufficient Data
Software Developmen	1	Model Hallucination
Mobile App developme	1	Reason unknown

Table 3: Error Analysis and Manual Review

6.5 Discussion

ProManage presents promising results across various experiments. The accuracy test reveals a 96% success rate, which is impressive, however, the remaining 4% inaccuracy may be critical to some projects. Therefore, human supervision is highly recommended. The answers from the chatbot must be cross verified by Project Managers before implementing them into projects or taking any impactful decisions. The versatility test reveals that the chatbot is capable of handling diverse projects with consistent accuracy. This is consistent with findings from previous research, for example, the study by Missonier and Asgari (2019) that states the significance of adaptability in PM Chatbots to serve all kinds of industries.

Experiment 3, Response Time Analysis, shows commendable performance with only 5% of the responses exceeding expected time limit. This shows that ProManage can overcome the limitations of conventional rule-based chatbots and handle complex context-dependent queries in a short amount of time. Finally, manual error analysis reveals interesting insights into the limitations of the model. This stresses the importance of well-structured and high-quality input data, as emphasized by Li et al. (2022). Hallucination is a very well-known drawback with Large Language Models and thus highlights the need for robust safeguards and human expertise.

While ProManage shows promising results and shows potential for commercial implementation, there is scope for improvement in both our methods of evaluation and performance of the bot. The chatbot needs to be tested on extensive datasets and across a huge number of industries. However, the unavailability of comprehensive real-world project data poses an obstacle. For this, Project Managers should be encouraged to organize all project data systematically so that it can be used to train models in the future. ProManage has been tested on hypothetical data for now, but it's evaluation can be extended to incorporate real-world data as well if available. The chatbot can be further developed to incorporate user feedback so that it can learn from it and improve response quality. Finally, user-feedback surveys can be conducted to assess ProManage's usefulness and relevance for industry users.

7 Conclusion and Future Work

This research paper was aimed at developing a virtual Project Management Assistant with the objective of creating a context-aware tool to improve project efficiency. The key research question was- Can one leverage advanced AI capabilities for Project Management? To address this, we developed ProManage which can assist users with complex queries, risk analysis and managing team dynamics across diverse project types. The chatbot was integrated with a user-friendly interface via Gradio and hosted the server on HuggingFace spaces. A website was designed for users' ease and was hosted through Carrd.co. The system architecture is such that it facilitates seamless communication between client and server side. ProManage achieved a high level of accuracy (96%) in answering user queries across different domains. The model's low response time makes it even more usable.

This study can have significant implications in the field of project management and the model holds potential for commercial implementation after real-world testing and refinement. In fact, in the future, customized models can be built for each industry so as to provide even better-quality results and information that is based on industry-specific scenarios. This can be done by incorporating user feedback and improving the model based on surveys. Feedback from industry professionals can be collected to tailor the model for each industry, keeping in mind the needs of the users.

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