RESEARCH PROJECT

PROJECT TITLE : MULTILINGUAL HATE SPEECH DETECTION

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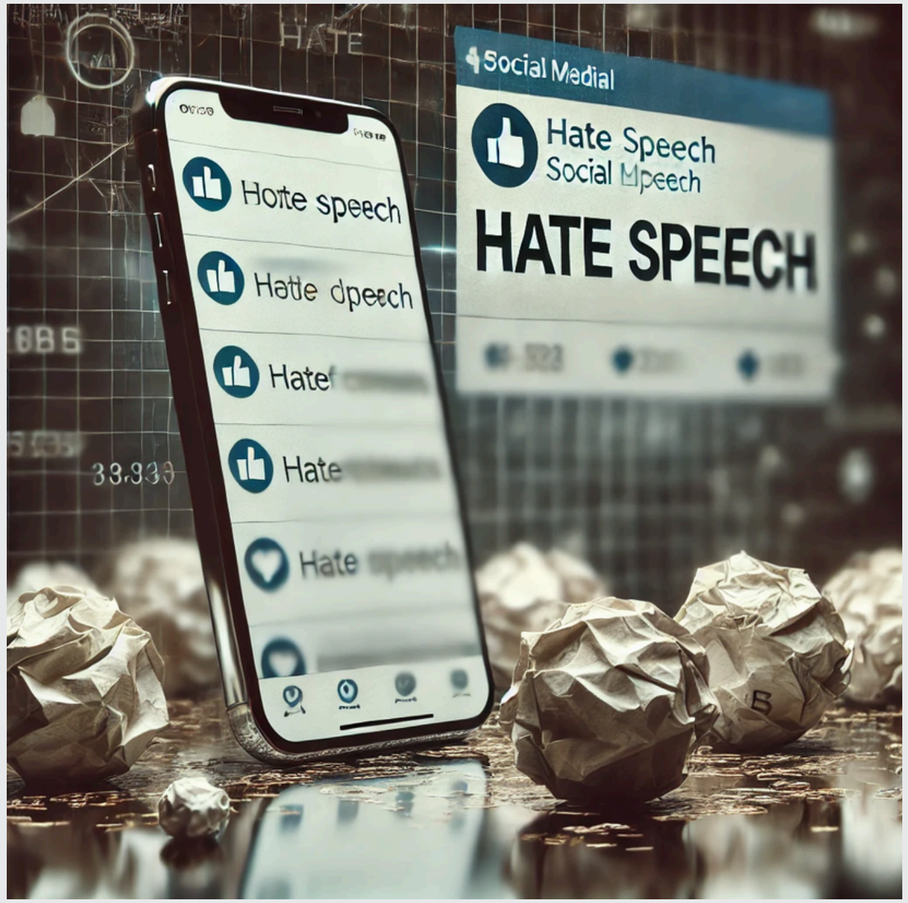
INTRODUCTION

- HATE SPEECH DISRUPTS SOCIETAL HARMONY, FOSTERS DISCRIMINATION, AND INCITES VIOLENCE, ESPECIALLY ONLINE.
- MULTILINGUAL HATE SPEECH DETECTION IS ESSENTIAL FOR PROTECTING LOW-RESOURCE LANGUAGES LIKE HINDI, TAMIL, AND BENGALI.
- KEY CHALLENGES INCLUDE LINGUISTIC DIVERSITY, CODE-MIXED TEXT, AND DEMOGRAPHIC BIASES IN DETECTION MODELS.



PROBLEM STATEMENT

Let $X = \{x1, x2, \ldots, xn\}$ be the set of input texts, and $Y = \{y1, y2, \ldots, yn\}$ be the corresponding labels for each input xi, where $Y = \{Hate, Non - Hate\}$ represents the hate speech or non-hate speech, respectively. The objective of the proposed model is to predict the conditional probability of the label y for a given input x , i.e., $P(y|x)$.

KEY PROBLEMS :

- **DATA SCARCITY :** Limited annotated datasets for regional languages like Hindi, Tamil, and Bengali.
- **CODE - MIXING :** Frequent blending of multiple languages, e.g., Hinglish (Hindi-English).
- **DEMOGRAPHIC GENERALIZATION :** Models trained on specific populations fail to adapt to other cultural contexts.

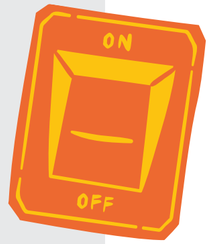
OBJECTIVE

MAIN OBJECTIVE :

Develop a robust multilingual hate speech detection model.

SUB-OBJECTIVE :

- **Development of an Attention-Based Framework for Multilingual Hate Speech Detection-** Introduces a multilingual model using attention mechanisms for hate speechdetection across diverse languages, including Hindi, Tamil, Bengali, Urdu, and Marathi.
- **Improved Handling of Code-Mixed and Low-Resource Languages-** Addresses the challenges of detecting hate speech in code-mixed and low-resource languages by incorporating multilingual embeddings and attention-driven context understanding.
- **Comprehensive Benchmarking Across Multilingual Datasets-** Provides evaluation of the proposed model on multiple language datasets.



LITERATURE REVIEW

S.No	Study	Languages	Model	Dataset	Result
1	Hate speech and offensive language detection in Dravidian languages using deep ensemble framework[8]	Malayalam and Tamil code-mixed	BERT, DNN, and MuRIL (Malayalam) DistilBERT, DNN and xlm-RoBERTa (Tamil)	[19]	F1-Score 0.802 (Malayalam) 0.933 (Tamil)
2	Hate speech detection on Twitter using transfer learning[9]	Urdu	DistilBERT	Not available	F1-score 0.69
3	Fighting hate speech from bilingual hinglish speaker's perspective, a transformer- and translation-based approach.[10]	Hinglish	Interpretation(translation and transliteration), mBERT, and Deep neural network	[20]	F1-score Hate (%)-0.56 Nonhate (%)-0.78
4	Investigating Hostile Post Detection in Hindi[11]	Hindi	MuRIL and XLM-RoBERTa	[21],[22]	Coarse Grained F1-sore 0.9716
5	Hate Speech Detection in Hindi [12]	Hindi	MuRIL.	[23]	F1-Score MuRIL: 0.73
6	Combining multiple pre-trained models for hate speech detection in Bengali, Marathi, and Hindi [13]	Bengali, Marathi, Hindi	Ensemble of mBERT and IndicBERT	[24], [25], [26]	F1-Score 0.923 (Bengali) 0.815(Marathi) 0.924(Hindi)
7	An empirical comparison of Hindi-BERT and MuRIL for hate speech detection on social media platforms in Hindi language[14]	Hindi	Hindi-BERT	[27]	Accuracy Hindi-BERT: 82.73 MuRIL: 75.9%
8	Hate Speech Detection from Code-mixed Hindi-English Tweets Using Deep Learning Models[15]	Hindi- English Code mixed	CNN 1D, LSTM, BiLSTM	[28]	Accuracy CNN-1D: 82.62%, LSTM: 80.21%, BiLSTM: 81.48%

KEY FINDINGS :

- Advanced models like BERT, MuRIL, and XLM-RoBERTa are commonly used for hate speech detection.
- Datasets include Hindi-English code-mixed text, Dravidian languages, and Bengali datasets.
- Limitations in prior work:
  - Poor handling of code-mixed languages.
  - Limited datasets for low-resource languages.
  - Challenges with demographic generalization.

CHALLENGED HIGHLIGHTED :

- Annotation biases and cultural variations.
- Overlap of non-hate and mild hate categories leading to misclassification.

DATA COLLECTION

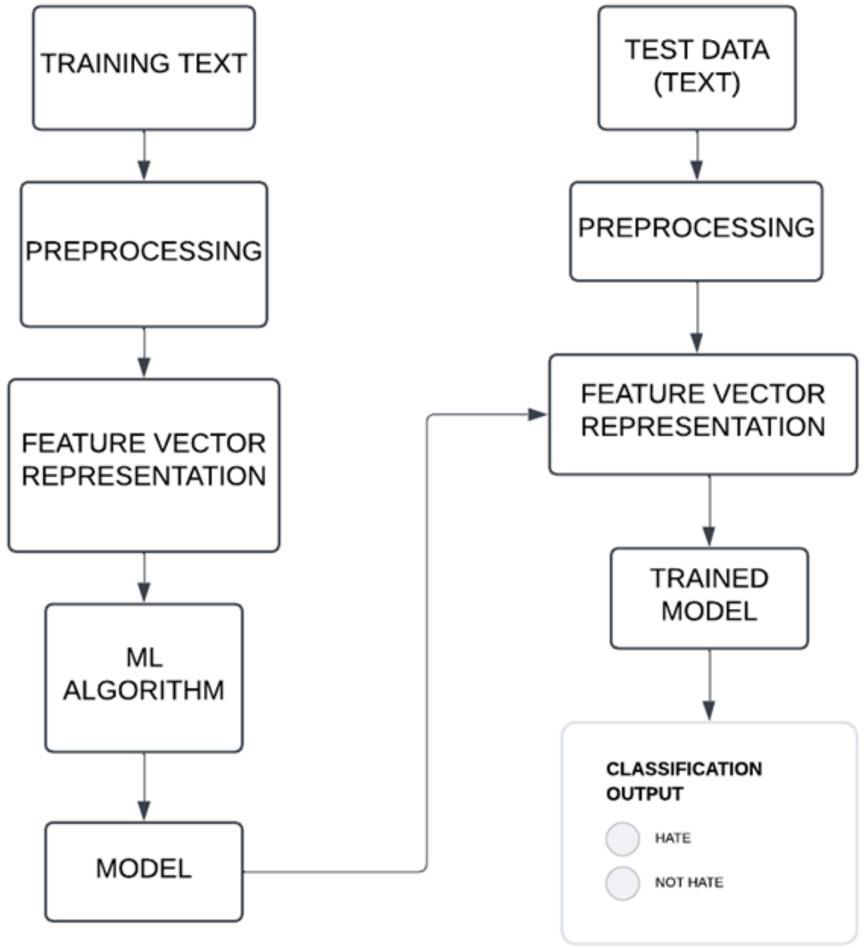
Dataset	Language	Total size	Hate speech size	Non-hate speech size
A Dataset of Hindi–English Code-Mixed Social Media Text for Hate Speech Detection[31]	Hindi-English Code mixed	4575	1661	2914
BD-SHS: A Benchmark Dataset for Learning to Detect Online Bangla Hate Speech in Different Social Contexts [32]	Bengali	50,281	24,156	26,125
HASOC-Dravidian-CodeMix [33]	Malayalam–English	5000	2465	2535
HASOC-Dravidian-CodeMix [34]	Tamil–English	5000	2455	2485
HASOC 2019 (Hindi)[34]	Hindi-English Code mixed	4665	2469	2196
L3Cube-MahaHate (Marathi)[35]	Marathi	12500	6250	6250

Datasets from multiple languages were gathered to ensure balanced representation in hate speech detection.

- **Hindi-English :** 4,575 samples (1,661 hate speech, 2,914 non-hate).
- **Bengali :** 50,281 samples (~50% hate speech).
- **Malayalam-English & Tamil-English :** 5,000 samples each with a mix of categories.
- **Marathi :** 12,500 samples (50% hate speech).

PROPOSED MODEL STEPS:

- **Data Collection**
- **Text Preprocessing**
- **Feature Extraction**
    1. mBERT
    2. XLM-RoBERTa
    3. IndicBERT
    4. MuRIL
- **BiLSTM Layer:** Capture contextual dependencies (both forward and backward).
- **Attention Layer:** Enhance focus on contextually significant words.



TEXT PRE-PROCESSING

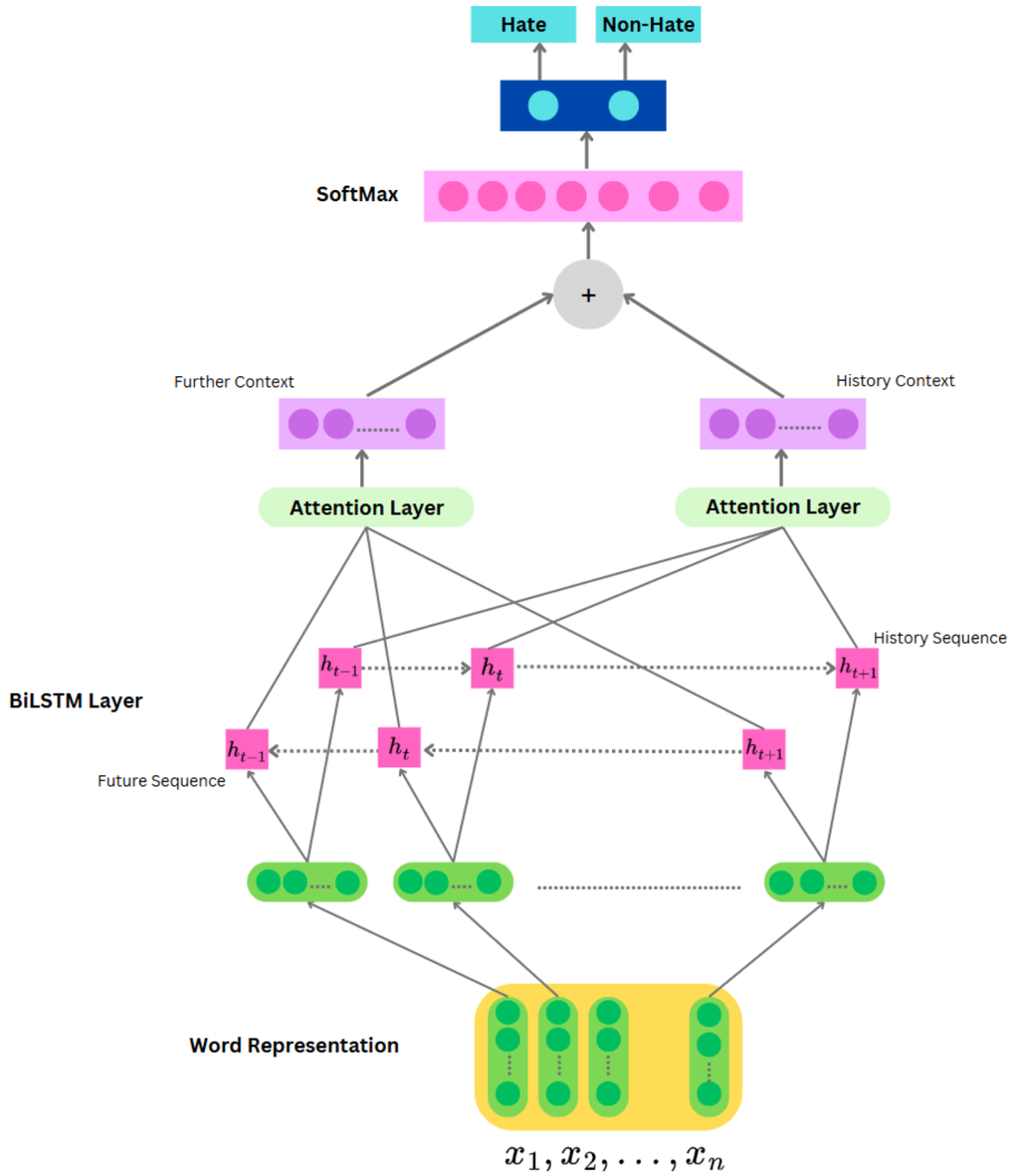
- **Noise Removal :** Eliminate URLs, emojis, hashtags, special characters, and punctuation.
- **Lowercasing**
- **Tokenization :** Using mBERT/XLM-RoBERTa tokenizer.
- **Stopword Removal**
- **Stemming & Lemmatization**

FEATURE EXTRACTION

Following word embeddings models will be explored in the study:

- **mBERT :** Supports 104 languages with 12 layers, 768 hidden dimensions, and ~110M parameters.
- **XLM-RoBERTa :** Optimized for 100 languages. Variants include Base (125M parameters) and Large (355M parameters).
- **IndicBERT :** Lightweight model for 12 Indian languages, based on ALBERT, with 12M parameters.
- **MuRIL :** Pretrained on Indian languages ,12 layers, 768 hidden dimensions, and ~110M parameters.

BLOCK DIAGRAM OF THE PROPOSED MODEL



BiLSTM Layer

Purpose : Captures both forward and backward dependencies in the text sequence.

Input : Feature representation of text ($X = \{x1, x2, \dots, xn\}$), where each $xi \in \mathbb{R}d$ is a word embedding.

Mechanism :

- **Forward LSTM :** Processes the sequence from start to end.
- **Backward LSTM :** Processes the sequence in reverse.
- **Hidden states at time t :**
  - **Forward :** $ht \rightarrow \quad LSTMforward(x_t, \overrightarrow{h_{t-1}})$
  - **Backward :** $ht \leftarrow LSTMbackward(x_t, \overleftarrow{h_{t+1}})$

Final state : Concatenation $ht = [ht \rightarrow, ht \leftarrow]$.

Output : Sequence of context-aware embeddings ($H \in \mathbb{R}n \times 2d$) capturing past and future context for each word.

ATTENATION LAYER

Purpose : Highlights important words (e.g., hate speech indicators) by dynamically weighting their relevance.

Process :

- **Hidden Representation:**
  - **Forward :** $U_f^{\rightarrow} = \tanh(\mathrm{W}h_f^{\rightarrow} + \mathrm{b})$
  - **Backward :** Similar computation for $hb \leftarrow$.
- **Attention Weights :** Calculate importance using a softmax over the similarity between u and a context vector v.
  - **Forward :** $$a_f^{\rightarrow} = \frac{exp\left(u_f^{\rightarrow} \cdot v_f^{\rightarrow}\right)}{\sum_{i=1}^{M} exp(u_f^{\rightarrow} \cdot v_f^{\rightarrow})}$$
  - **Backward :** Similar computation for $$a_b^{\leftarrow} = \frac{exp\left(u_f^{\leftarrow} \cdot v_f^{\leftarrow}\right)}{\sum_{i=1}^{M} exp(u_f^{\leftarrow} \cdot v_f^{\leftarrow})}$$
- **Context Representation :**
  - **Forward :** Weighted sum $Fc = \Sigma af \rightarrow i * hf \rightarrow i$.
  - **Backward :** Weighted sum $Hc = \Sigma ab \leftarrow i * hb \leftarrow i$.
- **Final Representation :** Concatenate forward and backward contexts: S = [Fc, Hc].

Output : Attention-enhanced representations are passed through a dropout layer and classified using a softmax layer as ‘Hate’ or ‘Non-Hate’.

RESULT ANALYSIS

Model Name	Accuracy	Precision	Recall	F1-Score
mBert	0.7678	0.5900	0.5804	0.5851
XLM-RoBERTa	0.7700	0.5804	0.5934	0.5868
mBert +LSTM	0.7560	0.6040	0.6120	0.6080
mBert+BiLSTM	0.7760	0.6190	0.5950	0.6070
XLM-RoBERTa+LSTM	0.7890	0.6200	0.6230	0.6215
Proposed Method	0.8000	0.6296	0.6296	0.6296

EVALUATION METRICS

- **Accuracy**
- **Precision**
- **Recall**
- **F1-Score**

Experimental Setup

- **Dataset :** Evaluated on the Hindi dataset.
- **Preprocessing :** Tokenized and padded to 128 tokens.
- **Model Configuration :**
  - Word Embeddings size: 768
  - BiLSTM with 128 hidden units and dropout.
  - **Learning rate :** 0.001 .
  - **Batch size :** 16, epochs: 50.
  - **Optimizer :** Adam.
  - **Loss**: Binary Cross-Entropy Loss

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THANK YOU