DE-42 (DC & SE)

**NUST COLLEGE OF**
**ELECTRICAL AND MECHANICAL ENGINEERING**

# LAWBOTPK – VIRTUAL LAW ASSISTANT

A PROJECT REPORT

DE-42 (DC & SE)

***Submitted by***

PC FAISAL NADEEM

PC MUHAMMAD HARIS FAYAZ

**BACHELORS**

**IN**

**COMPUTER ENGINEERING**

**YEAR**

**2024**

**PROJECT SUPERVISOR**

DR. WASI HAIDER BUTT

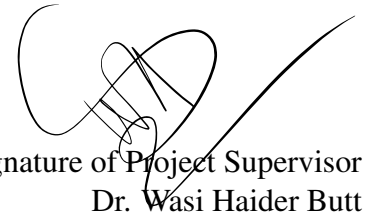
DR. ARSALAN SHAUKAT

DEPARTMENT OF COMPUTER & SOFTWARE ENGINEERING
COLLEGE OF ELECTRICAL & MECHANICAL ENGINEERING
NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY,
ISLAMABAD, PAKISTAN

YEAR 2024

# Certification

This is to certify that Faisal Nadeem, 359067 and Muhammad Haris Fayaz, 359075 have successfully completed the final project "Virtual Law Assistant: An AI-Enabled Chatbot to Guide in Legal Issues", at the NUST COLLEGE OF ELECTRICAL AND MECHANICAL ENGINEERING, to fulfill the partial requirement of the degree Computer Engineering.



Signature of Project Supervisor
Dr. Wasi Haider Butt
Associate Professor

# Sustainable Development Goals (SDGs)

| SDG No | Description of SDG | SDG No | Description of SDG |
|---|---|---|---|
| SDG 1 | No Poverty | SDG 9 | Industry, Innovation, and Infrastructure |
| SDG 2 | Zero Hunger | SDG 10 | Reduced Inequalities |
| SDG 3 | Good Health and Well Being | SDG 11 | Sustainable Cities and Communities |
| SDG 4 | Quality Education | SDG 12 | Responsible Consumption and Production |
| SDG 5 | Gender Equality | SDG 13 | Climate Change |
| SDG 6 | Clean Water and Sanitation | SDG 14 | Life Below Water |
| SDG 7 | Affordable and Clean Energy | SDG 15 | Life on Land |
| SDG 8 | Decent Work and Economic Growth | **SDG 16** | **Peace, Justice and Strong Institutions** |
| | | SDG 17 | Partnerships for the Goals |


Sustainable Development Goals

# Complex Engineering Problem

**Range of Complex Problem Solving**

| | Attribute | Complex Problem | |
|---|---|---|---|
| 1 | Range of conflicting requirements | Involve wide-ranging or conflicting technical, engineering and other issues. | |
| 2 | Depth of analysis required | Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models. | |
| 3 | Depth of knowledge required | Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach. | |
| 4 | Familiarity of issues | Involve infrequently encountered issues | |
| 5 | Extent of applicable codes | Are outside problems encompassed by standards and codes of practice for professional engineering. | |
| 6 | Extent of stakeholder involvement and level of conflicting requirements | Involve diverse groups of stakeholders with widely varying needs. | |
| 7 | Consequences | Have significant consequences in a range of contexts. | |
| 8 | Interdependence | Are high level problems including many component parts or sub-problems | |

**Range of Complex Problem Activities**

| | Attribute | Complex Activities | |
|---|---|---|---|
| 1 | Range of resources | Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies). | |
| 2 | Level of interaction | Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues. | |
| 3 | Innovation | Involve creative use of engineering principles and research-based knowledge in novel ways. | |
| 4 | Consequences to society and the environment | Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation. | |
| 5 | Familiarity | Can extend beyond previous experiences by applying principles-based approaches. | |

*Dedicated to*
*Our Parents who have been our inspiration throughout our project. Our accomplishment would not been possible without their love and guidance.*
*Our Supervisors, Dr. Wasi Haider Butt and Dr. Arsalan Shaukat for their continuous support and motivation. It's really inspired us that they are committed to our achievement.*
*Our Friends who have supported us throughout this journey. Without their confidence and assistance, this work would not be possible.*

# Copyright Statement

# Acknowledgment

First of all, Alhamdulillah, for giving us the strength, patience, and guidance to successfully complete our Final Year Project. We are thankful to Allah for the support and moral courage provided to us throughout this journey.

Secondly, we would like to express our sincere appreciation to our supervisors, Dr. Wasi Haider Butt and Dr. Arsalan Shaukat, for their support and guidance at every stage of our project. Their expertise and favor were significant to our success, and we are very thankful for their continuous support and mentorship.

Moreover, we extend our heartfelt thanks to our parents and friends. Their incredible support and continuous motivation played a vital role in the completion of our project. They were a constant source of inspiration, especially during challenging times, and their encouragement fueled our determination and efforts.

# Abstract

Most of the people of Pakistan especially the needy and lower class citizens are illiterate or lack access to proper resources to comprehend the family laws or seek legal assistance. Unfortunately, there is lack of such programs in Pakistan currently.

LawBotPK is a web based platform that uses Natural Language Processing to provide assistance for legal queries pretaining to family law. With a user friendly interface, users can ask their query related to any family matter and in response the system provides legal assistance by identifying relevant laws and sections. The project's significance lies in it's ability to bridge the gap between legal knowledge and the general public in Pakistan where many individuals may lack awareness of the specific laws applicable to their family matters. It offers users access to valuable information on family laws, helping them navigate legal complexities with clarity.

In conclusion, LawBotPK could be a strong step in the development of legal tech intended to address a key issue of enhancing the legal literacy level of the population. Thus, utilizing NLP to understand and answer legal questions guarantees the ready availability of key legal information for users, enhancing the general public's knowledge and increasing their autonomy.

# Contents

# List of Figures

# List of Tables

# Chapter 1

# Introduction

## 1.1 Motivation

As we are living in the world where it is easier to gain access to any piece of information, which has considerably advanced due to information technology, the area of law consultancy has not been simplified and is still not easily explained and reached by the common people. It is quite common for clients with legal problems especially in the area of family law to access relevant information that is accurate, timely, and affordable; often the costs and time involved are prohibitive, in addition to the possible confusion caused by legal terminology and procedures. However, the legal services sector generally has been resistant to innovation, and slow to adopt new technologies relative to other high-value sectors due to a combination of traditional practice and risk aversion[1]. The reason for the Virtual Law Assistant is derived from the idea that there is a lack of availability of legal information and materials and people should be availed the tools and the information they need so that they can be in a position to solve their own legal issues. Through the use of the latest technologies in Artificial Intelligence and Natural Language Processing, this project seeks to close the chasm that exists between the legal professionals and individuals in dire need of legal services with the aim of making justice easily accessible to every one on the planet.

## 1.2 Problem Statement

Legal issues with family law or any other issue that people face may be difficult for a common man to understand. Given the nature of the legal systems as well as the fact that people are unable to pay legal entities to get proper advise, people are always in a wrong track when it comes to handling their matters. The issues with conventional legal aid services are not only their expensive nature, but also the time it takes to acquire a legal help. Due to the easily accessible legal information, a large number of people did not pay attention to their rights when they encounter any particular problem. As the usage of AI solutions increases, it will be possible to expect more frequent appearances of new options for lawyers that will help them in making legal work more productive and precise. Nevertheless, the potential positive impact should not overshadow possible side effects such as data privacy and security in the case of using AI systems. The given sector now stands before a shift in its structure due to the technological factors and market demands. Companies that will not begin to consider the integration of AI into their business strategies will work under a disadvantage, which may have implications on the dynamics of the industry's competitiveness and its health in the global economy[2]. This project fulfills the gap of encountering a user-friendly solution when need assistance on different matters of family law.

## 1.3 Scope

The Virtual Law Assistant project aims to incorporate a deep learning chatbot that will help the users to get answers and solutions to the legal issues primarily addressing family law. This includes building and compiling a comprehensive list of regular legal inquiries and respective lawyer answers, fine-tuning a language generation model so it must provide correct and relevant information, and designing the chatbot to embrace a user-friendly website. The subject developed for the project is family law that is relevant to Pakistan's

jurisdiction; the project aims to provide important and more recent data to the potential users. Also, in this project, there are prospects to improve the general experience of interaction with the chatbot being available at all time, with concerns of confidentiality of the users, and with a creation of the space for interaction.

## 1.4 Aims and Objectives

The general purpose of the Virtual Law Assistant project is to create an efficient, and simple-to-use AI chatbot that will offer legal advice on family law issues. The specific objectives are:

- Design an accompanied digital interactive agent or an artificial intelligence-based program or model capable of helping in the field of family law.
- The next step to adopting the chatbot would be to infiltrate it into a usable and aesthetic website.
- Educate people about the laws of marriage, divorce, child custody and other related issues.
- Legal materials should be so current that changes can be reflected in authorized documents and statutory laws.
- Offer confidential legal service, which will be available any time of the year including holidays and midnights.

## 1.5 Outcomes

Some of the positive outcomes that would be obtained upon successful implementation of Virtual Law Assistant Project. First of all, it will provide ordinary people with an equal opportunity to get objective legal advice without overpaying for an attorney's consultation. This shall enable the users to be well equipped with the information they require to

solve their legal problems. Secondly, it will create awareness and educate the public on the existing family laws within the community, hence improving the community knowledge of the laws. Also, the feature of round the clock support and care will enable the users to seek legal consultancy any time they desire which makes the provision of legal aid more efficient and responsive. In the end, the Virtual Law Assistant has the goal to provide closer connection between lawyers and other people, make the population more legal-savvy.

## 1.6 Report Organization

The layout of this thesis is aimed at giving the reader a better understanding of the Virtual Law Assistant project. Chapter one begins with the background to the project highlighting the motivation, problem under consideration, scope of the project, purpose or aim and objectives, and the expected achievements of the project. In the second chapter, the extant literature and related work of AI, NLP, and legal help technologies are discussed. The third chapter is on the methodology which covers data gathering, model designing, and system incorporation. The fourth chapter focuses on the process of integration of the chatbot and the website. The fifth chapter provides the findings, comparing the efficiency and the precision of the chatbot. The last chapter provides a conclusion of the research study results, an evaluation of the implications of the study, and suggesting directions for future work.

# Chapter 2

# Background & Related Work

## 2.1 Background Overview

Advancement in AI technology have had a significant impact on the legal sector just like many other sectors. AI is a word that describes the replicating of human intellect in machines that have been developed to carry out tasks that normally need human intelligence like data analysis, decision making, and natural language processing (NLP). AI systems have been created in the legal field to help legal professionals and ordinary men with a variety of tasks including document automation, contract drafting, Legal research, and analysis. Conventional legal research was a physical process where one searched through the numerous case laws and legal opinions and statutes physically to find some materials and cases to base a case on [3]. The time and effort needed for legal research, however, can now be easily decreased due to AI-powered technologies that can quickly and precisely analyze and understand vast amounts of legal information. With the use of machine learning algorithms, these technologies extract and analyze legal data which makes it simpler for legal practitioners, law students, and common men seeking legal advice. AI systems are capable of contract analysis, clause identification, and even give amendment suggestions based on established criteria. Learning from past cases and trends, an AI solution

can predict the result of a particular trial, and in this manner, help lawyers to evaluate the advantages and shortcomings of a certain case and choose the most suitable tactics for a lawsuit [4].

## 2.2 Exploring Advantages and Challenges

To better understand the potential impacts of this technology, people need to understand the benefits and challenges of AI in the legal sector. Following are some Advantages and Challenges of AI in the legal sector:

### 2.2.1 Advantages of AI in Legal Sector

1. Improved Efficiency: AI technologies make it feasible to automate time-consuming processes like document screening, contract analysis, and legal research. This increases productivity.

2. Increased Accuracy: AI-driven algorithms can evaluate massive amounts of data rapidly and precisely. Hence, reducing the chance of human error. The accuracy of legal analysis and decision-making can be increased by using AI algorithms.

3. Cost Reduction: By automating repetitive tasks, AI can help law departments and law firms to reduce their operating costs. So that, legal services will get more widely available and cost-effective.

4. Legal Research and Analysis: AI techniques can assist lawyers and users in conducting in-depth legal research and case law analysis. AI-powered chatbots quickly find relevant legal information and provide precise legal advice.

5. Predictive Analytics: By analyzing historical data, AI systems are able to predict future risks, legal patterns, and case outcomes.

### 2.2.2 Challenges of AI in Legal Sector

1. Ethical Issues: The implementation of AI brings up issues with discrimination, privacy, and confidentiality. AI systems need to make sure that customer data is protected and kept strictly confidential.

2. Job Displacement: Legal professionals may lose their jobs as a result of AI automation especially those involved in reviewing documents and legal research. However, AI also leads to the creation of new employment opportunities in the field of data analysis and legal advising.

3. Insufficient Domain Expertise: The quality and quantity of data that is available is crucial for AI systems. AI applications may not be as effective in some specialized legal fields due to a lack of available data.

4. Regulatory Hurdles: The legal sector works within a complicated regulatory environment. The integration of AI technologies raises some issues regarding commitment to data protection rules, IP rights, and professional ethics. It is important to create suitable regulations that take into account the special features of AI in the legal framework. [5].

5. Trust and Acceptance: Active AI implementation in the legal field should be based on the approval and acceptance of legal workers, consumers, and the public.It is imperative to dispel any doubts regarding the stability of AI, its explanations, and its bias since trust and successful implementation of AI solutions are the key to their success.

## 2.3 Transformation of Legal Services

Over time, legal help has changed completely, moving from conventional meetings in person to the use of online platforms. In the past, the primary way to obtain legal services

was through personal meetings with lawyers. This way was beneficial but they often came with high fees and long wait times. Individuals now have a more convenient way to look up legal information through online legal resources which is made possible by the evolution of the internet.

The complicated areas of family law which involve matters like child custody, divorce, and inheritance, give unique problems. Individuals who are encountering these legal issues often find it difficult to navigate the legal system to understand their rights. The conventional approach to legal assistance, however, has not fully been able to address the problems with both affordability and accessibility that many individuals face. This gap has made it necessary to look into novel approaches for improving the convenience and availability of legal help.

## 2.4 Adoption of AI in Legal Practices

AI has changed the legal services industry by providing rapid legal research, automation of tasks, and improved decision-making. Artificial Intelligence (AI) techniques like machine learning (ML) and natural language processing (NLP) are very useful in the legal field [6]. Legal professionals can take advantage of a variety of AI technologies to increase productivity, simplify work, and provide better client care. Below are some examples where AI can help lawyers in a meaningful way:

- E-discovery and legal research (AI as a tool for managing and drafting documents)
- Predictive Legal Analysis (AI as a predictive analytical tool)
- Legal Review (AI as a tool for summarizing and reading)
- Case Management (AI as a tool for filing and scheduling)
- Automation of Legal advice and knowledge (AI as a tool for client support and communication)

- Marketing and Information (AI as a tool for marketing and learning)

The Deputy Head of Civil Justice for England and Wales, Lord Justice Briss, said that he had utilized ChatGPT to simplify a legal topic before incorporating it into his ruling. This was the first time a British Judge had used an AI chatbot [7]. AI in family law can give users, fast and precise advice by assisting them in determining which laws and sections are related to their particular circumstance.

## 2.5 Legal Tech in Pakistan

In Pakistan, there is no AI product in the Legal sector is there. We are still in the early stages of AI use in Legal services. There are some online platforms that provide legal databases and document preparation services but there are no complete AI-based legal assistance products that are particularly designed for family law assistance. In comparison, other countries are evolving Legal Tech where AI-based legal products are more common and advanced.

## 2.6 Related Products

### 2.6.1 Pakistan Law Site

Pakistan Law Site is an online, one-stop legal research service aiming to deliver users with Global access to Pakistani laws and materials. It was established by the Pakistani organization, Pakistan Law House, and constitutes one of the major online legal sources of the country with a wide selection of case laws, acts, rules, and regulations. Hence, PakistanLawsite effectively helps in reducing the time and effort required for conducting or researching any legal matters in Pakistan. Since it offers easy access to a large number of legal resources, the database allows legal professionals, scholars, and learners to keep abreast of changes within the sphere.

### 2.6.2 East Law

EastLaw is a competent online legal research tool that is designed and developed to cater to the needs of the lawyers practicing in the Pakistani courts. EastLaw offers a great opportunity to find a great number of legal materials such as case reports, statutes, regulations, and other legal texts that may be relevant to certain topics. The platform provides the innovative possibility for improving legal research both from the perspective of computational prepossessing and user experience.

### 2.6.3 Law Bot Pro

LawBot Pro is a working AI-based Application designed to provide answers to the legal questions and resolve the legal concerns in India. This unique application relies on the use of AI and natural language processing to provide legal advice and information to users in simple language. The features of LawBot Pro are useful for those individuals who require professional legal consultation; for those users who are lawyers but would prefer working with the legal software to make the process more efficient. LawBot Pro has brought tremendous change in the Indian legal framework by providing equal to everyone irrespective of their background. Its self-help services have been instrumental in providing affordability to people as well as closure between the legal community and the broader public.

# Chapter 3

# Methodology

## 3.1 Introduction

In this section, Our Research Design, Data Collection Methods, Analysis, Techniques Framework, and Tools/ Technologies used are described. In this work, we make use of the recent advances in natural language processing models in order to develop an AI-enabled chatbot for legal question answering and aim at providing highly accurate and correct answers to legal queries.

## 3.2 Literature Review

This study employs a quantitative research design that examines the development and evaluation of a legal chatbot for answering questions. The work is an example of a methodological study comprising data, model training, and performance assessment. It even includes something like data access, now from where we can get the data and is the data available online or not? if yes in which form etc. We talked to various lawyers who can help us with our project as they know the use case of the project. It also carries out searches on past activities made in related works to see if there is a literature review, research, or work done in this field. Also, the research outlines which areas of law deserve

attention for the purposes of accomplishing the goals of the project.

Additionally, the methodology embraces the selection of various models available for use with the possibility of tweaking that currently are offered for free. The required technologies and tools to work on the project and distribution of the work plan such as work sharing among team members are also included in the section.

## 3.3 Data Collection

First of all, we reached a number of lawyers to find out where we might gather the necessary information. For all the articles, we had the data in raw format, for example, PDF files, and we discussed the information with lawyers to fully understand the data and identify what should be input into the set as acts, sections, and proceedings.

This project's data was collected from legal databases that are easily accessible to the public, through forums, and from various law firms. A sample file of 1000 rows in CSV format included legal questions and answers. The data was also cleaned in that way to discard some features that would obviously be of no use to the analysis of the data. There was also the use of data augmentation to diversify the training set and provide the model with a more explicit and varied data set. This was important so that the model was trained properly to be able to answer all kinds of legal questions that may come its way in a short and in a more accurate and believable way.

## 3.4 Data Analysis

Data cleaning thus took a long time and Python and Pandas were adopted to clean up the data and prepare it for use as training data for the model. To start, the raw text data was screened for errors including missing data and unclean data, and, where necessary, was cleaned accordingly. The text data was preprocessed, and then the texts were tokenized and enumerated with the aid of the GPT-2 tokenizer from Hugging Face Transformers.

This step was important to help change the textual data into a form that which the AI model could work most efficiently.

After tokenization, the dataset was split into training and validation sets with a 90:10 ratio, While what they did is highly questionable it was an attempt to hedge its bets by diversifying its operations and to spread its risks across other sectors of the economy it operates in Through diversification it sought to harness other operations that could create employment in the economy and hence reduce risk by diversifying operations across different sectors of the economy it fully in operating in. This split was intended to classify the most part of the data as a training set, and the minority part as both test and validation data sets in order to train the model well, while also testing it in order to avoid overtraining. This is an important strategy in training and validation to guarantee that the model is tuned sufficiently for the task it is required to make, while at the same minimizing the risk of it being over-trained.

## 3.5 Transformer Architecture

Transformer architecture has many stacked layers of both the encoder and the decoder. It is a type of artificial neural network model that helps transform the nature of the input data while making predictions. Here's a brief explanation of the architecture:

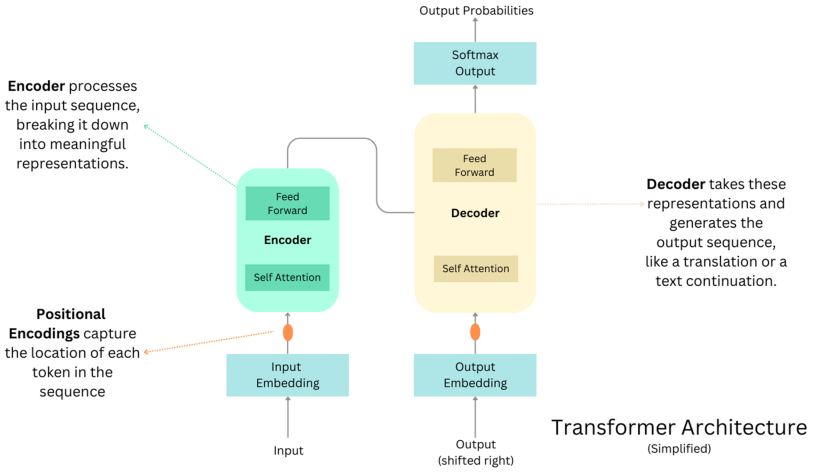



Figure 3.1: Transformer Architecture

### 3.5.1 Encoder

It splits the sequence into meaningful representations by passing the input data through a hierarchy of similar units, commonly, six. Each layer is composed of two sub-modules: concerns regarding its stability, as well as a multi-headed attention mechanism, and a fully connected feed-forward network.

#### 3.5.1.1 Self Attention

It can facilitate attention to parts of the input sequence that are relevant to its predictions or decisions, thus improving the internal workings of the model. It transcribes values for certain peculiarities of the sequence and to learn where it pays attention when it should complete some task.

#### 3.5.1.2 Positional Encoding

Unlike the sequenced model like LSTM, the transformer does not possess the knowledge of word order, so it incorporates positional encodings to provide the transformer with this knowledge.

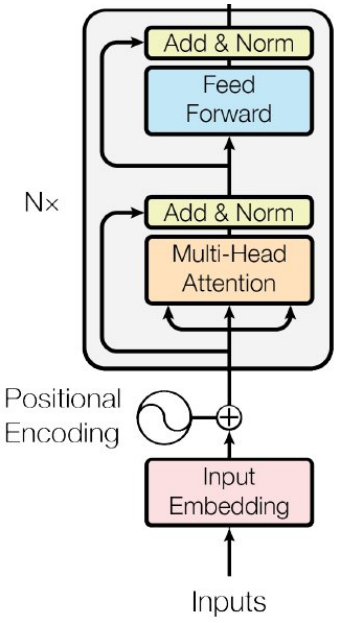



Figure 3.2: Encoder Architecture

### 3.5.2 Decoder

The decoder follows the encoder and owns the responsibility for decoding, which means it predicts the output sequence, for instance, the next word or a translation of the input text in case of machine translation. It also utilizes a stack of identical layers, with each layer having two sub-modules: These elements include masking a multi-headed attention component and resolving a fully connected feed-forward network.

#### 3.5.2.1 Masked Self-Attention

Closely related to self-attention but limits the ability of the model to attend the output tokens while training to the ones generated till the current moment which means that the model does not have a possibility to look at the tokens that come further in the output sequence.

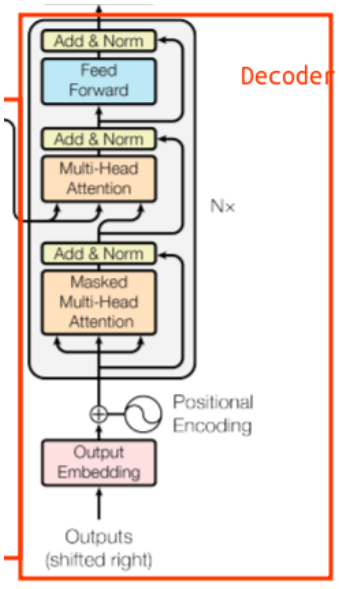



Figure 3.3: Decoder Architecture

## 3.6 Model Implementation

Initially, the plan was to deploy new kinds of models such as GPT-2, Falcon 7, and Llama 2 with considerable computing power. However, several constraints came up during our

testing: One of the restrictions was the lack of sufficient computing resources to employ Llama 2. We also talked, though in a more mechanical manner, with GPT-3. I also tried 5 Turbo but it was just an API and did not work well with respect to the engineering approach that we have taken for our project.

Given our small team and the limited time of the project, we had to concentrate on the extraction of as much of the useful information from our dataset. Some steps were taken in order to obtain a large amount of data that refers to most of the aspects of family law and the different acts involved. To begin, we investigated other models such as BERT, and realized that they are more efficient at duties like summarization as opposed to the current task at hand.

Based upon consultation and analysis, two models emerged as potential candidates; GPT-2 and GPT-2 Distilled and based on the volume of data that we aimed to process, it was clear that using the full GPT-2 model was neither feasible nor necessary. However, this is possible for a cheaper model and less number of parameters which make it suitable for our project compared to the original GPT-2 model.

### 3.6.1 Data Loading

First, we load the dataset in CSV format by using the pandas library.

```
from google.colab import drive
drive.mount('/content/drive')
data_sample = "/content/drive/MyDrive/Colab Notebooks/fyp2/Dataset1.csv"
df = pd.read_csv(data_sample)
print(df.head())
```

Figure 3.4: Data Loading

### 3.6.2 Tokenization

For our text data preprocessing, we followed the steps of tokenization and vectorization and here for tokenization, we have utilized a GPT-2 tokenizer. This process meant transforming the text data into tokens, which are easily digestible numerical units that can be accessed by the model. Through the help of the GPT-2 tokenizer, we strategically prepared the text data to be trained by the model which prepared the model to make predictions based on its training.

```
from transformers import GPT2Tokenizer, GPT2LMHeadModel
import torch

tokenizer = GPT2Tokenizer.from_pretrained('distilgpt2')
```

Figure 3.5: Loading GPT2 Tokenizer

### 3.6.3 Model Initialization

For this project, the DistilGPT-2 model is employed. This was achieved by loading the model and then transferring the model to a preferred device (either GPU or CPU as the case may be).

### 3.6.4 Custom Data Class

Thus, based on our requirements, we derived a new Language Dataset class, which would better suit our project's needs in terms of data handling and tokenization. This class has helped in the unification of the data ingestion process from the Pandas DataFrame so that the subsequent steps could easily fit into the training loop. Furthermore, it proposed the maximum length of tokenized sequences and helped increase the efficiency of our training process accordingly. I can also add that this approach did not only improve the cleanliness of our training loop but also its efficiency which in turn positively impacted the training

of better models and their subsequent performance.

### 3.6.5 Data Splitting

To ensure this, the dataset was split into training and validation sets using the random split function from PyTorch, affirming 95 Percent as the training set and 5 Percent as the validation set. Data Loaders were employed to gather the data into batches and next shuffle the data for the training and the validation.

### 3.6.6 Model Training

The sentences were generated as the model was fine-tuned with the DistilGPT-2 transformer. As the optimization strategy, we used the Adam optimizer, which adjusted the parameters based on gradients, and the CrossEntropyLoss function. For tracking the performance, the training as well as the validation loss was monitored and plotted in the graph. To achieve this we did not use an auto-train library and instead improvised by engaging in a hit-and-trial method to arrive at the best training parameters. At the beginning of this project, we hypothesized that the increase in the number of epochs would lead to an increase in accuracy. Nonetheless, we found that with this approach overfitting of data becomes a great problem we encounter. Through this iterative process, we were able to strike a balance in regard to the number of training examples used as well as other aspects of our training process, which allowed for the best performance of our models.

```
Training Epoch 1/5: 100%|██████████| 950/950 [00:52<00:00, 17.97it/s, Training Loss=0.339]
Validation Epoch 1/5: 100%|██████████| 50/50 [00:00<00:00, 82.07it/s, Validation Loss=0.557]
Epoch: 1, Validation Loss: 0.3325093936920166
Training Epoch 2/5: 100%|██████████| 950/950 [00:52<00:00, 18.05it/s, Training Loss=0.239]
Validation Epoch 2/5: 100%|██████████| 50/50 [00:00<00:00, 82.53it/s, Validation Loss=0.533]
Epoch: 2, Validation Loss: 0.3280719640851021
Training Epoch 3/5: 100%|██████████| 950/950 [00:52<00:00, 18.00it/s, Training Loss=0.158]
Validation Epoch 3/5: 100%|██████████| 50/50 [00:00<00:00, 82.38it/s, Validation Loss=0.528]
Epoch: 3, Validation Loss: 0.31935843676328657
Training Epoch 4/5: 100%|██████████| 950/950 [00:52<00:00, 18.04it/s, Training Loss=0.309]
Validation Epoch 4/5: 100%|██████████| 50/50 [00:00<00:00, 82.28it/s, Validation Loss=0.526]
Epoch: 4, Validation Loss: 0.32058427661657335
Training Epoch 5/5: 100%|██████████| 950/950 [00:52<00:00, 18.01it/s, Training Loss=0.246]
Validation Epoch 5/5: 100%|██████████| 50/50 [00:00<00:00, 80.46it/s, Validation Loss=0.527]
Epoch: 5, Validation Loss: 0.3174808770418167
```

Figure 3.6: Model Training

### 3.6.7 Loss Viaualization

The training and validation loss were shown with the intent to show the model's performance in the epochs.

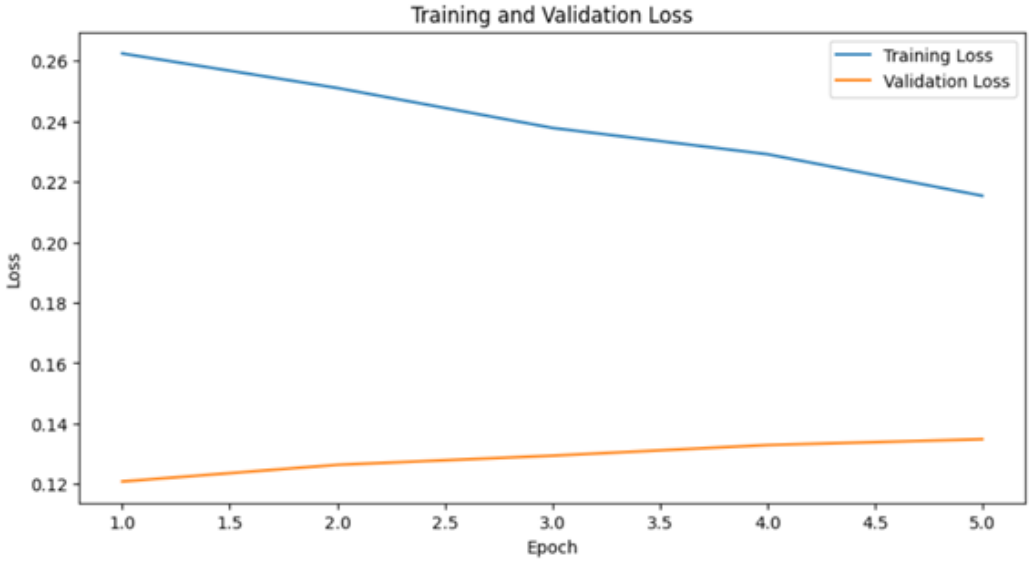



Figure 3.7: Training and Validation Loss

### 3.6.8 Model Evaluation

The trained model was saved and set to evaluation mode for inference or further training.

### 3.6.9 BLEU Score Evaluation

A permuted BLEU score was used for the evaluation of the model and its performance on the validation corpus to measure the relevance of the produced text to the reference answer texts. This metric offers a way of determining the extent to which the generated text is identical to the expected response, thus being helpful in evaluating the proficiency of the chatbot in dealing with legal questions.

```
from nltk.translate.bleu_score import sentence_bleu

# Reference output
reference = "Dower, also known as 'Mehr' in Islamic law, is a financial obligation that is provided by

# Generated output
generated_output = "Dower, also known as 'Mehr' in Islamic law, refers to a type of dower that is paya

# Calculate BLEU score
bleu_score = sentence_bleu([reference.split()], generated_output.split())
print(f"BLEU score: {bleu_score}")
```

```
BLEU score: 0.28782893232478673
```

Figure 3.8: Bleu Score Evaluation

## 3.7 Web Frontend Methadology

### 3.7.1 Technology Selection

The front end of the project was built using REACTJS as it is one of the popular JavaScript libraries to build user interfaces. By determining how best to structure the application's architecture and components, ReactJS has offered a component-based framework that caters to the scalability and extendibility of the architecture for use in large, complex applications.

### 3.7.2 Build Tool

The build tool Vite was selected because of its excellent protection time and hot module replacement that allows you to update the application throughout the development process. The benefit of this was that the process was more ordered than before and developer productivity increased.

### 3.7.3 UI Library

Out of all the libraries of React, Material-UI (MUI) was chosen for its comprehensive list of ready-made components and appearances that gave the application a clean and

welcoming aesthetic. The different components of MUI were used here to create the forms for user registration and logging in as well as other elements in the applications' interface.

### 3.7.4 User Registration and Login

The registration stage of the user is to enable the new users to create a new user account with reference to the unique email address and a password of their choice. On successful registration, users are taken to the login page where the new user can log in using the new credentials. The authentication service ensures the users sign in with both their email and password and then set up an authentication token in the stack memory of the browser.

#### 3.7.4.1 Sign Up Page

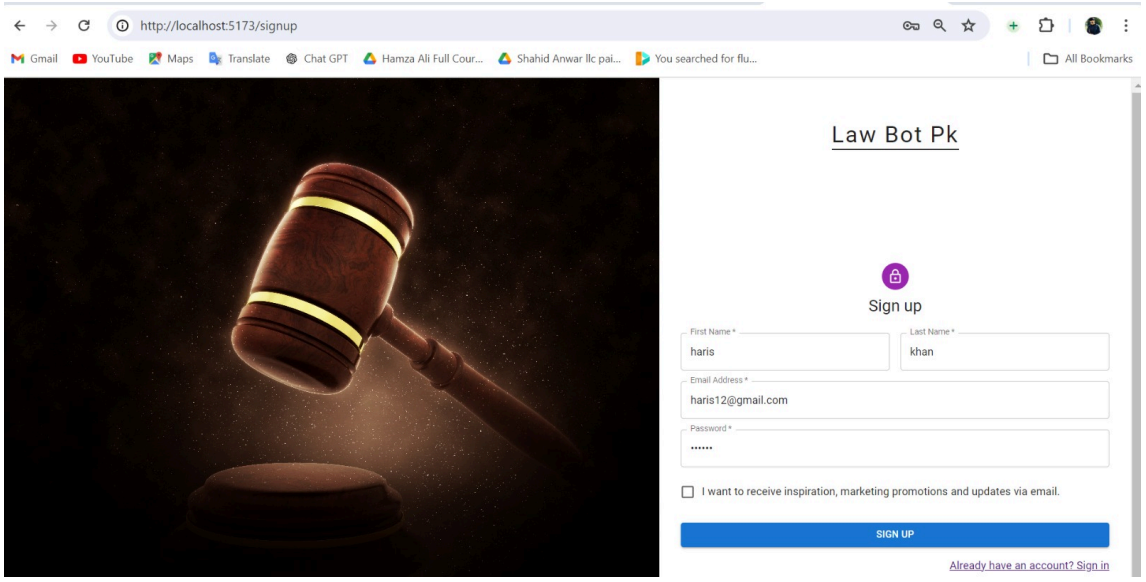



Figure 3.9: Sign Up Page

### 3.7.4.2 Log In Page

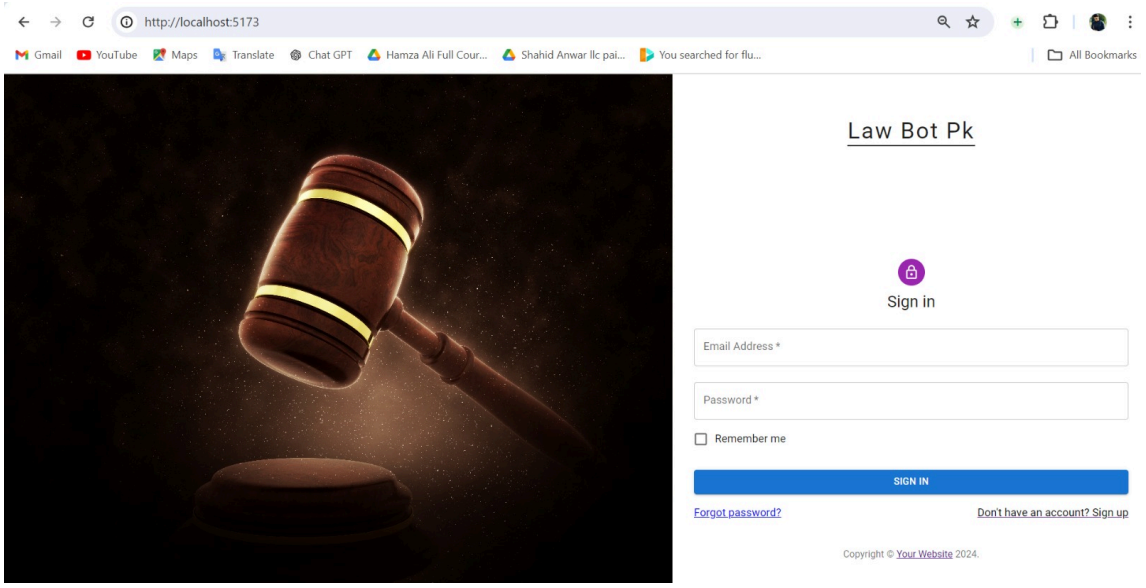



Figure 3.10: Log In Page

### 3.7.4.3 Main Page

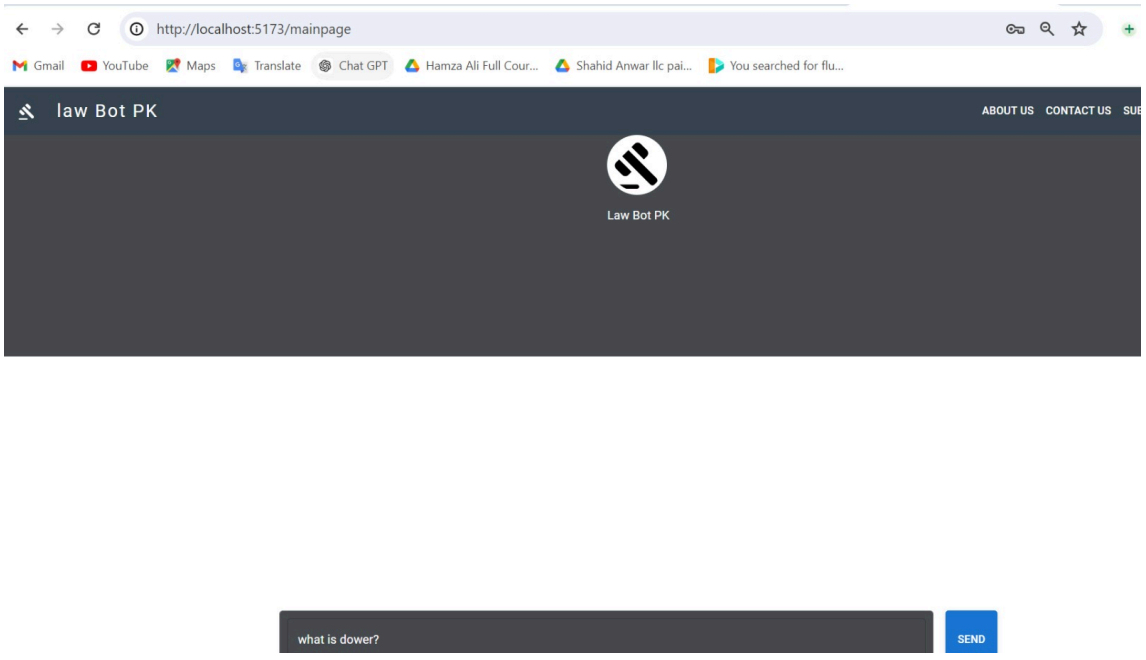



Figure 3.11: Main Page

### 3.7.5 Chat History

For the purpose of getting the entire chat history, a request is made to the backend API using the authentication token which is as follows: The back-end nodes validate the token received and send the chat history of the connected user, which is reflected in the header section of the 'chat' interface. The chat history is being synchronized as the messages are being changed, either sent or received.

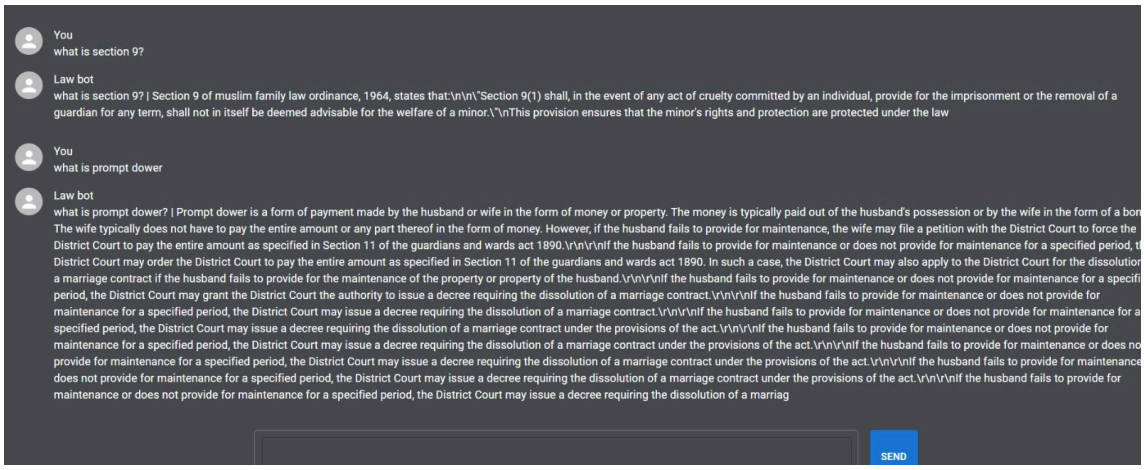



Figure 3.12: Chat Response

## 3.8 Backend Methadology

As part of the Lawbot project Backend development process, we paid particular attention to the final and development phase, where we laid down a solid framework and integrated fundamental capabilities to assist with the system's logistics in the backend. it also took time in selecting three advanced technologies, following proper software development life cycle, and incorporating various security measures to make the back end more reliable, more scalable and more secure.

### 3.8.1 Requirement Analysis and Technology Selection

To define the characteristics of the project and determine the requirements for the further development process, we analyzed functional and non-functional requirements necessary for the efficient functioning of the project. Broad consultations within and out of the organization was equally advantageous in identifying user preference and status of the market. from the surveys, questionnaires and face-to-face interview, the researchers had an insight of the expectations and difficulty faced by the users.

As we have identified during the course of our research and requirement analysis, we choose the right technology which is needed to achieve the goal of the project. As for backend development, we have chosen the Java Spring boot framework because it is stable, flexible, and has a vast community regarding support. spring boot Development's convention over configuration approach, and default parameters, including auto-configuration and basic templates of Spring starters, helped simplify and accelerates the process of developing applications to market.

### 3.8.2 Benefits of Java Spring Boot and Hibernate Integration

Java Spring Boot, coupled with hibernate for orm, offered numerous advantages for our backend development:

- Rapid Prototyping: Given that Spring Boot was developed specifically to include simplicity and productivity in its parameters, the creation of backend components was relatively swift and allowed for quick iterations and feedback.
- Scalability and Performance: This made spring boot to be lightweight and enabled support for microservices architecture, something that made it easy to scale up and for performance improvements.
- Simplified Database Interaction: As a part of hibernate orm, these features have hidden the complexities of interacting with the database to make Java objects and

the underlying MySQL database communicate.

### 3.8.3 Development of Restful APIs with Java Spring Boot

Java Spring Boot was instrumental in the design of restful APIs to perform business logic and enable business transactions. by fully utilizing the capability and configuration of spring boot as our backend framework, we carefully designed a series of APIs to handle multiple functional demands and guarantee communication with frontend, backend, and other systems.

### 3.8.4 Key API Endpoints Developed

#### 3.8.4.1 User Authentication Endpoints

APIs were also implemented to fully cater for the user registration, login, and authentication functions. The former was used for JWT-based secure user authentication while the latter provided runtime functionality of generating OTP.

#### 3.8.4.2 Chatbot Interaction Endpoints

The APIs developed were designed to facilitate signing in and signing up, as well as the processing of the AI chatbot module. the result of a query is an 'ok' response through the chatbot API, which is then stored in the database before being brought up on the front end.

#### 3.8.4.3 User Chat History Management

All user chat histories are also kept personal with each user data stored separately, mainly because the messages are encrypted.

### 3.8.5 Challenges Faced

While developing it we had to struggle against the major issue of storing the long responses produced by the chatbot in MySQL. This masthead problem was compounded by the fact that social media post topics generated these lengthy responses – the standard column size could not accommodate them. to address this, we have set the column size to 16000 characters/words to guarantee the whole response as far as it is delivered is stored without being sliced.

### 3.8.6 Backend Dependencies and Libraries:

The project utilized a curated set of dependencies and libraries within the maven configuration to support various backend functionalities:

#### 3.8.6.1 Spring Boot Starters

For web development, to validate the information received from the server, for data storage in the database jpa, for sending messages via email, for WebSocket communication, and for testing.

#### 3.8.6.2 JWT Libraries

In a nutshell, these trends are desirable for organizations seeking to develop more effective and secure authentication methods for systems and applications.

#### 3.8.6.3 model mapper and lombok

We appreciate that it helps in entity-to-dto mapping and in avoiding writing large amounts of duplicate code.

#### 3.8.6.4 Apache Commons IO and Java Servlet API

For optimized file inputs and outputs, HTTP request and response handling functionalities.

### 3.8.7 Security Measures and Best Practices

#### 3.8.7.1 JWT-Based Authentication

We have given a stateless and secure environment to authenticate the users.

#### 3.8.7.2 Runtime OTP Generation

Improved user authentication by implementing another layer of security whereby the new users are required to activate their accounts through a one-time passcode sent to the e-mail addresses provided by the users.

### 3.8.8 Outcome and Impact

This concluded the process of backend development with the goal of leveling up the backend environment and making it more robust, as well as more scalable and secure. Using Java Spring boot consumer, hibernate framework, and a few selected important dependencies and libraries, we have been able to create an efficient and reliable backend environment. thus, the resultant backend system complements the frontend and AI modules, giving a full-fledged enhanced application. in the future, it will facilitate the future development of the project as this backend structure will create a strong foundation to allow for further improvements and changes in order to satisfy the users' expectations.

# Chapter 4

# Deployment & Validation

## 4.1 Deployment Methodology

### 4.1.1 Environment Setup

#### 4.1.1.1 Environment Configuration

Strip the deployment environment down to Python and the required dependencies such as transformers, torch, fast API, uvicorn among others.

#### 4.1.1.2 Model Loading

GPT-2 model and tokenizer are to be loaded using the transformers library in Python before the further implementation of the model.

### 4.1.2 FastAPI Integration

#### 4.1.2.1 FastAPI Installation

It has a vibrant community of developers, and you can catch up with this framework easily if it is not installed already you can do so using the following command: pip install

fastAPI.

#### 4.1.2.2 Middleware Setup

Add CORS middleware to allow cross-origin and enhance data conveying.

#### 4.1.2.3 Model Prediction Endpoint

Develop a POST request route /pred to accept and preprocess the message from users, and feed it to the trained model to get a response which will be returned in JSON format.

#### 4.1.2.4 Request Handling

Read through the contents of the request body to obtain the user query and apply tokenization on it with the tokenizer that was imported.

#### 4.1.2.5 Model Prediction

GPT-2 for response generation – The input query will be generated based on the user's query and the response will be generated using the same pre-trained GPT-2 model.

#### 4.1.2.6 Response Formatting

This code should take the generated response, decode the message, and then return the response in JSON format.

### 4.1.3 Running the Server

#### 4.1.3.1 Run FastAPI Server

By using the uvicorn command, you start the FastAPI server by executing a Python script which is named 'app' in this case, and run the server on a specific port which is 8000 in this case: uvicorn app: app –host 0. 0. 0. 0 –port 8000.

#### 4.1.3.2 Testing

Check the deployment with the given below steps Take a POST request to the /pred with mandatory query string text='USER QUERY' where USER QUERY is the query provided/performed by the user.

### 4.1.4 Security Considerations

#### 4.1.4.1 Tokenization Security

Customer inputs should be correctly parsed, and any characters removed by sanitization to avoid the emergence of any other form of security threat.

#### 4.1.4.2 Endpoint Security

Secure the /pred endpoint by adding a proper authentication mechanism and authorization mechanism in the API.

### 4.1.5 Scalability and Performance

#### 4.1.5.1 Load Testing

Conduct load testing to determine the overall volume of clients the server is capable of handling before having to put in more resources to continue serving other clients.

#### 4.1.5.2 Scaling

Under scaling strategies, one is the Horizontal Scaling where multiple instances of the FastAPI server should be created behind a load balancer to manage the large traffic effectively.

### 4.1.6 Monitoring and Logging

#### 4.1.6.1 Logging

This can include designing a system to capture the details of the request, the specific events that are happening on the server, or the messages describing errors. There should be special management procedures for logs stored in files and it is called log rotation along with log retention policies.

#### 4.1.6.2 Monitoring

The above components require server monitoring solutions that involve using Prometheus and Grafana to track server metrics, monitor performance, and know when there are anomalies or failures. It is essential to check that servers are up and running all the time, quickly responding to queries, and consuming resources in an optimal manner.

## 4.2 Validation

For the validation of our results, we found a BLEU Score and also we validated the responses through Lawyers as well.

### 4.2.1 BLEU Score Evaluation

A permuted BLEU score was used for the evaluation of the model and its performance on the validation corpus to measure the relevance of the produced text to the reference answer texts. This metric offers a way of determining the extent to which the generated text is identical to the expected response, thus being helpful in evaluating the chatbot's proficiency in dealing with legal questions.

```
from nltk.translate.bleu_score import sentence_bleu

# Reference output
reference = "Dower, also known as 'Mehr' in Islamic law, is a financial obligation that is provided by

# Generated output
generated_output = "Dower, also known as 'Mehr' in Islamic law, refers to a type of dower that is paya

# Calculate BLEU score
bleu_score = sentence_bleu([reference.split()], generated_output.split())
print(f"BLEU score: {bleu_score}")
```

```
BLEU score: 0.28782893232478673
```

Figure 4.1: Results Validation

### 4.2.2 Validation through Legal Experts

The primary direction of validation was carried out with the help of the questionnaire, which involved experienced lawyers in the sphere of Family Law to measure the accuracy and reliability of our Virtual Law Assistant. This step was essential to check the accuracy of the AI responses as well as legal advice given by the chatbot and consistency with modern legislation and regulations.

The validation process was initiated with the creation of a data set that consists of policy-related topics and their related answers. This was done initially by categorizing them based on the kind of problem or question one might come across when dealing with family law. We then invited a panel of legal experts to review the dataset that has been established according to the benchmarked guidelines. The lawyers themselves carefully Sri Kite and Olga reviewing AI answers for correctness, relevance, and clarity. They pointed out aspects that could be corrected in the questions answered by the chatbot so that the legal advice was useful but not overly technical for anyone.

Besides evaluating the first data set, the lawyers also analyzed how the chatbot would perform in live cases. They input hypothetical legal questions to the API and then evaluated the performance of AI in providing relevant legal advice. The iterative structure of question-answering and the feedback provided by students and the journalists helped to

improve the reproducibility of the AI's answers in case of their inconsistency or inaccuracy.

Touching on the validation of the Virtual Law Assistant, it is noteworthy that the participation of legal experts helped not only to increase the credibility of the developed solution but also to provide the necessary level of compliance with the requirements for providing legal assistance. First, it was possible to engage expert input in the development of a tool to which the target users can turn for relevant matters concerning family law.

If you had not called for this validation process to be as rigorous as it is, then you would have found legal assistance to be reliable and user-friendly at this point in time. It also underscores the relevance of cross-specialty cooperation to create AI solutions that are promptly required to address specific societal demands.

# Chapter 5

# Conclusion and Future Work

## 5.1 Conclusion

In conclusion, the creation and implementation of the Virtual Law Assistant are a step forward for using artificial intelligence within the framework of legal activities. This project has effectively met the presented challenge of providing comprehensible, clear, and timely counseling in the sphere of family law in Pakistan. We have thus used the features of natural language processing and machine learning to develop an efficient tool that not solely acts as an intermediary between the legal kingdom and the common populace but also makes access to legal knowledge more accessible. The concept of Virtual Law Assistant has demonstrated efficacy in delivering prompt and meaningful legal advice, thereby enabling people to become knowledgeable about the legal matters affecting them and sort them out without unreasonable cost and technicalities associated with traditional law services.

The legal industry is being significantly transformed by AI in various ways. There is no doubt that technologies based on AI will bring an increase in the scope and speed of assessing legal analysis while the increase of productivity at the same time. Nevertheless, the application of AI in law throws considerable ethical questions that rely mostly on bias

and employment displacement [8]. AI and ML are sure to find their place in the legal field because such technologies are capable of analyzing vast and complicated databases to find the laws, rules, and precedents that would have been useful for the process and faster [9].

The success achieved within the framework of the project has proven that AI is capable of revolutionizing the sphere of legal and contributing to creating a future where technologies can greatly improve the availability of legal aid services. This preliminary specialization in family law has provided a solid ground to show that AI is capable of addressing complex legal questions and generating correct solutions and as a result, it can be extended to a number of other branches of law.

## 5.2 Future Work

Our long-term goal is to increase the area of specialization of the Virtual Law Assistant, focusing on family law, but branching out into other disciplines as well. Understanding the necessity to address the numerous legal needs of the population, our plan is to expand the use of AI-based legal services and consultation in such fields as Labor law, Criminal law, etc. This expansion will include the addition of new data sets and recalibration of our models to minimize error with respect to these extra-legal disciplines. Thus, we strive to extend the coverage of comprehensive legal aid services, which can be considered a path to increased provision of justice.

### 5.2.1 Increasing Legal Domains

The next step to the evolution of the Virtual Law Assistant is to incorporate a variety of other areas of law into the system. Incorporation of additional data and focus on labor laws will meet the demand for easier access to information in the sector where workers and employers often face legal issues. In the same manner, it will be useful to incorporate criminal law assistance in a country where simply understanding one's rights or the

provisions of criminal procedures can prove complex.

This expansion will require gathering large amounts of legal information from specialists in these areas and carefully building a corpus of data to feed into our systems. The introduction of new legal areas will not only increase the number of the assistant's specialties but also strengthen our focus on the creation of the all-in-one legal help assistant. This will make Virtual Law Assistant a one-stop solution to numerous legal issues by making sure that users have legal information that is relevant and credible as per different legal practices.

### 5.2.2 Integration of Lawyer Database

Apart from broadening the existing areas of legal practice, the next step in the development of the Virtual Law Assistant application will be the addition of a database of lawyers. This feature shall allow users to get an online lawyer just as to one can book an appointment with a doctor, through apps like Oladoc or Marham. Those seeking lawyers will be able to find them depending on their area of practice, location, and time that they are available or willing to take up what has been offered to them by the application. This integration will require the creation of the right database foundation, a permanent, easy-to-use, and easy-to-access solution. We will also incorporate a rating and reviewing system which will assist users in making the right decision as per their requirements in a particular lawyer. As to the purpose of the Virtual Law Assistant, we are to provide access to legal experts to make the tool not only informative but also advisory for clients who need legal consultation in addition to legal information.

### 5.2.3 AI Legal Drafting

Another future improvement of the Virtual Law Assistant mentioned is the inclusion of a feature of legal writing with the help of artificial intelligence. It might take some time and legal drafting can only be done by professionals because of the challenges associated

with it. In utilizing the AI legal drafting, it is possible to avoid much time and energy in creating various legal forms and contracts aside from other necessary documents. This feature will use a complex adaptation of natural language processing (NLP) to generate legal and personalized documents for the users' needs.

This feature will entail using artificial intelligence to pass through a wide variety of legal documents and legal templates to get the best draft and also legally sound. This will help to cut down the time and efforts being spent in preparing legal documents which in turn will make the availability of legal services cheaper. This will be important to users as they will be able to produce their documents in a short span of time and with much accuracy which is soothing for those who cannot afford to employ the services of professional legal drafters.

# References


[1] C. Brooks, C. Gherhes, and T. Vorley, "Artificial intelligence in the legal sector: pressures and challenges of transformation," *Cambridge Journal of Regions, Economy and Society*, vol. 13, pp. 135–152, 01 2020.

[2] N. Madaoui, "The impact of artificial intelligence on legal systems: Challenges and opportunities," *Problems of legality*, vol. 1, pp. 285–303, 05 2024.

[3] S. N., "Artificial intelligences effects on the legal sector transforming legal practice," vol. II, pp. 1–20, 07 2023.

[4] E. F.-V. Bart Custers, "Law and artificial intelligence: Regulating ai and applying ai in legal practices," vol. 35, 2022.

[5] T. Cabral, *AI and the Right to Explanation: Three Legal Bases under the GDPR*. 01 2021.

[6] S. Khan, M. Zakir, S. Bashir, and R. Ali, "Artificial intelligence and machine learning in legal research: A comprehensive analysis," *Qlantic Journal of Social Sciences*, vol. 05, pp. 307–317, 03 2024.

[7] V. Umana, "Leveraging the use of artificial intelligence in legal practice," April 2024.

[8] S. Beegum and D. Antony Thekkanath, "The impact of artificial intelligence on law," vol. Volume 4, pp. pp 1811 – 1814, 09 2023.

[9] L. Singh, K. Joshi, R. Koranga, S. Pant, and P. Mathur, “Artificial intelligence in the legal profession: A review on its transformative potential and ethical challenges,” 02 2024.