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Project Report On

Virtual Courtroom

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

Computer Science and Engineering

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CERTIFICATE

This is to certify that the project report entitled ***Virtual Courtroom*** *is a bonafide record of the work done by* ***Nanditha Jinesh (U2103149),Nayan A Menon (U2103150), Riya Salim (U2103177), Rohan Chandy Mathews (U2103178)****, submitted to the Rajagiri School of Engineering & Technology (RSET) (Autonomous) in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B. Tech.) in Computer Science and Engineering during the academic year 2024-2025.*

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Abstract

The Virtual Courtroom project is a groundbreaking effort to modernize legal proceedings through the use of advanced Machine Learning (ML) and Natural Language Processing (NLP) technologies. This platform is designed to simulate real-world courtroom proceedings, particularly in the domains of criminal Law, with the goal of delivering fast and efficient draft verdict. By integrating cutting-edge technologies, the system reimagines traditional courtroom processes, making them faster.

Key features include speech-to-text conversion using models like Whisper, NLP for analyzing legal documents and draft verdict generation process using ML models.

The Virtual Courtroom enhances accessibility by allowing users to submit case details via text, audio, or document uploads. It supports the integration of witness statements, creating a comprehensive platform for legal argumentation and evaluation. Designed with Indian legal provisions in mind, it focuses on straightforward cases but represents a significant leap in legal technology.

By automating various aspects of the judicial process, the Virtual Courtroom aims to reduce procedural delays and deliver timely verdicts, ultimately contributing to a more efficient and equitable legal system.

Contents

List of Abbreviations

ML - Machine Learning

CNN-Convolutional Neural Network

NLP-Natural Language Processing

KEMCAN - Knowledge Enriched Multi-Cross Attention Network

MANN-Multichannel Attentive Neural Network

YOLO-You Only Look Once

LJP-Legal Judgment Prediction

IPC-Indian Penal Code

ResNet-50 - Residual Network 50

T5 - Text to Text Transfer Transformer SBERT-Sentence Bi directional Encoder Representation FAISS- Facebook AI Similarity Search

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Chapter 1

Introduction

This chapter introduces the concept of Virtual Courtroom. It elaborates on the scope of the project and the background of the concept considered. The project is about creating a virtual judicial platform that can be accessed by all, speeding up the legal procedures and enabling justice for everyone. The idea for this project came from the urgent need to fix the inefficiencies and delays occurring in the legal system.This chapter, gives a clear picture of what the project is about, the challenges for developing the system and the impact it could bring to society.

1.1 Background

The Virtual Courtroom project provides a solution to modernize the legal proceedings using ML and NLP. This project focuses on criminal law and aims to simulate real-world court hearing. Many core aspects of the legal workflow are automated such as case scheduling, handling cross examination and generating a draft verdict. The platform saves time for the individuals involved in the case by removing the chances for procedural delays. The system uses NLP techniques to extract critical information extraction from petition. It handles cross examination and analyzes the data recorded using high-end ML models to provide a final draft verdict. The project aims to bring a revolutionary change in judicial practices by including technology-based solutions for faster and more efficient criminal law proceedings.

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1.2 Problem Definition

The goal of the Virtual Courtroom Project is to deal with flaws within criminal legal proceedings using ML and NLP. The project aims to establish a virtual platform that can

limit procedural delays and deliver draft verdicts.

1.3 Scope and Motivation

Scope: The Virtual Courtroom is a project that automates the criminal legal proceedings. Some of its core features include slot booking for scheduling cases, petition uploading, and analyzing court proceeding transcript. The project makes use of ML and NLP in its core to help in the overall functionality of the project. Virtual Courtroom helps in assisting lawyers and judges in concluding to a draft judgment. This project may grow in scope from focusing just on criminal cases for the time being to other classifications of cases in the future.

Motivation: The Virtual Courtroom project was initiated because of the delays and injustice in the Criminal Legal Justice system. Traditional ways of handling documents and cross-examination cause the judgment to be delayed. This project helps to speed up the procedures to decrease the amount of case backlogs and deliver justice to all. The application of AI makes the processing faster and reduces the amount of errors. The platform can hence provide timely verdicts.

1.4 Objectives

1. Document analysis using OCR tools for lawyers to quickly review legal documents.
2. Case scheduling done via online slot booking system to improve efficiency.
3. Convert spoken words to text using speech-to-text models for record-keeping.
4. Assist in delivering preliminary verdicts by generating draft decisions using the case details and submitted documents.

1.5 Challenges

The Virtual Courtroom project must be secure in terms of data protection. Sensitive legal information must be kept safe from unauthorized access. Moreover, in order to interpret the meaning of legal documents and spoken testimony accurately, advanced ML and NLP models are needed, which can be complex to develop and fine-tune.

1.6 Assumptions Considered

1. Accept documents in standard formats like PDF and DOCX to ensure compatibility with NLP models for analysis.

2. Cross-examinations will take place in a quiet environment to allow accurate speech-to-text conversion.

3. The ML models will rely on detailed and relevant input data to make predictions and analysis.

1.7 Societal / Industrial Relevance

The Virtual Courtroom project has very important applications within society and for the legal industry in making the system of justice more efficient, and reliable.In the legal industry, automation of routine activities such as document review and scheduling can save labor for legal professionals to engage in more complex aspects of cases. Moreover, this project will facilitate faster verdicts, hence making the judicial process less time-consuming and cheaper.

1.8 Organization of the Report

The project report will start with an introduction detailing the aim of the virtual courtroom system, its objectives, and the importance of automating legal proceedings using ML and NLP. Followed by a Literature Survey that reviews related papers, focusing on techniques like MANN, KEMCAN, YOLO.The requirements to make this platform work are mentioned as a chapter.The architecture and workflow of the platform is discussed in the chapter System Architecture. The working of the modules and the implementation strategies used are detailed in the chapter System Implementation. The results section presents the system performance, evaluating the effectiveness, and addressing the limitations.Conclusion will summarize the findings.

1.9 Summary of the Chapter

This chapter introduces the virtual courtroom project, that could automate the conduct of a case by use of ML and NLP technologies in order to aid the judiciary in its functions. It defines the aims of the scope of the project, specifically focusing on the automation of legal judgments. The motivations of the projects are well elaborated by the need for the system in today's legal landscapes to make services more faster and transparent. Furthermore, the project's relevance will be discussed both in society and industry, in relation to the challenges being faced.

Chapter 2

Literature Survey

This chapter discusses the literature that contributed to the project. Some of the relevant works identified are: CoNeTTe, MANN, KEMCAN, YOLO. The chapter explores the methodologies used in these methods and also compares the method based on their advantages and disadvantages.

2.1 CoNeTTE: An efficient Audio Captioning system leveraging multiple datasets with Task Embedding[1]

2.1.1 Introduction

This paper handles the audio to text part of Virtual Courtroom where the advocates speak during the cross examination and the audio is converted to text. Automated Audio Captioning (AAC) is a field of machine learning that deals with the translation of audio events into descriptive text, applied in multimedia tagging, accessibility, and environmental monitoring. CoNeTTE is a model in AAC, introducing innovations such as an efficient ConvNeXt encoder, which adapts vision-based processing for audio in order to improve accuracy with fewer parameters. Additionally, CoNeTTE's Task Embedding (TE) tokens enhance cross-dataset adaptability by recognizing the source of each audio input, reducing performance gaps between datasets.

2.1.2 Methodology

CoNeTTE adopts an encoder from ConvNeXt, modified for audio, where depthwise separable convolutions and inverted bottleneck blocks efficiently extract high-quality audio features with fewer parameters. Then, the Transformer decoder translates these embeddings into captions, while beam search decoding and stop-word filtering produce fluent, human-readable text. It also adopts Task Embedding tokens to adapt decoder output ac-

cording to specific styles and vocabulary of each dataset, thereby improving adaptability and cross-dataset performance.

For better generalization and smaller dataset biases, data augmentation techniques in CoNeTTE include Mixup, SpecAugment, and label smoothing—all of which enhance robustness and the accuracy of models. It handles dataset biases by balancing the amount of data coming from each dataset per epoch and excluding overlapping files, therefore reducing overfitting and facilitating fair evaluation.

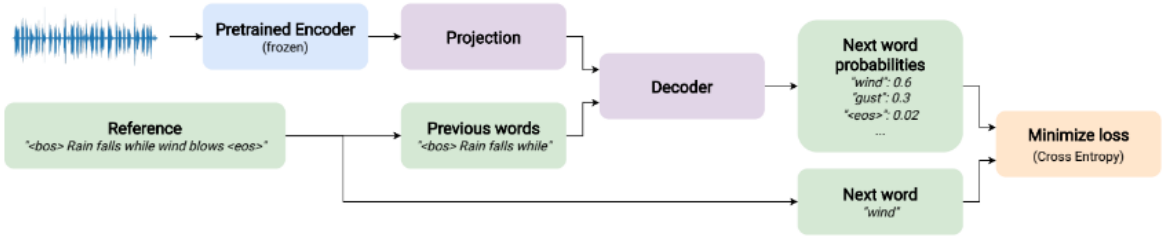


Figure 2.1: Overview of AAC process

2.1.3 Conclusion

CoNeTTE advances AAC by introducing a flexible, efficient encoder-decoder architecture with Task Embeddings that improve cross-dataset performance. The model Achieves high SPIDEr and FENSE scores, showing versatile and state-of-the-art performances on the tasks of the AAC benchmark.

2.2 MANN:Multichannel Attentive Neural Network for Legal Judgment Prediction [2]

2.2.1 Introduction

This paper handles the Legal Judgment Prediction part of Virtual Courtroom where generating the verdict is the final output of the work. MANN is the first framework to address the intricate challenges of Legal Judgment Prediction. Unlike traditional models focused on single aspects like charge prediction, MANN incorporates advanced neural architectures and attention mechanisms to capture the intricate relationships among facts, statutes, and precedents emulating the holistic analysis of human legal experts.

2.2.2 Components

Multichannel Arhitecture

The architecture of MANN includes three channels, i.e., the Fact Channel, Article Channel and Persona Channel. These are interconnected and help in the execution of legal cases. The Fact Channel uses NLP techniques to extract context, key events and features of the case. The Article Channel maps the facts to relevant law articles. The Persona Channel works on the factors, like their demographics, criminal history and circumstances that can provide an elaborate picture of the defendant. The three interconnected channels can enable MANN to make context-sensitive and informed predictions in legal judgment scenarios.

Hierarchical Attention Mechanism

MANN's Hierarchical Attention Mechanism contains three levels of attention: word, sentence, and document, each designed to focus on relevant information in legal texts. It recognizes important legal terms at the word level and assesses the relevance of the word with context. The sentence level emphasizes key facts and inter-sentence relationships, which help to understand complex stories. The document level prioritizes the most important sections and groups related themes, even if they are not presented sequentially. This mechanism fuses information from all these levels into a coherent system, following a bottom-up flow where word-level details inform higher levels and top-down guidance where document context refines lower-level focus. By doing so, MANN can process lengthy legal documents with high accuracy and interpretability to support explainable AI in the legal domain.

2.2.3 Architecture

The MANN framework consists of three main components that together produce accurate legal judgment predictions:

1. **Input Layer**: This layer preprocesses data by converting defendant information (age, criminal history) and case facts into a usable format through tokenization and normalization. It also extracts candidate law articles using keyword matching and NLP techniques to identify relevant legal statutes.

2. **Multichannel Attentive Encoders**: These encoders process input through specialized channels for different data types (e.g., defendant persona, case facts). Each channel uses attention mechanisms to prioritize relevant information and then merges the output to build a cohesive case representation.

3. **Output Predictors**: Based on encoded data, this component predicts likely charges, relevant law articles, and estimated prison terms, using attention-weighted features to ensure accurate legal context in the predictions.

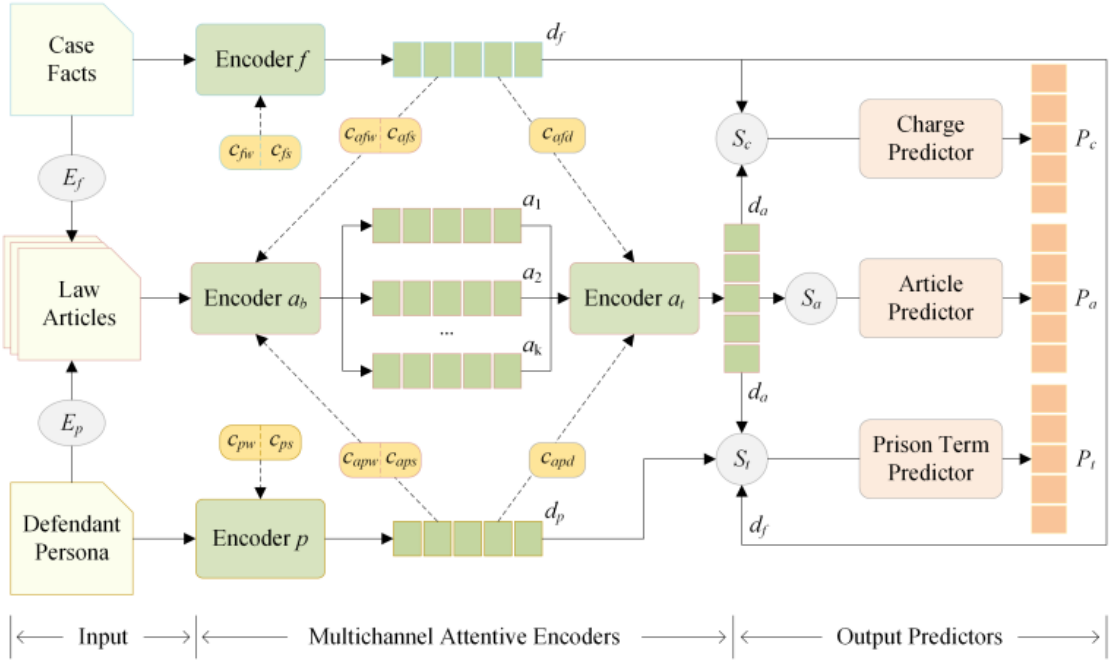


Figure 2.2: Overview of MANN framework

2.2.4 Conclusion

The MANN goes beyond LJP by outperforming traditional models in datasets and improving legal decision making, fairness, and efficiency. Although MANN requires more time and resources in training, practical applications in case predictions and legal research demonstrate its value in the real world. With data-driven approaches becoming increasingly popular in law, MANN offers a transformative framework that is likely to drive further innovations in legal technology.

2.3 KEMCAN:Knowledge Enriched Multi-Cross Attention Network for Legal Judgment Prediction[3]

2.3.1 Introduction

The work shows the model of KEMCAN for predicting the legal judgment, i.e. the law article and legal charge. KEMCAN is an innovative approach to improving the accuracy of legal judgement prediction by integrating knowledge of legal charges into its framework. Traditional LJP models, which are easily puzzled by charges and law articles, especially for similar fact patterns, often result in incorrect predictions. To address this, the model employs a cross-attention mechanism to model relationships between fact descriptions and legal charge definitions, which captures subtle nuances in legal texts. Experimental results on real-world datasets yield significant improvements over existing methods, and thus KEMCAN would be a useful tool for judicial assistance and legal consultation.

2.3.2 Methodology

KEMCAN employs a cross-attention mechanism to integrate fact descriptions of legal cases with legal charge knowledge.

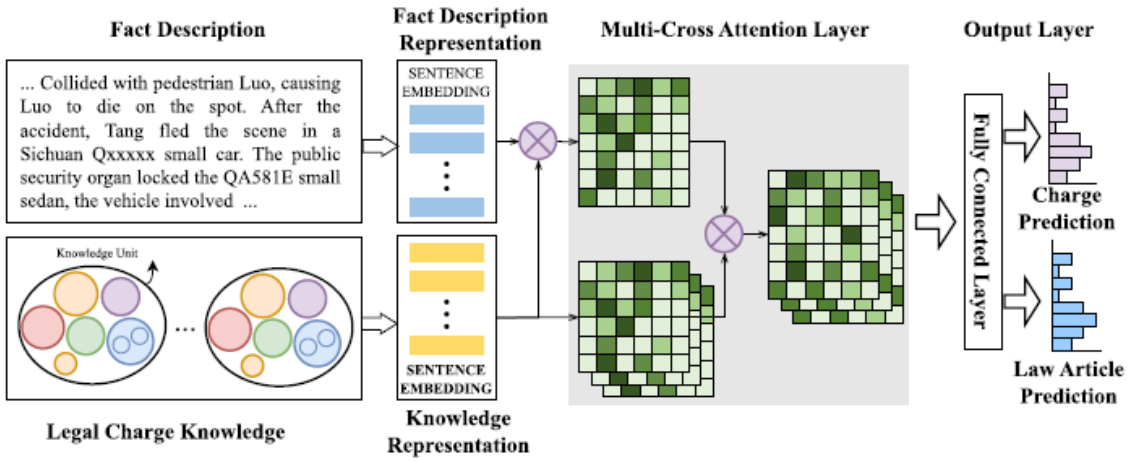


Figure 2.3: Architecture Diagram of KEMCAN

1. **Legal Charge Knowledge Construction**: Data charge knowledge is represented as a six-tuple that captures the key elements, including crime definition, subject

and object of the crime, and legal basis. This knowledge is extracted from reliable legal sources using a web crawler and organized for model use.

2. **Problem Formulation**: The problem is framed as a task of predicting legal charges and law articles given case fact descriptions, where the system needs to map factual descriptions to corresponding relevant legal outcomes.

3. **Fact Description Representation:** The facts are represented in the form of structured data, often in text, which is then prepared in a way that allows the model to understand the legal context by processing it further.

4. **Knowledge Representation:** Charge knowledge is embedded into a vector space, allowing the model to efficiently access the relevant legal context for accurate prediction of charges.

5. **Multi-Cross Attention Layer**: This layer captures the complex relationships between fact descriptions and legal knowledge by attending to both the facts and legal charge elements, improving the model's ability to understand nuances in legal texts.

6. **Output Layer**: The output layer generates predictions for legal charges and law articles based on the processed inputs, leveraging the integrated knowledge to make accurate legal judgments.

2.3.3 Conclusion

KEMCAN represents a significant breakthrough in legal judgment prediction by combining structured legal charge knowledge with case fact descriptions. This would make it better suited for intricate cases where similar facts result in different charges, thus outperforming SVM and Word2Vec and FLA. Cross multi-attention used in KEMCAN aligns case facts with appropriate legal knowledge, capturing important distinctions to yield good judgment prediction results, especially in imbalanced datasets with rare charges. Rigorous testing shows that KEMCAN performs better than its competitors, particularly in Macro-F1 scores, and thus has potential as a very useful tool for judicial systems, thereby setting a new benchmark for context-aware LJP models in legal AI.

2.4 Summary and Gaps Identified

2.4.1 Summary

TITLE	ADVANTAGES	DISADVANTAGES
CoNeTTe	Use of task embedding enables it to adapt to multiple audio captioning datasets	Complexity can lead to higher computational costs.
KEMCAN	Effectively utilizes knowledge graphs to enhance the understanding of legal contexts and relationships, improving prediction accuracy	The complexity of knowledge graphs may require considerable pre-processing and maintenance efforts, which can be resource-intensive.
MANN	Captures multiple aspects of legal documents and relationships, leading to a more nuanced understanding of legal contexts	The model's complexity may lead to over-fitting, especially when trained on smaller datasets without sufficient regularization.

Table 2.1: Summary Table

2.4.2 Gaps Identified

1. CoNeTTE struggles with cross-dataset generalization indicating limited adaptability across diverse data sources.
2. The MANN model cannot handle cases where there is more than one defendant.
3. KEMCAN can only handle Chinese legal cases as it is trained with Chinese law.

2.5 Conclusion

In this chapter, various models used for legal judgment prediction is explored. The relevant projects are identified and studied. CoNeTTe is used for audio-to-text conversion. MANN and KEMCAN are useful in predicting the legal judgment, i.e., the final output. The YOLO model is used for identifying and processing the evidence uploaded during the cross-examination part of the project. The advantages and disadvantages of each model is studied.

Chapter 3

Requirements

3.1 Hardware Requirements

- Processor: Intel Core i5 or higher for fast processing.It ensures smooth execution of ML and NLP tasks.
- RAM: Minimum 16GB provides sufficient memory to handle large datasets and model loading during runtime.
- SSD : 512GB of storage enables fast data access and efficient storage of heavy files.
- Operating System: Windows 11 offers compatibility for latest development tools.
- GPU :NVIDIA RTX 3050 or higher to speed up image and audio processing tasks.

3.2 Software Requirements

- Frameworks:Flutter(3.1 or higher) ,Flask (3.0 or higher).
- Database: PostgreSQL
- IDE: Visual Studio Code
- Petition handling : PaddleOCR
- Speech to text and speaker identification : Whisper,PyAnnote
- Transcript Summarisation : T5 model (text to text transfer transformer)
- Innocence Checker :custom made Binary Classification model
- Verdict Generation : SBERT, FAISS

Chapter 4

System Architecture

4.1 System Overview

This chapter discusses the architectural design of the Virtual Courtroom platform. The platform follows a modular architecture utilizing various technologies to to support legal proceedings. The system has four main modules : Slot Booking, Petition, Cross Examination and Legal Judgment Prediction module that ensures a logical workflow. By adopting a modular approach, the design enhances clarity and scalability, allowing each part of the platform to function independently while contributing to the overall objective. These modules are interconnected to manage the core functions of a courtroom altogether.

4.2 Module Division

Virtual Courtroom platform has 4 main modules that ensure a smooth and efficient court proceeding.

1. **Slot Booking Module**

   The slot booking module makes the process of scheduling court proceedings much easier and efficient. A traditional courtroom's process of scheduling cases can be time-consuming. This virtual procedure avoids such delays. The prosecutor first selects a few time slots for a day and shares them with the defendant via mail. The defendant then picks a slot that works for them. This module ensures that both lawyers agree on a time for the court proceeding ensuring a smooth process.

2. **Petition Module**

   The Petition Module is where the first input is given. The prosecutor uploads the petition document that usually contains the charges and case details. To make the document readable by our system, PaddleOCR is used to automatically extract the

text content. The extracted text is stored and viewed later on by the judge. The main goal of this module is to digitize the petition information so it can be analyzed and referenced easily.

3. **Cross Examination Module**

   The Cross Examination Module is the interactive part of the virtual courtroom. In this module, the lawyers, witness and judge gets to speak during the cross examination phase enabling a court hearing in the virtual form. The recorded audio is taken as an input to generate the transcript and later on for the draft verdict.It supports audio-to-text features to make the input process more flexible.

4. **Legal Judgment Prediction Module**

   This module is the intelligent layer of the system that processes the inputs to give a final draft verdict. The inputs like petition and transcript of the court hearing is analyzed using NLP and ML models to create a draft verdict that mentions the charges and punishments related to the case. This module acts as a decision-making support system as it assists the judge in finalizing on a verdict by speeding up the analysis.

4.3 Module-Block Diagrams

4.3.1 Slot Booking Module

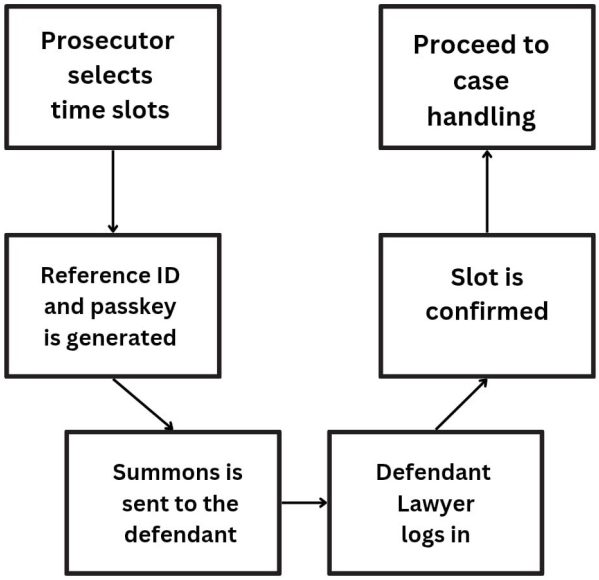


Figure 4.1: Slot Booking Module

4.3.2 Petition Module

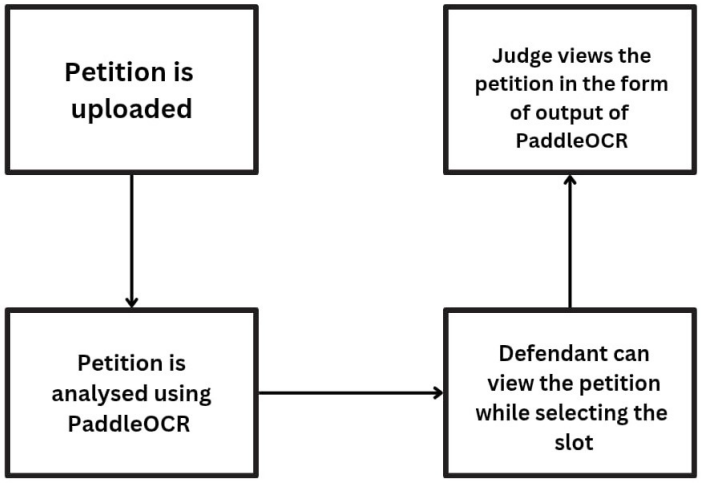


Figure 4.2: Petition Module

4.3.3 Cross Examination Module

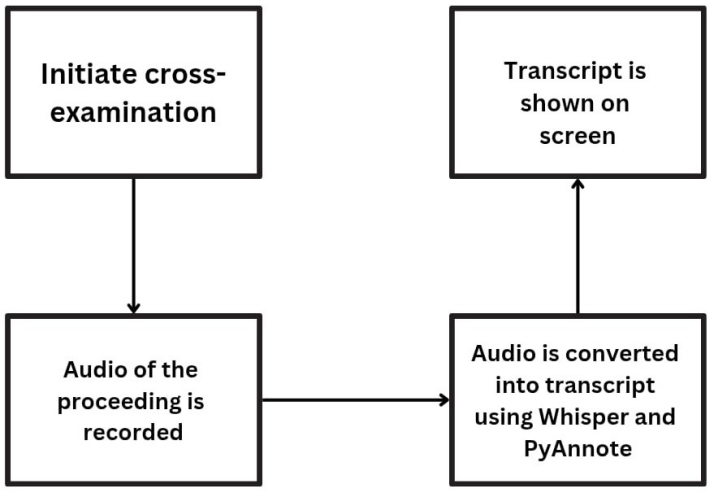


Figure 4.3: Cross Examination Module

4.3.4 Legal Judgment Prediction Module

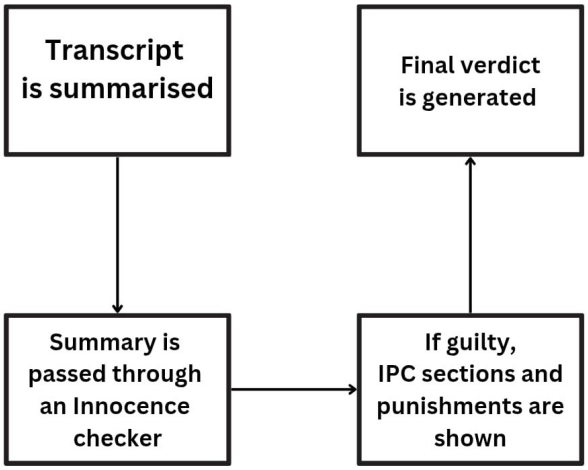


Figure 4.4: Judgment Prediction Module

4.4 Architecture Design

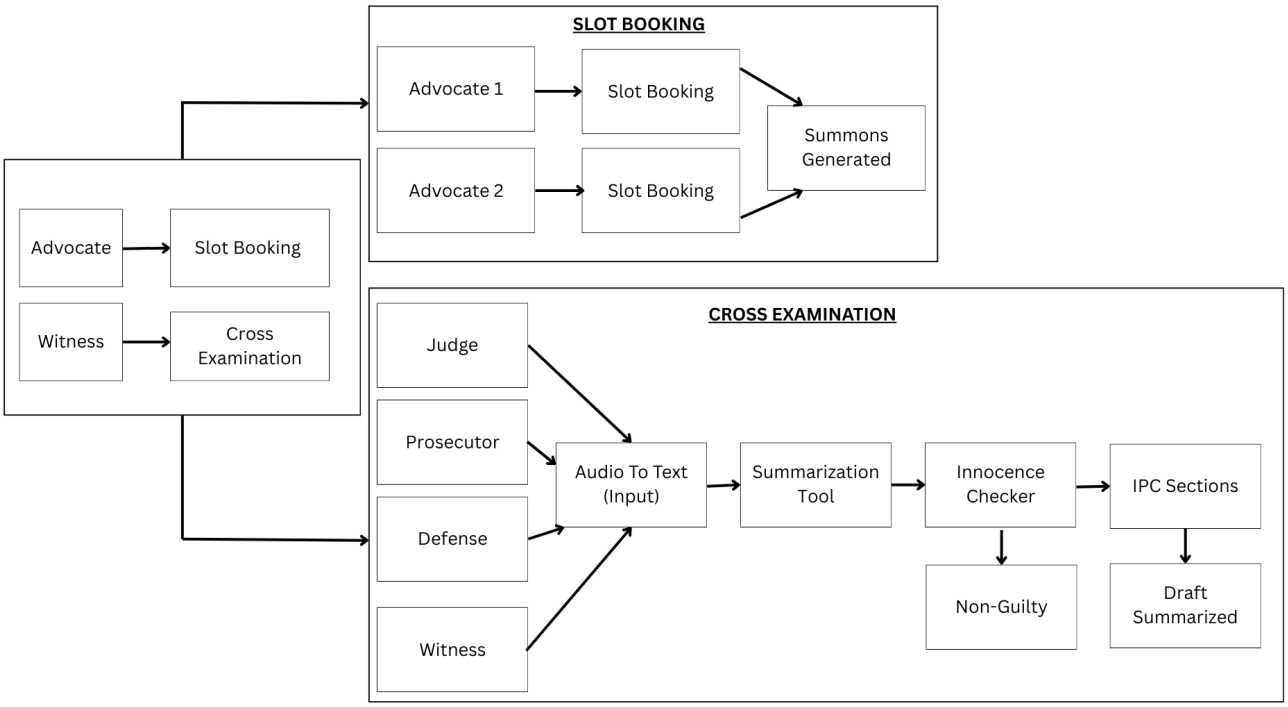


Figure 4.5: Architecture Diagram

4.5 Workflow - Gantt Chart

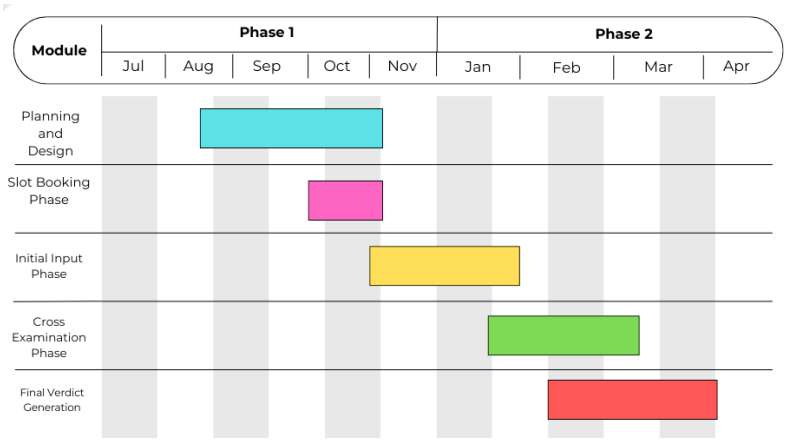


Figure 4.6: Gantt Chart

Chapter 5

System Implementation

The implementation of the Virtual Courtroom involves the integration of several technologies to ensure a seamless and automated judicial process.The system is built with Flutter for the front-end, Flask as the back-end and PostgreSQL for database management.All modules were built independently but integrated to ensure scalability and modularity. ML models are intergrated to provide key functionalities like petition text extraction using PaddleOCR, speaker identification and transcription using Whisper and PyAnnote.We also use a T5 model for transcript summarization and a binary classification model was custom made to find out whether the accused is guilty or innocent.The system also integrates Google Drive API for document retrieval and SMTP for sending mails. This chapter details the step-by-step implementation of each module, including the technologies to ensure an efficient virtual courtroom platform.

5.1 Proposed Methodology

The Virtual Courtroom System is designed to be a structured, multi-model platform that automates various processes to ensure a smooth and transparent legal proceeding. The use of ML and NLP technologies enhances the functionality of the platform.The proposed methodology is as follows:

1. User Authentication and Role-Based Access

   The main users of this platform are prosecutor, defense lawyer and Judge. They all login through a Flutter based frontend. Authentication is managed through Flask ensuring secure access to case details [4]. Role based access control determines the functionalities available to each user.

2. Slot Booking and Petition Submission

   Prosecutor creates a case by entering the case name and defendant's mail ID. Prosecutor generates a Reference ID and password and selects multiple time slots.Prosecutor uploads the petition. Defense lawyer is notified via mail. Defense lawyer logs in using the credentials sent via mail and selects an available time slot already approved by Judge and opted by prosecutor. Defense lawyer gets to access the petition. Petition is uploaded via Google Drive API and PaddleOCR processes the petition to extract text from it [5]. The case details and time slots are stored in PostgreSQL.

3. Cross Examination Phase

   The judge logs in and views the scheduled cases for the day and their corresponding time slots. Judge reviews the petition processed through PaddleOCR before starting the examination. PyAnnote and Whisper handles speaker identification and speech-to-text transcription of the court session [6][7]. The generated transcript is used as the input for the next step.

4. Judgment Prediction and Verdict Generation

   The transcript is summarized using a fine-tuned T5 model to extract just the key details [8]. The summarized text is passed on as the input for a binary classification model[9] to determine whether the accused is guilty or innocent. If the accused is found guilty , then the IPC sections and punishments related to the crime are shown. The case details are also shown. A final verdict stating whether the accused is guilty or innocent is drafted along with details that found them guilty or not guilty.

5.2 Implementation Strategy

The implementation of Virtual Courtroom is done in a modular and scalable manner. The platform has 4 main modules : Slot Booking, Petition, Cross Examination and Legal Judgment Prediction Module. By integrating several technologies, this platform ensures a streamlined legal proceeding. The implementation is detailed below:

5.2.1 Slot Booking Module

The Slot Booking Module is an important feature that simplifies the scheduling of legal proceedings. It allows the prosecutor to select an available time slot for a case through an intuitive user interface. Once a slot is chosen, the system processes the request and generates a unique Reference ID and Passkey. This ensures a secure access. These credentials are sent to the defendant's lawyer. The defendant's lawyer can then log in using the provided credentials to confirm the slot. Upon mutual acknowledgment by both parties, the system confirms the booking, sending notifications to all involved. This module eliminates manual scheduling inefficiencies, ensuring that all parties are informed and the proceedings can begin at the scheduled time. It also integrates with the database to maintain accurate records of slots and user access information.

5.2.2 Petition Module

The Petition Module handles the initial input stage, where prosecutor upload legal petitions containing crucial information, such as the details of the accused, the petitioner and the crime scenario. This module uses PaddleOCR (a Python based OCR tool) to scan and extract textual data from uploaded documents, converting unstructured content into a structured fact sheet. It processes the extracted data and stores it as a text file. By automating the document processing step, it reduces the dependency on manual review and ensures a more accurate understanding of the case.

5.2.3 Cross Examination Module

The cross-examination module enacts a courtroom proceeding by allowing the judge, prosecutor, defense and witness to participate in an interactive session. This module allows interactive court session and transcript generation.

Court Proceeding and Audio-to-Text

The judge gets to review the petition once they log in. The petition is the text file generated by PaddleOCR that was stored earlier after processing of the petition. A 'Start Transcription' button is available, clicking of which starts the cross-examination session.Participants including the judge, prosecutor , defense advocate and witness are

required to identify themselves when they first speak. This helps in identifying the voice and better processing of the audio. After the proceeding is over, they have to click the 'Stop Transcription' button after which the audio is processed and transcript is created. The audio file is stored as a .wav file. PyAnnote from HuggingFace is loaded for speaker identification and assigning speaker labels. The transcription process is then handled by Whisper from OpenAI.The timestamps provided by the Whisper model helps in mapping the transcription to the speaker segment identified by PyAnnote [10]. The combined use of PyAnnote and Whisper ensures a precise, structured transcript. This transcript is passed on as the input of the Legal Judgment Prediction module.

5.2.4 Legal Judgment Prediction Module

The Legal Judgment Prediction (LJP) is responsible for analyzing the transcript of the courtroom proceedings and predicting the final verdict. This module takes the court transcript as input and uses NLP methods to summarize and classify the case outcome to generate the final verdict.

Summarization of Court Proceedings

The court transcript is the first input for this module. Since the raw transcripts are lengthy and unstructured, they are summarized by a fine-tuned T5 model. The T5 (text-to-text Transfer Transformer) is a powerful NLP model developed by Google that can convert input text to a specified output format making it ideal for summarization tasks[11]. The model was trained on a dataset of court transcripts and their summaries to effectively extract key details from the court proceedings. The summary of the transcript is stored locally and serves as the next input.

Innocence Checker

A binary classification model is used to decide whether the accused in the case is guilty or not guilty. The model was trained on a dataset that had two columns: case summaries and their corresponding verdicts (not guilty or guilty). The model classifies the accused as either guilty or not guilty based on the summary. If the accused is proved innocent then the verdict is directly generated but if the accused is found guilty then more data is

retrieved.

Verdict Generation

The platform generates a structured verdict regardless of the prediction of guilt. If not guilty, the verdict says the accused was found innocent but if they are found guilty, the IPC sections, punishments related to the crime and the case description is generated.The model that generates this information is SBERT using vector database.SBERT is a variation of the model BERT (Bi-directional Encoder Representation) that has contextual understanding [12]. The vector database for training SBERT was created using FAISS(Facebook AI Similarity Search).FAISS is a library developed by Meta, it uses nearest neighbour search and vector indexing methods for various applications[13]. The final verdict is formed using the information provided by SBERT. Automating the verdict generation enhances the decision making efficienct and ensures consistency in the verdict. It also eliminates human bias from legal proceedings.

5.3 Conclusion

The system implementation of the Virtual Courtroom explains the integration of various technologies to streamline the judicial process. By using Flutter for the front end, Flask for the back end and PostgreSQL for database management, the platform enables a seamless and efficient user experience. PaddleOCR is used for document processing and ML models like SBERT enhances the efficiency of LJP, while the secure authentication process protects case data. This chapter details the step-by-step implementation of the main modules ie, the slot booking, petition , cross examination and legal judgment prediction modules and demonstrate how each module contributes to the system's functionality.

Chapter 6

Results and Discussions

6.1 Results

The virtual Courtroom was implemented successfully and tested for various criminal cases. The system efficiently integrates machine learning and natural language processing technologies to automate different phases of the court proceeding. The following results were observed for each phase:

1. Slot Booking and Petition Phase

   The prosecutor was able to create cases, generate unique Reference IDs and passwords, and schedule time slots.The prosecutor was able to upload petition. The defendant could view the petition and select an available time slot for the court hearing.The petition document was successfully extracted using PaddleOCR.SMTP worked as expected making email transfers successful.

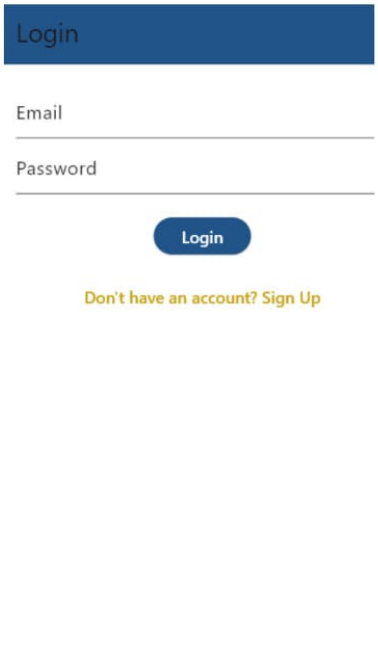
2. Cross Examination Phase

   The judge could view scheduled cases for the day and their corresponding time slots. The speech to text conversion using PyAnnote and Whisper was accurate in transcribing the court hearing, correctly identifying the speakers.

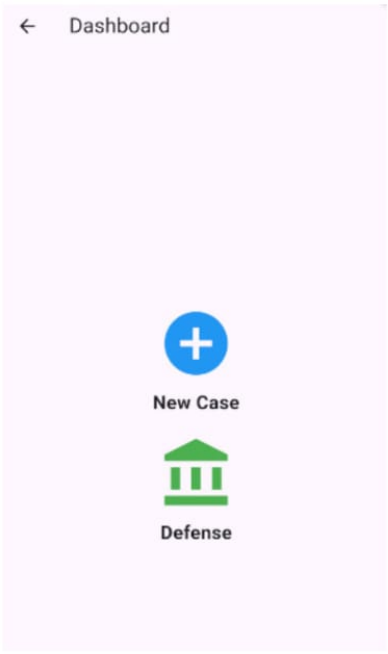
3. Legal Judgment Prediction Phase

   The T5 model based summarization of the transcript was effectively produced.The summary served as an input for the binary classification model categorizing the defendant as guilty or not guilty. For guilty defendants, IPC sections and related punishments were shown. The platform generated a structured verdict declaring the accused guilty or innocent.

6.2 Output Screenshots

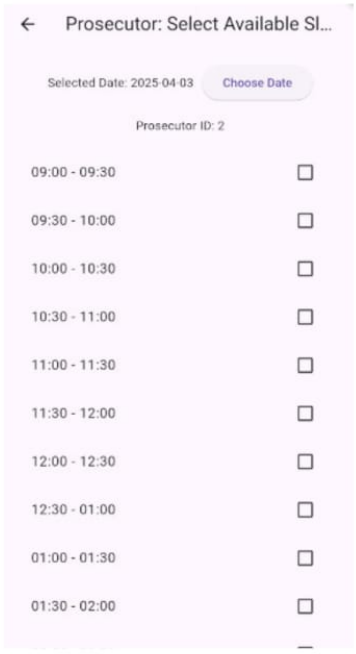


1. Login Page

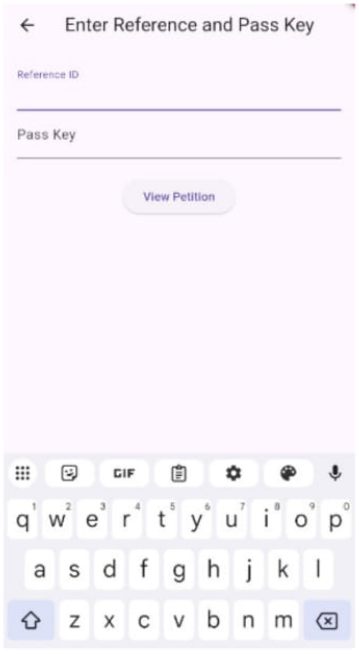


2.Prosecution/ Defense

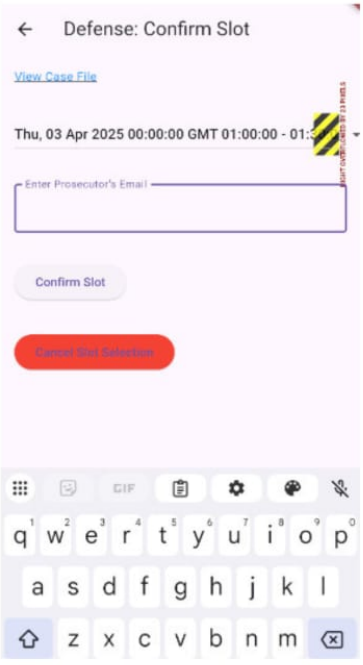
3.Creating New Case



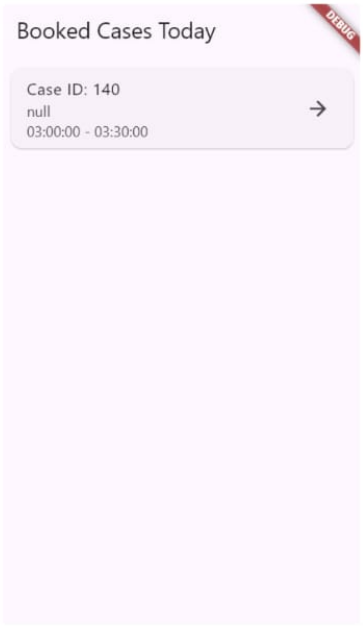
4.Prosecution Slot Booking



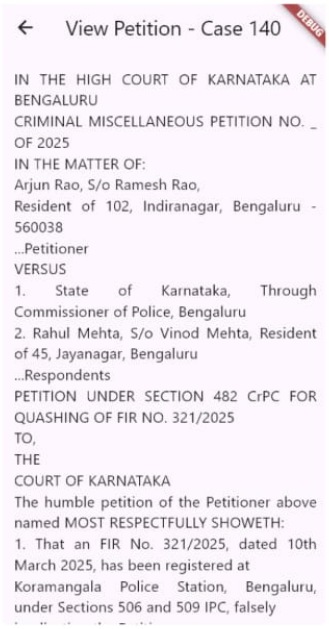
5.Defense UI



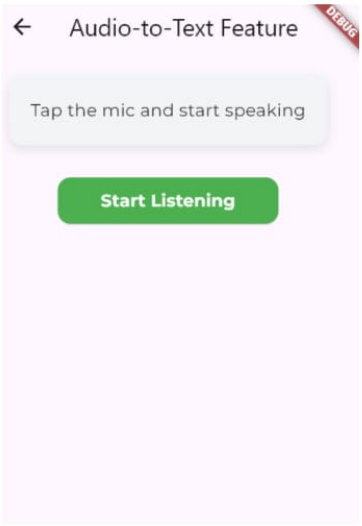
6.Defense views petition and confirms slot



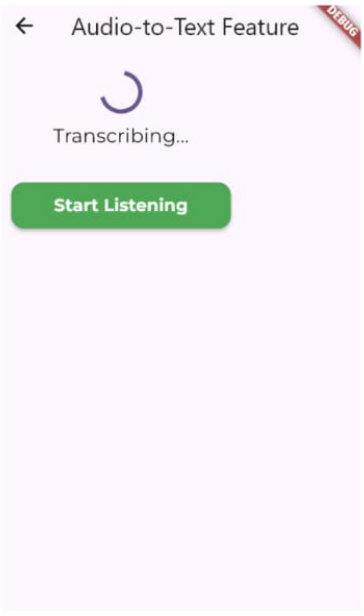
7.Judge views cases for the day



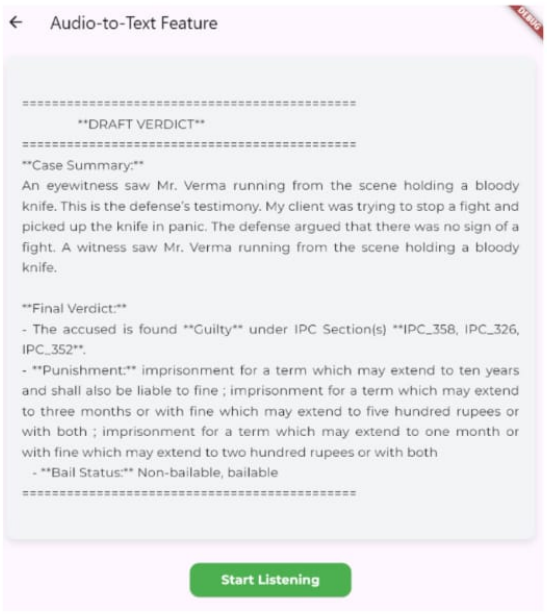
8.Judge views petition



9.Cross Examination starts



10. Generating Transcript



11. Draft Verdict Generated

Chapter 7

Conclusion

The Virtual Courtroom is a novel initiative that reduces inefficiencies in the legal system by utilizing modern technologies like Machine Learning and Natural Language Processing. Slot booking, petition processing, cross examination, and judgment prediction are all crucial aspects of case processes that can be automated to reduce delays. NLP model helps in analyzing petition. Interactions between all parties are ensured by an efficient interface. The desired outcome of the project will be obtained by enabling participation, providing transcriptions, and deliver AI-driven draft verdicts. This reduces any chances of human errors and provides a more effective and efficient way of carrying on the legal procedures. The Virtual Courtroom has scope for future enhancements by including other classifications of cases like constitutional, family etc, and improve its ability to handle complex cases.

In conclusion, this project represents automation of court proceedings using advanced technologies.It addresses the challenges of case backlogs, human error and procedural inefficiencies. The prroject speeds the trial and automates court proceedings.

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Appendix A: Presentation

Virtual Courtroom

Project Presentation

Project Guide
Dr. Tripti C
Associate Professor
DCS, RSET

Team Members
Riya Salim (U2103177)
Rohan Chandy Mathews (U2103178)
Nanditha Jinesh (U2103149)
Nayan A Menon (U2103150)

Contents

Problem Definition

The current legal system faces several challenges, including case posting,lack of automation causing procedural delays,document review delays.

Purpose and need

The purpose of this project is to create a virtual courtroom platform to automate various aspects of the legal process, improving efficiency and the overall quality of court proceedings.

Key Needs Addressed by the Virtual Courtroom:

1. Faster Legal Proceedings
2. Efficient Cross-Examination
3. Reducing Human Error
4. Cost and Resource Efficiency

Objective

The objective of this project is to create a Virtual Courtroom Platform that automates and streamlines legal proceedings using AI and machine learning. The main goals are:

1. Automate Document Processing: Use NLP to analyze petitions.
2. Speech-to-Text: Convert statements to text using pre-trained models.
3. Automate Cross-Examination: Facilitate structured argument presentation
4. Generate Automated Verdicts: Automate decision-making based on speech to text.

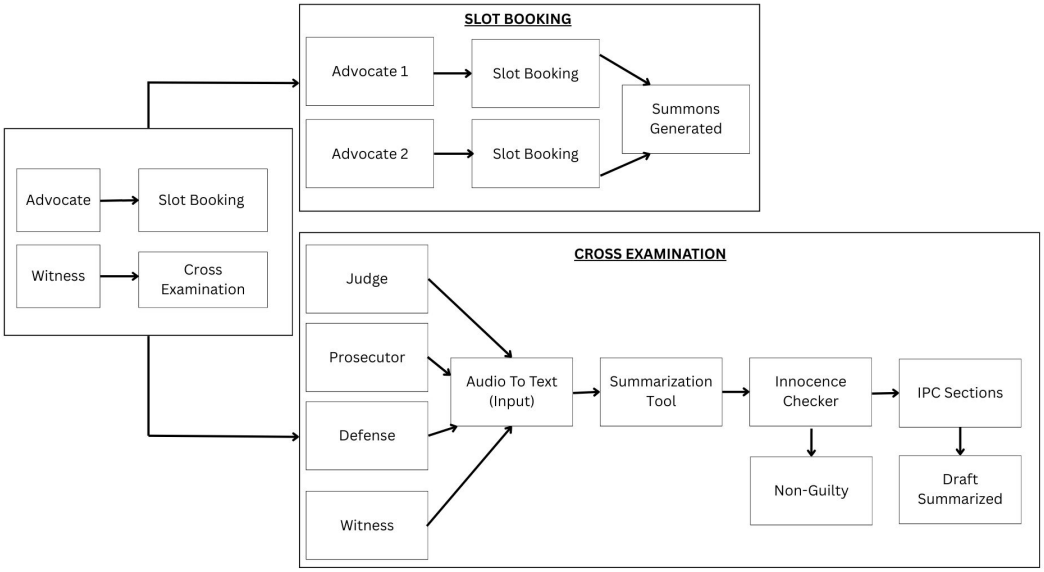
Literature Survey

Paper	Advantage	Disadvantage	Usage
S. Li, H. Zhang, L. Ye, X. Guo and B. Fang, "MANN: A Multichannel Attentive Neural Network for Legal Judgment Prediction",2019	Has multiple input channels.	Cannot handle cases where there is more than one defendant	Verdict Generation
C. He, T. -P. Tan, X. Zhang and S. Xue, "Knowledge-Enriched Multi-Cross Attention Network for Legal Judgment Prediction",2023	Incorporates charge knowledge and fact sheet to as input.	Relies heavily on quality and quantity of legal data to construct legal charge knowledge.	Verdict Generation

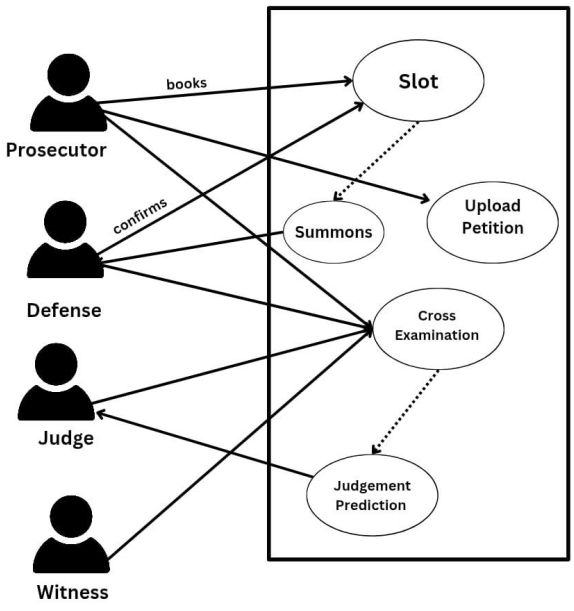
Literature Survey

Paper	Advantage	Disadvantage	Usage
É. Labbé, T. Pellegrini and J. Pinquier, "CoNeTTE: An Efficient Audio Captioning System Leveraging Multiple Datasets With Task Embedding",2023	Improves the cross-dataset performance	Requires careful balancing of the training data.	Audio to Text phase

Architecture Diagram



Use Case Diagram



Methodology

1. Slot Booking Phase

- **Database Management**:
  - Use PostgreSQL to store information regarding available slots, user credentials, and case details.
- **Backend Development**:
  - Implement a Flask backend that handles API requests related to slot bookings.
  - The prosecution will book a slot, which is then stored in the SQL database.
  - Notify the advocate through the defendant with a unique reference ID and passkey for login.

Methodology

2. Initial Input Phase

- **Document Scanning**:
  - Utilize **PaddleOCR** to scan and extract text from court petition.

3. Cross-Examination Phase

- **Audio Transcription**:
  - Employ **Whisper along with PyAnnote for speaker diarization** for conversion of spoken testimony into text.
  - The output will be accurate transcriptions of the proceedings, which will be stored for analysis.

Methodology

- **Text Analysis**:
  - Implement a T5 model to summarize the transcript.
  - The summary is then passed on for further analysis.

4. Judgment Drafting Phase

- **Innocence Checker**:
  - The summary is passed on to classify the accused as guilty or not guilty.
  - If proven guilty, the IPC (Indian Penal Code) sections related to the crime is shown.
  - A verdict is drafted based on the basis of innocence.

Methodology

5. Final Verdict Generation Phase

- **Output Presentation**:
  - The drafted verdict will be formatted and presented to the judge through the Flutter frontend.
  - This phase ensures that the final decision is accessible for review and approval, maintaining transparency and clarity in the legal process.

Modules

1.Slot Booking

2.Petition

3.Cross Examination

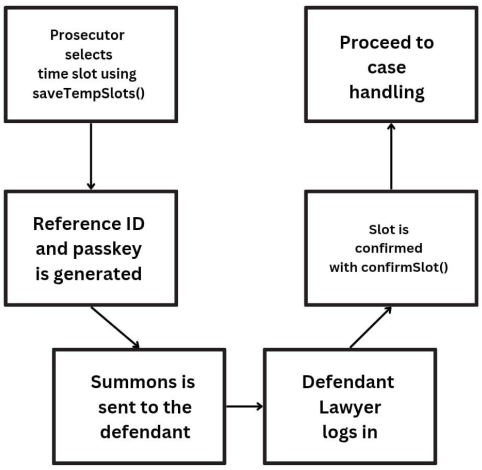
4.Legal Judgement Prediction

Slot Booking

The Slot Booking Module is a crucial part of the virtual courtroom platform, allowing advocates to schedule case proceedings efficiently.The steps involved are:

1. The prosecutor logs in to the platform and enters the case name and the defendant's mail ID.
2. A reference ID and password is generated.
3. The prosecutor selects multiple time slots for a day.
4. An email is containing the credentials are sent to the defendant.
5. The defendant logs into the platform using the credentials and selects a slot.
6. A confirmation mail with the slot for case hearing is sent to the prosecutor.

Slot Booking-Block Diagram

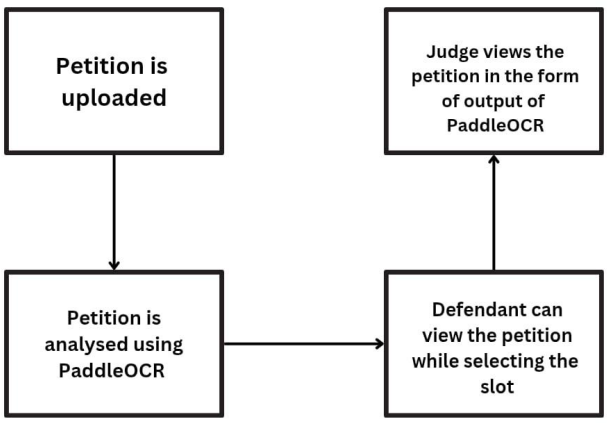


Petition

Petition acts as the first input. The steps involved in the petition module are:

1. The petition is uploaded by the prosecutor while booking the slot.
2. The petition is analysed using PaddleOCR.
3. The defendant gets to view the petition when they select a slot.
4. The judge gets to view the petition in the form of a text file (output of PaddleOCR) as they log in.

Petition-Block Diagram

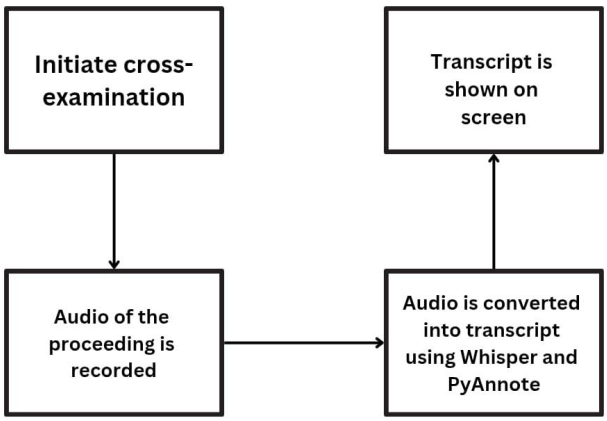


Cross Examination

Cross examination module is the equivalent of court hearing.The steps involved are as follows:

1. The judge logs in to the platform. Cross examination takes place in his account.
2. They are redirected to a page where they start the cross examination. They start speaking and the audio is recorded.
3. The recorded audio is analysed using Whisper and PyAnnote to identify the voices and create the transcript accordingly.
4. The transcript is shown on the screen.

Cross Examination-Block Diagram

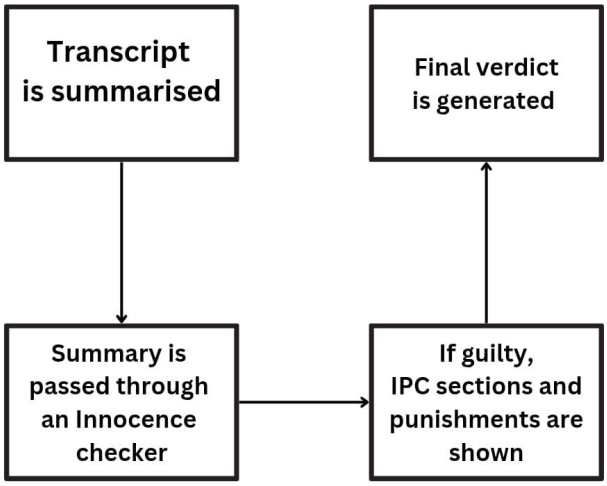


Legal Judgement Prediction

This is the final module of the project which handles the verdict generation. The steps in this module are as follows:

1. The transcript is summarised using a T5 model.
2. The summary is passed onto a binary classification model to check whether the accused is guilty or not.
3. If proven guilty, the IPC sections, punishments and case details are shown.
4. A final verdict is generated regardless of the innocence checker output (binary classification model).

Legal Judgement Prediction - Block Diagram



Assumptions

- The system will have distinct user roles: defendant's lawyer, prosecutor and witnesses, each with different permissions and access rights.
- The uploaded documents will be in standard formats such as PDF or DOCX.
- Cross examination will take place in audio mode will be interpreted precisely given a noiseless environment.
- Model only understands English language.
- All participants are present in the same location.
- The ML model will predict legal charges and law articles based on the provided document and cross examination. It assumes the data input is comprehensive and relevant.
- Judge is available at the booked slots.

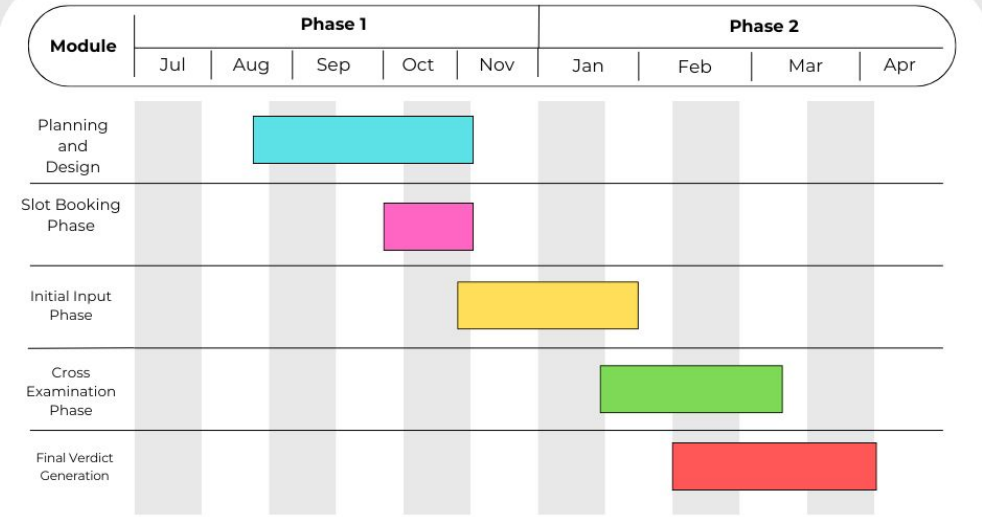
Work Breakdown and Responsibilities

1. Nanditha Jinesh Slot Booking/Petition Module/Judgement Prediction	***2. Riya Salim*** Slot Booking/Cross Examination/Judgement Prediction
3. Nayan A Menon Slot booking/Petition Module/Judgement Prediction	***4. Rohan Chandy Mathews*** Slot Booking/Cross Examination /Petition Module

Requirements

Software	Hardware
FrontEnd: Flutter **Backend:**Flask **Database**: PostgreSQL **NLP Models**:PaddleOCR, SBERT,T5,Whisper **Developing Environment** : VSC, Google Colab	● 16GB RAM minimum ● GPU - NVIDIA GTX 1660 or higher ● Windows 11

Gantt Chart



Risk and Challenges

Risks

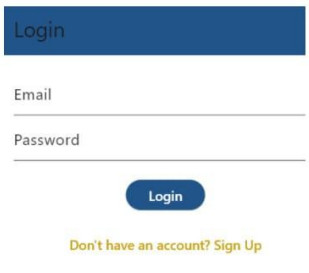
Misjudgment by AI can be caused due to limitation in training data or complex cases.

Poor audio quality during cross-examination can lead to errors in speech recognition.

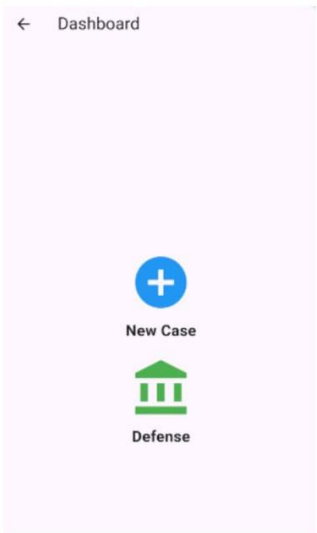
Challenges

Network connectivity issues can lead to inefficient processing.

Results



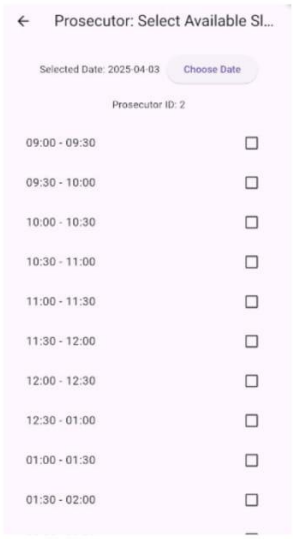
1. Login Page



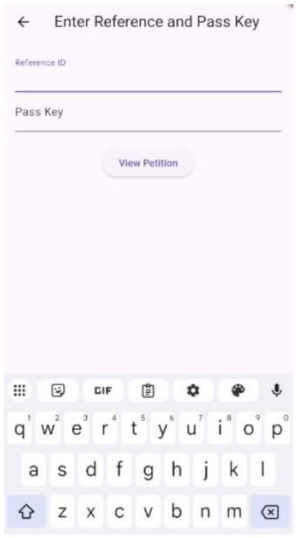
2.Prosecution/ Defense

3.Creating New Case

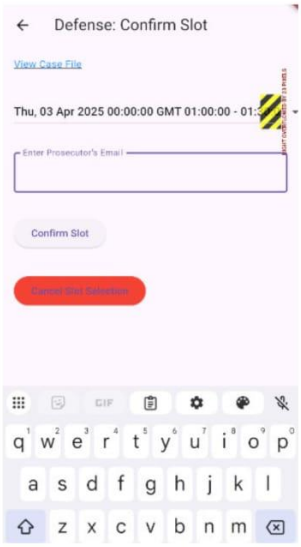
Results



4.Prosecution Slot Booking

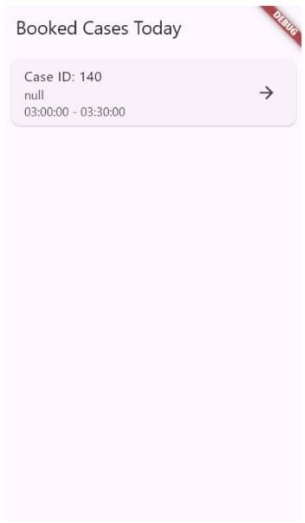


5.Defense UI

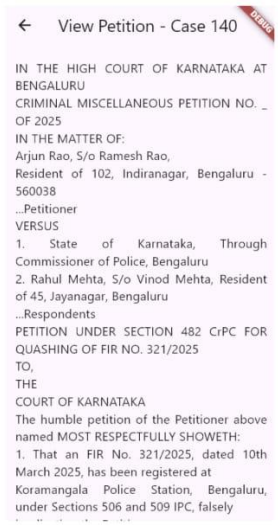


6.Defense views petition and confirms slot

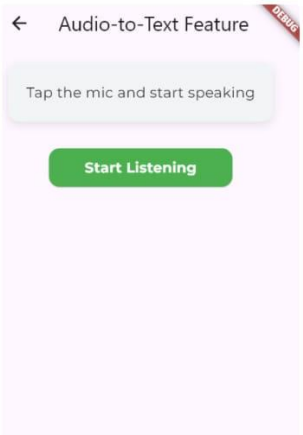
Results



7.Judge views cases for the day

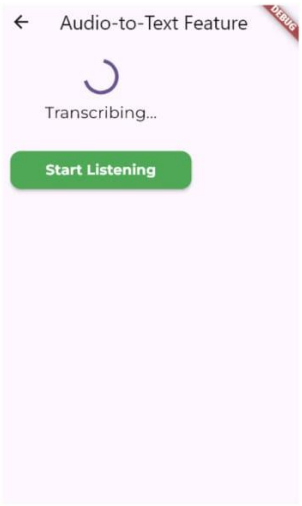


8.Judge views petition

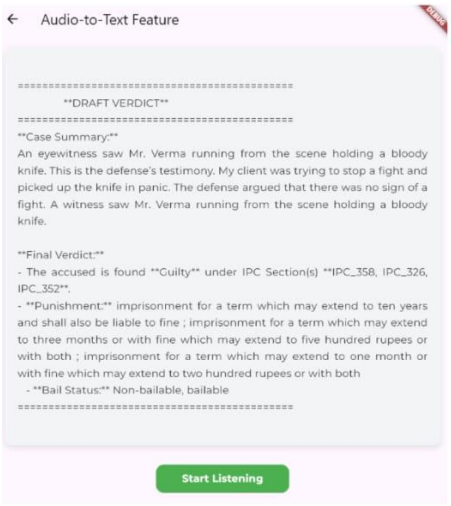


9.Cross Examination starts

Results



10. Generating Transcript



11. Draft Verdict Generated

Future Scope

- **Ensure credibility of inputs**:Since the platform relies on the inputs without checking their authenticity, it can cause lead to inability to predict fair justice.
- **Expanding to other classifications of cases:** Focusing solely on criminal cases restricts the system's versatility, as it won't be applicable to other types of legal disputes, reducing its broader impact on the judicial system.

Conclusion

The Virtual Courtroom Project aims to revolutionize legal proceedings by leveraging advanced technologies to enhance efficiency. By integrating machine learning models and a user-friendly interface, the system facilitates streamlined interactions among advocates, defendants, and witnesses, ultimately contributing to a more effective and transparent justice system.

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Thank You

Appendix B: Vision, Mission, Programme Outcomes and Course Outcomes

Vision, Mission, Programme Outcomes and Course Outcomes

Institute Vision

To evolve into a premier technological institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

Institute Mission

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

Department Vision

To become a centre of excellence in Computer Science and Engineering, moulding professionals catering to the research and professional needs of national and international organizations.

Department Mission

To inspire and nurture students, with up-to-date knowledge in Computer Science and Engineering, ethics, team spirit, leadership abilities, innovation and creativity to come out with solutions meeting societal needs.

Programme Outcomes (PO)

Engineering Graduates will be able to:

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSO)

A graduate of the Computer Science and Engineering Program will demonstrate:

PSO1: Computer Science Specific Skills
The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science and thereby engage in national grand challenges.

PSO2: Programming and Software Development Skills
The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry.

PSO3: Professional Skills
The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur.

Course Outcomes (CO)

After the completion of the course the student will be able to:

Course Outcome 1: Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: Apply).

Course Outcome 2: Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: Apply).

Course Outcome 3: Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: Apply).

Course Outcome 4: Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: Apply).

Course Outcome 5: Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: Analyze).

Course Outcome 6: Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: Apply).

Appendix C: CO-PO-PSO Mapping

COURSE OUTCOMES:

After completion of the course, the student will be able to:

SL.NO	DESCRIPTION	Bloom's Taxonomy Level
CO1	Model and solve real-world problems by applying knowledge across domains (Cognitive knowledge level:Apply).	Level3: Apply
CO2	Develop products, processes, or technologies for sustainable and socially relevant applications. (Cognitive knowledge level:Apply).	Level 3: Apply
CO3	Function effectively as an individual and as a leader in diverse teams and comprehend and execute designated tasks. (Cognitive knowledge level:Apply).	Level 3: Apply
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level:Apply).	Level 3: Apply
CO5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level:Analyze).	Level 4: Analyze
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level:Apply).	Level 3: Apply

CO-PO AND CO-PSO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3												2	
CO2		2	3										2		3
CO3			3		3									3	3
CO4					3				2	2					2
CO5	2			3			2						2	2	
CO6	2	2	2		3					2	2	2	3	2	3

3/2/1: high/medium/low

JUSTIFICATIONS FOR CO-PO MAPPING

Mapping	Level	Justification
101003/CS822U.1-PO1	M	Knowledge in the area of technology for project development using various tools results in better modeling.
101003/CS822U.1-PO2	M	Knowledge acquired in the selected area of project development can be used to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions.
101003/CS822U.1-PO3	M	Can use the acquired knowledge in designing solutions to complex problems.
101003/CS822U.1-PO4	M	Can use the acquired knowledge in designing solutions to complex problems.
101003/CS822U.1-PO5	H	Students are able to interpret, improve, and redefine technical aspects for design of experiments, analysis, and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS822U.1-PO6	M	Students are able to interpret, improve, and redefine technical aspects by applying contextual knowledge to assess societal, health, and consequential responsibilities relevant to professional engineering practices.
101003/CS822U.1-PO7	M	Project development based on societal and environmental context solution identification is the need for sustainable development.
101003/CS822U.1-PO8	L	Project development should be based on professional ethics and responsibilities.
101003/CS822U.1-PO9	L	Project development using a systematic approach based on well-defined principles will result in teamwork.
101003/CS822U.1-PO10	M	Project brings technological changes in society.
101003/CS822U.1-PO11	H	Acquiring knowledge for project development gathers skills in design, analysis, development, and implementation of algorithms.

101003/CS822U.1-PO12	H	Knowledge for project development contributes engineering skills in computing and information gatherings.
101003/CS822U.2-PO1	H	Knowledge acquired for project development will also include systematic planning, developing, testing, and implementation in computer science solutions in various domains.
101003/CS822U.2-PO2	H	Project design and development using a systematic approach brings knowledge in mathematics and engineering fundamentals.
101003/CS822U.2-PO3	H	Identifying, formulating, and analyzing the project results in a systematic approach.
101003/CS822U.2-PO5	H	Systematic approach is the tip for solving complex problems in various domains.
101003/CS822U.2-PO6	H	Systematic approach in the technical and design aspects provides valid conclusions.
101003/CS822U.2-PO7	H	Systematic approach in the technical and design aspects demonstrates the knowledge of sustainable development.
101003/CS822U.2-PO8	M	Identification and justification of technical aspects of project development demonstrates the need for sustainable development.
101003/CS822U.2-PO9	H	Apply professional ethics and responsibilities in engineering practice of development.
101003/CS822U.2-PO11	H	Systematic approach also includes effective reporting and documentation, which gives clear instructions.
101003/CS822U.2-PO12	M	Project development using a systematic approach based on well-defined principles will result in better teamwork.
101003/CS822U.3-PO9	H	Project development as a team brings the ability to engage in independent and lifelong learning.

101003/CS822U.3-PO10	H	Identification, formulation, and justification in technical aspects will be based on acquiring skills in design and development of algorithms.
101003/CS822U.3-PO11	H	Identification, formulation, and justification in technical aspects provides the betterment of life in various domains.
101003/CS822U.3-PO12	H	Students are able to interpret, improve, and redefine technical aspects with mathematics, science, and engineering fundamentals for the solutions of complex problems.
101003/CS822U.4-PO5	H	Students are able to interpret, improve, and redefine technical aspects with identification, formulation, and analysis of complex problems.
101003/CS822U.4-PO8	H	Students are able to interpret, improve, and redefine technical aspects to meet the specified needs with appropriate consideration for public health and safety, and the cultural, societal, and environmental considerations.
101003/CS822U.4-PO9	H	Students are able to interpret, improve, and redefine technical aspects for design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS822U.4-PO10	H	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools for better products.
101003/CS822U.4-PO11	M	Students are able to interpret, improve, and redefine technical aspects by applying contextual knowledge to assess societal, health, and consequential responsibilities relevant to professional engineering practices.
101003/CS822U.4-PO12	H	Students are able to interpret, improve, and redefine technical aspects for demonstrating the knowledge of, and need for sustainable development.

101003/CS822U.5-PO1	H	Students are able to interpret, improve, and redefine technical aspects, apply ethical principles, and commit to professional ethics and responsibilities and norms of the engineering practice.
101003/CS822U.5-PO2	M	Students are able to interpret, improve, and redefine technical aspects, communicate effectively on complex engineering activities with the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
101003/CS822U.5-PO3	H	Students are able to interpret, improve, and redefine technical aspects to demonstrate knowledge and understanding of the engineering and management principle in multidisciplinary environments.
101003/CS822U.5-PO4	H	Students are able to interpret, improve, and redefine technical aspects, recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
101003/CS822U.5-PO5	M	Students are able to interpret, improve, and redefine technical aspects in acquiring skills to design, analyze, and develop algorithms and implement those using high-level programming languages.
101003/CS822U.5-PO12	M	Students are able to interpret, improve, and redefine technical aspects and contribute their engineering skills in computing and information engineering domains like network design and administration, database design, and knowledge engineering.
101003/CS822U.6-PO5	M	Students are able to interpret, improve, and redefine technical aspects and develop strong skills in systematic planning, developing, testing, implementing, and providing IT solutions for different domains, which helps in the betterment of life.

101003/CS822U.6-PO8	H	Students will be able to associate with a team as an effective team player for the development of technical projects by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS822U.6-PO9	H	Students will be able to associate with a team as an effective team player to identify, formulate, review research literature, and analyze complex engineering problems.
101003/CS822U.6-PO10	M	Students will be able to associate with a team as an effective team player for designing solutions to complex engineering problems and design system components.
101003/CS822U.6-PO11	M	Students will be able to associate with a team as an effective team player, use research-based knowledge and research methods including design of experiments, analysis, and interpretation of data.
101003/CS822U.6-PO12	H	Students will be able to associate with a team as an effective team player, applying ethical principles and committing to professional ethics and responsibilities and norms of the engineering practice.
101003/CS822U.1-PSO1	H	Students are able to develop Computer Science Specific Skills by modeling and solving problems.
101003/CS822U.2-PSO2	M	Developing products, processes or technologies for sustainable and socially relevant applications can promote Programming and Software Development Skills.
101003/CS822U.3-PSO3	H	Working in a team can result in the effective development of Professional Skills.
101003/CS822U.4-PSO3	H	Planning and scheduling can result in the effective development of Professional Skills.
101003/CS822U.5-PSO1	H	Students are able to develop Computer Science Specific Skills by creating innovative solutions to problems.

101003/CS822U.6-PSO3	H	Organizing and communicating technical and scientific findings can help in the effective development of Professional Skills..