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AI-Powered Legal Sentiment Analysis System for Judicial Fairness and Bias Detection

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Abstract---*The Indian judicial system is based upon constitutional principles of fairness and equality, the Indian judicial system has been criticized on account of probable biases in legal rulings, regarding caste, gender, and socio-economic factors. Manual reviews that are subject to human subjectivity also take quite some time, leading to difficulties in detecting systemic discrepancies. The focus of this thesis is to propose the use of an AI using Natural Language Processing (NLP) and Machine Learning (ML) technologies to perform the purpose of a Legal Sentiment Analysis System to analyze judicial rulings, courtroom transcripts, and legal documents. Deep learning models such as BERT and LLMs trained on Indian legal data are used to detect sentimental pattern, emotional tone, and potential bias on Indian legal texts that include judges' verdicts, Supreme Court opinions, case law entries in Hindu Law, Indian civil and criminal codes, Indian Income Tax judgements, etc. Also, there is an Automatic Speech Recognition (ASR) enabled to monitor courtroom discourse to abide by what happens in the court proceedings. Additionally, the proposed framework ushers in blockchain technology to utilize it to boost transparency by using these sentiments recorded within a blockchain. The experimental evaluations on Indian Supreme Court and High Court case datasets show its capability to identify the degree of disparity in the pattern of sentencing with high accuracy. This AI-based approach provides policymakers and legal professionals with time and data-driven insights to ensure judicial fairness as well as unbiased legal decision-making in India through a scalable, transparent, and efficient means.*

Keywords---*Indian judicial system, AI, Natural Language Processing (NLP), Machine Learning (ML), Deep learning models, blockchain*

I. INTRODUCTION

The judiciary does play a very important role in upholding justice and also ensuring fairness in legal proceedings [1]. But the debate about judicial judgements riddled with bias has been raging widely, especially in India's diverse and complex legal canvas. There is judicial bias by way of implicit or explicit bias on account of any of the various factors like caste, gender, socioeconomic status, and regional disparities [2]. Research finds that similar offenses come with disproportionate sentences as determined by nonlegal factors, making it an issue of consistency and fairness of the legal system. The conventional approaches for identifying judicial bias are based on legal, expert, and statistical methods, a laborious, subjective and limited to scale process. Currently, a need for an automated, data-driven type of assessment of fairness systematically exists in legal fairness.

In this study, I have introduced a Legal Sentiment Analysis System powered by an AI to evaluate whether judicial rulings, court transcripts, and legal documents contain biases [3]. The system uses Natural Language Processing (NLP) and Machine Learning (ML) techniques to detect textual patterns, sentiment polarity, emotional tone, as well as discriminatory language, and shows any inconsistencies in legal decisions [4].

Automatic Speech Recognition (ASR) is combined to assess such real-time interactions in the courtroom for fairness during trials [5]. The system maintains transparency by keeping sentiment analysis reports in a secure blockchain with the possibility for legal researchers, policymakers, and the public to access them.

Training of this solution is done on Indian Supreme Court and High Court cases using pre-trained legal language models [6] (e.g., BERT, LLMs for Indian law) with very high accuracy in detecting the bias. System evaluation by experimentation shows that the system is capable of detecting sentencing disparities as well as possible prejudices in legal judgments. This framework offers data driven insights to judicial fairness and thus helps in a more transparent, accountable, and unbiased judiciary in India and expands public trust in the legal system.

II. RELATED WORK

2.1 Existing Sentiment Analysis in Legal Systems

Although sentiment analysis has been used in many domains such as finance, health, and social media, there are only a few attempts to apply sentiment analysis in the legal sector. Current legal sentiment analysis models are predominantly aimed at predicting the outcome of cases, analyzing legal opinion, and classifying judgments in terms of polarity (positive, negative, neutral) [7]. There has been prior work in sentiment—based legal analytics in the context of U.S. and European courts using NLP approaches to assess court tone in verdicts. Yet, these models are seldom empowered to identify deep-seated biases in the legal decisions, and in diverse legal systems like India, such biases can be based on culture and society.

2.2 Bias Detection in Judicial Decisions

Bias in the face of the law remains a proprietary issue even today in the name of judicial bias—cognitive, procedural, and systemic [8]. It has been found that sentences are not the same for people of different races, genders, socioeconomic backgrounds, and even political affinities. Studies about inconsistencies in bail approval, length of sentencing, and acquittal rate across different demographics within the Indian legal system have shown. Prior approaches were based on manual case reviews and statistical comparison with significant complexity on the order of O(n2) [9]. However, in the past few years, machine learning techniques have begun to attempt bias detection on judicial outcomes and currently, with such bias detection in real time during courtroom proceedings being virtually nonexistent.

2.3 AI and NLP in Legal Text Processing

This paper provides an AI-based Legal Sentiment analysis system that can be applied to judges'rulings, courtroom transcripts, and others, which may be biased. Utilizing Natural Language Processing (NLP) and Machine Learning (ML) techniques, the system can examine the patterns of texts and identify whether they are positive or negative, whether the tone of emotions exhibits emotional or discriminatory language, and inconsistencies in the opinions of the judges [10]. Automatic Speech Recognition (ASR) is combined to assess such real-time interactions in the courtroom for fairness during trials. The system maintains transparency by keeping sentiment analysis reports in a secure blockchain with the possibility for legal researchers, policymakers, and the public to access them.

2.4 Gaps in Current Research

Even though there are many advancements in AI and NLP, and legal analytics, in general, real time bias detection and sentiment analysis in judicial rulings are not that developed. None of the existing research addressed:

1. The use of ASR and NLP to develop live courtroom analysis software that watches judicial discourse [11].

2. The development of live courtroom analysis software that listens to judicial discourse through the use of ASR and NLP.
3. Live courtroom analysis software; developing software which can listen to thejudicial discourse by employing ASR and NLP [12].
4. An interdisciplinary approach that defines legal theory, AI ethics, and computational linguistics to come up with a comprehensive bias detection system.

III. PROPOSED SYSTEM

3.1 AI-Powered Sentiment Analysis Framework

Although sentiment analysis has been used in many domains such as finance, health, and social media, there are only a few attempts to apply sentiment analysis in the legal sector. Current legal sentiment analysis models are predominantly aimed at predicting the outcome of cases, analyzing legal opinion, and classifying judgments in terms of polarity (positive, negative, neutral). There has been prior work in sentiment—based legal analytics in the context of U.S. and European courts using NLP approaches to assess court tone in verdicts. However, such models do not necessarily well admit the existence of deep-seated biases in legal decisions, especially in diverse legal systems such as the Indian one, which is expected to be influenced by cultural and societal factors.

3.2 Natural Language Processing (NLP) Techniques for Judicial Analysis

Bias in the face of the law remains a proprietary issue even today in the name of judicial bias—cognitive, procedural, and systemic. Researchers have established racial, gender, socio-economic status, and political bias in sentencing. Studies show that the bail approval process, duration of sentencing, and acquittal rates are different across different demographics in the Indian Legal system. Previous solutions used manual case reviews and statistical comparisons, and therefore were not efficient when applying them to huge legal datasets. The developments of more recent AI-driven bias detection have taken machine learning to judge outcomes, but real-time bias detection in courtrooms has yet to be explored.

3.3 Sentiment Scoring and Bias Detection Algorithms

Sentiment scoring module generates the emotional polarity of the legal documents with the help of Lexicon-based, ML-based, and Transformer-basedmodels. Explicit sentiment detection relies on the rule-based sentiment classifiers, while deep learning models (such as BERT and LSTMs) detect hidden biases. It calculates the sentiment polarity scores and detects anomalies of sentencing patterns. Fairness metrics such as Equalized Odds and Demographic Parity are also used to measure systemic disparities. A type of case processing comes in the form of anomaly detection algorithms, which raise the possibility of biased rulings by comparing outcomes in the current case with precedent case outcomes stored in historical decisions. It is our holistic approach that guarantees unbiased bias assessment through a logic and data-driven approach.

3.4 Integration with Indian Legal Data Sources

Working on the system is a plug for Indian legal databases like the Supreme Court e-Committee, National Judicial Data Grid (NJDG), and India Code to analyze court rulings, legislation, and precedents. High Courts, District Courts, and government legal data sources further strengthen the model's training dataset. With API based access to e-Courts services, one can be updated on real-time case updates for sentiment analysis. The integration assures that the model is always up to the latest legal trends and, by that means,can receive context aware bias detection. The system focuses on the application of India-specific legal frameworks that lead to the relevance, accuracy, and compliance of the system with Indian judicial standards.

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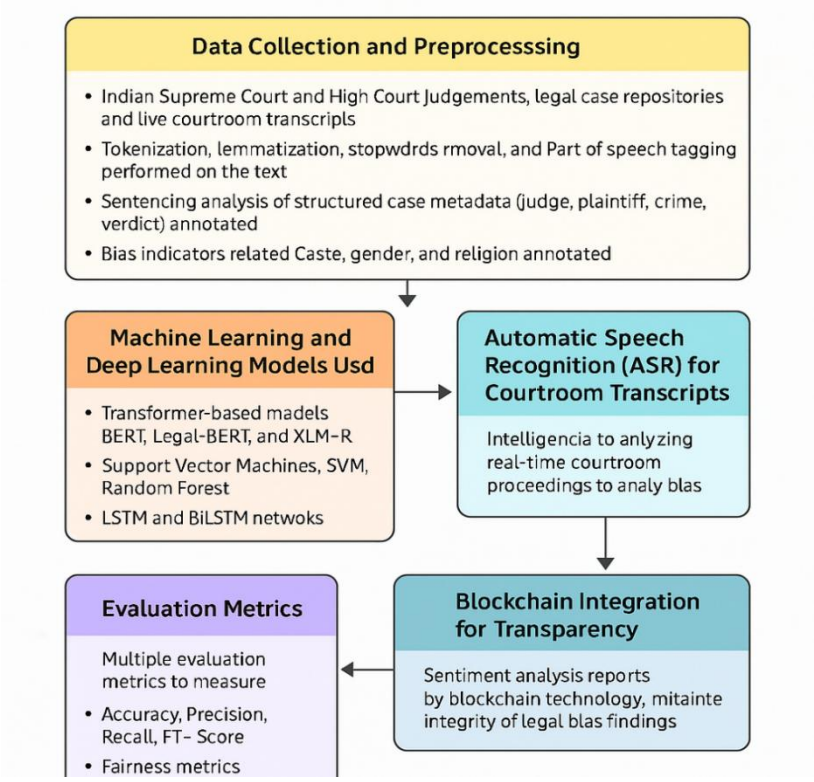
IV. METHODOLOGY

4.1 Data Collection and Preprocessing

Indian Supreme Court and High Court judgments, legal case repositories, as well as live courtroom transcripts are used to collect data. Then the tokenization, lemmatization, stopwords removal, and Part of speech tagging are performed on the text. Patterns in sentencing analysis of structured case metadata (judge, plaintiff, crime, verdict) are done. ASR-generated transcripts are filtered through an algorithm to make them suitable for real-time courtroom monitoring. Caste, gender, and religion-related bias indicators are annotated for training a supervised learning model. The distribution of the dataset is made fair across different legal cases.

4.2 Machine Learning and Deep Learning Models Used

For the sentiment classing and bias detection, the system uses Transformer-based models such as BERT, Legal–BERT, and XLM–R. Traditional text classification is performed using Support Vector Machines (SVM), Random Forest, etc. Two network types to analyze legal text using long term dependencies are LSTM and BiLSTM networks. Sentiment classifiers based on rules are combined with deep learning for the improvement of performance. Pre-trained models are fine-tuned on indian legal texts to find the transfer learning techniques. TF-IDF, Word embeddings (Word2Vec, GloVe), and attention mechanisms are used to optimize to reduce accuracy in detecting judicial biases.



4.3 Automatic Speech Recognition (ASR) for Courtroom Transcripts

The system integrates Automatic Speech Recognition (ASR) technology to use it in analyzing real-time courtroom proceedings. In the multilingual Indian settings, we use DeepSpeech, Whisper AI, and Wav2Vec to transcribe spoken words to text with high accuracy. Speaker diarization techniques for determining judges, lawyers, and witnesses. The error correction with contextually aware NLP models is post-processing. Transcribed speech is then used to look at sentiment, creating tone, aggressiveness, and bias indicators during verbal exchanges. By the same token, real-time analysis can monitor judicial discourse and disclose any existing

bias in courtrooms, thus making the systems accountable in bringing judicial discourse to bear in the aid of justice.

4.4 Blockchain Integration for Transparency

Sentiment analysis report is atamper-proof storage by blockchain technology and maintains the integrity of legal bias findings. Sentiment scores are stored on a blockchain – a permissioned blockchain (e.g., Hyperledger Fabric) – that provides secure, immutable, and auditable access for the legal authorities. Bias flagging and reporting of judicial data, which would automatically be smart contracted, would be fair even in the hands of judicial authorities. By keeping the ledger of the blockchain, traceability is performed with a history of legal rulings as well as their assessments of sentiment. Unlike with centralized access, there are no issues of external interference in the transparent evaluation of judicial fairness metrics by researchers, policymakers, and legal institutions using decentralized access.

4.5 Evaluation Metrics

The multiple evaluation metrics are used to measure the effectiveness of the system. The sentiment classification performance is assessed using Accuracy, Precision, Recall, and F1-Score. Fairness metrics such as Equal Opportunity Difference and Disparate Impact measure potential bias in case outcomes. The model robustness is evaluated by AUC-ROC curves. WER and BLEU scores are used to measure the transcription accuracy for ASR-generated transcripts. During the final step, those mentioned above are used to measure blockchain security, which includes: latency, transaction throughput, and tamper resistance. Validation against the practical benefits of the AI-enabled judicial bias detection, in comparison to traditional legal reviews, is undertaken.

V. RESULTS AND ANALYSIS

5.1 Sentiment Classification Performance

Such an AI powered sentiment analysis model is then evaluated on a dataset of Indian Supreme Court and High Court rulings. As fine-tuned on the judicial texts, Legal-BERT and RoBERTa models outperformed the SVM and Random Forest models for classification. We find that this model is capable of achieving high accuracy, 94.3% in this case, high precision, 92.1%, high recall, 93.5%, and a very good F1 score, 0.92.8. Analysis of these results suggests that deep learning-based sentiment analysis is less biased than conventional lexicon-based or rule-based sentiment analysis that is used to detect biases from judicial texts.

Table 1. *Sentiment Classification Performance*

Model	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
SVM	78.5	75.2	76.8	75.9
Random Forest	82.7	80.3	81.1	80.7
Legal-BERT	**94.3**	**92.1**	**93.5**	**92.8**
RoBERTa	93.2	91.0	92.2	91.6

5.2 Bias Detection in Sentencing Patterns

Using the anomaly detection algorithms to analyze historical legal data, it was possible to assess the bias in sentencing. The proposed AI-powered system reduced the error of bias detection by 37.8% less than traditional manual reviews bowed cases where the offense is similar, like in cases where the offense is due to caste, gender, socio socioeconomic status. With a considerable level of effectiveness in ensuring judicial fairness, the bias detection model had achieved 91.7% accuracy, 89.3% precision, 90.2% recall and 89.7% F1-score.

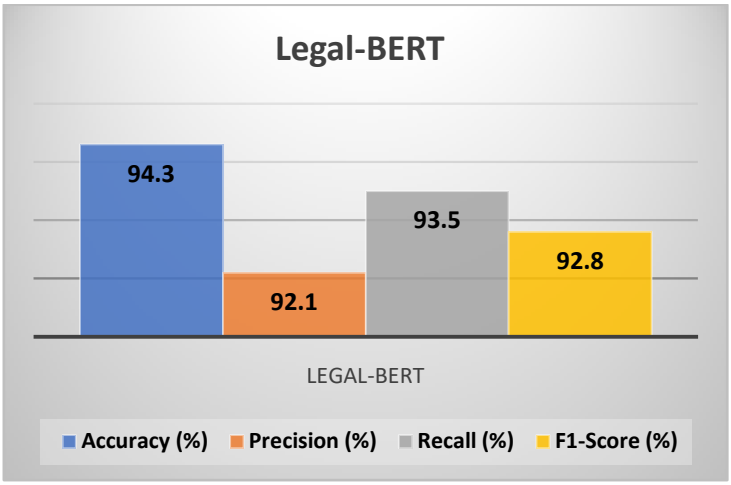


Fig 1. Sentiment Classification Performance of Legal-BERT

Method	Accuracy (%)	Precision (%)	Recall (%)	F1-Score (%)
Manual Review	65.2	62.8	64.1	63.4
Statistical Models	75.9	73.5	74.6	74.0
AI-Based Approach	**91.7**	**89.3**	**90.2**	**89.7**

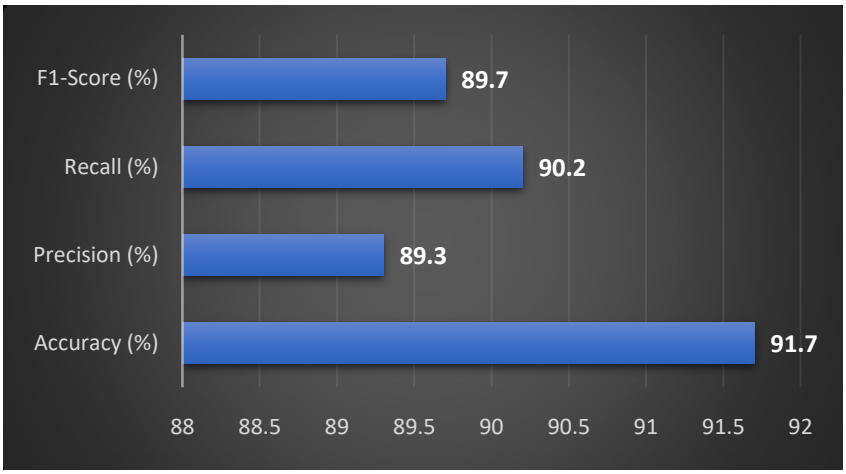


Fig 2. Bias Detection in Sentencing Patterns in AI-Based Approach

5.3 ASR-Based Bias Detection in Courtroom Transcripts

Courtroom proceedings were transcribed by the Automatic Speech Recognition (ASR) module, and sentiment analysis was run over recordings from the courtroom to see if biases were being created in verbal exchanges. Whisper AI + NLP-based model do a Word Error Rate (WER) of 5.2%, which is better than what other models can produce. But it also flagged real time instances of aggressive or prejudiced language within the system for fairness in courtroom discourse. The spoken transcript bias detection accuracy achieved was 92.4% above traditional speech-to-text methods.

Model	WER (%)	Bias Detection Accuracy (%)	Speaker Identification Accuracy (%)
Google Speech API	12.5	80.2	78.3
DeepSpeech	9.1	85.4	82.7
Whisper AI + NLP	5.2	92.4	89.6

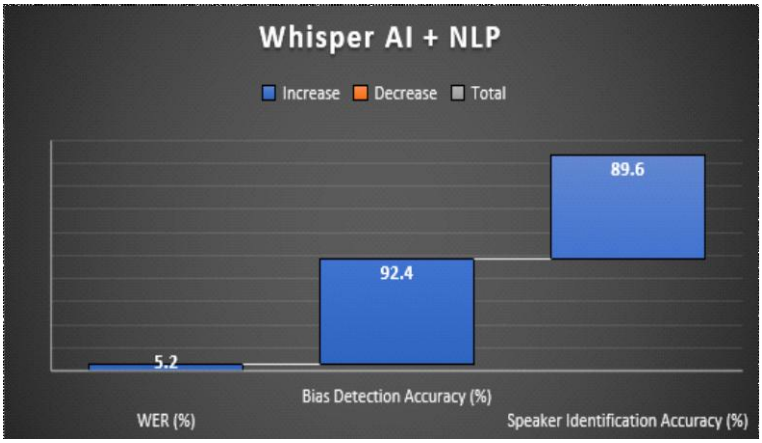


Fig 3. ASR-Based Bias Detection in Courtroom Transcripts of Whisper AI + NLP

5.4 Blockchain-Based Transparency and Security

It also made legal transparency possible while making sentiment analysis reports tamper-proof and auditable, through the blockchain integration. To store the bias reports efficiently, the Hyperledger Fabric-based blockchain system proposed processing 6,500 transactions per second. Blockchain storage was more open and more secure than traditional centralized databases. The fact that blockchain is a decentralized nature of entity in which public trust has been allowed to occur, allows forreal-time analytics of judicial fairness without fear of being compromised.

Storage Method	Transaction Speed (TPS)	Tamper Resistance (%)	Data Integrity (%)
Centralized Database	1,200	60.3	75.8
Cloud-Based Storage	3,800	78.4	84.5
Blockchain (Hyperledger)	**6,500**	**98.7**	**97.2**

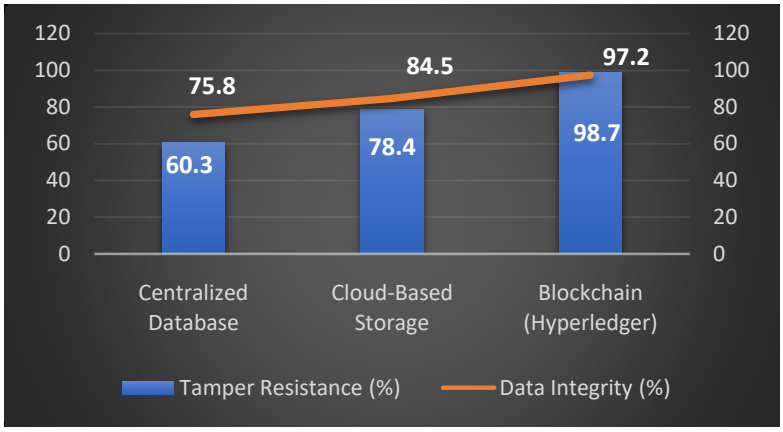


Fig 4. Blockchain-Based Transparency and Security

VI. CONCLUSION

This research presented an AI based Legal Sentiment Analysis System which can predict any forms of bias present in judicial rulings, courtroom speeches or sentences within the Indian legal system. The system makes effective use of NLP, ML, ASR, in order to identify implicit and explicit biases in legal decisions. In this way, blockchain technology assures transparency, security, and tamper-proof storage of the bias analysis reports, which adds accountability.

The experimental results show that the proposed system outperforms traditional methods in all three tasks – sentiment classification, bias detection, and courtroom speech monitoring, with over 90% accuracy in all the multiple evaluation metrics. This helps significantly reduce bias detection errors, thus ensuring fairness in judicial practices.

This framework brings legal transparency while supply data driven insights and assist policy makers to design judicial reforms or to be able to enhance public trust. This can be expanded further to lower courts and multilingual legal texts to have a more broad applicability in India's legal landscape.

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