

Final Year Project:

# **Litigat8: Your AI Legal Advisor for Tenant-Landlord Law**

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# **Abstract**

Renting and lending has been a pillar in the human history since the beginning. And in the current day an age with the growing population there is a huge influx in the number of people that are currently either renting out a place or are either lending it out. But with that there is growing concern of people not being aware of the rules and regulations around this domain which can cause serious legal issues for both of the parties. Hence, the need of this proposed solution which is a web-based application using the powers of NLP technology to help people of this age navigate through the realms of property law more specifically household and tenant law. This application not only provides legal advice but can also help the users find the case law or reference they are looking for.

The following are covered by the report:

- A comprehensive history of NLP along with its current and future application in the field of law
- A detailed analysis of what software management methods and principles were used to complete the project
- An overview of the implementation of the application along with how it was tested
- A reflection/Evaluation of what has been done in the project and what could be done in the future

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## **Introduction**

From the beginning of time the way people get legal help has changed a lot. In the past there was a time when getting legal advice was expensive for most people. As the world changed so did the need for legal help which became more complicated. Technology has played a big role in changing how we get legal support today. Now legal help is a key part of dealing with many problems in life.

Thanks to the recent development in technology getting legal advice is easier than before. Smartphones have gone from just being ways to talk to each other to important tools for handling different parts of our lives including legal issues. This technology lets people find legal information easily it empowers them by giving them the power to handle their legal matters more actively. But there is a problem many good legal apps cost money every month or people have to use many different apps to find what they need. This can make the whole process a lot more frustrating than it already is.

My project Litigat8 is here to make things better. I've created Litigat8 to be a complete source of legal support especially for issues between landlords and tenants. Whether it's understanding your rights as a tenant or knowing what a landlord can or cannot do or getting advice on how to handle a dispute Litigat8 is designed to help. The application offers easy-to-understand advice and resources for tenant and landlord laws.

Litigat8 is more than just information. It's a tool that helps users get answers to the question they are looking thus fulfilling the legal needs easily. This made this application to be a helper and a guide in the complex world of tenant and landlord laws. By making legal support accessible. My goal was to make everyone feel confident about their rights. Litigat8 isn't just an app it's a step towards a world where legal help is a tool for justice for everyone

## **Background Research**

### **Research Methodology**

This section displays the approach employed for conducting literature search selection and subsequent analysis focusing on the role of Natural Language Processing in improving access to justice.

### **Literature Search**

The literature search was performed across various academic databases to ensure a broad collection of relevant studies. The databases queried include Google Scholar, IEEE Xplore and the ACM Digital Library. The search strategy used combinations of key terms such as "Natural Language Processing," "NLP in law," "access to justice," "legal informatics," "automated legal assistance," "bias in NLP applications," "privacy in legal NLP," "NLP in household and tenant



law“ and "future of NLP in law." Boolean operators (AND, OR) were employed to refine the searches ensuring a focused retrieval of literature.

## Selection Criteria

### Inclusion Criteria:

- Peer-reviewed articles and conference papers written in English.
- Studies that specifically explore the application of NLP technologies in the legal domain or for enhancing access to justice including in the household and tenant law domain.
- Publications that provide insights into the current trends, challenges, and future directions of NLP in legal applications.

### Exclusion Criteria:

- Non-peer-reviewed articles grey literature.
- Articles without empirical data clear results on NLP's effectiveness or a detailed methodology.

## What is NLP?

Natural Language Processing (NLP) serves as a bridge between human communication and computer understanding serving itself as a base in both Artificial Intelligence and linguistics. Designed to make the interactions between humans and computers easy and more accessible. NLP aims to enable computers with the ability to understand human language with ease thus

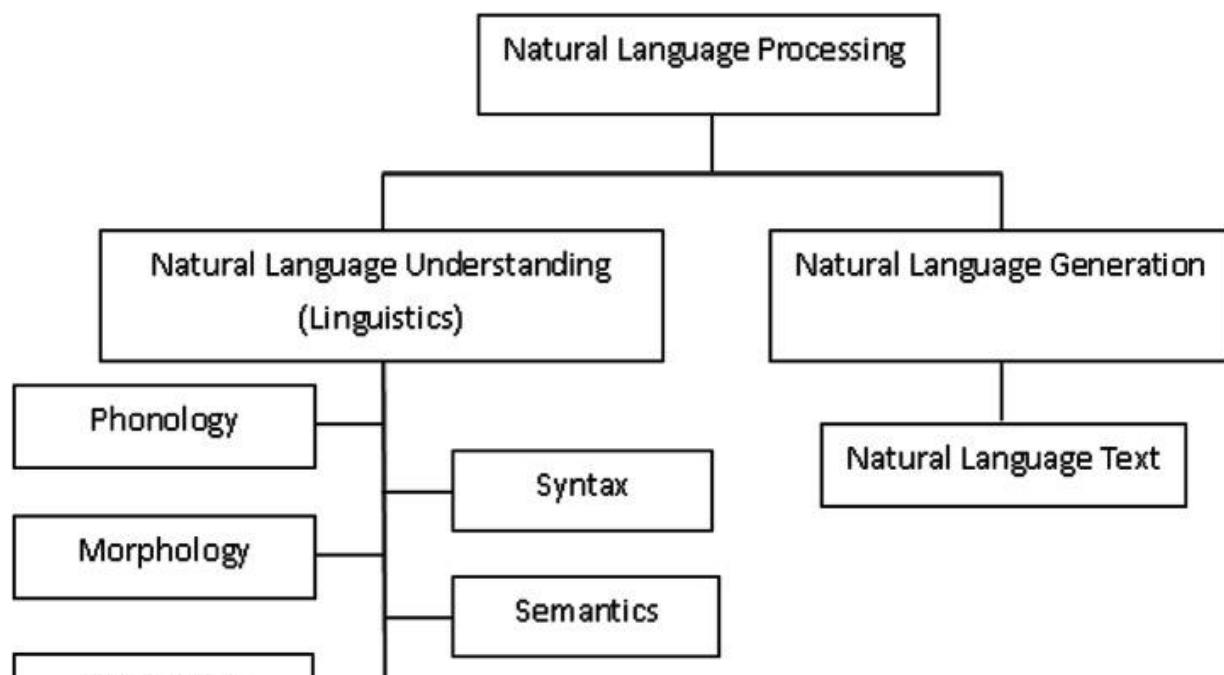


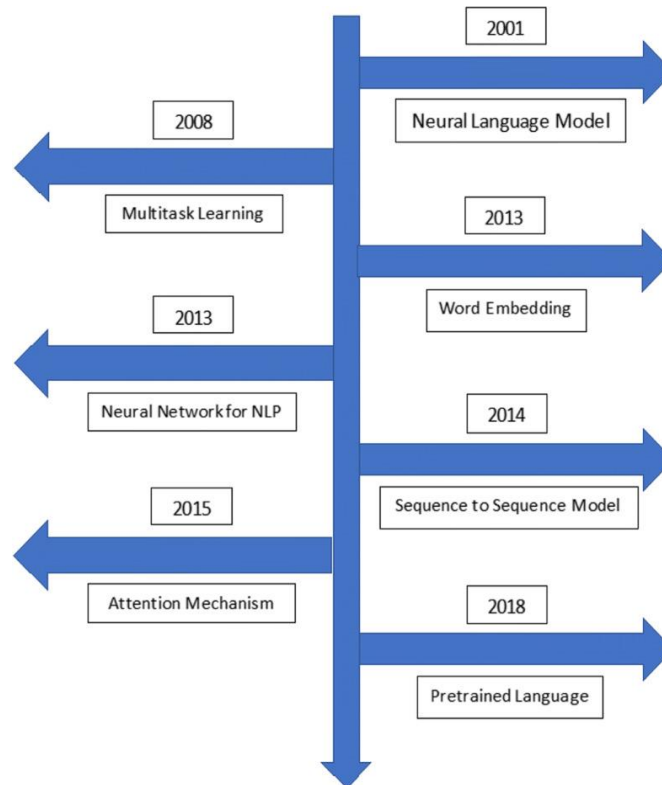
Figure 1 Showing the Hierarchy of NLP

overcoming the need for people to master complex computer languages. NLP divides into two main branches, Natural Language Understanding and Natural Language Generation, focusing on understanding and the generation of human like text respectively. Linguistics the scientific study of language is crucial to NLP and it includes everything from phonology to semantics.

## History of NLP

The history of NLP can be traced back to the 20th century marked by technological advancements and contributions from different disciplines. This idea of NLP began in the late 1940s period when NLP as a term wasn't coined yet. The initial steps towards machine understanding of human language were being laid (Hutchins, W.J., 1986). The initial focus was on Machine Translation a task that planned to automatically translate text from one language to another in the beginning the two languages that were chosen were Russian and English. This era was characterized by optimism. The ambitious projects that were planned aimed at breaking down language barriers using computers.

However this development faced a setback when the ALPAC report was released in 1966. Which stated that the future for MT was not so bright and therefore recommended a reduction in funding for such research (Hutchins, W.J., 1995). This report significantly hindered the progress of NLP research leading to a period of re calculation of goals within the field. Despite this roadblock some MT projects continued to operate slowly refining their approaches and continued laying the groundwork for future development of NLP.

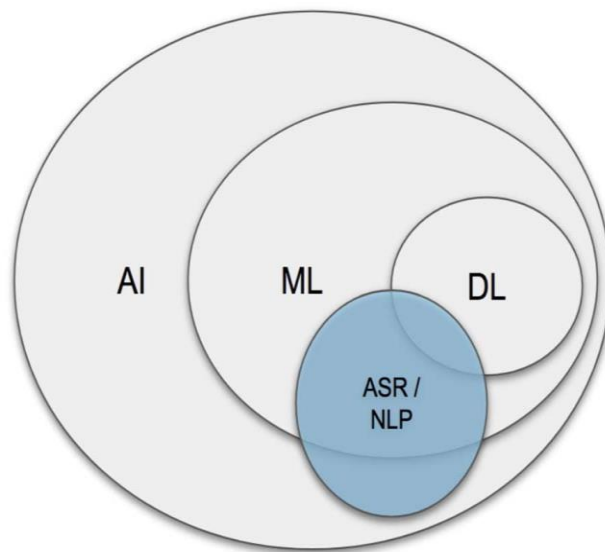


*Figure 2 Showing the Development of NLP overtime*

Today NLP stands as a dominant and very important field in computer science which stands at the unison of AI, linguistics and computer science. This field of AI is continuously evolving with the introduction of new models and datasets. But the history showcases its journey of overcoming challenges adaptation of new methodologies and expanding the boundaries of what machines can understand and use that understanding to generate meaningful and informative information. The future of NLP promises more applications of it in other applications such as law, customer service etc. It also promotes deeper understanding of linguistics and development of applications that extend beyond current capabilities of NLP.

### Machine learning in NLP

Machine Learning plays a very important role in NLP which have facilitated the advancement in the field which have revolutionized the way machine understand the give text data and generate Reponses based on that. The way it has been possible is by using patterns in data machine learning algorithms enable computers to perform complex NLP tasks without specific programming for each specific task beforehand. This use of ML in NLP has led to the development of applications such as speech recognition software's, sentiment analysis models, Text Translation models and chatbots which are just some of its applications and more of its applications are still being worked on.



*Figure 3 Showing the Overlap of NLP with ML and DL*

Machine learning models like Naive Bayes, decision trees and support vector machines to advanced neural networks have provided NLP with the stepping stones to move forward resulting in wide variety of applications. These models are trained on large datasets learning to predict or classify text data.

With the development of transformer models i.e., BERT and GPT. The development of these models showcase a leap forward in the development of NLP. These models have set new standards for a lot of wide range of NLP tasks by capturing deep contextual relationships within text (Vaswani, A. et al., 2017; Devlin, J. et al., 2019). Their ability to pre-train on vast amounts

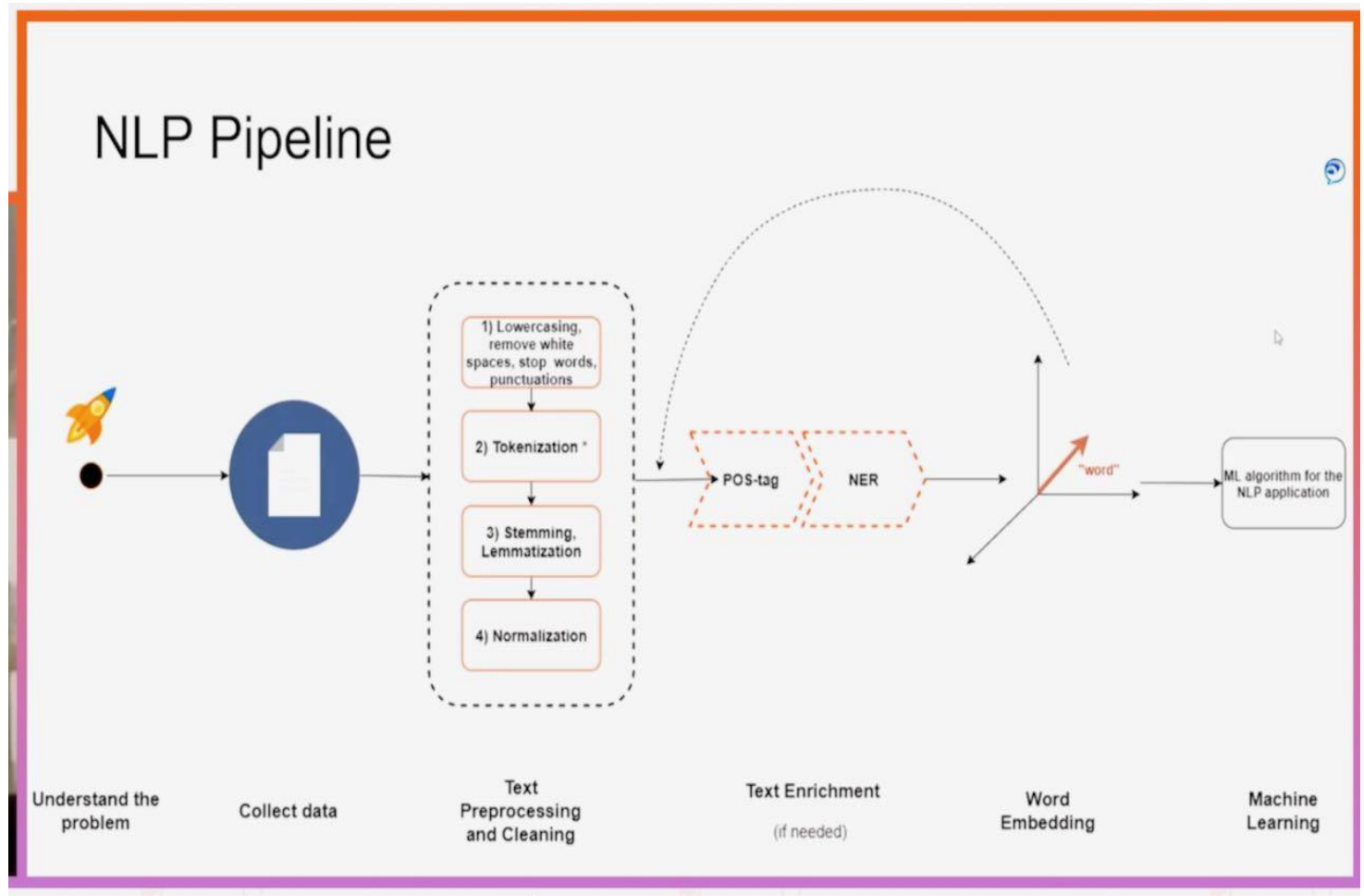


Figure 4 Showing the NLP Pipeline

of text data and fine-tune for specific NLP tasks has made it more accessible and relatively easy to get accuracy in language understanding and generation of information based on specific NLP tasks.

Despite significant progress being made in the field integrating machine learning into Natural Language Processing for further development of NLP presents a lot of challenges. Some of the challenges include the need for large datasets with detailed and correct annotations for training which can be resource intensive. Additionally, machine learning models struggle to understand the complexities of human language as they have lot ambiguous/unclear references in the form of sarcasm or something that is said out of the context of the topic. These models also require a lot computational power to train making the development of the models expensive and relatively difficult task to achieve. Furthermore, there is an ongoing effort to make these models more transparent in regards on how they make decisions to reduce biases that may be present in the training data used for training the model. Addressing these issues is very important for developing the NLP technologies further and to make sure the development is fair and understandable.

## The Role of NLP in Enhancing Access to Justice

The role of Natural Language Processing (NLP) in enhancing access to justice is significant by using the power of AI in law we have been able to bridge the gap between the existing legal services and the people who are in need of these services. This is achieved as a result of automating and streamlining the legal process and procedures that exists. With the help of NLP, we have been able to make legal information more accessible, understandable and actionable either by individuals or communities who back in the day wouldn't have resources for legal representation

### Make the Legal Language simple

One of the primary problems in accessing justice is the complexity of legal language. NLP tools have enabled us to translate legal terms/jargons into plain language which in return makes legal documents, regulations and procedures more understandable to a common person who doesn't have any knowledge about the legal terms. The NLP can also make law more accessible by providing summaries of legal texts and also by explaining legal concepts in simple terms. Thus, NLP enables individuals in navigating the legal system more confidently which results in them making more informed decisions about their legal dilemmas (Katz, D.M., Bommarito II, M.J., and Blackman, J., 2017).

### Automated Legal Assistance

Legal chatbots and virtual assistants which are powered by NLP, offer initial legal advice and assist in document preparation which range from simple contracts to more complex legal filings. Thus making the whole process a lot more convenient and easy for individuals. This application would also be explored in the case Litigat8 as well. These types of applications can guide users through legal processes, such as asking the relevant questions according to the problem the user is in and generate documents such as contracts, tenancy agreements based on the user's responses which in fact significantly lowers the barrier to start legal actions or responding to legal issues (Sourdin, T., 2018).

### Enhancing Legal Research

NLP helps lawyers and legal researchers quickly search through huge amounts of legal documents like court cases and laws. By employing NLP tools, lawyers and researchers can easily find important past cases it can also detect trends in legal decisions and collect evidence for their current cases if they are working on any. This makes their work more efficient which also helps to reduce costs. As a result, people who might not have a lot of money benefit because they can get better legal help that they can afford. (Alarie, B., Niblett, A., and Yoon, A.H., 2018).

## **Accessible Dispute Resolution**

There are Online Dispute Resolution (ODR) platforms which utilize NLP to offer accessible means for resolving disputes outside of traditional court settings. These platforms automate parts of the mediation. The ODR platforms can resolve conflicts more quickly and with less financial strain on the parties involved which in results make justice accessible for all even if they are less fortunate (Rule, C., 2017).

## **Identifying and Mitigating Bias**

### **Privacy and Security Concerns in Legal NLP Applications**

When it comes to NLP Privacy and security concerns are one of the biggest concerns in the deployment of Natural Language Processing applications within the legal domain. The Legal NLP applications, which handle sensitive and potentially confidential information makes it important to put in place some strict protocols and security measure to protect the user data as it can be confidential and of sensitive nature. The processing of legal documents, client communications between the NLP model and User and other sensitive information which can be possessed by NLP systems raises substantial concerns about data protection, unauthorized access and the potential misuse of information.

One of the primary challenges faced by legal NLP applications is ensuring the confidentiality and integrity of the data processed by it. The used legal documents often contain confidential information, trade secrets and personal data subject to various privacy laws such as the General Data Protection Regulation (GDPR) in Europe (Voigt, P., and Von dem Bussche, A., 2017). Because of these reasons, the NLP systems used in the legal field must incorporate robust encryption methods for data storage and transmission, coupling it with secure access controls to prevent unauthorized access to sensitive information.

Furthermore, the use of NLP in legal applications involves ethical considerations such as the fairness and transparency of automated systems. The Bias in legal NLP models can lead to unfair outcomes or discrimination in the response generated or the legal advice which causes us to undermine the trust in automated legal analysis (Barocas, S., Hardt, M., and Narayanan, A., 2019). Therefore, NLP models generated for legal applications must be designed with fairness in mind and it should be made sure to incorporate methods to detect and mitigate bias in training data and model predictions.

Moving on ,another significant concern of NLP in legal applications is the potential for data breaches and the unauthorized leakage of sensitive information associated either with users or the

law firm for instance using that application. It should be made sure that the Legal NLP applications must comply with legal standards for data protection, and they must implement stringent/strict security protocols and they development body should regularly audit systems for vulnerabilities (Romanosky, S., 2016). Moreover, there is a need that we put in place clear guidelines and regulations which should govern the use of AI and NLP in legal contexts ensuring that these technologies are used responsibly and ethically.

In summary, privacy and security concerns in legal NLP applications are critical issues that require careful consideration and proactive measures to prevent them from happening. Protecting sensitive legal information while ensuring the fairness and transparency of NLP systems is essential for maintaining client trust and compliance with legal and ethical standards and thus important for NLP to flourish in this field.

## Current Trends and Future Directions of NLP in law

The integration of Natural Language Processing within the legal domain has been very evolving in the recent years reshaping how legal professionals in practice interact with vast amounts of textual data and how they use it to streamline various aspects of legal research, document analysis and client services. As NLP technologies continue to develop several current trends and future directions of NLP in legal settings are emerging in the field of law which promise to further revolutionize they field of law as we know it right now.

### Current Trends

#### ***1. Automated Legal Document Analysis:***

One of the applications of legal NLP is to automate the analysis of documents like contracts. The way NLP model helps is by quickly finding and pulling out relevant and important information from these documents. Which can then be analyzed for whatever purpose the legal professionals want to use it for. For example, a legal NLP model can identify key clauses in contracts and can summarize long legal opinions which results in saving time and thus making legal work more efficient. This application of legal NLP not only speeds up the process of reviewing legal documents but also reduces the chance of making mistakes thus resulting in improved accuracy and reliability of legal research or due diligence. This application of NLP has streamlined many routine tasks in legal practices. (Zhong, H., Guo, Z., Tu, C., Xiao, C., Liu, Z., and Sun, M., 2020).

## ***2. Legal Chatbots and Virtual Assistants:***

One of the other applications of NLP is Legal chatbots and virtual assistants which have NLP capabilities and they are becoming more prevalent and more used in day to day legal needs. These NLP technologies offer basic legal advice to the public helping them navigate through the complexities of the legal world and they also help in drafting simple legal documents and provide support for customer service operations in law firms making legal services more accessible (Kreutzer, R.T., and Sirrenberg, M., 2019).

## **Future Directions**

### ***1. Enhanced Legal Predictive Analytics:***

The future of NLP in law includes the development of more advanced prediction and analytics tools. The way this system would work is by analyzing historical legal data and then the NLP models would be able to predict the outcomes of cases like what would be the decision based on the precedent set by the cases related to the case that is being analyzed this would help lawyers make better informed decisions about case strategies and thus would increase the chances of success (Ashley, K.D., 2017).

### ***2. Ethical Use of NLP in Legal Applications:***

As NLP technologies become more common in legal practice, there will be an increased focus on ensuring the ethical and safe use of these tools. This will include addressing concerns related to unbalanced/bias outcomes and transparency of NLP models to ensure fair and impartial legal outcomes (Branting, L.K., 2021). To solve these problems work is being done to develop methods to test and correct biases in algorithms along with designing systems that can explain their own decisions and can follow strict guidelines to uphold ethical standards in their applications.

### ***3. Cross-lingual and Multijurisdictional Legal NLP Applications:***

Another possible application of Future NLP systems will likely become more adept at handling multiple languages and legal jurisdictions which would facilitate in cross-border legal research and global compliance tasks in different countries instead it being locked up by the knowledge of just single country. This advancement could come in really handy for international law firms and organizations dealing with cases which fall in under lots of jurisdictions legal issues (Tsarapatsanis, D., and Aletras, N., 2021).



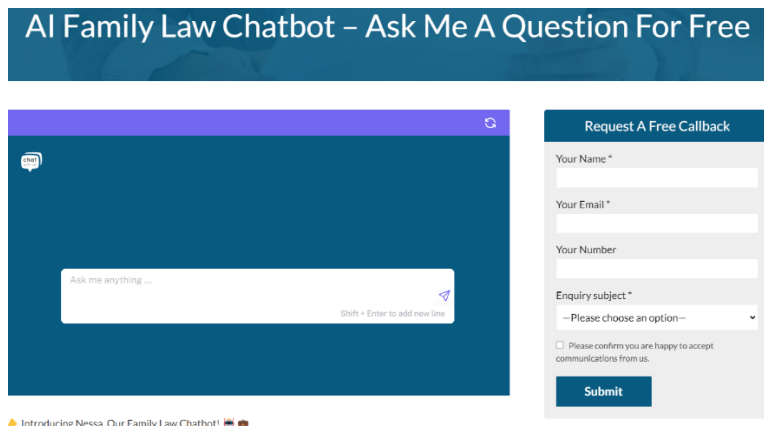
## Market Analysis

### The Existing Market of household and Tenant law

When we consider the practical applications of NLP in legal systems, certain domains can benefit significantly, such as Property Law or Household and Tenant Law. These areas are particularly relevant given the market size and the number of active individuals who, at some point in their lives, must deal with the legal jargon of property law. According to Nimblefins, there are almost 8.5 million households currently renting in the UK property market. To put this into perspective, that number represents households, not individuals; thus, the actual count of people involved in this market is far greater. These figures include just tenants; there are also millions of landlords who must address the needs and problems of every tenant. Due to a lack of legal knowledge about this particular domain of law, many tenants face significant trouble dealing with courts and lawyers, which can be economically intensive for both parties simply because they lack basic guidance on how to navigate these issues, such as whether they even need a lawyer. According to ITV, there were almost 30,230 no-fault evictions in the UK as of 2023, which could have been easily avoided if the tenants and households had sought guidance earlier rather than getting into legal trouble by turning to lawyers when it was too late. Likewise, for landlords, just in the city of Sheffield, the disrepair cases rose from 117 in April 2018 to over 1,750 cases, where the landlords had to pay the tenants, compensation totaling around 3 million pounds. Hence, there exists a gap that needs to be filled to make people more accessible to the knowledge of household and tenant law.

### Existing Solutions for Household and Tenant Law

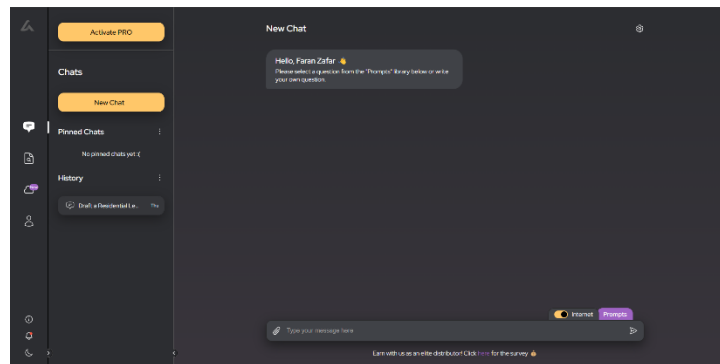
When it comes to existing solutions for household and tenant law in the NLP domain, search queries like "household and tenant law chat app," "NLP app in household and tenant law," and vice versa were used, but there wasn't a solution that existed in this domain. However, I found many use cases and examples of NLP in law. For instance, Nessa, an LLM solution developed by OLS Solicitors, was recognized as it did the job of providing basic advice regarding matters of family law. The solution that was developed was based on the GPT-4 model. Even though it provided basic advice, it wasn't able to generate case law references for the advice given, even when specifically asked for it, and this was a gap I feel could be filled with the help of Litigate, making sure it provides case law references to the user if prompted too.



*Figure 5 Showing the Nessa App Interface*

The Nessa app didn't have the ability to save or store your chat session, which I feel makes it look a little less personalized and maybe even not that attractive to the user.

Following the analysis of Nessa another innovative solution was analyzed as well and which as AI Lawyer, which was more focused on the domain of law research and had tones of innovative features like ability to draft documents and upload document to question the NLP model for. The UI was very innovative and can serve as an inspiration for the development of Litigate but because of it being a paid service a proper analysis of the platform couldn't be carried out.



*Figure 6 Showing AI Lawyer interface*

A feature that it was lacking was legal advice generation and case law reference based on the specific advice. This again leaves a gap for this proposed solution to solve, which would be discussed in the next chapter of this report.

# **Project Proposal**

## **Project Details:**

Litigate would be an online, hosted chat application accessible as a web application. Users can find legal advice related to household and tenant law on the go. There will be a no age limit for accessing the platform, people from all backgrounds will be able to use the application. An NLP model working in the backend in relation to a database, will process user queries in real-time and produce appropriate responses using NLP techniques. The responses will include basic advice about the matter and, if available, a case law relevant to the issue from the database would be produced.

## **Project Specification/Objectives:**

### **Project Scope and Objectives:**

The scope of the project has been defined by the identified said objectives that need to be accomplished throughout the development of the project. The primary objectives carry more weight as they would be allocated the most resources and time before the presentation of the project in April, 2024. If the primary objectives are achieved only then the secondary objectives would be considered implementing into the overall workflow of the application.

### **Primary Objectives:**

1. ***User Interface Development:*** Design a user-friendly interface desktop platform that allows users to easily interact with the chat application.
2. ***Natural Language Processing Integration:*** Implement a robust NLP model to understand and process user queries accurately in real-time.
3. ***Legal Database Creation:*** Compile a database that includes relevant case laws, statutes, and legal precedents in the form of documents pertaining to household and tenant law.
4. ***Real-time Response Generation:*** Develop a system capable of generating accurate legal advice and relevant case law references in response to user queries.

### **Secondary Objectives:**

1. **Accessibility and Inclusivity:** Ensure the app is accessible to users from all backgrounds, with considerations for those with disabilities
2. **Security and Privacy:** Implement robust security measures to protect user data and ensure privacy especially when handling sensitive legal queries.
3. **User Authentication:** Create a secure user authentication system requirement for accessing the platform.
4. **Feedback Mechanism:** Incorporate a feedback mechanism to collect user responses on the accuracy and helpfulness of the legal advice provided facilitating continuous improvement.

## Project Functional and Non-Functional Requirements

### Functional Requirements:

ID	System Component	Requirement Description
FR1.1	User Account Management	The system shall allow users to register
FR1.2	User Account Management	The system shall implement a secure login mechanism with password authentication.
FR1.3	User Account Management	The system shall provide a secure logout function
FR1.4	User Account Management	The system shall manage user sessions
FR2.1	NLP Integration	The system will integrate a Natural Language Processing engine
FR2.2	NLP Integration	The system shall use the NLP engine to interpret and understand the context of legal queries.
FR3.1	Legal Database Management	The system shall compile and store a database of legal documents
FR3.2	Legal Database Management	The system shall provide search functionality to retrieve legal information from the database.
FR4.1	Real-time Response	The system shall generate responses to user queries by extracting relevant information
FR4.2	Real-time Response	The system shall display the generated legal advice and case law references

*Table 1 Showing Functional Requirements of Litigat8*

## Non-Functional Requirements:

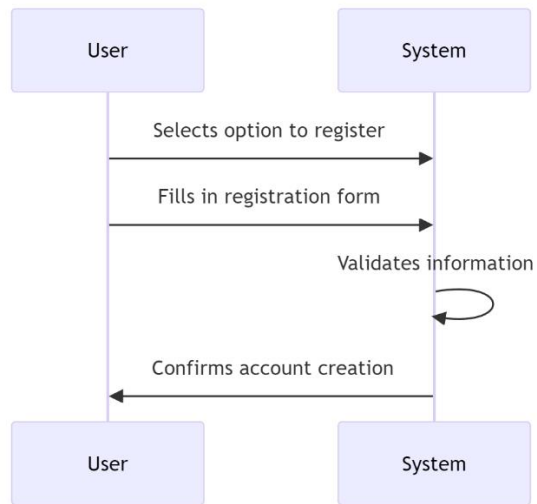
ID	Category	Requirement Description
NFR1.1	Feedback and Improvement	The system shall provide a mechanism for users to give feedback
NFR1.2	Feedback and Improvement	The system shall use user feedback to improve the accuracy.
NFR2.1	Performance and Scalability	The system shall be scalable to accommodate additional functionalities
NFR3.1	Security and Privacy	User data shall be encrypted in transit and at rest
NFR3.2	Security and Privacy	The system shall ensure privacy of user queries and responses
NFR4.1	Usability	The user interface shall be intuitive and easy to navigate
NFR4.2	Usability	The system shall provide clear and understandable responses to user queries.
NFR5.1	Reliability	The system shall have an uptime of 99.9%
NFR5.2	Reliability	The system shall provide consistent and accurate legal advice
NFR6.1	Accessibility Compliance	The system shall include features that make it accessible to users with disabilities
NFR7.1	Chat Session Management	The users shall be able to create new chat sessions
NFR7.2	Chat Session Management	The users shall be able to review their previous chat sessions

*Table 2 Showing Non Functional Requirements of Litigat8*

## Project User Stories

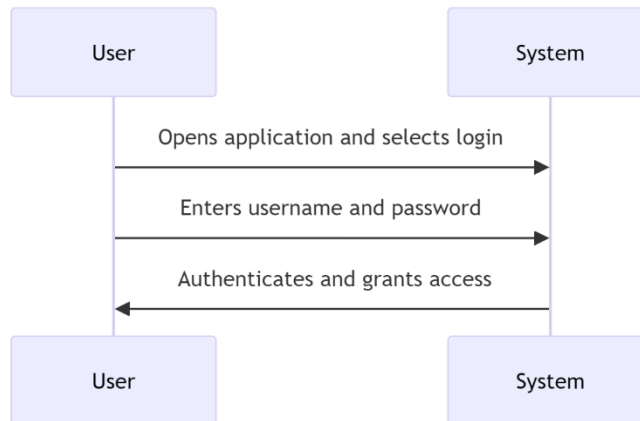
Keeping the Objectives and the idea of the project in mind. I brainstormed the potential use cases a user can have with the application. Which would further be broken down using other analysis techniques such as MoSCoW depending on the resources and time available. Following are the potential use cases of a user with the application:

### Use Case 1: User Registration



*Figure 7 Showing User Registration Use Case*

## **Use Case 2:** User Login



*Figure 8 Showing User Login Use Case*

## **Use Case 3:** User Receives Legal Advice

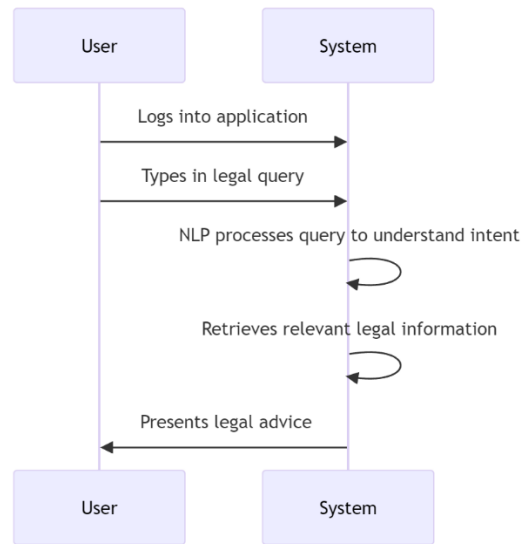


Figure 9 Showing User Legal Advice Use Case

#### Use Case 4: User Reviews Chat History

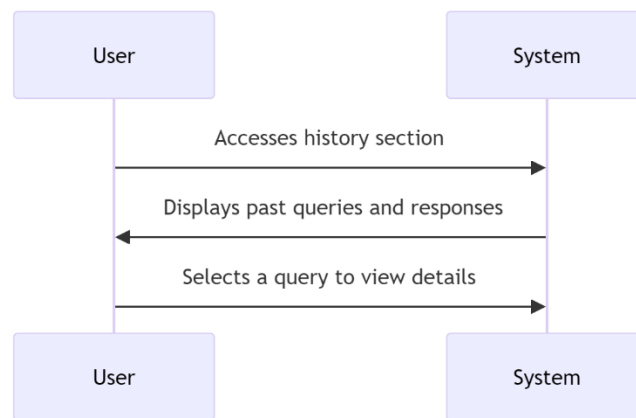
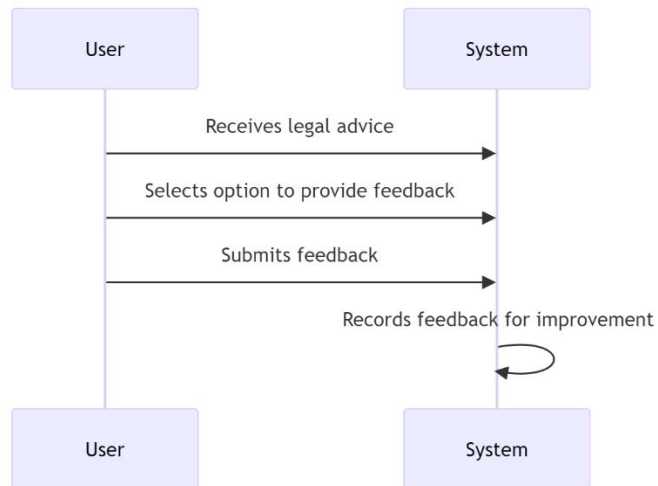


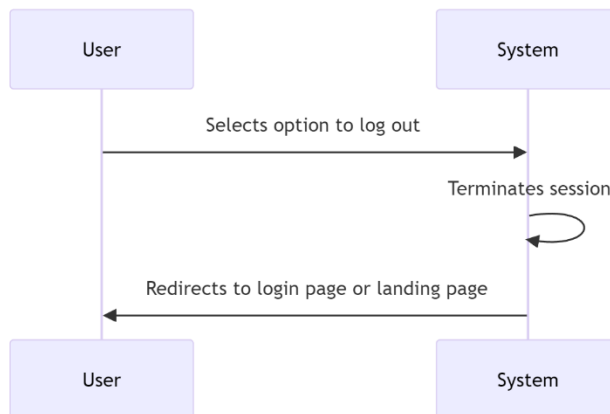
Figure 10 Showing User Chat History Review Use Case

## Use Case 5: User Provides Feedback



*Figure 11 Showing User Providing Feedback Use Case*

## Use Case 6: User Logs Out



*Figure 12 Showing User Logout Use Case*



## High Level System Design:

In line with the user stories I've decided to focus on, sketching out a high-level design (HLD) helps us map out the system's architecture in a nutshell. This overview helps pinpoint the necessary hardware and software interactions, data exchanges, and communication flows across

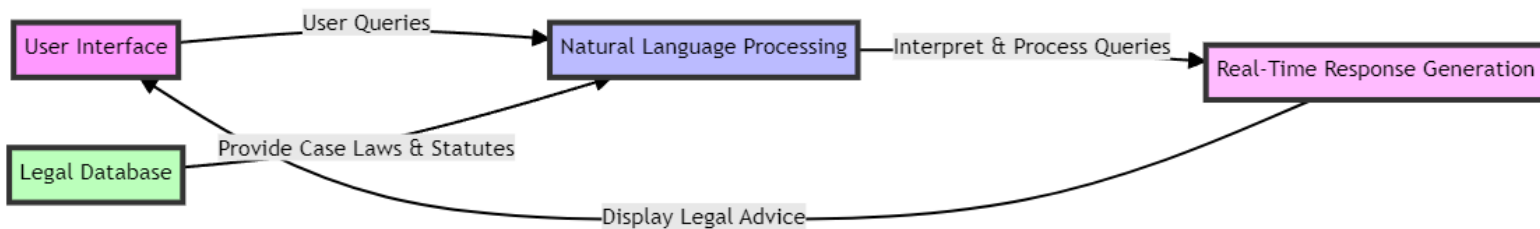


Figure 13 Showing General Overview of the Application

the system. At the heart of the architecture is a user interface designed to retrieve and update information from database tables. One of the key advantages of our approach is its scalability. As new data needs arise in the future, our system can easily expand to accommodate these additional data sources.

This diagram shows a high-level flow of data between different software and hardware components.

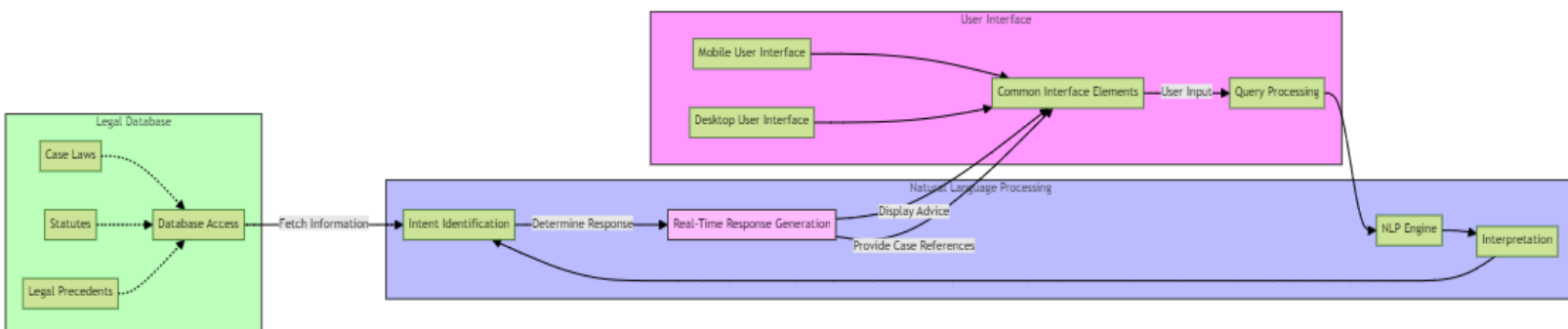


Figure 14 Showing HLD Design of Litigat8

One of the disadvantages of using the architectural design and solution, is the current technological skillset that is needed to achieve this implementation of the project. The Mitigation of the potential risks will be taken into account by discussing the it with the supervisor every week.

The diagram presented offers a detailed view of our proposed high-level design, showcasing the different elements, connections, and data movements.

## **Requirement Analysis:**

The requirements would be defined using the MoSCoW Analysis and according to the objectives defined before.

### **MoSCoW Analysis**

Based on the objectives mentioned in the Project Scope and objective I was able to shortlist the requirements for the project using the Moscow Method. Where the Must have requirements take the highest priority followed by should have and could have requirements respectively. And I thought of the requirements that could be implemented as a part of future development of the project

ID	Requirement ID	Category	Requirement Description	MoSCoW
M1	FR1.1	User Account Management	The system shall allow users to register	Must Have
M2	FR1.2	User Account Management	The system shall implement a secure login mechanism	Must Have
M3	FR1.3	User Account Management	The system shall provide a secure logout function.	Must Have
M4	FR1.4	User Account Management	The system shall manage user sessions.	Must Have

ID	Requirement ID	Category	Requirement Description	MoSCoW
M5	FR2.1	NLP Integration	The system will integrate a Natural Language Processing engine.	Must Have
M6	FR2.2	NLP Integration	The system shall use the NLP engine	Must Have
M7	FR3.1	Legal Database Management	The system shall compile and store a database of legal documents.	Must Have
M8	FR3.2	Legal Database Management	The system shall provide search functionality to retrieve legal information	Must Have
M9	FR4.1	Real-time Response	The system shall generate responses to user queries	Must Have
M10	FR4.2	Real-time Response	The system shall display the generated response	Must Have
M11	NFR3.1	Security and Privacy	User data shall be encrypted in transit and at rest.	Must Have
M12	NFR3.2	Security and Privacy	The system shall ensure privacy of user queries and responses.	Must Have
M13	NFR5.1	Reliability	The system shall have an uptime of 99.9%.	Must Have
S1	NFR1.1	Feedback and Improvement	The system shall provide a feedback mechanism	Should Have
S2	NFR1.2	Feedback and Improvement	The system shall use user feedback to improve the accuracy.	Should Have
S3	NFR7.1	Chat Session Management	The users shall be able to create new chat sessions.	Should Have
S4	NFR7.2	Chat Session Management	The users shall be able to review their previous chat sessions.	Should Have
C1	NFR4.1	Usability	The user interface shall be intuitive	Could Have
C2	NFR4.2	Usability	The system shall provide clear and understandable responses	Could Have
C3	NFR2.1	Performance and Scalability	The system shall be scalable	Could Have
W1	NFR6.1	Accessibility Compliance	The system shall include features that make it accessible to users with disabilities.	Won't Have

Table 3 MoSCoW analysis of Litigat8

## Project System Requirement:

Based on the requirement analysis done for the project. I have decided on the software and hardware requirements of the project. As the requirements of the project are modest and it would only be hosted on the localhost for the MVP. I have kept the requirements at minimum for the functioning of the project.

### **Development Languages and Tools:**

1. ***Backend Programming Language:*** Python chosen for its extensive library support, particularly for natural language processing (NLP) tasks. I decided to choose this language for the access of the existing information for python in compared to other languages such as C++. And another factor that contributed to its selection was my own proficiency in the language given the duration of the project. It would have been very highly unlikely to complete the project if I had decided to proceed with the language, I didn't have command on.
2. ***Frontend Web Technologies:*** HTML, CSS, and JavaScript, for creating an interactive and user-friendly web interface. The User interface is decided to kept simple as most of the resources and time would be allocated to developing the NLP model. Hence, no frontend framework is being used at the moment but if time is left. I'm planning to implement React as the frontend framework for the application.
3. ***NLP Library:*** NLTK, utilized for implementing the chat application's NLP capabilities to process and understand user queries. From the NLTK libraries, I'm going to be using PortStemmer , stopwords, word\_tokenize to implement functions such as tokenization, stemming and bag of words.. For developing and making the vector database for the project I would be using libraries such as Pincone and Chroma. While for the rest of the functionality of the NLP model I would be using LangChain which in itself has many libraries such as OpenAI, Ctransformers which would be used and detailed in the implementation section
4. ***Web Framework:*** Flask, selected for its simplicity and efficiency in setting up lightweight web applications, suitable for a project focused on functionality demonstration. Option of Django was considered as well for the development of the project but given the simple nature of the MVP I decided to settle down for flask. And I had some previous experience using this framework so it was a natural choice for me.
5. ***Database System:*** MySQL is used due to its ease of integration with Python applications and sufficiency for the storage needs of a development-stage project.
6. ***Integrated Development Environment(IDE):*** VsCode will be used for its support for Python and web technologies alongside it conda would be use to set up a virtual environment. Github, would also be implemented for version control of the project.

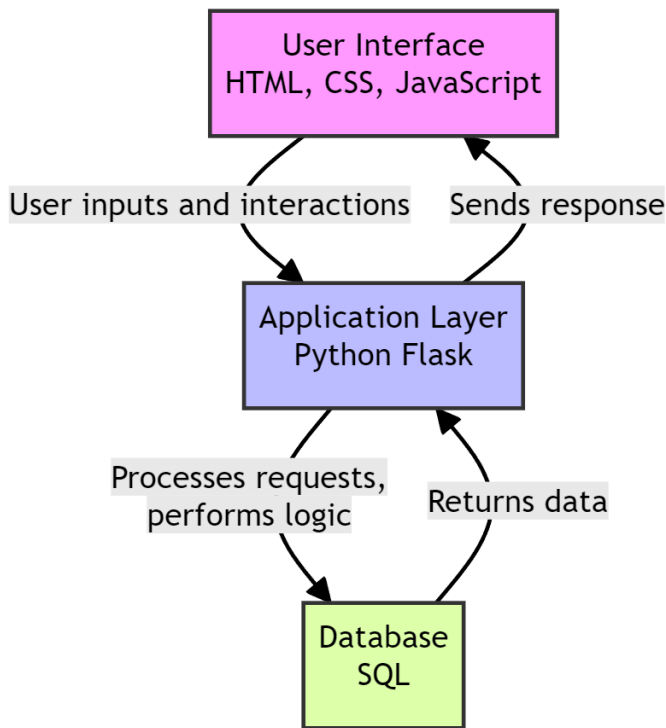


Figure 15 Showing Different Layers of Litigat8

Vector Database and other dependencies.

### Hardware Requirements:

Given the localized hosting and demonstration focus of the project, the hardware requirements are kept simple:

1. **Processor:** A minimum of a Dual-core processor is required to ensure smooth running of the development server and NLP processes.
2. **Memory:** At least 4 GB RAM to support the simultaneous execution of the development environment, web server etc.
3. **Storage:** A minimum of 5 GB of available disk space to accommodate the application codebase, MySQL database, and

### Traceability Matrix:

After carrying out in depth analysis of the requirements of the application and potential use cases, a traceability matrix was designed to ensure that the objectives put in place are fully achieved by meeting the defined use cases along with the MoSCoW requirements for Litigat8 .

Requirement ID	Requirement Description	Linked Use Case	Supported Primary Objective	Supported Secondary Objective
FR1.1	User registration	Use Case 1	P1	S3
FR1.2	Secure login mechanism	Use Case 2	P2	S3
FR1.3	Secure logout function	Use Case 6	P2	S2
FR1.4	Manage user sessions	Use Case 6	P2	S
FR2.1	Integrate NLP engine	Use Case 3	P2.	
FR2.2	Use NLP engine	Use Case 3	P2	

Requirement ID	Requirement Description	Linked Use Case	Supported Primary Objective	Supported Secondary Objective
FR3.1	Compile legal database	Use Case 3	P3	
FR3.2	Search legal information	Use Case 3	P4	
FR4.1	Generate legal advice	Use Case 3	P4	
FR4.2	Display legal response	Use Case 3	P4	
NFR3.1	Encrypt user data	All Use Cases	P2	S2
NFR3.2	Ensure privacy	All Use Cases	P2	S2
NFR5.1	System uptime 99.9%	All Use Cases	P4.	
NFR1.1	Feedback mechanism	Use Case 5	P4	S4
NFR1.2	Use feedback	Use Case 5	P4	S4
NFR7.1	Create chat sessions	Use Case 4	P1	
NFR7.2	Review chat history	Use Case 4	P1	
NFR4.1	Intuitive User Interface	All Use Cases	P1	S1
NFR4.2	Clear responses	Use Case 3	P4	
NFR2.1	System scalability	All Use Cases	P3	
NFR6.1	Accessibility features	All Use Cases	P1.	S1

Table 4 Showing Traceability Matrix

## **Project Solution**

### **Assumptions, Constraints, Risks:**

#### **Assumptions:**

#### ***Technical Capabilities:***

It's assumed that the chosen technologies and frameworks for NLP(NLTK, LangChain, OpenAI, HuggingFace), database generation (Chroma), and other functionalities will effectively support

the development of Litigat8. As this is a realm still to be explored and considering the limited time and resources available full-scale deployment of the project can be somewhat troublesome. But the given requirements for a Minimum Viable Product (MVP). It is assumed that all the technical requirements are satisfactory.

### ***Data Availability:***

Adequate and accurate tenant-landlord law documents, statutes, and regulations are available for populating the database. As I'm going to be preparing the dataset myself. It is assumed that the dataset would have adequate information for the model to produce appropriate responses for the user. And all the information contained in the dataset is correct. Even though there can be discrepancies in the dataset

### ***User Feedback:***

Users will provide feedback for system enhancement and that the feedback will be constructive. It is assumed that the feedback provided is constructive and explainable but still there can be instances where the feedback isn't constructive or comprehensible. And User Feedback is one of the secondary objectives hence it would take less resources during the production of software.

### ***Compliance and Legal Clearance:***

All necessary legal clearances and compliance requirements related to providing legal advice and handling user data will be obtained. It is assumed that the model has been approved of giving legal advice in the matters of household and tenant law. As law and AI is a very tricky domain where you have to be careful about the data that is produced and dispersed to the user. As this is a demonstration of its capabilities and the project is being made for **ONLY** this purpose. Hence, it is assumed it has all the legal clearance.

### ***Budget and Time:***

The project will be completed within the allocated budget and time frame. According to the defined user stories and analysis of requirements using methods like MoSCoW. It is assumed that all the set requirements would be completed within Budget and Time. But as this can vary depending on various factors. But for the sake of convenience an assumption is put into place.

### **Constraints:**

#### ***Single Stakeholder:***

As the sole stakeholder, your availability and decision-making will be critical for the project's progress and direction. As I'm going to be the only one that would be directing the progress of the project along with the supervisor which can put a bit of constraint on the project in a sense that I would have to make all the critical decision instead of having a shared responsibility of the decision-making progress.

#### ***Budget Limitations:***

Budget constraints may limit the scope of development, particularly concerning the scalability and future plans for web and mobile interface accessibility. The options of cloud hosting and own professional domain will be looked in the future if there are enough resources allocated to the project if there are investors involved in the project but for this development cycle it is constraint to be hosted locally without a domain.

### ***Technological Limitations:***

The performance of Litigat8 may be constrained by the capabilities of the chosen technologies. Some of the technologies chosen for the project for instance python in itself may not be the best choice when it comes to making heavy load models. But for the sake of demonstration and to have an MVP to show for by the end of April. Some of the technologies were given more weight.

### ***Geographical and Jurisdictional Limitations:***

Legal advice and statutes provided will be limited to specific geographical regions or jurisdictions. As this model is being developed just for the jurisdiction of UK law hence it would only be able to provide support and advice for Tenant and Household law in UK.

### **Risks:**

Some of the foreseeable risks have been identified that could potentially happen in the duration of the project. The mitigation techniques for these risks would be discussed with the supervisor in the weekly meetings. And sufficient alternative pathways would be setup for the project if I encounter any unforeseen circumstances which could lead to failure of any component of the project.

### ***Technology Failure:***

Risks of technology failure impacting the accuracy and reliability of legal advice provided. As there are going to be lots of functioning elements in the project from the interface to the database lots of different factors would be involved. Hence, there is a risk of technological failure if one of the components crashes or fails due to unforeseen circumstances. But sufficient steps would be taken in order to prevent that from happening. Ensuring good coding practices and proper documentation of the project to ensure any unforeseen circumstances should be dealt with using proper protocols put in place.

### ***Dependency on External Systems:***

Future dependency on external cloud hosting platforms and cloud-based database like firebase and Pinecone. I have yet to decide if I want to go for an inbuilt database like Chroma and Firebase. Which would be talked about in the meeting with the supervisor which would be safer approach. If its decided on settling for cloud-based databases then there is a potential risk that the application might not work because of being depended on an external firebase database. But steps would be taken and would be discussed with the supervisor to mitigate the risk as much as possible.



## **Solution Description:**

Based on the extensive information that was collected during the research and the requirement analysis of the project, sufficient evidence is provided for the case that a web application would be suffice to resolve the said user stories , objectives and requirements that have been identified for the project. A web application would enable to design a proper interface for the user for ease of access along with a functioning backend layer with an NLP model which in itself is very intensive which would also include a vector database for Retrieval Q/A chain and alongside that would the database for the whole system which would allow to create, update and delete user data along with the chat data. However, due to number of limitations, it is limited in its ability to create complete system. Therefore, the proposed system would deliver a proof of concept, which would only show the potential of the system in case if it's implemented as a complete system.

The poof-of-concept application (litigat8) will showcase the process to input the query as a string and then the system would be able to process the information to come with appropriate responses along with case laws and statues if they exist for that specific case

The application would showcase how the user would be able to go back to his/her queries if he or she wants to look over his/her queries again.

## **Project Management Approach:**

### **Agile Methodology**

In line with modern software development practices the project adopted the Agile methodology starting from October 15 with a projected end date of April 15. This approach is characterized by its flexibility and iterative nature it emphasizes adaptability to evolving requirements as in the case of Litigat8. Agile methodology as it is defined by Beck et al. (2001) offers a dynamic alternative to the rigid linear progression of the Waterfall model. It flourishes in an environments like the one that is needed for litigat8 where user needs and system functionalities may not be fully understood from the start of the project.

### **Project Management Using Scrum Framework**

Scrum a subset of Agile is chosen as the operational framework for its fit with the project's objectives. It provided a structured yet adaptable environment to create a user-centered platform. The Scrum methodology facilitated constant supervisor engagement enabling me to incorporate feedback iteratively and ensure that the platform remains aligned with the project objectives.

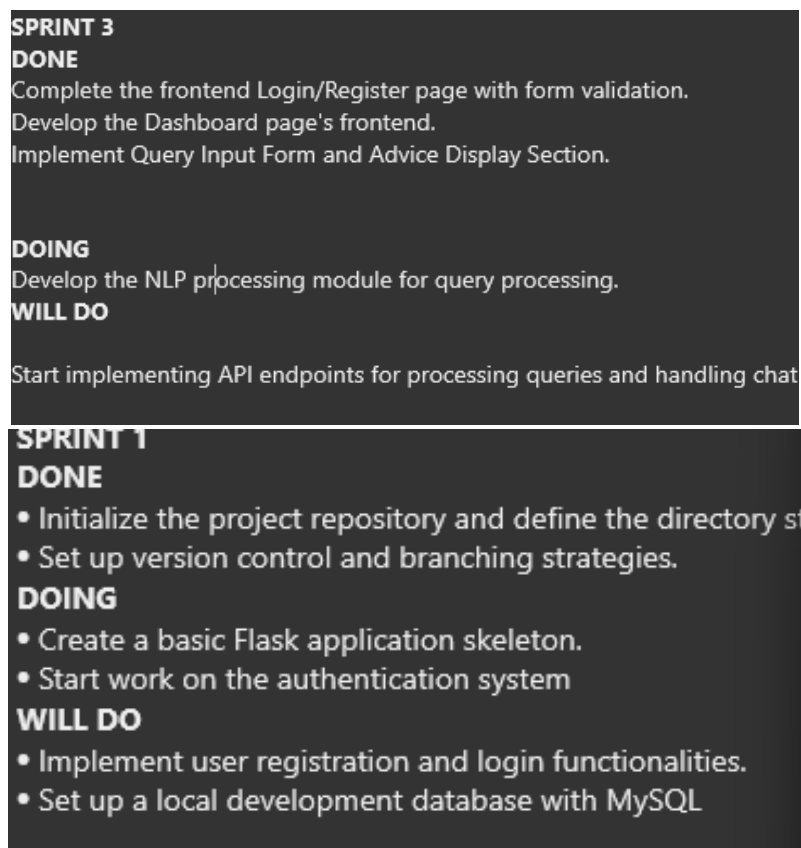
Weekly sprints were scheduled, wherein I focused on delivering specific, prioritized features from the product backlog. Regular sprint reviews and retrospectives ensured that the project adapted to feedback and improved upon the processes continuously.

## Scrum Sprints

After analyzing the total time left for the project to be completed and the list of features and tasks that need to be carried out during the project development, five sprints in total were deemed sufficient for the development of Litigate. The first two sprints were a week long, and the last three were two weeks long.

At the beginning of each sprint, a sprint planning session was held, ranging from one to two hours. This session identified the problems that are of the highest priority and it ensured that a good amount of time is provided to them as they are essential for the success of the project. It is of utmost importance that the issues that originate are kept on track. For this purpose sticky notes and Trello board will be used on windows. The features will be split into three sections: Done, Doing, and Will Do.

Sticky notes and Trello Board were preferred for Scrum because they are easy to use and accessible. Sticky notes served as a quick source of information for me when working on the development device but Trello board served as version control to make sure the same sprint was being developed across all devices. i.e. Laptop and My PC



*Figure 16 Sample Showing Sprints*

Regular meetings were held with the supervisor to ensure that the development is going according to plan and is not deviating from the set objectives.

With new features being added, complete testing of the features was carried out using debug statements as well as unit testing and integration testing, thus making sure all potential discrepancies and risks were captured.

At the end of each sprint, a review was also be conducted to estimate the tasks to be done and the tasks that have been completed, to ensure that no tasks are left uncompleted before moving to the next sprint.

## Project Management Tools

Trello was instrumental in organizing the workflow. It enabled the categorization of tasks into boards representing different Scrum artifacts along with that it also helped in time management. Trello's visual interface and ease of reorganization along with the dynamic nature of Agile project

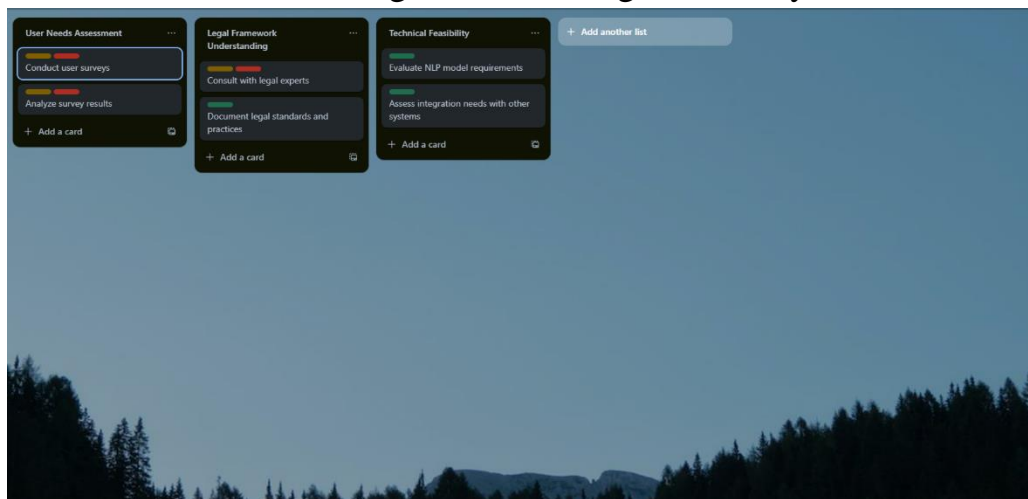


Figure 18 Showing Trello Board for litigat8- 1

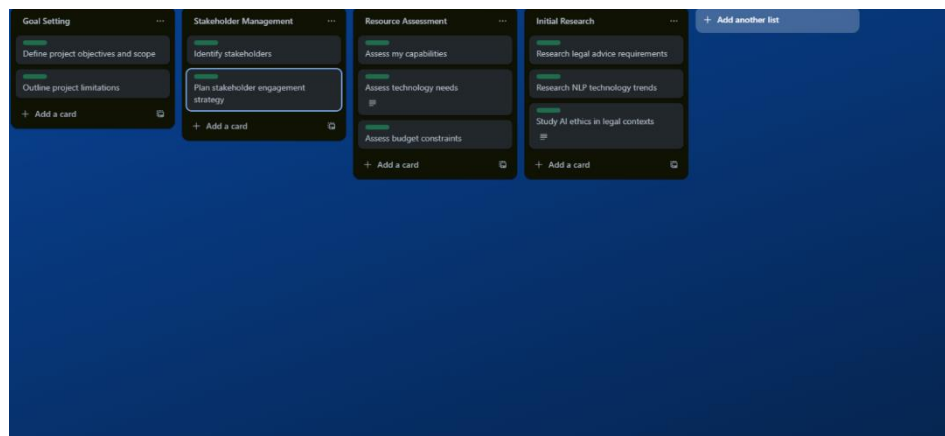


Figure 17 Showing Trello Board for litigat8- 2

management did the job of providing transparency and a high-level overview of the project's status at any given time.

## **Gantt Chart**

Task Name	Start Date	End Date	Duration	Progress %	Dependency	Resources	Color	Timeline (Oct 2023 - May 2024)																											
								0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Project Initiation	Oct 10, 2023	Oct 18, 2023	7 days	100			Orange																												
Requirement Gathering & Analysis	Oct 19, 2023	Nov 16, 2023	21 days	30	1FS		Blue																												
Project Planning	Nov 17, 2023	Dec 14, 2023	20 days	0	2FS		Pink																												
Design Phase	Dec 15, 2023	Feb 15, 2024	45 days	0	3FS		Red																												
Development Phase	Feb 16, 2024	Apr 25, 2024	50 days	0	4FS		Yellow																												
Testing & Refinement	Apr 26, 2024	Jun 05, 2024	29 days	0	5FS		Cyan																												
Deployment & Launch	Jun 06, 2024	Jun 21, 2024	12 days	0	6FS		Purple																												
Continuous Activities	Oct 16, 2023	Jun 26, 2024	183 days	10			Blue																												

						Oct. 03	Nov. 03	Dec. 03	Jan. 04	Feb. 04
--	--	--	--	--	--	---------	---------	---------	---------	---------



out using a Gantt chart. This served as a visual planning tool to set key milestones and task durations. It offered a grand view of the project's lifecycle ensuring adherence to the broad deadline and it facilitated the management of dependencies between tasks.

## **Version Control with GitHub**

GitHub was selected for version control considering its a robust platform for collaborative coding and it being preferred by most of the developers in the software development community. GitHub's branching mechanism allowed for the isolated development of features while making sure the integration into the main codebase of each developmental increment after thorough review and testing. This practice not only ensured the integrity and continuity of the development but also encouraged experimental development without risking the system.

The project's GitHub repository acted as a single source of maintaining a controlled environment for the development for the project where each modification was tracked and if there is any problem the changes were thoroughly analyzed and the problems were eliminated following the analysis

## **Design Phase:**

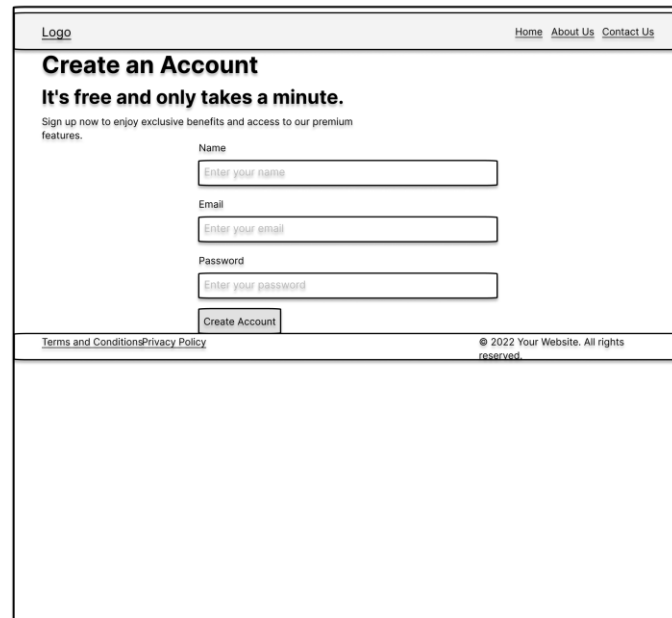
This stage marks the design phase of the application where I would be designing the required systems that would be operating within the

## **Wireframes:**

Wireframes were used to form a design the front-end for the application keeping in mind accessibility and functionality. A great consideration was taken to keep in my mind the requirements as well for the system so that it performs as such as it is planned. The wireframes were designed in **Figma** using the tools provided by the application. The aim was to make the front-end as intuitive as much as possible so the users don't have any problem navigating through the application.

## **Registration:**

The registration page was designed to accomplish the first objective of having a user authentication system. The frontend was kept as simple as possible with three input placeholders for name/username, email and password. This design would help the users with the ease of registration.




The registration page wireframe features a header with a 'Logo' on the left and navigation links 'Home', 'About Us', and 'Contact Us' on the right. The main content area is titled 'Create an Account' with the subtext 'It's free and only takes a minute.' Below this, a prompt encourages users to sign up for exclusive benefits. The form includes three input fields: 'Name' (placeholder: 'Enter your name'), 'Email' (placeholder: 'Enter your email'), and 'Password' (placeholder: 'Enter your password'). A 'Create Account' button is positioned below the password field. The footer contains links for 'Terms and Conditions' and 'Privacy Policy' on the left, and a copyright notice '© 2022 Your Website. All rights reserved.' on the right.

Figure 22 Showing Registration Wireframe

## **Login:**

Extending on the authentication system keeping the same objective in mind to keep it simple. The front-end was designed with two input placeholders for email/username and password. Thus making the logging in process as simple as possible for the User.



The login page wireframe has a header with a 'Logo' on the left and navigation links 'Home', 'About', and 'Contact' on the right. The main content area is titled 'Login' and contains two input fields: 'Username/Email' (placeholder: 'Enter your username or email') and 'Password' (placeholder: 'Enter your password'). Below the password field is a 'Remember Me' checkbox and a 'Login' button. A 'Create Account' button is located below the login form. The footer includes links for 'Terms and Conditions' and 'Privacy Policy' on the left, and a copyright notice '© 2022 Your Website. All rights reserved.' on the right.

Figure 23 Showing Login Wireframe

## **Chat Main Page:**

The main page was designed following the same intuition of accessibility and functionality. The design was kept simple with the input prompt at the bottom and a simple send button to send

queries to the NLP model to be processed at the backend. On the Left side is the chat history if the user wants to refer to it at anytime in the future or to go back to reflect on it.



Figure 24 Showing Main Chat Interface Wireframe

The sections conclude the front-end design of the application of the application. As most of the utility would be designing the backend/NLP model. But ample consideration was given to the frontend to improve the user experience as much as possible.

### Database Design:

This schema defines a simple yet effective structure for managing users, chat sessions, and conversations in a chat application. The reasoning behind the design choices is as follows:

- **User Model:** Represents the individuals using the chat application. Each user has a unique username and a password. Storing the password implies that it should be securely hashed before storage to ensure security. The uniqueness of the username ensures that each user can be distinctly identified.

User			
int	id	PK	Primary Key
string	username		Unique, Not Null
string	password		Not Null

Figure 25 Showing User Model

- **ChatSession Model:** Each session represents a period during which a user is actively engaged in conversation. It is linked to the User model via a foreign key (**user\_id**), establishing a one-to-many relationship between users and chat sessions. This means a single user can have multiple chat sessions over time. The **start\_time** field automatically records when each chat session begins.

ChatSession			
int	id	PK	Primary Key
int	user_id	FK	Foreign Key to User.id, Not Null
datetime	start_time		Default: Current Timestamp

Figure 26 Showing ChatSession Model

- **Conversation Model:** The conversation model Captures individual messages from within a chat session. It includes a foreign key to **ChatSession**, establishing a one-to-many relationship between a chat session. This allows the application to organize messages under their respective chat sessions. Each message has a **type** to distinguish between user and AI messages, supporting the interactive nature of the chat. The **timestamp** field captures the exact time each message was sent, which is crucial for displaying messages in the correct order and context.

Conversation			
int	id	PK	Primary Key
int	chat_session_id	FK	Foreign Key to ChatSession.id, Not Null
string	message		Not Null
string	type		Not Null, 'user' or 'ai'
datetime	timestamp		Default: Current Timestamp

Figure 27 Showing Conversation Model



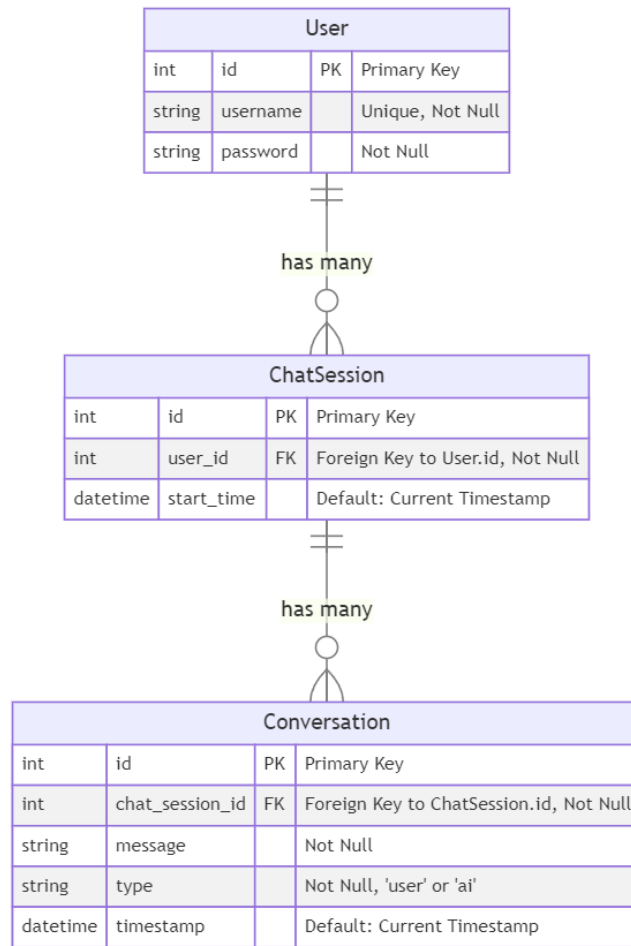


Figure 28 Showing the ERD Diagram for Litigat8 Database

## Dataset Workflow/Design:

The proposed dataset was constructed with Pdfs/Text documents available publicly for household and tenant law which included public articles or research papers etc. All of the entities were publicly available to refer and the model just analyzed the text in these to reference later. And The collected data was put through various data preprocessing steps such as Text Lowercasing, punctuation removal and Tokenization etc. To ensure the efficiency of the dataset and to remove the noise from the dataset. This would increase the overall efficiency of the NLP model to process data.

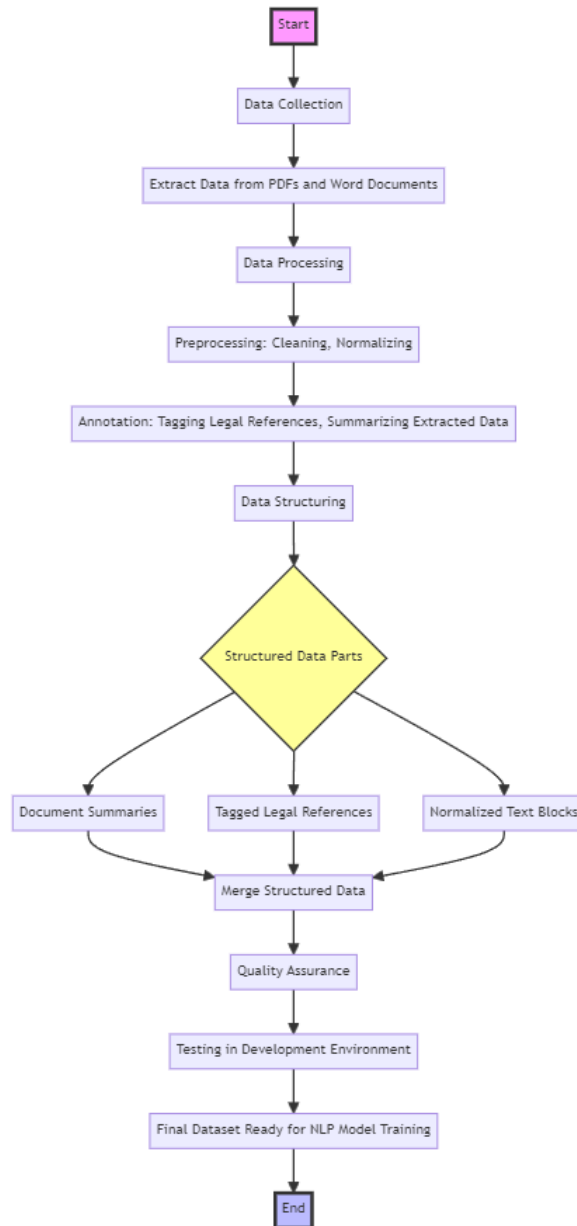


Figure 29 Showing the Framework for the Data Collection and Preparation for Litigat8 Training

The data that would be used would be analyzed beforehand to make sure it is from a valid source and it is publicly available. And all the documents/ articles that would be used were referenced appropriately.

## LLD Design:

The proposed LLD Design shows a comprehensive technical view of the system which was modelled after doing the requirement analysis of the project.

The LLD Diagram for the project solution was implemented for detailing the implementation scheme of the application as LLD provide a blueprint of how every feature and component within the system would be implemented. The displayed LLD shows the exact programming constructs, algorithm, interface design and data models. There are few reasons why the LLD was proposed the most important one being that LLD ensures good code quality. As it helped me during the development to adhere to the agreed set of standards and maintain consistency. It also enabled

me to reduce risks and uncertainty in the project as everything was modelled before the implementation of the program which helped during the project to mitigate risks.

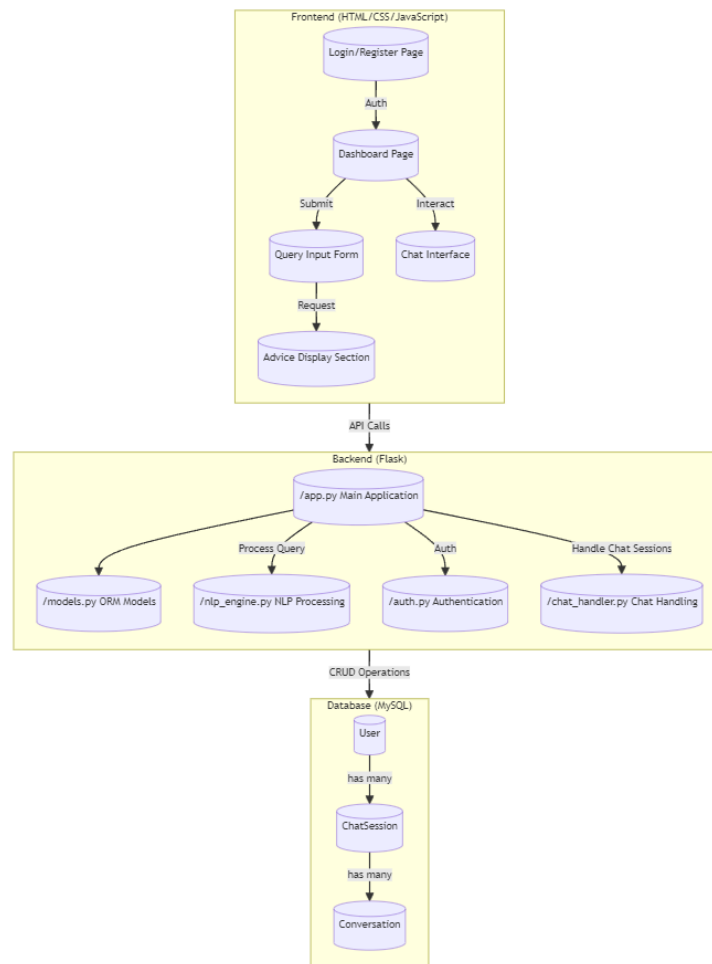


Figure 30 Showing the Low-Level Design (LLD) for Litigat8

With the LLD it the main functionality of the applicaiton can be identified with ease. The front-end would handle all the requests from the User in a structured way making use of JavaScript and AJAX. Ensuring that the information is fed properly from the front-end to the backend on specific routes. The backend is designed to handle all the POST and GET requests that are initialized. The authentication will be handled by programming structure labeled as **auth.py** in the diagram which would communicate with the MySQL database to validate the user details and redirect to the main dashboard page. The **Models.py** would be responsible for making the database tables of Users, ChatSession and Conversation models. The programming structure defined as **chat\_handler.py** would be responsible for handing the requests and functionality related to the chat with the NLP model i.e., saving the chat session, generating responses from the **nlp\_engine.py** file and handling all the POST and GET requests generated in the meanwhile. The **nlp\_engine.py** would handle all the logic related to the model training and preparation and would be responsible for generating the responses based on the user queries.

# Implementation:

## Database Implementation and Connection:

The database was set up using SQLAlchemy which is a library inside of python. This enabled me to make the dataset dynamically by just making the models of each entity.

```
from .database.models import *
from datetime import datetime
from .blueprints.auth import auth
from .blueprints.chat import chat
def create_app():
    app = Flask(__name__)

    app.config['SQLALCHEMY_DATABASE_URI'] = 'mysql+pymysql://root@localhost:8080/litigat8'

    # app.config['SQLALCHEMY_DATABASE_URI'] = 'mysql+pymysql://root:@localhost:3306/litigat8'
    # app.config['SQLALCHEMY_DATABASE_URI'] = 'mysql+pymysql://root:@viaduct.proxy.rlwy.net:58016/litigat8'

    app.config['SQLALCHEMY_TRACK_MODIFICATIONS'] = False
    app.secret_key = 'your secret key'

    app.register_blueprint(auth, url_prefix='/auth')
    app.register_blueprint(chat, url_prefix='/chat')
    db.init_app(app)
    with app.app_context():
        db.create_all()
```

Figure 31 Showing the Setup of Database Config

With the database initiation its assigned to the flask application by setting up the correct URL, username and password for the database inside of the SQL database. The variable **db** can be used to access any of the model i.e User, ChatSession and Conversation. Making the overall access of the database really easy instead of using SQL statements running directly on MySQL.

```
from flask import Flask
from flask_sqlalchemy import SQLAlchemy

db = SQLAlchemy()
```

Figure 32 Setting up the Database

The models set up are made on accordance with the database schema which is displayed in the Figure 25. All of them have a primary key but ChatSession and Conversation have foreign keys and one-to-many relationship with the User\_ID.

```

from flask import Flask
from flask_sqlalchemy import SQLAlchemy

from .. import db

class User(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    username = db.Column(db.String(50), unique=True, nullable=False)
    password = db.Column(db.String(200), nullable=False)

class ChatSession(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    user_id = db.Column(db.Integer, db.ForeignKey('user.id'), nullable=False)
    start_time = db.Column(db.DateTime, default=db.func.current_timestamp())
    conversations = db.relationship('Conversation', backref='chat_session', lazy=True)

class Conversation(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    chat_session_id = db.Column(db.Integer, db.ForeignKey('chat_session.id'), nullable=False)
    message = db.Column(db.String(200), nullable=False)
    type = db.Column(db.String(10), nullable=False) # 'user' or 'ai'
    timestamp = db.Column(db.DateTime, default=db.func.current_timestamp())

```

Figure 33 Setting up the Models for Database

Table	Action	Rows	Type	Collation	Size	Overhead
<input type="checkbox"/> chat_session		6	InnoDB	utf8mb4_general_ci	32.0 KiB	-
<input type="checkbox"/> conversation		40	InnoDB	utf8mb4_general_ci	32.0 KiB	-
<input type="checkbox"/> user		3	InnoDB	utf8mb4_general_ci	32.0 KiB	-
<b>3 tables</b>	<b>Sum</b>	<b>49</b>	<b>InnoDB</b>	<b>utf8mb4_general_ci</b>	<b>96.0 KiB</b>	<b>0 B</b>

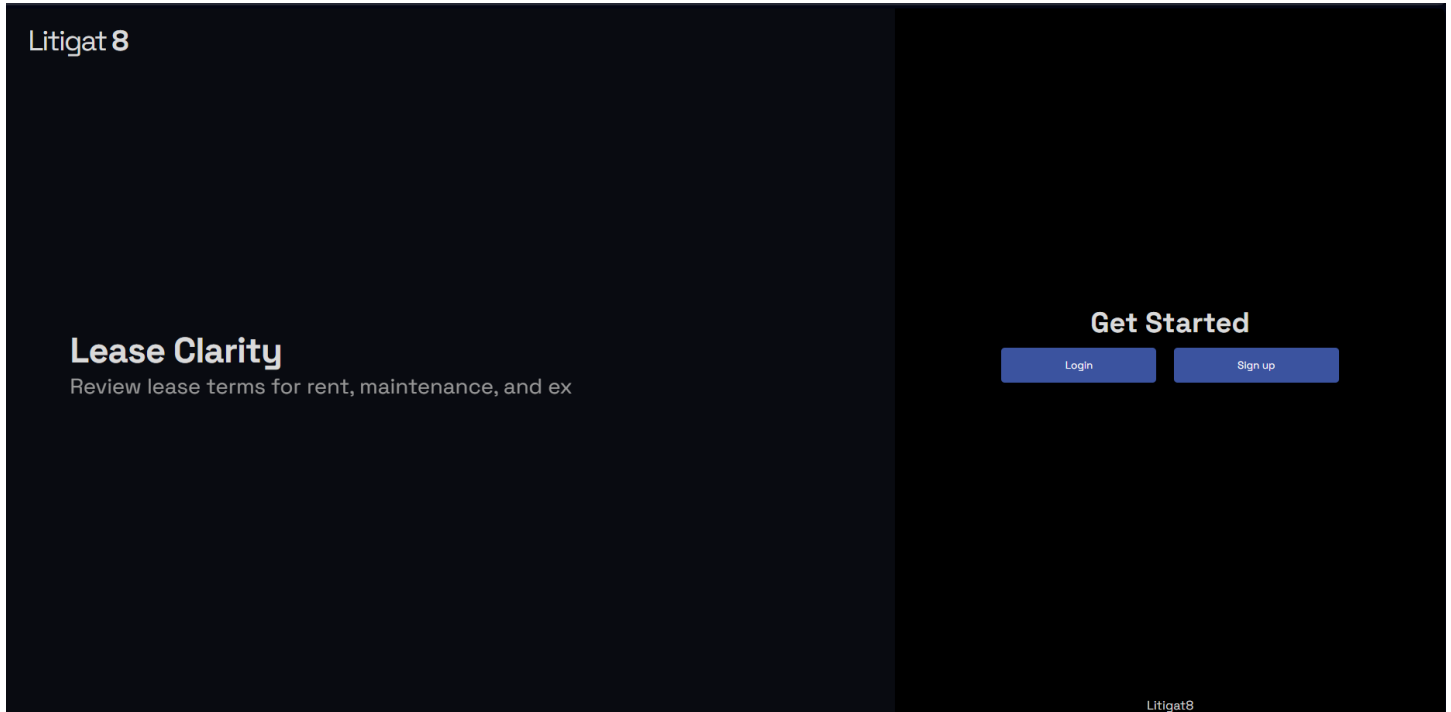
Figure 34 Showing the constructed Table in the Litigate Database

The chapter concludes the setting up of the database for Litigat8 application.

## Front-end Implementation:

### Main Home Page:

The main page is designed based on the initial approach of keeping the user interface as intuitive as possible while keeping the functionality of the page. The initial design was designed using wireframes to make sure the it has all the essential components are present in the page.

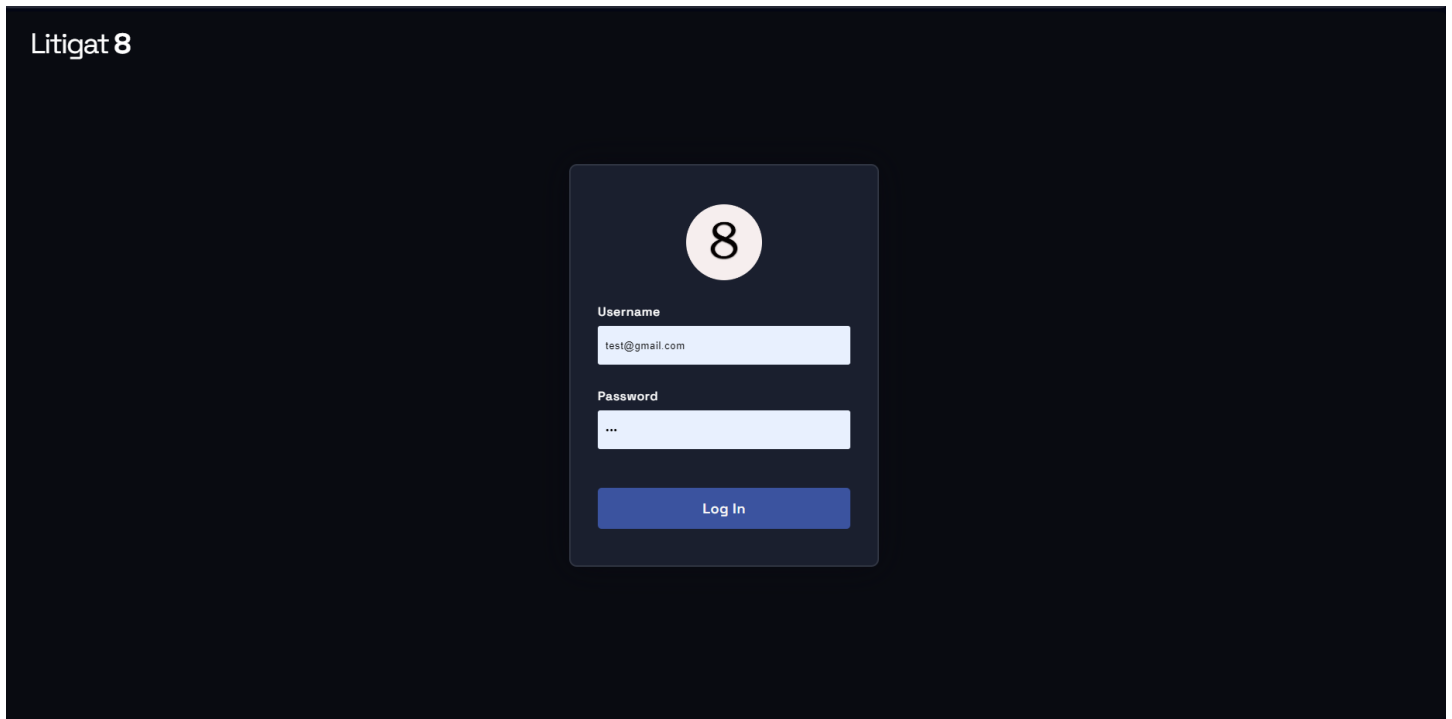


*Figure 35 Showing the Front-end Implementation of Main-Page*

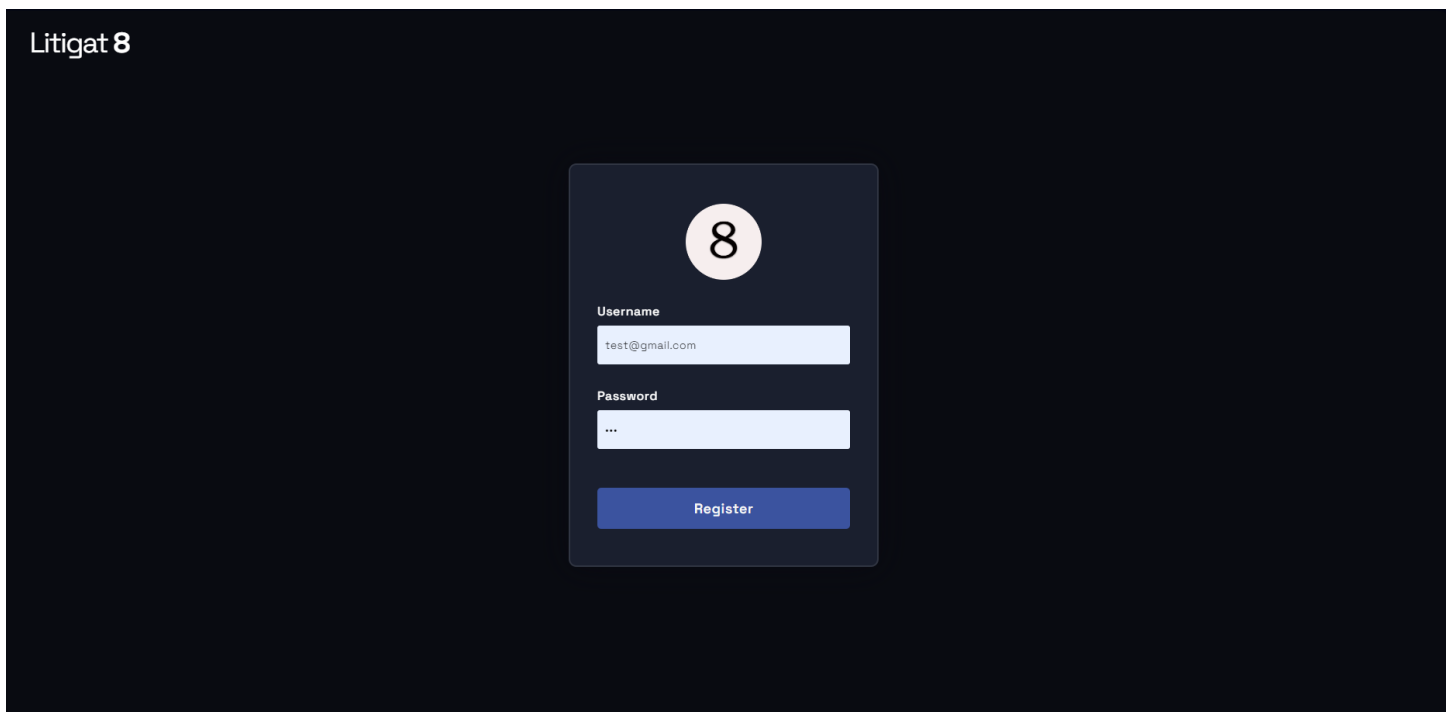
An additional feature of typewriting was implemented as well as well to give it a bit more dynamic look.

### Login And Sign-Up Page:

Following on the intuitive and approachable design of the pages, the design was based on the wireframes that was designed earlier. With two input field in login page and three input field in resistration page asking for the desired input from the users.

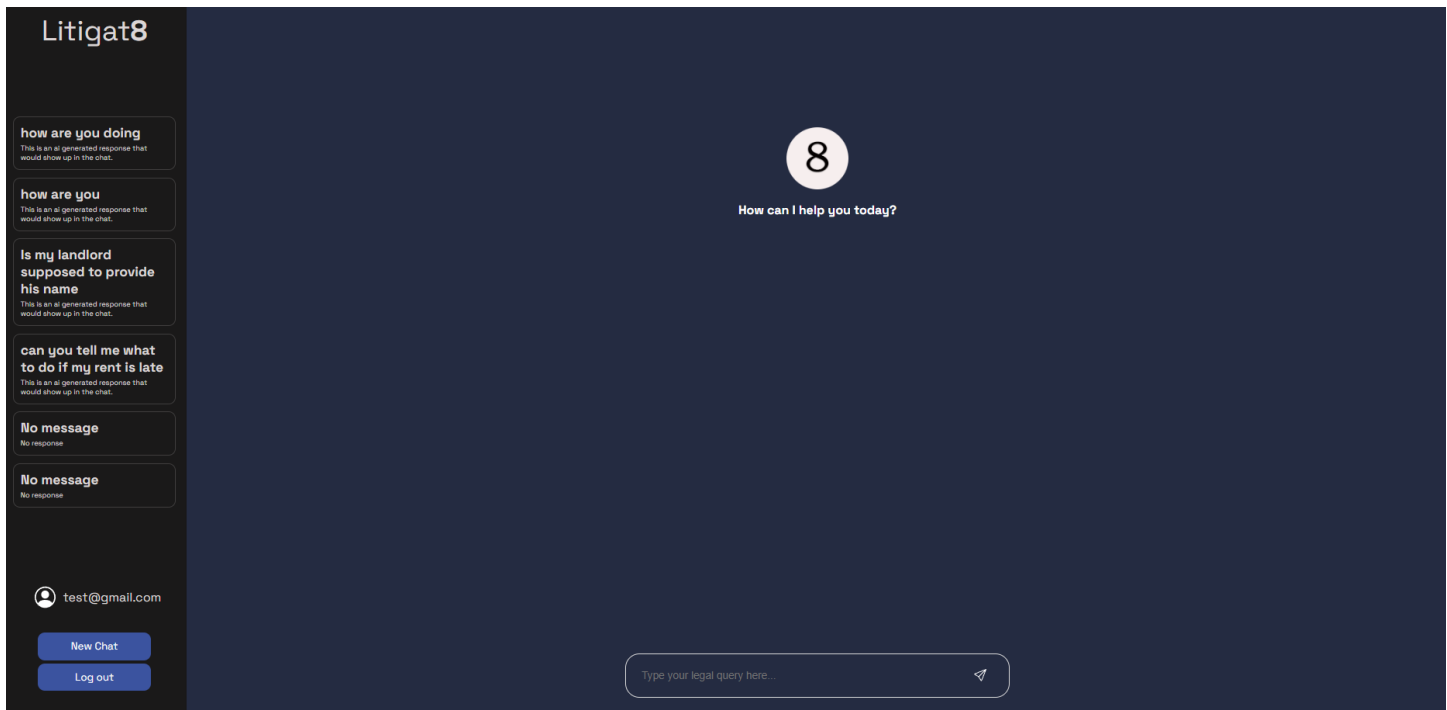


*Figure 36 Showing the Front-end Implementation of Login Page of Litigate*



*Figure 37 Showing the Front-end Implementation of Register Page of Litigate*

## **Chat Interface:**



*Figure 38 Showing the Front-end Implementation Chat Interface of Litigate*

The main chat interface was build using combination of JavaScript, Html and CSS. The page followed the initial requirements set up by wireframes. With all the essential component present in the design. An input form to take in the User queries, a panel to display all the previous chat session with two buttons to either logout of the system or to start a new chat session.

This Marks the end of the front-end design implementation of the Litigat8. All the essential design elements have been put into place for the backend element to work on and make it dynamic. Moving to the next chapter the report would show the implementation of the backend of the system.

## Backend-Server Side:

For the implementation of the backend of the Litigat8 app various libraries were used such as **flask**, **SQLAlchmey**, **functools**, **werkzeugsafe** etc. which worked in coordination to provide the implementation of the application based on the plans that were designed in the design phase of the project.

## Setting Up the App:

The python flask application was set in the `__init__.py` file which would let you run the application using a simple **flask run** command in the CLI which is much more convenient then setting it in a different file that's why I decided to go with that approach. The functionalities of the app was made modular and important functions stored in different files. All the necessary



imports were made in the `__init__.py` file before setting up the app. The `creat_app()` func sets up the application for us assimilating all the routes and database configuration.

```
from flask import *
from markupsafe import escape
from werkzeug.security import generate_password_hash, check_password_hash
from functools import wraps
from .extensions import db
import requests
import openai
from openai import OpenAI
import os
from .database.models import *
from datetime import datetime
from .blueprints.auth import auth
from .blueprints.chat import chat
def create_app():
    app = Flask(__name__)

    app.config['SQLALCHEMY_DATABASE_URI'] = 'mysql+pymysql://root@localhost:8080/litigat8'

    # app.config['SQLALCHEMY_DATABASE_URI'] = 'mysql+pymysql://root:@localhost:3306/litigat8'
    # app.config['SQLALCHEMY_DATABASE_URI'] = 'mysql+pymysql://root:@viaduct.proxy.rlwy.net:58016/litigat8'

    app.config['SQLALCHEMY_TRACK_MODIFICATIONS'] = False
    app.secret_key = 'your secret key'

    app.register_blueprint(auth, url_prefix='/auth')
    app.register_blueprint(chat, url_prefix='/chat')
    db.init_app(app)
    with app.app_context():
        db.create_all()

    def login_required(f):
        @wraps(f)
        def decorated_function(*args, **kwargs):
            if 'user_id' not in session:
                flash('You need to be logged in to view this page.')
                return redirect(url_for('auth.login'))
            return f(*args, **kwargs)
        return decorated_function
```

Figure 39 Showing the implementation of Flask App with Configuration

For setting up the routes for the flask application instead of setting it up directly in the app. **Blueprints** were used to set up the routes respective to their functionality. Two main blueprints were set **chat.py** and **auth.py** the **chat.py** handles all the routes to handle the server side functionality of chat functions linked with the specific routes. Whereas **auth.py** handles the logic used for authentication and registration of the user adding a bit more security and modularity to the system.

### Setting Up Blueprints:

```
from flask import Blueprint, request, render_template, redirect, url_for, flash, session
from werkzeug.security import generate_password_hash, check_password_hash
from ..extensions import db # Import your database instance from your main app module
from ..database.models import User # Import your User model

# Creating the Blueprint
auth = Blueprint('auth', __name__)
```

Figure 40 Showing the Implementation of Auth Blueprint

```
from flask import Blueprint, request, jsonify, session, url_for, redirect
from datetime import datetime
from ..extensions import db # Make sure to import your database instance
from ..database.models import ChatSession, Conversation # Import your models
from werkzeug.security import check_password_hash, generate_password_hash
from ..nlp.nlp import get_ai_response # Import your AI response function
# Creating the chat Blueprint
chat = Blueprint('chat', __name__)
```

Figure 41 Showing the Implementation of Chat Blueprint

## Authentication Handling:

The authentication of the User was done by using POST requests that are originated from the front-end. As a result of the POST request the function queries the database to check if the user exists or not and handles the results accordingly to the outcome. And all the routes that needed login of the user were locked using **wraps from functools** which prevent unauthorized access to the system thus making the application more secure

```
@auth.route('/login', methods=['GET', 'POST'])
def login():
    if request.method == 'POST':
        username = request.form['username']
        password = request.form['password']
        user = User.query.filter_by(username=username).first()
        if user and check_password_hash(user.password, password):
            session['user_id'] = user.id
            return redirect(url_for('main_chat')) # Assuming 'main' is the Blueprint name for your main app routes
        else:
            flash('Invalid username or password.')
    return render_template('login.html')
```

*Figure 42 Showing the setting up of Login Function Server Point*

```
@auth.route('/register', methods=['GET', 'POST'])
def register():
    if request.method == 'POST':
        username = request.form['username']
        password = request.form['password']
        hashed_password = generate_password_hash(password)
        new_user = User(username=username, password=hashed_password)
        db.session.add(new_user)
        db.session.commit()
        return redirect(url_for('auth.login')) # Note the Blueprint name prefix
    return render_template('register.html')
```

*Figure 43 Showing the setting up of Register Function Server Point*

Registration is done with a simple POST request as well to the URL **auth/register/** which on being called inserts the User details into the database. And all the user passwords were encrypted to make sure their passwords are kept safe.

```
@auth.route('/logout')
def logout():
    session.pop('user_id', None)
    return redirect(url_for('index')) # Assuming 'main.index' is the route to your main page
```

*Figure 44 Showing the setting up of Logout Function Server Point*

The logout simply just pops out the user details if they exist in the flask application.

## Chat/Response Handling Generation and Chat Session Handling:

### **Python Server Side to Handle Requests:**

This section shows the implementation of how chat session are stored and retrieved. The **start\_chat\_session()** take in both kind of requests POST and GET. The function works by making Chat Session entry whenever the function is call and then the chat session id is stored in the session to be used later.

```
chat.route('/start_chat_session', methods=['POST','GET'])
def start_chat_session():
    user_id = session.get('user_id')
    if not user_id:
        return jsonify({'error': 'User not authenticated'}), 401

    new_chat_session = ChatSession(user_id=user_id, start_time=datetime.utcnow())
    db.session.add(new_chat_session)
    db.session.commit()

    # Set the chat_session_id in the user's session
    session['chat_session_id'] = new_chat_session.id

    return jsonify({'message': 'New chat session created', 'session_id': new_chat_session.id}), 201
```

Figure 45 Showing the implementation of start\_chat\_session Server Point

The **/end\_chat\_session** works just by removing the chat\_session\_id from the session thus making not accessible anymore.

```
@chat.route('/end_chat_session', methods=['POST','GET'])
def end_chat_session():
    if 'chat_session_id' in session:
        chat_session_id = session['chat_session_id']
        # Here you can update the database to mark the chat session as ended, if needed
        session.pop('chat_session_id', None) # Remove chat_session_id from session
        return redirect(url_for('chat.start_chat_session'))
    return jsonify({'error': 'No active chat session'}), 400
```

Figure 46 Showing the implementation of end\_chat\_session Server Point

The **/chat/submit** route is linked with **submit()** function that calls onto the **ai\_response()** func which is imported from **app.nlp.nlp\_engine** which serves as the base function for generating the AI response which then gets send to the font-end as JSON object to be printed out in a user understandable form. Using JSON to transfer data comes in really handy given the flexibility it provides.

```

@chat.route('/submit', methods=['GET', 'POST'])
def submit():
    user_id = session.get('user_id')
    interactions = [] # Adjust as needed

    if request.method == 'POST':
        print("this works")
        if request.is_json:
            data = request.get_json()
            user_input = data.get('user_input')
        else:
            user_input = request.form.get('user_input')
        print(user_input)
        if not user_input:
            return jsonify({'error': 'No user input provided'}), 400

        # Example process, adjust as needed
        ai_response = get_ai_response(user_input)

        interactions.append({'type': 'user', 'text': user_input})
        interactions.append({'type': 'ai', 'text': ai_response})

        return jsonify({'user_input': user_input, 'ai_response': ai_response})

```

Figure 47 Showing the implementation of server handling of /submit route

The function **save\_interaction()** makes use of a helper function **save\_conversation\_message()** they both work to gather to save the interaction between the User and the AI to be referred later to be stored with a reference to the chat session I used helper function instead of defining the functionality in the save\_interaction func because it helped me made the code more modular thus more robust. And the other function **get\_conversation/session\_id** was designed to get all the conversation stored in the database for a specific id. Which then are displayed on the front-end in a structured way.

```

@chat.route('/save_interaction', methods=['POST'])
def save_interaction():
    data = request.json
    user_id = session.get('user_id')
    # Retrieve the current chat session ID from the session or other means
    chat_session_id = session.get('chat_session_id') # Ensure this is being set somewhere in your application

    user_input = data['user_input']
    ai_response = data['ai_response']

    # Save both messages with their respective types
    save_conversation_message(user_id, chat_session_id, user_input, 'user')
    save_conversation_message(user_id, chat_session_id, ai_response, 'ai')

    return jsonify({'status': 'success'})

def save_conversation_message(user_id, chat_session_id, message, message_type):
    # Create a new message with the chat session ID
    new_message = Conversation(chat_session_id=chat_session_id, message=message, type=message_type)
    db.session.add(new_message)
    db.session.commit()

```

Figure 48 Showing the implementation of server handling of /save\_interaction route

```

@chat.route('/get_conversations/<int:session_id>', methods=['GET'])
def get_conversations(session_id):
    user_id = session.get('user_id')
    if not user_id:
        return jsonify({'error': 'User not authenticated'}), 401

    chat_session = ChatSession.query.filter_by(id=session_id, user_id=user_id).first()
    if not chat_session:
        return jsonify({'error': 'Chat session not found or access denied'}), 404

    conversations = Conversation.query.filter_by(chat_session_id=session_id).order_by(Conversation.timestamp.asc()).all()

    conversation_data = [{
        'type': conv.type, # Use the 'type' directly from the model
        'message': conv.message
    } for conv in conversations]

    return jsonify(conversation_data)

```

Figure 49 Showing the implementation of server handling of /get\_conversation/session\_id route

The loading of all the chat session to be displayed for the user was done by the use of **fetch\_chat\_histories()** function which gets all the conversation enteries between the user and ai which have the same chat session id. It is then converted into a json object which then gets displayed at the front-end with the help of Javascript.

```

@chat.route('/fetch_chat_histories')
def fetch_chat_histories():
    user_id = session.get('user_id')
    if not user_id:
        return jsonify({'error': 'User not authenticated'}), 401

    chat_sessions = ChatSession.query.filter_by(user_id=user_id).all()

    chat_histories = []
    for chat_session in chat_sessions:
        # Fetch the first user and AI messages in this session as a snippet
        user_message = Conversation.query.filter_by(chat_session_id=chat_session.id, type='user').first()
        ai_message = Conversation.query.filter_by(chat_session_id=chat_session.id, type='ai').first()

        chat_histories.append({
            'session_id': chat_session.id,
            'user_snippet': user_message.message if user_message else 'No message',
            'ai_snippet': ai_message.message if ai_message else 'No response'
        })

    return jsonify(chat_histories)

```

Figure 50 Showing the implementation of server handling of /fetch\_chat\_histories route

## NLP Model Implementation:

This chapter marks the implementation of the NLP Model. The steps that were taken to make a functioning LLM that would answer the User queries about household and tenant law would be discussed in this chapter. Many libraries were used to make the final proof-of-concept model for the application such as Langchain, OpenAI, Chroma, OpenAI, NLTK etc. These libraries served the foundation on which the application was build.

### Data Preprocessing/Text Preprocessing:

Before starting with the development of the model, it was essential that the data is preprocessed before any work was done using it thus many preprocessing steps were taken to ensure there aren't any discrepancies in the data. Four major preprocessing steps were taken, the first one

being tokenization of the text. Which essentially breaks down the text into smaller units called tokens. There are different types of tokenization's word tokenization, character tokenization etc. but in my case I decided to use word tokenization which is based on Penn Treebank tokenization because of the fact it can handle complex cases, such as contractions (e.g., splitting "don't" into "do" and "n't") and special punctuation patterns, thanks to its underlying use of regular expressions and the Penn Tree Bank tokenization standards.

```
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Assembling a 'kind of' home in the UK private renting sector
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ARTICLE INFO
Keywords:
Assemblage theory
Home making
Private renting sector
United Kingdom
ABSTRACT
Drawing on assemblage-thinking and specific assemblage concepts, this article explores the ways in which
young, less affluent people create a sense of home in an unregulated, market-based private renting sector (PRS) that confers reduced
tenant agency and frequent, undesired residential mobility. The concept of 'home-assembling' to account for the ontologically, normatively and emotionally different processes
involved in constructing a sense of home than those connoted by home-making.
Through in-depth telephone interviews and photo elicitation, we explore the transient, incomplete nature of
practices of home personalisation; the destabilising effect of broken things which erode the sense of home and
instill feelings of unworthiness; and processes of de-territorialisation, particularly unwanted real/feared re-
location, space sharing and confinement in small rooms. We document that the struggle to continually assemble, de-assemble and re-assemble a sense of home drastically reduces private
renting tenants' anxiety, depression and alienation. However, we also indicate potential lines of change towards alternative
futures not least by the emergence of tenants' 'collective body' as well as by casting tenants' housing ill-being as a matter of public concern.
1. Introduction
Every dwelling, owned or rented, is an aggregate of materials,
money, emotions and practices while concomitantly serving as a roof
over one's head, a place of home, an investment vehicle, a store of
wealth and a symbol of status (Bourdieu, 1989; Cook et al., 2013). The
idea of assemblage is one way of understanding how these hetero-
geneous material, social and emotional components co-function as an
emerging 'whole'—e.g. 'tenure', 'home', 'neighbourhood'—while also
participating in other socio-spatial formations, such as the financial
sector or the built ecology of the city. The notion of assemblage has
been generally employed to understand emerging formations at the
large scale of the global (Acuto and Curtis, 2014; Collier, 2006), the
region (Allen and Cochrane, 2010) and the city (Jacobs, 2012; McCann,
2011; McFarlane, 2011b). We wish to engage it to the small scale of the
house.
```

Figure 51 Showing the text data structure before pre-processing steps

The second pre-processing was lowercasing of all the words in a token. This made the whole text normalized which is essential to make sure there are not discrepancies in the corpus of the data.

The third pre-processing step that was taken was the removal of stop words in the case of English stop words like is, the, in don't generally contribute to the meaning of a text for the analysis process thus they are removed from the dataset in the case of Litigat8 as well.



```

import nltk
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.tokenize import word_tokenize

nltk.download('punkt')
nltk.download('stopwords')
def preprocess_text(text):
    # Tokenize
    tokens = word_tokenize(text)
    # Lowercase
    tokens = [token.lower() for token in tokens]
    # Remove punctuation and non-alphabetic characters
    tokens = [token for token in tokens if token.isalpha()]
    # Remove stop words
    stop_words = set(stopwords.words('english'))
    tokens = [token for token in tokens if token not in stop_words]
    # Stemming
    stemmer = PorterStemmer()
    tokens = [stemmer.stem(token) for token in tokens]

    return ' '.join(tokens)

```

✓ 0.8s

[nltk\_data] Downloading package punkt to  
[nltk\_data] C:\Users\FZ\AppData\Roaming\nltk\_data...  
[nltk\_data] Package punkt is already up-to-date!  
[nltk\_data] Downloading package stopwords to  
[nltk\_data] C:\Users\FZ\AppData\Roaming\nltk\_data...  
[nltk\_data] Unzipping corpora\stopwords.zip.

Figure 52 Showing the preprocessing steps i.e., Tokenization, Lowercasing, Removing Stop Words, Stemming

The 4th pre-processing step taken was stemming, which essentially breaks down the words to there root word for instance “Punctuation” would become “Punctuat” after applying stemming to it. There are number of benefits as it allowed to me to increase the relevance and search in information retrieval from the database.

content list avail sciencedirect geoforum journal homepag : www.elsevier.com/locate/geoforum assembl ' kind ' home uk privat rent sector adriana mihaela soaitaa , b , \* , kim mckeec , t scholarship mostli remain centr norm mean andqual ( clapham,2011 ) .assemblage-thinkingallowsustoattend ' thesmallag ' ofth ( bennett,2010 , p.95 ) therebyexpand problematis exclus vieu organis ; itsemployeesandbuildingarepartsofthewholebutthey reduc organis sinc peopl concomitantli part unrel assemblag ( famili , commun , profession network ) build contributesto commu present imagin altern futur . dittmer ' ( 2014 , p.394 ) borrow concept ' bodi polit ' help captur emerg call system chang ground subject ident assembl intoa ' collectivebodi ' .forthi whati ' dlike toknow iswhi thisstudyislimitedbyag ? researchersreallybelievethatgenerationrentstopseffectingpeopl age 36 ? unfortun far truth . weagree.in2017,44percentofallprivately-r ( power , 2017 ) , yet four particip pet , without author- isat ; two cat featur pictur , show witti agenc . howev skirmish seek authoris hide pet across success tenanc diminish tenant cat . leav , feel like ' home ( salena , 21 , bristol ) . partner chronic mental health issu , ' rebotherceivingtreatmentforourhealthproblem , andithink livinginaflatwherey ' renamedter make realli uncomfort , ' man . final , three particip lodger . two lodg friend , whichdrawsattentiontodeeplinequalitiesbetweenyoungpeopl , landlord ( soaita et al . , 2016 ) . one parti particip experienc homeless between-but sens home erod success move . therefor propos assemblage-inspir empiri- cally-supportedconceptof home-assembl thatreferstoontolog , norm emot di leahi , s . , mckeec , k . , crawford , j . , 2018 . gener confus , concern , precar right rent scheme scotland . antipod 50 ( 3 ) , 604-620 . lloyd , j . , vasta , e . , 2017 . reimagin homi law commiss consult paper 168 rent home 2 : co-occup , transfer success consult paper london : tso law commiss set section 1 law commiss act 1965 purpos promot reform law . law commission : honour mr justic toulson , chairman professor hugh beal qc mr stuart bridg professor mar tin i iii83-250-04 law commiss rent home 2 : co-occup , transfer success content paragraph page part : introduct 1 introduct 1.1 1 scope propos 1.3 1 exclus 1.4 1 subordin natur consult paper iparagraph page effect applic bring new joint occu pier 3.51 27 joint occupi seek withdraw agreement 3.59 29 formal rout 3.62 29 inform rout 3.102 35 non-contractu arrang 3.113 38 pos: vparagraph page special case 6.14 64 right transfer mutual exchang 6.15 64 transfer potenti successor 6.42 68 transfer order famili court 6.57 70 effect transfer right occupi anoth 6.72 viparagraph page hous law land law 8.10 105 polici land law 8.12 105 statutori except land registr scheme 8.16 106 overridi ng interest 8.26 108 impact licenc 8.30 109 conclus 8.37 110 1part introduct introduct 1.1 first consult paper aris current project - rent home 1 : statu secur , consult paper 162 ( henceforth " cp 162 " ) - set provision propos simplif law relat 2form owner occup rather way rent home . otherwis , argu except possible.1 1.5 final recommend scope scheme propos , cours , await analysi respons cp 162 consider thereof . subordin nat 3occupi ) , lodger sub-occupi . deal categori , respect , part iii , iv v. 1.10 addit , occupi may want transfer right occup other . circumst might possibl consid part vi . problem alsu 4 1.17 order avoid wholesal repetit argument cp 162 , gener taken content paper read . necessari , summaris princip featur argument made ; frequent cross-ref cp 162 discuss matter dealt 5landlord . also consid particular matter extent occupi may enter arrang exchang right occup anoth . consider also given situat court order adjust occup right . ( 5 ) success . part vi: 6 ( 3 ) period time contract last . structur contract 1.25 suggested3 contract would contain three differ type term : ( 1 ) core term ; ( 2 ) compulsori term ; ( 3 ) default term . 1.26 7agreement requir agreement termin new one creat . address issu paper . period time agreement last 1.32 includ propos provis relat possess proceed may brought occup agreement gener ruli 8part ii obtain consent introduct 2.1 part iii , v vi consid number situat requir obtain consent requir transact go ahea d. exampl : whether occupi entitl add new occupi joint occup agi 9and hous act 1996 deal , varieti way , circumst sub -let and/or assign permit , consequ failur obtain requisit consent . rule affect landlord tenant act 1927 landlord tenant act 1988 . 10act 1927 1988 , appli qualifi prohibit , appli absolut prohibitions.5 2.12 even absolut prohibit tenanc agreement , noth stop landlord agre assign sub-let . reason absolut coven assign 11simplifi option 2.16 think scope simplif option . landlord ' veto 2.17 appar analysi , practic littl differ absolut prohibit " mere qualifi " prohibit . first requir landlord anyth ; 12conclus 2.24 provision propos three standard possibl recognis : ( 1 ) requir consent ; ( 2 ) requir landlord give consent , withhold reason ground ; ( 3 ) landlord ' veto . contain or 13structur . suggest particular context , refin constitut reasonableness.12 would welcom view whether gener test reason subject structur discret whether particular factor court requir 1 14should satisfi remain simpli " reason " whether precis defin . preliminar view precis definit would use . 2.38 provision propos compulsori term agreement person whose consent transac 15effect transact necessari consent obtain 2.45 present law , transact breach coven assign sub-let - whether absolut , mere qualifi fullli qualifi - prevent assign sub-let valid .19 inst 16 2.49 necessari consent obtain , effect occupi continu occupi , posit differ unlaw sub-occupi unlaw assigne . 2.50 unlaw sub-occup agreement take effect way agre sub-occupi occupi , 17 2.55 new scheme believ potenti problem landlord artifici claim realis know receiv rent new occupi , thu claim given consent new arrang avoid . happen , point head agreement termin , 18purport collect money lieu rent , pend proceed possess materialise.28 2.60 accept may reason expect landlord start proceed day learn exist new occupi . also accept may reason expect : 19to determin court whether landlord agre refrain delay possess action return payment ? 2.66 may case social landlord would want enter long-term type agreement unlaw sub-occupi would wi 20part iii co-occup agreement introduct 3.1 note outset paper , cp 162 written deliber simplist assumpt landlord would enter contract grant right occupi premis one person - occupi . neu 21 3.6 secondli , anoth featur joint tenanc ( oppos tenanc common ) liabil meet oblig joint tenanc agreement , unless provis contrari , " joint sever " . mean tenant liabil meet full ob: 22procedur chang enhanc posit non-contractu occupi possess proceed . joint occup agreement - creation 3.14 seek disturb current land law rule number person legal joint tenanc grant lim: 23joint occup agreement - liabil 3.20 suggest question relat liabil aris joint occup agreement base analog current law joint tenanc . would mean joint occupi would joint sever 1: 24 3.26 view , notion joint sever liabil well establish understood residenti rent sector . landlord would certainli expect impos enter agreement new scheme . appear us reason . 3.27 juu 25to home like continu . situat envisag includ joint commit spous , friend , unpaid live-in carer . guidanc provid local author " normal " grant joint tenanc group , subject advers imp: 26provid particular landlord ; , case social hous , seek exploit right joint occup jump hous queue ; , gener , unlik abl pay rent . 3.36 also think one factor landlord take account whe

Figure 53 Data Structure after Data Pre-Processing

```
#splitting the text into
text_splitter = RecursiveCharacterTextSplitter(chunk_size=1000, chunk_overlap=200)
texts = text_splitter.split_documents(documents)
```

Figure 54 Chunking/Splitting of the Text Data

page\_content= "Contents lists available at ScienceDirect\nGeotourism journal homepage: www.elsevier.com/locate/geotourism\nAssembling a 'kind of' home in the UK private renting sector\nndr page\_content= \"young, less affluent people create a sense of home in an unregulated, market-based private renting sector (PRS) that confers reduced tenant agency and frequent, undesired residential mobility. Fort page\_content= anxiety, depression and alienation. However, we also indicate potential lines of change towards alternative futures notwithstanding the emergence of tenants' collective body'. as well page\_content= been generally employed to understand emerging formations at the large scale of the global (Acuto and Curtis, 2014; Collier, 2006), the region (Allen and Cochrane, 2010) and page\_content= cality, region or cosmos (Heidegger, 1971), we wish to refocus the concept of home-making on the materialities of home for 'there is no nowhere without innerspace' (Bryden, 2018). page\_content= because the space is physically inappropriate or unaffordable (Lancione, 2018; Lloyd and Vasta, 2017; Tete, 2012). The new materialist ontologies (Bennett, 2010; Del page\_content= scholarship that has mostly remained centred on normative meanings and qualities (Clapham, 2011). Assemblage-thinking allows us to attend to 'the small agency' of things (Bennett, 2010). page\_content= with some Nordic and central European countries offering regulated, insecure PRSs in which renters enjoy similar occupancy arrangements with homeowners (Hulse et al., 2018). page\_content= McKee et al., 2017; Soaita et al., 2016). To problematise 'generation rent' discourses, we focus on less affluent young people for whom private renting is likely to become a permanent reality of home in a growing PRS in long overdue (Lloyd and Vasta, 2017). A critical discussion of the labour of (re)assembling a sense of home in the UK's PRS poses important page\_content= blage to the study of home rather than housing, we aim to contribute much needed 'thick descriptions' (Anderson et al., 2012) to the as-assembly-informed research; our page\_content= materialities of self, i.e. the attempt to personalise home through objects. Section 5 focuses on the agency of broken things and their capacity to destabilise the home. See page\_content= 2. Home as assemblage\nThe currency of assemblage-thinking is stronger in urban and political studies where it has been applied at the large scale of the planetary/global page\_content= wells understood as tenants construct a sense of home in an unregulated market-based PRS. There are different theoretical routes to thinking about assemblage (see, e.g. related page\_content= p. 2). In the de laet and assemblage can be grasped through metaphors, such as the archipelago as the assemblage informed by different individual islands; the page\_content= simplest division cuts between regulated/secure and unregulated/insecure PRSs. However, this binary should be conceived as a continuum in order to account for the multi-page\_content= organisation; its employees and building departments of the whole but they cannot be reduced to the organisation since people are concomitantly parts of other unrelated assemblages page\_content= De laet exemplifies this by a knife having the material property of being sharp and the actual/virtual capacities of scratching, cutting or killing that which can be scratched page\_content= on space/time availability, particularly in tight housing markets. The concept of 'individual singularity' (Normark, 2009, p. 432) is key to understanding home as an assemblage of materials page\_content= home and the expression of self through the material expressivity of cherished objects, e.g. family photographs, a teapot or architectural features (Cieraad, 2006; Marci page\_content= lenders over home buyers and landlords over tenants (Hulse et al., 2011; Martin et al., 2018). Consequently, in homeownership societies, middle-class meanings of home as heaven, home page\_content= tinct from the chaotic space of cosmos (Buchanan and Lambert, 2005). In the home assemblage can be territorialised/stabilised through habit, impersonalisation of space, performance of page\_content= interchangeably with (de)stabilisation, these concepts are conceived in relative and absolute terms (Buchanan and Lambert, 2005; Delanda, 2006, 2016); an assemblage can destabilise page\_content= desired residential mobility caused by divorce/separation, war or eviction. While tenants move for various reasons, it is still the tone of the individual privately-renting household page\_content= constructing a sense of home in an unregulated, market-based PRS involves an ontologically, normatively and emotionally different relational process than home-making page\_content= the 'small agency' of things (Bennett, 2010, p. 95), which have sufficient coherence to make a difference, produce effects, alter the course of events' (idem, p. vii) (page\_content= 2010). Consequently, some authors have chosen to combine assemblage theory with the Bourdieusian concept of field (Lovell and Smith, 2010) nor complexity theory (Dittmer, 2014). Others have page\_content= present and imagining alternative futures. Dittmer's (2014, p. 394) borrowed concept of 'bodily politics' is helpful in capturing emerging calls for systemic change grounded page\_content= the home-assemblage affects (de)territorialisation and the capacities of things. To reiterate, assemblage-thinking enables us to conceptualise home in a simple and novel way as a page\_content= spaces of possibility. Given the constrained use and high residential mobility within the UK's PRS, the axis of (de)/(re)territorialisation is best suited to represent our findings page\_content= decided by participants. Participation was sourced via social media (project Twitter and Facebook; n=4) and public online platforms (Shelter, Generation Rent, ACORN). page\_content= nexus between high rents and low/insecure wages has clearly framed participants' home experiences, primarily in terms of afforded housing inequality and capacity to personalise page\_content= interviews but more importantly, they directed our attention to the labour of home-assembling, inductively inspiring our way of thinking, prompting immersion in the assemblage page\_content= (Bennett, 2010, p. xiv), with codes/themes attending to practices (doing), materiality (being) and discourse (saying). Given our small, exploratory sample, we refrain from making general

*Figure 55 Data After Chunking/Splitting*

The next step in the development was embeddings generation which are vector representation of text, words, phrases and entire documents. It maps the entities into a continuous multi-dimensional space where it reflects semantic relationships which exist in the space. There are number of reasons I employed this technique first was to establish semantic relationships between the words which improved my model's similarity search functions. Which resulted in overall improvement of the model. Two different models were explored for making the embeddings, OpenAI embedding model **text-embedding-3-large** and hugging face **all-MiniLM-L6-v2**, they



Both were an excellent choice when generating the embeddings, the only deciding factor to go with OpenAI was time it required to make the embeddings which was relatively faster than hugging face model.

```
embedding = OpenAIEmbeddings()
```

Figure 56 Showing the implementation of OpenAI Embedding Model

```
#download embedding model
def download_hugging_face_embeddings():
    embeddings = HuggingFaceEmbeddings(model_name="sentence-transformers/all-MiniLM-L6-v2")
    return embeddings

embeddings = download_hugging_face_embeddings()
```

Figure 57 Showing the implementation of Hugging Face Embedding Model all-Mini-LM-L6-v2

### Vector Database Generation:

The next step was to create vector database to store all the vectors that are created as a result of embeddings. The reason a vector database was employed was because of traditional database such as MySQL are not optimized to type of queries machine learning applications require such as finding the nearest neighbors in a high dimensional space such as in the case of Litigat8. Setting up the vector database allowed me to do functions such as semantic search and dynamic content discovery.

```
#Initializing the Pinecone
pinecone.init(api_key=PINECONE_API_KEY,
              environment=PINECONE_API_ENV)

index_name="Litigat8"

#Creating Embeddings for Each of The Text Chunks & storing
docsearch=Pinecone.from_texts([t.page_content for t in text_chunks], embeddings, index_name=index_name)
```

Figure 58 Showing the Implementation of Pinecone Vector Database

While making the vector database two different libraries were Analysed **Pinecone and Chroma**. Both of these libraries had there merits the Pinecone database was an online vector database while chroma was a database on disk. Traditionally for larger project **Pinecone** would be the ideal

choice and hence that option was explored first but due to recent development in the **Pinecone** structure some of their methods and function have been depreciated while there were alternatives to that but the version that I was using for Lang chain wasn't compatible for that. Ample time was given to make Pinecone work but due to not being enough resources available online and time constraints. I wasn't able to get it functioning with my model hence I decided to look for alternatives instead and thus decided to settle for an on-disk database built using **Chroma**. Even though it might not be the ideal choice but for the scope of this application it provided enough value.

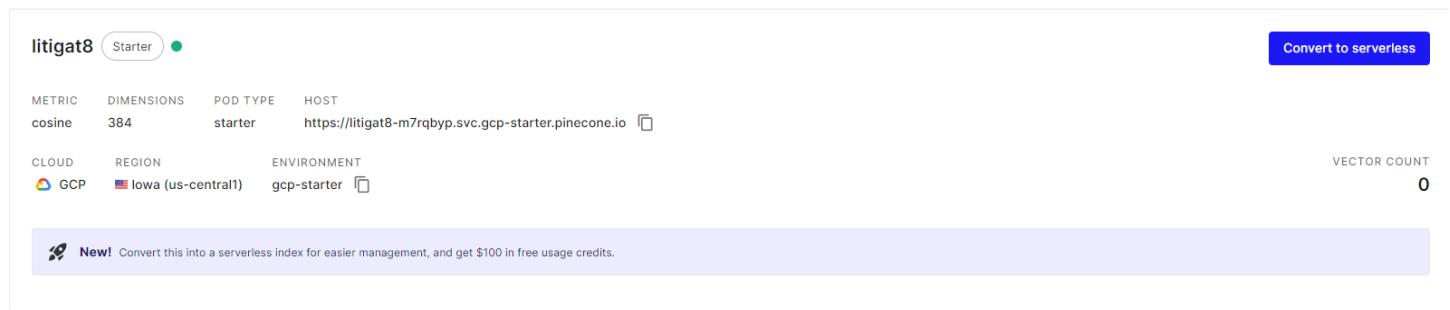


Figure 59 Showing the Setting Up of Pinecone Database on the Website

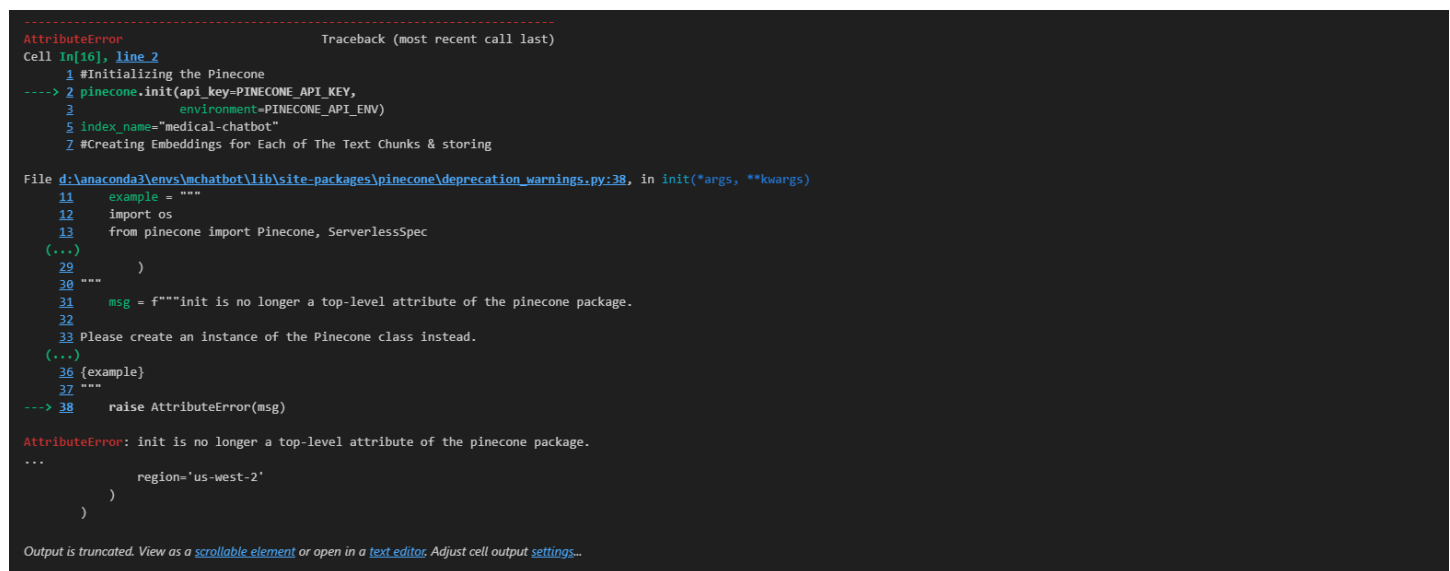


Figure 60 Showing the Depreciation Warning of Pinecone

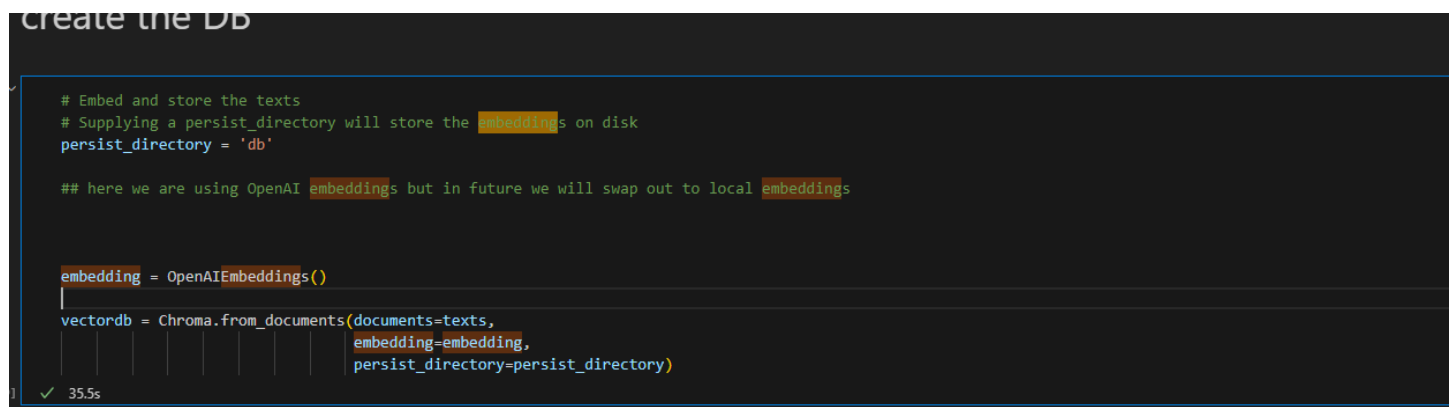


Figure 61 Showing the creation of Vector Database

## Making a Retriever:

The retriever that was constructed from the database served as a way to query the database to get the specific piece of that that was required according to the query of the user.



```
retriever = vectordb.as_retriever()

docs = retriever.get_relevant_documents("what is household and tenant law?")
print(docs)

len(docs)

retriever = vectordb.as_retriever(search_kwargs={"k": 2})

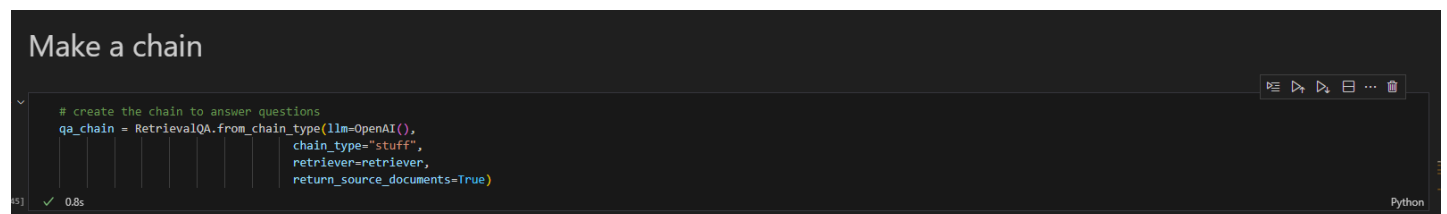
retriever.search_type
```

The screenshot shows a Jupyter Notebook interface with five code cells. The first cell defines a retriever. The second cell queries the retriever for documents related to 'household and tenant law' and prints them. The third cell checks the length of the retrieved documents, which is 4. The fourth cell updates the retriever to return the top 2 results. The fifth cell checks the search type of the retriever, which is 'similarity'.

Figure 62 Showing the Implementation of VectorDb Retriever

## Making a Retrieval-based QA Chain for answering the question:

The second last step in the development of the model was setting up the retrieval-based QA chain, which was done with the help of LangChain library. It helped me process the user question and understand key terms or entities. And enables me to retrieve information based on the processed user input and give that as a context to the model. And retriever was passed as a parameter as well which served as a way to get the information from the vector database.



```
# create the chain to answer questions
qa_chain = RetrievalQA.from_chain_type(llm=OpenAI(),
                                     chain_type="stuff",
                                     retriever=retriever,
                                     return_source_documents=True)
```

The screenshot shows a Jupyter Notebook interface with a single code cell. The code creates a RetrievalQA chain using an OpenAI LLM, a 'stuff' chain type, the retriever from the previous figure, and sets return\_source\_documents to True.

Figure 63 Showing the implementation of Retrieval-based QA Chain Using OpenAI() LLM

## Generating Responses with Source Citation:

```
## Cite sources
def process_llm_response(llm_response):
    print(llm_response['result'])
    print('\n\nSources:')
    for source in llm_response['source_documents']:
        print(source.metadata['source'])

query = "Can you tell me about rent repayment plans"
llm_response = qa_chain(query)
process_llm_response(llm_response)
```

The Rent Repayment Orders (Supplementary Provisions) (England) Regulations 2007, along with the Residential Property Tribunal Procedure (England) Regulations 2006, outline the process for obtaining a re

Sources:  
new\_articles\Rent Repayment Order-Tenants Guide.pdf  
new\_articles\Rent Repayment Order-Tenants Guide.pdf

Figure 64 Showing the Response Generation with Source Citation

## Prompt Engineering:

The final step of the model configuration was to set prompts for the Gen AI so that it doesn't answer questions out of the context or it doesn't answer question answer question which it doesn't know answer for.

## Making Sure the Generative AI doesn't Answer Question Out of Context:

```
prompt_template="""
Use the following pieces of information to answer the user's question.
If you don't know the answer, just say that you don't know, don't try to make up an answer.

Context: {context}
Question: {question}

Only return the helpful answer below and nothing else.
Helpful answer:
"""

PROMPT=PromptTemplate(template=prompt_template, input_variables=["context", "question"])
chain_type_kwargs={"prompt": PROMPT}
```

Figure 65 Setting up the context for the LLM

I played around the prompt settings to find the best prompt that would result in the best responses generated from the AI. Different versions of the prompts were created two of them are displayed in the Figure 71 and Figure 72.

```
# break it down
query = "What is the news about football match in uk?"
llm_response = qa_chain(query)
process_llm_response(llm_response)
llm_response

✓ 1.2s

I'm sorry, but I couldn't find any news about a football match in the UK. If you have any other questions related to UK household and tenant law, feel free to ask!

Sources:
new_articles\The role of private landlords in making a rented house a home.pdf
new_articles\No.123-Landlord-and-Tenant-Responsibility-for-State-and-Condition-of-Property.pdf

{'query': 'What is the news about football match in uk?',
 'result': "I'm sorry, but I couldn't find any news about a football match in the UK. If you have any other questions related to UK household and tenant law, feel free to",
 'source_documents': '[Document(page_content='INTERNATIONAL JOURNAL OF HOUSING POLICY 119\nIncluded studies\nunsurprisingly, the set of included studies is dominated by Document(page_content="Deifiis v. Milne [1913] 1 Ch. 98. \nHerne v. Bembow (1813) 4 Taunt. 764. \n12' 2 Roll. Abr. 816, pl. 36, 37. \nCheetham v. Hampson (1791) 4 Term R
```

Figure 66 Showing the LLM answer to a Question out of Context

## Modifying the Prompt to get the Desired Outcome and Limiting the Gen AI:

```
prompt_template="""
Given the user's question, provide advice specifically tailored to UK household and tenant law. Make every effort to include relevant UK case law as reference to support your advice. If the question

Context: {context}
Question: {question}

If the question relates to UK household and tenant law:
- Offer advice that is compliant with UK legislation and regulatory frameworks.
- Strive to cite specific UK case law or legal statutes with every piece of advice, ensuring the information is accurate and up to date.
- Present the advice in a clear, concise manner that is accessible to individuals without a legal background.

If the question is about "Faran":
- Respond by saying, "Faran is my maker."

If the question is outside the domain of UK household and tenant law, or if it pertains to legal jurisdictions outside the UK:
- Politely inform the user that the question falls outside the service's expertise area or geographic focus and suggest consulting a relevant legal professional within the appropriate jurisdiction.

Helpful answer:
"""
```

Figure 67 Prompt Engineering Version 1

```
prompt_template="""
Litigat8, designed by Faran for his final year project, offers tailored advice on UK household and tenant law, using the most up-to-date information available up to its last training cut-off

Context: {context}
Question: {question}

Guidelines for response by Litigat8:
1. **User-Friendly Language:**
   - Communicate legal advice in clear, straightforward language, making complex legal principles accessible to those without a legal background.
2. **Feedback Mechanism:**
   - Encourage feedback on the advice's usefulness and understandability, using this input to enhance Litigat8's future interactions.
3. **Privacy Considerations:**
   - Avoid unnecessary collection of personal information, ensuring users' privacy and confidentiality in providing generalized legal guidance.
4. **Update Mechanism:**
   - Regularly refresh Litigat8's knowledge with the latest case law, legislation, or changes in UK household and tenant law to maintain the accuracy of its advice.
5. **Limit Scope Wisely:**
   - Focus Litigat8's advice within the realm of UK household and tenant law, avoiding areas outside its expertise or current knowledge.

**Detailed Instructions for Litigat8:**
**For UK household and tenant law queries:**
- Utilize current UK legislation and case law to form detailed advice, addressing legal ambiguities and guiding users towards professional advice when necessary.

- **For questions about "Faran" or "Litigat8":**
  - For "Faran": Respond with, "Faran is my maker."
  - For "Litigat8": Share that it is an AI designed for providing legal advice on UK household and tenant law as a final year project by Faran.

- **For out-of-scope inquiries:**
  - Inform users when their questions fall outside Litigat8's domain or geographic focus, recommending professional legal consultation.

**Handling Ambiguities and Uncertainty:**
- Clearly explain when legal issues are ambiguous and suggest seeking further advice for complex matters.

**Communicating with Users:**
- If needed, ask for clarification to offer more precise advice, always respecting user privacy and focusing on enhancing understanding.

**Feedback and Continuous Improvement:**
- Include a feedback option for users to rate the helpfulness of advice and suggest improvements, aiding in the ongoing development of Litigat8.

Helpful answer:
"""
```

Figure 68 Prompt Engineering Version 2

## **Comparison of ChatGPT 3.5 Turbo Vs ChatGPT 4.0 Turbo Vs Llama 2:**

The final step that was to be implemented was to do a comparative analysis between the LLM models that exists to finalize which would serve the function of litigate the best. The technical comparative analysis had two metrics which lead to the evaluation of the model the first one being the response time as one of the objectives were to display advices in real-time so it was of paramount the model should be able to generate responses according to that. The second metric was semantic similarity score of the response generate to figure out if the response generated has a meaning full context and semantic relation with the question that was asked by the user. In addition to that conversation coherence analysis was done was well which was carried out by myself to see how coherent the sentences are which model produces more meaningful and well-structured sentences.

```
from langchain.llms import CTransformers

# Set up the turbo LLM
turbo_llm = ChatOpenAI(
    temperature=0,
    model_name='gpt-3.5-turbo'
)
gpt_turbo_llm = ChatOpenAI(
    temperature=0,
    model_name='gpt-4'
)

llm=CTransformers(model="llama-2-7b-chat.ggmlv3.q4_0.bin",
                  model_type="llama",
                  config={'max_new_tokens':4096,
                        'temperature':0.8,
                        'context_length' : 2048})
```

*Figure showing the implementation of gpt-3.5-tubo , llama-2-7b Model , gpt-4.0*

## **Technical Analysis: Semantic Analysis and Response Time Comparison:**

The evaluation was carried out by setting up dummy questions and answer which were linked to specific prompts. And then the response generation time and the accuracy score (semantic score) were compared in the end for all three of the models.

```

import time
from sentence_transformers import SentenceTransformer, util

def semantic_similarity_score(response, correct_answer):
    model = SentenceTransformer('all-MiniLM-L6-v2')

    if not isinstance(response, list):
        response = [response]
    if not isinstance(correct_answer, list):
        correct_answer = [correct_answer]

    response_embedding = model.encode(response, convert_to_tensor=True)
    correct_answer_embedding = model.encode(correct_answer, convert_to_tensor=True)
    similarity = util.pytorch_cos_sim(response_embedding, correct_answer_embedding)

    return similarity.item()

def compare_llms(prompts, correct_answers, turbo_llm, llama_llm, gpt_turbo_llm):
    performance_metrics = {
        'turbo_llm': {'accuracy': [], 'response_time': []},
        'llama_llm': {'accuracy': [], 'response_time': []},
        'gpt_turbo_llm': {'accuracy': [], 'response_time': []}
    }

    turbo_llm = RetrievalQA.from_chain_type(llm=turbo_llm,
                                           chain_type="stuff",
                                           retriever=retriever,
                                           return_source_documents=True)

    llama_llm = RetrievalQA.from_chain_type(llm=llama_llm,
                                           chain_type="stuff",
                                           retriever=retriever,
                                           return_source_documents=True)

    gpt_turbo_llm = RetrievalQA.from_chain_type(llm=gpt_turbo_llm,
                                           chain_type="stuff",
                                           retriever=retriever,
                                           return_source_documents=True)

    # Loop over each prompt and get responses from both LLMs

```

Figure 69 Setting Up the Semantic Similarity func and Comparison func

```

# Example usage:
prompts = ["What are rent repayment Plans?", "Can you give me some case laws where the tenant got evicted for not paying rent?"]
correct_answers = {
    "What are rent repayment Plans?": "Rent repayments refer to the process where a tenant may be entitled to reclaim rent from their landlord in certain circumstances, such as when the property is damaged or the landlord is responsible for the repairs.",
    "Can you give me some case laws where the tenant got evicted for not paying rent?": "In the UK, there are several cases where tenants have been evicted for not paying rent. One notable case is Smith v. Griggs, where a tenant was evicted for not paying rent for several months."
}

comparison_results = compare_llms(prompts, correct_answers, turbo_llm, llama_llm, gpt_turbo_llm)

```

Figure 70 Setting up the Prompts and Correct Answers

```

{'turbo_llm': {'accuracy': [1, 1],
               'response_time': [1.692568302154541, 1.3909106254577637],
               'average_response_time': 1.5417394638061523,
               'average_accuracy': 1.0},
 'llama_llm': {'accuracy': [1, 1],
               'response_time': [13.296113967895508, 75.26336598396301],
               'average_response_time': 44.27973997592926,
               'average_accuracy': 1.0},
 'gpt_turbo_llm': {'accuracy': [1, 1],
                   'response_time': [12.599728345870972, 8.483205080032349],
                   'average_response_time': 10.54146671295166,
                   'average_accuracy': 1.0}}

```

Figure 71 Showing the Comparison Result

## Conversational Coherence Analysis

After the technical analysis, the models were compared on the bases of conversational coherence with a simple metric which response was more appealing to me as a user who's seeking advice on a matter. For this purpose, a model question was decided on and was asked all three of the models and the responses were evaluated which would be discussed in the next chapter.

**Evaluation Sentence:** "What are rent repayments how can I pay them can you tell me?"

## LLAMA 2 Response time 2Min >

Response : To reclaim rent paid during a period when you were not legally required to pay it, you will need to apply for a Rent Repayment Order (RRO). To do this, you need to provide evidence of the rent paid during the period. To pay rent repayments, you can use a payment method accepted by the landlord or managing agent, such as bank transfer or cheque. If you have paid in cash and do not have receipts, you will need to provide evidence of the rent paid. If you are unsure about how to claim rent repayments or have any questions, please let me know, and I will do my best to assist you.

Figure 72 Showing the response generated LLMA-2

Q 4m 30.2s Python

Response : Thank you for reaching out to Litigat8! We're here to help with any questions or concerns related to UK household and tenant law. Please feel free to ask us anything, and we'll provide you with the best possible advice. Please remember that Litigat8 is a machine learning model designed as a final year project by Faran, and while it strives to provide accurate advice, it may not always be perfect or up-to-date. If you have any further questions or need assistance with the process of reclaiming rent payments, feel free to ask for more specific guidance.

Response : "Dear user, thank you for reaching out to Litigat8 regarding rent repayments. Based on the information provided, it appears that you are seeking guidance on how to claim rent repayments from your landlord. As an AI language model trained on UK household and tenant law, I can advise you on the most up-to-date legal principles and procedures for making a claim. However, please note that Litigat8's response is not a substitute for legal advice. To start, it would be helpful to have evidence of the rent paid during the period of up to twelve months. If you do not have a rent book or receipts for the rent, please make a list of all the rent payments made, such as a rent statement or a copy of the tenancy agreement. Once you have gathered the necessary information and evidence, you can submit your claim to your local council for housing benefits. They will review your application and provide guidance on the next steps. Please feel free to ask if you have any further questions or concerns regarding rent repayments or UK household and tenant law. Your feedback is invaluable in improving Litigat8's services."

Figure 73 Showing the response generated LLMA-2

## GPT4 1Min >

Response : Rent repayments refer to situations where a tenant may be entitled to reclaim rent payments from their landlord. This could happen if the landlord has not met their legal obligations, such as not providing a valid tenancy agreement or not paying council tax. To pay rent repayments, you would typically need to apply for a Rent Repayment Order (RRO) through the First-tier Tribunal. You would need to provide evidence of the rent payments made, such as a rent statement or a copy of the tenancy agreement. It's important to note that the period for reclaiming rent may end earlier under certain circumstances, such as if you have moved away, if the landlord has changed, or if the landlord has applied for a possession order. If you have further questions or need assistance with the process of reclaiming rent payments, feel free to ask for more specific guidance.

Figure 74 Showing the response Generated by gpt-4

## GPT 3.5 Turbo : 10 sec>:

Response : Rent repayments refer to the process of reclaiming overpaid rent from your landlord. To pay them, you will need to apply for a Rent Repayment Order (RRO) and provide evidence of the rent you have paid.

Figure 75 showing the response generated by gpt-3.

## Outcome Discussion

Based on the results that were generated for the models **GPT-4**, **GPT-3.5-Turbo** and **LLAMA2**. When it comes to accuracy all three models performed as expected with having semantic relationship between the question asked and the response generated. Hence, they all passed on this evaluation. Moving on to the next evaluation, response time **GPT 3.5-turbo** was the fastest with response time ranging between 8 to 10 sec followed by **GPT-4** and then **LLAMA 2**. Hence **GPT 3.5-turbo** was the clear winner in the technical evaluation. Moving on to the Conversational Coherence Analysis **GPT-3.5-turbo** and **GPT-4** provided with the best responses in the context of the data that was provided to them but **LLAMA 2** responses were accurate to some extent covering the context that was provided to it but it was lacking a bit structure and meaning . As a result of all these observation **GPT-3.5-turbo** was selected as its stand true for all the metrics that were required for Litiagat8 to functions.



This marks the end of the implementation the next chapter would discuss the testing and evaluation of the application that was carried out. And how the identified bugs and problems were rectified.

## **Testing:**

The testing of the application was carried out in accordance to the primary objectives and use cases set out by the project. Thus, the tests would focus on the parts of the program that are critical for the success of the application.

## **Unit Testing**

This chapter discusses the implementation and outcome of the unit tests that were designed for the application. The Unit tests **TC-001**, **TC-002**, **TC-003**, **TC-005**, **TC-010** and **TC-011** were designed in accordance to the development of the User interphase and testing its robustness these tests mainly focused on use case **UC4** testability. Whereas, the unit tests **TC-006**, **TC-007** and **TC-003** were also part of the primary objective but focused on **UC1**, **UC2** and **UC6**, and thus checked their robustness. Moving on the unit test **TC-009** focused on Primary objective P2 and P4 and thus tested the UC4. The P3 objective didn't need testing as it was one of task which didn't need to be repeated again and again thus making it function one time was enough. And would not let to the failure of the system if anything goes wrong.

## **Designing the Unit Tests Using Pytest:**

### **Setting up the Test Environment and setting up the database before the Tests::**

```

@pytest.fixture(scope='module')
def test_client():
    flask_app = create_app()
    with flask_app.test_client() as testing_client:
        with flask_app.app_context():
            yield testing_client

@pytest.fixture(scope='module')
def init_database(test_client):

    _db.create_all()

    user1 = User(id=1, username='TestUser', password='Password')
    _db.session.add(user1)
    _db.session.commit()

    yield # No need to return _db

    _db.session.remove()
    _db.drop_all()

```

### Pytest for Ending Chat Session:

```

def test_end_chat_session(test_client, init_database):
    login_user(test_client)
    with test_client.session_transaction() as session:
        session['chat_session_id'] = 1

    response = test_client.get('/chat/end_chat_session', follow_redirects=True)
    assert response.status_code == 200

```

### Pytest for form submission and AI Response:

```

def test_submit(test_client, init_database):
    login_user(test_client)
    user_input = "Hello, AI!"
    response = test_client.post('/chat/submit', data=json.dumps({"user_input": user_input}), content_type='application/json')
    data = response.get_json()
    assert response.status_code == 200
    assert data['user_input'] == user_input

```

### Pytest Authentication/ Login:

```

def login_user(test_client, username=None, password="testpassword"):
    if username is None:
        username = f"user_{uuid4()}" # Generate a unique username
    user = User(username=username, password=password)
    db.session.add(user)
    db.session.commit()
    with test_client.session_transaction() as session:
        session['user_id'] = user.id # Mock login
def test_submit(test_client, init_database):

```

### Pytest Authentication/ Login Failure:

```
def test_login_failure(test_client, init_database):  
    response = test_client.post('/auth/login', data={  
        'username': 'wronguser',  
        'password': 'wrongpassword'  
    }, follow_redirects=True)  
  
    # Assertions about the response  
    assert response.status_code == 200  
    assert 'Invalid username or password.' in response.data.decode('utf-8')
```

### Pytest Authentication/ Login Success:

```
def test_login_success(test_client, init_database):  
    # First, create a user  
    hashed_password = generate_password_hash('mysecurepassword')  
    user = User(username='existinguser', password=hashed_password)  
    _db.session.add(user)  
    _db.session.commit()  
  
    # Attempt to login  
    response = test_client.post('/auth/login', data={  
        'username': 'existinguser',  
        'password': 'mysecurepassword'  
    }, follow_redirects=True)  
    assert response.status_code == 200  
    assert 'user_id' in session
```

### Pytest Authentication/ Register:

```
def test_register(test_client, init_database):  
    # Mimic form submission with POST data for registration  
    response = test_client.post('/auth/register', data={  
        'username': 'testuser2',  
        'password': 'testpassword'  
    }, follow_redirects=True)  
    assert response.status_code == 200  
    assert User.query.filter_by(username='testuser').first() is not None
```

### Pytest Saving Iteration of Users and ChatSession:

```

# Make sure this test also uses the init_database fixture
def test_save_interaction_authenticated(test_client, init_database):
    # Ensuring a chat session exists in the database for the user
    chat_session = ChatSession(user_id=1, start_time=datetime.utcnow())
    _db.session.add(chat_session)
    _db.session.commit()

    with test_client.session_transaction() as session:
        session['user_id'] = 1
        session['chat_session_id'] = chat_session.id

    data = {'user_input': 'Hello', 'ai_response': 'Hi there!'}
    response = test_client.post('/chat/save_interaction', json=data)
    assert response.status_code == 200
    assert b'success' in response.data

```

### Pytest to get chat sessions:

```

def test_get_chat_sessions_unauthenticated(test_client):
    response = test_client.get('/chat/get_chat_sessions')
    assert response.status_code == 200

```

```

def test_get_chat_sessions_authenticated(test_client, init_database):
    with test_client.session_transaction() as session:
        session['user_id'] = 1

    response = test_client.get('/chat/get_chat_sessions')
    assert response.status_code == 200

```

### Pytest to start chat session:

```

def test_start_chat_session_unauthenticated(test_client):
    with test_client.session_transaction() as sess:
        sess.pop('user_id', None)

    response = test_client.post('/chat/start_chat_session')
    assert response.status_code == 302 # Or 401, depending on your auth handling

# Adjusted to use the init_database fixture for database setup
def test_start_chat_session_authenticated(test_client, init_database):
    with test_client.session_transaction() as sess:
        sess['user_id'] = 1

    response = test_client.post('/chat/start_chat_session')
    assert response.status_code == 201

```

### Pytest get chat histories:

```

def test_fetch_chat_histories(test_client, init_database):
    login_user(test_client, "user_for_history", "password")
    user = User.query.filter_by(username="user_for_history").first()

    # Create mock chat sessions and messages
    chat_session = ChatSession(user_id=user.id)
    db.session.add(chat_session)
    db.session.commit()

    message1 = Conversation(chat_session_id=chat_session.id, message="Hi", type='user')
    message2 = Conversation(chat_session_id=chat_session.id, message="Hello", type='ai')
    db.session.add_all([message1, message2])
    db.session.commit()

    response = test_client.get('/chat/fetch_chat_histories')
    data = response.get_json()
    assert response.status_code == 200
    assert len(data) > 0 # Assuming at least one history exists
    # Further asserts can check the structure of the returned history data

```

## Unit Tests Outcome:

This chapter concludes the unit tests that were conducted for the Litigat8. The test results were all satisfactory with almost 80% complete success rate. With 2 test cases that resulted that resulted in warnings but they carried out the function they were supposed to. The two tests that resulted in warnings would be discussed in the next chapter.

ID	Component	Test Case	Input	Expected Output	Success Criteria	Outcome
TC-001	Start Chat Session (Authenticated)	User is logged in and starts a chat session	User session with user_id set	HTTP status code 201, indicating creation of a new chat session	Test passes if the response status code is 201	Pass
TC-002	Start Chat Session (Unauthenticated)	User is not logged in	No user_id in session	HTTP redirect (302) or 401 Unauthorized, depending on auth handling	Test passes if the response is a redirect (302) or 401	Pass
TC-003	Get Chat Sessions (Authenticated)	User is logged in and fetches chat sessions	User session with user_id set	HTTP status code 200 and a list of chat sessions associated with the user	Test passes if the status code is 200 and the response contains the user's chat sessions	Pass
TC-004	Get Chat Sessions (Unauthenticated)	User is not logged in	No specific input needed	HTTP status code 200,	Test passes if the status code is 200	Pass
TC-005	Save Interaction (Authenticated)	User is logged in and saves an interaction	User session with user_id and chat_session_id set JSON payload with user_input and ai_response	HTTP status code 200 with a success message	Test passes if the interaction is successfully saved and the response contains 'success'	Pass
TC-006	Register User	New user registration	POST data with username and password	HTTP status code 200 and the new user is found in the database	Test passes if a new user is created and can be found in the database	Pass

ID	Component	Test Case	Input	Expected Output	Success Criteria	Outcome
TC-007	Login (Success)	Existing user logs in successfully	POST data with valid username and password	HTTP status code 200 and session contains user_id, indicating successful login	Test passes if the user is logged in and session contains user_id	Pass
TC-008	Login (Failure)	User fails to log in	POST data with invalid username and password	HTTP status code 200 with an 'Invalid username or password.' message	Test passes if the response contains the invalid login message	Pass
TC-009	Submit (Authenticated)	User submits input in a chat	JSON payload with user_input, User session contains user_id	HTTP status code 200 and the response JSON contains the same user_input	Test passes if the response status is 200 and echoes user_input	Pass
TC-010	End Chat Session (Authenticated)	User ends a chat session	User session with chat_session_id set	HTTP status code 200, chat session was successfully ended	Test passes if the chat session ends successfully	Pass
TC-011	Fetch Chat Histories (Authenticated)	User fetches their chat histories	User session contains user_id	HTTP status code 200 and a JSON payload containing the user's chat histories	Test passes if the response contains the user's chat histories and status code is 200	Pass

Table 5 Showing Unit tests

## report.html

Report generated on 31-Mar-2024 at 16:09:09 by [pytest-html](#) v4.1.1

### Environment

Python	3.11.8
Platform	Windows-10-10.0.22631-SP0
Packages	<ul style="list-style-type: none"><li>pytest: 8.1.1</li><li>pluggy: 1.4.0</li></ul>
Plugins	<ul style="list-style-type: none"><li>anyio: 4.2.0</li><li>html: 4.1.1</li><li>metadata: 3.1.1</li></ul>

### Summary

11 tests took 00:00:05.

(Un)check the boxes to filter the results.

0 Failed, 11 Passed, 0 Skipped, 0 Expected failures, 0 Unexpected passes, 0 Errors, 0 Reruns

[Show all details](#) / [Hide all details](#)

Result	Test	Duration	Links
Passed	app/tests/system_test.py::test_start_chat_session_authenticated	156 ms	
Passed	app/tests/system_test.py::test_start_chat_session_unauthenticated	2 ms	
Passed	app/tests/system_test.py::test_get_chat_sessions_authenticated	3 ms	
Passed	app/tests/system_test.py::test_get_chat_sessions_unauthenticated	1 ms	
Passed	app/tests/system_test.py::test_save_interaction_authenticated	79 ms	
Passed	app/tests/system_test.py::test_register	77 ms	
Passed	app/tests/system_test.py::test_login_success	214 ms	
Passed	app/tests/system_test.py::test_login_failure	2 ms	
Passed	app/tests/system_test.py::test_submit	00:00:04	
Passed	app/tests/system_test.py::test_end_chat_session	5 ms	
Passed	app/tests/system_test.py::test_fetch_chat_histories	43 ms	

Figure 76 Showing the results of pytest for Unit Tests

Passed	app/tests/system_test.py::test_get_chat_sessions_authenticated	3 ms	
Passed	app/tests/system_test.py::test_get_chat_sessions_unauthenticated	1 ms	
Passed	app/tests/system_test.py::test_save_interaction_authenticated	79 ms	
Passed	app/tests/system_test.py::test_register	77 ms	
Passed	app/tests/system_test.py::test_login_success	214 ms	
Passed	app/tests/system_test.py::test_login_failure	2 ms	
Passed	app/tests/system_test.py::test_submit	00:00:04	

Captured stdout call

this works  
Hello, AI!  
Hello! How can I assist you today with UK household and tenant law? Feel free to ask your question, and I'll do my best to provide you with clear and helpful advice. Remember, your privacy is important, and I'm here to offer guidance within the scope of UK household and tenant law.

expand [-]

Figure 77 Showing the Unit Test for Interaction with Litigat8 NLP Model

```
===== warnings summary =====
app/tests/system_test.py::test_login_success
  D:\WorkOpus\Litigate\Litigate\app\__init__.py:62: LegacyAPIWarning: The Query.get() method is considered legacy as of
the 1.x series of SQLAlchemy and becomes a legacy construct in 2.0. The method is now available as Session.get() (deprec
ated since: 2.0) (Background on SQLAlchemy 2.0 at: https://sqlalche.me/e/b8d9)
    user = User.query.get(user_id)

app/tests/system_test.py::test_submit
  D:\anaconda3\envs\Litigat8\Lib\site-packages\langchain_core\api\deprecation.py:117: LangChainDeprecationWarning: The
function '__call__' was deprecated in LangChain 0.1.0 and will be removed in 0.2.0. Use invoke instead.
    warn_deprecated(

-- Docs: https://docs.pytest.org/en/stable/how-to/capture-warnings.html
===== 11 passed, 2 warnings in 7.12s =====

(Litigat8) D:\WorkOpus\Litigate\Litigate>
```

Figure 78 Showing Warnings Generated by the Tests

## Unit Tests Outcome Discussion:

### Component Login(Success) :

**func test\_login\_success:** The warning was originated from SQLAlchemy. Which warned me about the Query.get() method has depreciated in the version 2.0 of the library. And instead advised me to use Session.get() instead to resolve the warning and any other compatibility issues in the future.

As a result, the login functions was updated to use the newer version of the function thus eliminating the warning for the test\_login\_success function



```
@auth.route('/login', methods=['GET', 'POST'])
def login():
    user_id = session.get('user_id')
    if user_id:
        return redirect(url_for('main.chat'))
```

*Figure 79 Showing the Fix of Login (Success) component warning*

### **Component Submit (Authenticated):**

#### **func test\_submit:**

The warning was originated from langchain\_core\_api warning about the deprecation of `__call__` function within the version LangChain 0.1.0 and warning that it would be removed in 0.2.0. I wasn't able to exactly pinpoint which method would be required to change as the error is not being originated from. But for the sake of this project and the version of LangChain that is being used for the project. It wouldn't affect the functioning of the project.

### **Integration Testing Plan:**

Integration testing was carried out with the development of each sub system of the project to make sure that addition of a new functionality doesn't compromise the stability of the system and doesn't break it. The results of the integration testing were mostly positive as a result of through unit testing which reduced the number of problems to be face in the integration testing.

## Integration Testing Outcomes:

Integration Components	Test Case	Input	Expected Output	Success Criteria	Outcome
Frontend <-> Backend API Calls	Test login API call	User login credentials	User authenticated / Session token	User can log in and start a session	Pass
	Test query submission API call	Valid query	Query accepted / Advice returned	Query processed and advice returned	Pass
Backend <-> Database CRUD Operations	Test user creation in database through backend	New user details	User created in Users table	New user can log in	Pass
	Test query processing and storage	Sample query	Query stored in UserQueries & NLPAnalysis	Query results and analysis are stored	Pass
NLP Engine <-> Database	Test storing NLP analysis results	Sample query	Results stored in NLPAnalysis	Analysis results retrievable for the query	Pass
Authentication <-> Database	Test authentication with database-stored credentials	User credentials	Authentication success/failure	Correct authentication against database data	Pass
Chat Interface <-> Chat Handling <-> Database	Test chat message flow	Chat message	Message stored in ChatHistories	Chat history updated with new message	Pass

*Table 6 Showing Integration Test Outcome*

## Evaluation:

There were two sets of objectives—primary and secondary—that defined the scope of the project. Primary objectives were of utmost importance for the success of the project, followed by secondary objectives. Following an agile solution approach with SCRUM outputs were produced during each sprint, serving as building blocks for the application, thus resulting in a fully functioning application. The resulting application demonstrates a wide variety of functional features, which, combined with the functional and non-functional system requirements analyzed by the MoSCoW Method, address the set four primary objectives. However, in the case of secondary objectives, two failed to be accomplished.

The **P1** objective, which stated the development of a User Interface that is intuitive and accessible, was accomplished. The objective was accomplished by following a proper agile solution approach with an emphasis on time management, where tools like the Trello board and Gantt Chart were used and helped me put a proper management system in place which led to the success of this objective. The objective was approached systematically, where the initial design was constructed using wireframes, which were then implemented in code to avoid any changes in design at a later stage. Following **P1**, the **P2** and **P3** objectives were put under development. The focus of **P2** was on developing a natural language processing system unit that could understand user queries and process them accurately in real-time. The accomplishment of this objective was challenging, as I had to work with many new technologies. However, thanks to proper time management and a sound solution approach, I was able to tackle it appropriately, thus producing a proof-of-concept NLP model capable of performing the set tasks using libraries such as LangChain, CTransformers, OpenAI(), etc. The **P3** objective was carried out in parallel, where many articles concerning household and tenant law were collected and integrated into the NLP model by creating vector databases. Most of the articles collected were in PDF format, thus the processing of this information was facilitated by libraries such as **PyPDF Loader**. Both of these objectives were completed systematically following the proper plan and designs set in place.

Moving on to the final primary objective, **P4**, real-time response generation technologies like JS Fetch Requests and Flask Server Handling were used to initiate requests, gather responses, and display them on the front-end. This enabled users to receive advice from the AI in real-time. Comparative studies were also conducted to find the best model and parameters for quick advice, which resulted in the best configuration of the model, thus enabling the accomplishment of this objective.

When it comes to secondary objectives, **S1** was achieved partly due to most resources and time being allocated to achieving the primary objectives. Steps were taken to make the application accessible as possible but I feel like there is still room for lot of development. The objective that wasn't accomplished was **S4**, to establish a feedback system for the model in such a way that it would remember the conversation with the user and use that as context for the conversation,

which will still be part of the future development of the project. Objectives **S2** and **S3** were accomplished by setting up an authentication model with ample security measures, such as locking the URLs and using **Bcrypt** to encrypt all passwords for users, signifying the successful completion of these objectives.

Using the Scrum project solution approach, I was able to tackle all the problems I faced in a timely manner. Putting in place a proper time management system ensured that I was able to accomplish my objectives on time, whether they were primary or secondary. Through requirement analysis and planning, I was able to prioritize all objectives that were of prime importance for the success of the project. Using these techniques, I was able to complete the project and produce a proof-of-concept application that met the objectives set out for it, which I am really proud of. These techniques ensured that if any problems arose, there would be a failsafe in place

## **Future Work:**

There are number of areas that could be improved in the scope of this project. Which I believe can be implemented to make the system more robust and have a lot more features than it currently has.

The first improvement that would be implemented in the future for this application would be to establish a **feedback system** along with chat remembering feature for the AI so that the user could have a conversation with the model and gradually improve the output the model results in. And the feedback would make the model learn and gradually improve its performance.

The second improvement that would be implemented will be an **online vector database** to increase its accessibility across devices. One of the implementations of it was explored but was failed to be implemented for the current application. So, I would like to explore alternatives such as Weaviate to implement it. Thus adding more versatility to the project.

The third improvement would be to explore models like **Grok** to implement the functionality as this model can support upwards of 314 billion parameters with context token size of 8K tokens. Which is great improvement from gpt-3.5-turbo model but still relatively less effective than GPT-4 and I want to test if this can server as a better option relative to gpt-3.5-turbo model in response time.

The fourth improvement I would like to make it is to increase the information available in the dataset and focus on **other domains of law** as well which I feel like would provide more utility instead of just focusing on a single domain but given the restraint of time and resources for this proof-of-concept application it couldn't be implemented in this development phase but if this application is decided to work on this improvement would be implemented.

The fifth improvement would be to make the response that's generated out of the model should be more structured with headings and sub-headings which I believe would be done with the help

of **markdown language**. This would make the advice look more readable and more understandable for the user.

The sixth area of development would be supporting **file uploads to proof-read-contracts** or even draw up contracts for you like tenancy agreement and such. Which I believe would provide a lot of utility to the users and hence would greatly increase user satisfaction. And I feel like this area would make Litigat8 stand out and provide real utility to the users.

These are some of the key areas of improvements that could be worked on to improve the litigat8's application and functionality. If decide to work on the application beyond proof-of-concept then all of these improvement areas would be analysed and worked on and would be implemented in the real-world application.

## **Conclusion:**

To conclude the development of the project and the planning and management that was put into place for it, it is evident from the report that as the sole developer of the Litigat8 project, the set NLP application was successfully developed.

The application resulted after the development as able to successfully provide basic legal advice to the users and it was also able to provide case law references of certain queries depending on their availability. The users were successfully able to register/login to the application to use the features and the users could also look back at there chat history and review all the conversation that they had with the NLP model.

All of the features that were implemented in the application were tested and made sure that they perform the task related to them without any problem. The user interphase that was implemented was properly planned with lots of design principles and patterns kept in mind

All the set objectives were attained through using the scrum framework. Where in each scrim priority was given to an objective that was planned for that specific sprint in the sprint planning session. All though there was lots of problems along the way many technological hurdles and obstacles but thanks to the flexibility of scrum framework I was able to tackle them with an iterative approach and each.

Despite failing to achieve S4 objective to implement a feedback system due to lack of time and enough domain knowledge, using of techniques such as MoSCoW analysis and Functional and Non Functional requirements I was able to implement the features that were of utmost important for the success of this project.

Finally, in case of litigation there are number of gaps left still to be filled or improved upon and some of which have been discussed in this report however the room of improvement is unlimited.

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