



*Mini Project Report On*  
**Malayalam Parser for Dataset Creation**

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

**Bachelor of Technology**  
*in*  
**Computer Science & Engineering**  
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# CERTIFICATE

*This is to certify that the mini project report entitled "**Malayalam Parser for Dataset Creation**" is a bonafide record of the work done by **Fathima Jennath N K (U2103089)**, **Gautham C Sudheer (U2103092)**, **Godwin Gino (U2103096)**, **Mohammed Basil (U2103139)**, submitted to the APJ Abdul Kalam Technological University 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 2023-2024.*

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## Abstract

The “Malayalam Parser for Dataset Creation” project aims to address the scarcity of annotated datasets in the Malayalam language for Natural Language Processing (NLP) applications. The primary objective is to develop a robust Malayalam parser capable of analyzing the syntactic and semantic structures of Malayalam sentences. The creation of this parser involves several key steps, including data collection from diverse sources, preprocessing to ensure data quality, and manual annotation of a representative subset of the data with grammatical and syntactic information. The parser development process encompasses the selection of an appropriate parsing approach, whether rule-based, statistical, or machine learning-based. The model is trained using the annotated Malayalam dataset, focusing on capturing the unique linguistic nuances of the Malayalam language. Evaluation metrics are employed to assess the parser’s performance on a separate test set, guiding iterative refinement and enhancement. The resulting Malayalam parser serves as a valuable tool for the analysis of grammatical structures in new Malayalam text data. Its application contributes to the creation of high-quality Malayalam datasets, crucial for advancing NLP research and applications in the Malayalam language. This project encourages collaboration with linguists, researchers, and the Malayalam-speaking community to ensure linguistic accuracy and relevance in the development of the parser. The “Malayalam Parser for Dataset Creation” project aligns with the broader goal of promoting linguistic diversity in NLP, addressing the challenges posed by the scarcity of resources for underrepresented languages. Through the development of this parser, the project aims to facilitate further research and innovation in Malayalam NLP, opening avenues for the exploration of various language-related tasks and applications.

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## **List of Abbreviations**

NLP - Natural Language Processing

NER - Named Entity Recognition

POS - Part-of-Speech

# **Chapter 1**

## **Introduction**

### **1.1 Background**

Malayalam is spoken widely in Kerala and neighboring areas but has not received as much attention in the tech world as bigger languages like English. This lack of attention has led to a scarcity of tools for analyzing Malayalam text, despite its complex grammar and word forms.

Our project aims to address this issue by creating a specialized system for Malayalam that can understand and process Malayalam text more effectively than current tools. This system will facilitate tasks such as sentiment analysis, translation, and summarization, benefiting areas such as education and business.

We are designing our system to be adaptable and scalable, ensuring that it can evolve to meet diverse needs. Our ultimate goal is to establish a strong foundation for Malayalam language technology, paving the way for future improvements and innovations.

In short, our project focuses on using technology to make working with Malayalam text more efficient, enabling individuals to achieve more in various fields.

### **1.2 Problem Definition**

The aim of the project is to create a Malayalam Parser for Dataset Creation, involving data collection, preprocessing, manual annotation, and training using various parsing approaches to address the scarcity of annotated datasets in Malayalam for NLP applications.

### **1.3 Scope and Motivation**

#### **Scope:**

The Malayalam Parser project aims to develop an advanced tool capable of understanding

and processing Malayalam text efficiently. It encompasses essential tasks such as tokenization, part-of-speech tagging, parsing, and semantic analysis, providing a comprehensive breakdown of Malayalam sentences. The system's scope extends to facilitating tasks such as identifying different parts of speech and extracting meaningful insights from text. Additionally, the parser's design includes provisions for future expansion, allowing for the incorporation of domain-specific or specialized parsing tasks. This flexibility ensures that the parser can adapt to evolving needs and requirements, making it applicable across various domains and applications.

### **Motivation:**

The motivation behind the Malayalam Parser project stems from the necessity for effective tools to process Malayalam text, essential for informed decision-making and strategic planning. By implementing parsing tasks such as tokenization, part-of-speech tagging, parsing, and semantic analysis, the system enables data-driven decision-making processes, enhancing strategic planning and execution. Furthermore, the project's innovation lies in the creation of annotated datasets, crucial for training and evaluating models for sentiment analysis, machine translation, question answering, and domain-specific parsing. Through these efforts, the project aims to advance natural language processing capabilities in Malayalam, contributing to the improvement of Malayalam language processing technologies and fostering innovation in linguistic research and technology development.

Parsing Tasks	Description
Tokenization	Breaking down sentences into individual words or tokens.
Part-of-Speech Tagging	Assigning grammatical tags to each word in a sentence.
Parsing	Analyzing the structure of sentences to understand their grammatical relationships.
Semantic Analysis	Extracting the meaning and context from sentences.

Table 1.1: Description of parsing tasks

### **1.4 Objectives**

- Develop parsing algorithms to accurately identify linguistic components such as words, phrases, and sentences in Malayalam text, laying the foundation for com-

hensive analysis.

- Implement functionalities to determine the grammatical structure, syntax, and semantics of Malayalam sentences, facilitating precise linguistic analysis and comprehension.
- Incorporate part-of-speech tagging, syntactic parsing, and semantic analysis capabilities tailored specifically for the Malayalam language, enabling detailed linguistic processing.
- Enhance the Malayalam Parser system to effectively handle compound words, inflections, and variations in word forms commonly encountered in Malayalam text, ensuring robust parsing capabilities.
- Ensure compatibility and interoperability with existing linguistic analysis frameworks, facilitating seamless integration and utilization of the Malayalam Parser within broader NLP applications.
- Continuously refine and optimize the Malayalam Parser system to improve efficiency, accuracy, and adaptability in analyzing and processing Malayalam text data.

## 1.5 Challenges

1. Morphological Complexity: Malayalam words can change a lot by adding suffixes, making it hard for the parser to figure out their basic forms and parts of speech. This makes it tough to understand the meaning and grammar of sentences.
2. Limited Resources: The scarcity of Malayalam-specific NLP tools and datasets complicates the development and training process. Adapting existing tools from other languages or creating new ones becomes necessary, potentially slowing down progress and hindering the effectiveness of the parser.
3. Syntactic Freedom: Malayalam's relatively flexible sentence structure allows for varied word orders, challenging parsing algorithms in determining precise word relationships. This freedom introduces complexity in identifying grammatical elements like subjects, objects, and verbs, especially when word order isn't a definitive indicator.

4. Data Annotation: The process of manually annotating data for parts of speech (POS), named entities, and intents is meticulous and time-consuming, requiring expertise in Malayalam grammar. It's crucial to ensure the quality and comprehensiveness of annotated training data for the parser's success, although this can be resource-intensive.
5. Model Selection and Training: Optimal performance of POS tagging, named entity recognition, and intent recognition tasks relies on choosing suitable algorithms and training them effectively. However, training on potentially limited or imbalanced datasets necessitates careful optimization, such as data augmentation and hyperparameter tuning, to mitigate any shortcomings.

## **1.6 Assumptions**

1. Availability of Training Data: The project assumes a certain amount of high-quality Malayalam text data will be available for annotation and training the parser for POS tagging, NER, and intent recognition.
2. Effectiveness of Algorithms: The project assumes that the selected algorithms for POS tagging, NER, and intent recognition will be capable of accurately handling the linguistic complexities inherent in the Malayalam language.
3. Computational Resources: Adequate computational resources are assumed to be accessible for training the parser models, as this process can be computationally demanding.
4. Annotation Quality: The project assumes the quality of the annotations in the training data, including accuracy and consistency, as these factors greatly influence the performance of the parser models.

## **1.7 Societal / Industrial Relevance**

The project aims to preserve and promote Malayalam, enhancing understanding and analysis of Malayalam text, providing datasets for parts-of-speech tagging, named entity recognition, and intent recognition. It supports research and learning in NLP and

Malayalam linguistics, improving access to information for Malayalam speakers online. The project also supports the development of local language technologies for industries in Malayalam-speaking regions, expanding market opportunities in e-commerce and social media.

## 1.8 Organization of the Report

The organization of the report are as follows:

- **Chapter 1-Introduction:** The introduction covers the background of the project, the problem definition, the scope and motivation, the objectives, the societal and industrial relevance, the assumptions and the challenges faced by the project.
- **Chapter 2-Software Requirements Specification:** This chapter outlines the functional and nonfunctional requirements of the NLP tools for Malayalam. It defines the overall description of the software, external interface requirements, system features, and other nonfunctional requirements necessary for the development and deployment of the tools.
- **Chapter 3-System Architecture and Design:** The system architecture and design chapter provides an overview of the project's technical framework. It includes discussions on the system overview, architectural design, identified datasets, proposed algorithms, implementation strategies, module division, and a work schedule presented as a Gantt chart for project planning and management.
- **Chapter 4-Results and Discussions:** This chapter presents an overview of the testing process and discussion.
- **Chapter 5-Conclusion:** This chapter comprises the conclusion of the study along with suggestions for future research directions.

## Chapter 2

# Software Requirements Specification

### 2.1 Product Perspective

This software represents a new, standalone product developed to fulfill the crucial task of parsing and analyzing Malayalam language text. Unlike existing systems or components, this software is designed from the ground up to specialize in the intricacies of Malayalam language parsing, catering to the specific needs of users requiring accurate linguistic analysis in Malayalam. The Malayalam Parser software does not belong to a product family but serves as an independent solution, tailored specifically for parsing Malayalam text. It is not intended as a replacement for existing systems but rather as a complementary tool to enhance language processing capabilities in Malayalam. While it operates autonomously, it may interface with other systems or applications, such as text input sources or linguistic databases, to facilitate seamless integration within broader linguistic analysis frameworks.

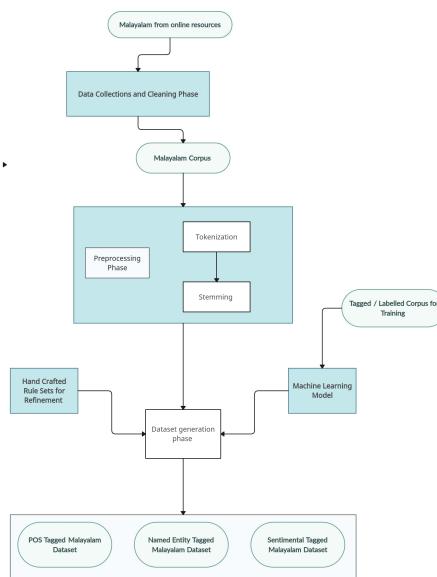


Figure 2.1: System design

### **2.1.1 Product Functions**

Major Functions of the Malayalam Parser:

- Parse and analyze Malayalam language text to identify linguistic components such as words, phrases, and sentences.
- Determine grammatical structure, syntax, and semantics of Malayalam sentences to facilitate accurate linguistic analysis.
- Provide functionality for part-of-speech tagging, syntactic parsing, and semantic analysis tailored for the Malayalam language.
- Support for handling compound words, inflections, and variations in word forms commonly found in Malayalam text.
- Generation of a part-of-speech tagged dataset, named entity dataset, and sentimental tagged dataset, contributing to the advancement of language processing technologies in Malayalam

### **2.1.2 Operating Environment**

For creating the Malayalam Parser, the operating environment encompasses the following specifications:

#### **Hardware Platform**

- The software should be compatible with standard computing hardware commonly used for software development and deployment.
- Minimum hardware requirements include a modern processor (e.g., Intel Core i5 or equivalent), sufficient RAM (at least 4GB), and available storage space for software installation and data processing.

#### **Operating System and Versions**

- The software should be compatible with popular operating systems used for software development and deployment, including Windows, MacOS, and Linux distributions.

- Specific operating system versions supported include:

Windows 10 or later

MacOS 10.13 High Sierra or later

Ubuntu 18.04 LTS or later

## Software Components and Applications

- The Malayalam Parser may require integration with various software components and applications for development, testing, and deployment purposes.
- Development tools such as Python (version 3.6 or later), Java Development Kit (JDK), or other programming languages and frameworks suitable for NLP development may be necessary.
- Libraries and frameworks for natural language processing, such as NLTK (Natural Language Toolkit), spacey or TensorFlow, may be utilized.
- Database systems such as SQLite, PostgreSQL, or MongoDB may be employed for data storage and retrieval if necessary.

## 2.2 Design and Implementation Constraints

The development of the Malayalam Parser is subject to various constraints and limitations, including:

- **Hardware Limitations:** The software must be optimized to operate within hardware limitations, including timing and memory constraints. Performance optimizations are crucial to ensure efficient operation across different hardware configuration.
- **Integration with External Systems:** The parser must support standard interfaces and data formats for interoperability with other language processing tools or databases. Ensuring smooth integration is a technical requirement.
- **Language Requirements:** The Malayalam Parser must be designed and implemented to meet the linguistic complexities of the Malayalam language. This includes handling unique grammar rules, character encoding, and text processing requirements inherent to Malayalam.

- **Character Encoding and Localization:** Proper handling of character encoding specific to Malayalam and localization considerations are crucial. The parser should accurately interpret and process Malayalam characters.
- **Security Considerations:** Security measures such as encryption, access control, and data integrity must be incorporated into the design and implementation of the Malayalam Parser to safeguard against security threats and vulnerabilities.
- **Design Conventions and Programming Standards:** Adherence to design conventions, programming standards, and coding guidelines is paramount. Developers must follow established best practices and organizational standards to ensure maintainability, readability, and consistency of the codebase.

### 2.3 Assumptions and Dependencies

1. **Third-Party or Commercial Components:** It is assumed that the development of the Malayalam Parser will rely on third-party or commercial components. The project is intended to be developed from existing models, without significant dependencies on pre-existing software solutions or proprietary libraries.
2. **Development Environment:** The assumption is made that the development environment for the Malayalam Parser will be properly configured and equipped with necessary tools, including programming languages, development frameworks, and version control systems.
3. **Operating Environment:** It is assumed that the operating environment for testing and deployment of the Malayalam Parser will meet the specified requirements, including compatibility with supported operating systems and hardware configurations.
4. **Constraints and Limitations:** The project assumes that constraints and limitations identified in the SRS, such as corporate policies, regulatory requirements, and hardware limitations, will be properly addressed and accounted for during the development process.

5. **External Dependencies:** The project does anticipate reliance on external dependencies or reused software components from other projects. Any dependencies arising during development will be clearly documented and managed accordingly.
6. **Availability of Resources:** It is assumed that the necessary resources, including human resources, budget allocation, and development timelines, will be available and allocated appropriately to support the successful development and completion of the Malayalam Parser project.

## 2.4 External Interface Requirements

### 2.4.1 User Interfaces

The project has the potential to be utilized in various future applications, particularly in educational tools designed for teaching purposes. Additionally, it can serve as a foundation for developing apps focused on language learning, text analysis, and speech recognition. This versatility opens up opportunities for creating interactive and innovative tools that cater to different learning styles and linguistic analysis needs. By leveraging the project's capabilities, we can create user-friendly applications that enhance the learning and analysis experience for users. These applications can play a significant role in promoting the Malayalam language and its usage in various contexts.

### 2.4.2 Hardware Interfaces

The software interacts with the hardware components of the system through various interfaces, each with specific communication protocols. It communicates with the CPU to execute algorithms, process data, and manage computational tasks, utilizing the CPU's instruction set architecture. The software uses RAM for temporary storage of linguistic data, parsing results, and intermediate processing steps, managing memory efficiently for complex linguistic analyses. For long-term storage, the software reads and writes data to the storage device, employing file systems for dataset management and data integrity. Optionally, the software can access external datasets, online resources, or collaboration tools through a network interface, using standard networking protocols such as HTTP or FTP for data exchange. User interaction and data visualization are facilitated through in-

put/output devices such as keyboards, mouse, and monitors, utilizing standard interfaces for user input and output display.

#### **2.4.3 Software Interfaces**

The Malayalam parser integrates with various software components, including databases such as SQLite, PostgreSQL, and MongoDB for data storage and retrieval. It is designed to run on popular operating systems like Windows 10 or later, MacOS 10.13 High Sierra or later, and Ubuntu 18.04 LTS or later. Development and NLP tasks are facilitated by Python (version 3.6 or later) along with libraries like NLTK, Spacy, and TensorFlow. These tools aid in implementing NLP algorithms and processing linguistic data. The system may also include integrated commercial components for specific functionalities, each with its own data formats, configurations, and communication protocols. To ensure consistent data sharing, the system may implement global data areas or standardized data formats, depending on the software components involved. Detailed application programming interface (API) protocols should be referenced for precise communication details.

#### **2.4.4 Communication Interfaces**

The software requires communication functions for fetching inputs from websites, email, and network server communications. It needs to support standard email protocols like SMTP for sending emails, following MIME standards for message formatting. For web scraping, it should interact with web servers using HTTP or HTTPS for secure communication, and handle HTML parsing for extracting data from web pages. Network server communication may require protocols like FTP or SFTP for file transfers, adhering to communication standards for compatibility and security. Secure protocols such as SMTPS, SFTP, or TLS should be used for data transmission, with defined data transfer rates and synchronization mechanisms for efficiency.

### **2.5 System Features**

The system features for the Malayalam Parser are organized to highlight the major services provided by the product:

1. **Text Parsing:** The parser breaks down Malayalam language text into its constituent components such as words, phrases, and sentences.
2. **Grammatical Analysis:** It identifies the parts of speech, syntactic structure, and grammatical relationships within Malayalam sentences.
3. **Semantic Analysis:** The system determines the meaning and interpretation of Malayalam text, capturing semantic relationships between words and phrases.
4. **Part-of-Speech Tagging:** Each word in a Malayalam sentence is assigned appropriate part-of-speech tags, indicating its grammatical function.
5. **Syntactic Parsing:** It analyzes the syntactic structure of Malayalam sentences, identifying constituents and their hierarchical relationships.
6. **Error Handling:** Mechanisms are in place to detect and handle errors or inconsistencies in input Malayalam text, ensuring parsing reliability.
7. **Customization and Extension:** Users can customize and extend the parser with custom linguistic rules, dictionaries, or algorithms for domain-specific parsing tasks.

### 2.5.1 Parsing Malayalam Text

#### Description and Priority

This feature involves analyzing and understanding the linguistic structure of Malayalam text, including sentence segmentation, word tokenization, and part-of-speech tagging. It is of high priority as it forms the core functionality of the system.

#### Stimulus/Response Sequences

Stimulus: User inputs a Malayalam text.

Response: The system parses the text, segments sentences, tokenizes words, and tags parts of speech.

#### Functional Requirements

1. The system shall be able to segment sentences in Malayalam text based on punctuation marks and grammatical rules.

2. The system shall tokenize words in Malayalam text, considering compound words and affixes.
3. The system shall tag each word in Malayalam text with its respective part of speech (e.g., noun, verb, adjective).
4. The system shall handle variations in spelling and word forms commonly found in Malayalam text.
5. The system shall provide error messages for invalid inputs or unsupported characters.
6. The system shall process text efficiently, aiming for a parsing speed of at least X characters per second.
7. The system shall be able to handle text inputs of up to Y characters in length.

### **2.5.2 Lemmatization and Morphological Analysis**

#### **Description and Priority**

This feature involves performing lemmatization to identify the base form of words and morphological analysis to understand the grammatical properties of words. It is of high priority as it enhances the accuracy of language analysis.

#### **Stimulus/Response Sequences**

Stimulus: User inputs a Malayalam word

Response: The system lemmatizes the word and performs morphological analysis to determine its grammatical properties.

#### **Functional Requirements**

1. The system shall lemmatize Malayalam words to identify their base forms.
2. The system shall analyze the morphology of Malayalam words to determine their grammatical properties.

3. The system shall handle variations in word forms and inflections commonly found in Malayalam.
4. The system shall provide error messages for invalid inputs or unsupported characters.
5. The system shall process words efficiently, aiming for a lemmatization speed of at least X words per second.
6. The system shall be able to handle word inputs of up to Y characters in length.

### **2.5.3 Dependency Parsing**

#### **Description and Priority**

Dependency parsing involves identifying the syntactic dependencies between words in a sentence, which is crucial for understanding the relationships within the sentence. It is of high priority as it provides valuable linguistic information for further analysis.

#### **Stimulus/Response Sequences**

Stimulus: User inputs a Malayalam sentence.

Response: The system parses the sentence to identify syntactic dependencies between words.

#### **Functional Requirements**

1. The system shall parse Malayalam sentences to identify syntactic dependencies between words.
2. The system shall generate dependency trees that represent the syntactic structure of parsed sentences.
3. The system shall handle complex sentence structures and dependencies between words.
4. The system shall provide error messages for invalid inputs or unsupported characters.

5. The system shall process sentences efficiently, aiming for a parsing speed of at least X sentences per second.
6. The system shall be able to handle sentence inputs of up to Y characters in length.

#### **2.5.4 Syntax Tree Generation**

##### **Description and Priority**

Syntax tree generation involves creating syntax trees that represent the grammatical structure of sentences. It is of high priority as it provides a visual representation of the sentence's structure, aiding in linguistic analysis.

##### **Stimulus/Response Sequences**

Stimulus: User inputs a Malayalam sentence.

Response: The system analyzes the sentence's grammatical structure and generates a syntax tree.

##### **Functional Requirements**

1. The system shall generate syntax trees for Malayalam sentences based on their grammatical structure.
2. The system shall use standard tree representation formats (e.g., Penn Treebank format) for generated syntax trees.
3. The system shall handle complex sentence structures, including coordination and subordination.
4. The system shall provide options for visualizing syntax trees, such as tree diagrams or textual representations.
5. The system shall process sentences efficiently, aiming for a tree generation speed of at least X trees per second.

### **2.5.5 Semantic Analysis**

#### **Description and Priority**

Semantic Analysis is a critical feature of the system, with a high priority. It involves determining the meaning and interpretation of Malayalam text, capturing semantic relationships between words and phrases.

#### **Stimulus/Response Sequences**

Stimulus: User inputs Malayalam text for analysis.

Response: The system processes the text to extract meaning and semantic relationships.

#### **Functional Requirements**

1. The system shall identify subject-verb-object relationships in Malayalam sentences.
2. It shall detect and interpret negation, conjunctions, and other semantic features in the text.
3. The system shall extract key concepts and entities from the text.
4. It shall handle ambiguous phrases and provide contextually appropriate interpretations.
5. The system shall support the identification of sentiment and emotions expressed in the text.
6. It shall provide an API or interface for developers to access the semantic analysis results.
7. The system shall handle errors gracefully, providing informative messages for incorrect inputs.
8. It shall process text efficiently, aiming for a response time of less than 1 second for short to medium-length texts.
9. It shall be able to process text with a wide range of vocabulary and language complexity levels, including formal and informal language variants.

## **2.5.6 Part-of-Speech tagging**

### **Description and Priority**

Part-of-Speech Tagging is a critical feature of the system, with a high priority. It involves assigning grammatical tags to words in Malayalam sentences, indicating their syntactic role and category.

### **Stimulus/Response Sequences**

Stimulus: User inputs Malayalam text for analysis.

Response: The system processes the text and assigns appropriate part-of-speech tags to each word.

### **Functional Requirements**

1. The system shall identify the part of speech for each word in the input Malayalam text.
2. It shall handle compound words and inflected forms, assigning appropriate tags based on their usage in context.
3. The system shall support standard part-of-speech tag sets for Malayalam, ensuring compatibility with existing linguistic resources.
4. It shall provide an option to output the tagged text in a readable format for users.
5. The system shall be able to handle texts with varying levels of complexity and vocabulary.
6. It shall provide an API or interface for developers to access the tagged text and integrate it into their applications.
7. The system shall handle errors gracefully, providing informative messages for incorrect inputs.

### **2.5.7 Performance Requirements**

#### **Description and Priority**

Performance optimization involves improving the efficiency and speed of the system. It is of low priority as it is desirable but not critical for basic functionality.

#### **Stimulus/Response Sequences**

Stimulus: System performance falls below specified thresholds.

Response: The system implements optimization techniques to improve performance

#### **Functional Requirements**

1. The system shall monitor performance metrics, such as processing speed and resource usage.
2. The system shall identify performance bottlenecks and areas for improvement.
3. The system shall implement optimizations, such as algorithmic improvements or resource management strategies, to enhance performance.
4. The system shall provide configuration options for adjusting performance settings based on user needs

### **2.6 Other Nonfunctional Requirements**

#### **2.6.1 Performance Requirements**

##### **Parsing Malayalam Text**

Rationale: Parsing text should be fast to provide timely analysis for user interactions or batch processing.

Requirement: The system should be able to parse Malayalam text at a rate of at least 1000 characters per second.

## **Lemmatization and Morphological Analysis**

Rationale: Lemmatization and morphological analysis are core linguistic processes that should not introduce significant delays.

Requirement: The system should be able to perform lemmatization and morphological analysis for at least 100 words per second.

## **Dependency Parsing**

Rationale: Dependency parsing is computationally intensive but crucial for understanding sentence structures.

Requirement: The system should be able to perform dependency parsing for at least 50 sentences per second.

## **Syntax Tree Generation**

Rationale: Syntax tree generation requires complex computations and should be efficient for real-time applications.

Requirement: The system should be able to generate syntax trees for at least 20 sentences per second.

## **Semantic Analysis**

Rationale: Semantic analysis involves processing text to understand its meaning, requiring significant computational resources. Efficient performance is crucial for real-time or near real-time applications, such as chatbots or text summarization systems.

Requirement: The system should be able to perform semantic analysis for a minimum of 1000 words per second, ensuring timely and responsive processing for various use cases.

## **Part-of-Speech tagging**

Rationale: Part-of-speech tagging is a fundamental task in natural language processing, providing essential grammatical information about words in a sentence. Efficient tagging is necessary for various downstream tasks such as parsing, machine translation, and information extraction.

Requirement: The system should be able to perform part-of-speech tagging for a minimum of 1000 words per second, ensuring fast and responsive tagging for different text lengths and complexities.

## **Performance Optimization**

Rationale: Performance optimization ensures that the system meets its performance requirements under varying loads and conditions.

Requirement: The system should implement optimization strategies to maintain performance levels even under heavy loads, ensuring that response times do not exceed specified thresholds.

### **2.6.2 Safety Requirements**

Loss, Damage, or Harm Concerns: The product must ensure user and property safety, preventing physical harm or damage. It must also safeguard sensitive data from unauthorized access.

Actions to be Taken: The product should provide clear instructions and warnings to prevent misuse or accidental damage. Regular maintenance and updates are crucial for safe operation.

Actions to be Prevented: Unauthorized modifications and operations that could lead to data loss or corruption should be prevented.

External Policies or Regulations: Compliance with safety standards and regulations is essential, including guidelines from regulatory bodies and industry standards organizations.

Safety Certifications: Obtaining safety certifications demonstrates compliance with standards and builds user trust in the product's safety.

### **2.6.3 Security Requirements**

The system must prioritize the security and privacy of the data used or created by the system. It should implement robust measures to prevent unauthorized access, disclosure, or modification of sensitive information, such as annotated dataset files. User identity authentication should be incorporated to verify the identity of users accessing the system, ensuring that only authorized users can access or modify the dataset files. The system

must comply with external policies and regulations regarding security and privacy issues, adhering to guidelines set by regulatory bodies or industry standards organizations. Obtaining security and privacy certifications is essential to demonstrate compliance with these standards, reassuring users of the parser's commitment to data security and privacy protection.

#### **2.6.4 Software Quality Attributes**

The Malayalam parser for dataset creation must prioritize correctness and reliability, ensuring accurate parsing and consistent results. Maintainability is crucial for easy updates, while usability requires an intuitive interface. Portability enables the parser to run on different platforms, and interoperability allows integration with other NLP components. Testability ensures thorough testing, and adaptability allows for evolving requirements. These characteristics collectively ensure the parser's efficiency, effectiveness, and adaptability.

# **Chapter 3**

## **System Architecture and Design**

### **3.1 System Overview**

The aim of the project to develop a Malayalam parser is to create a system that can effectively process Malayalam text for tasks such as sentiment analysis, named entity recognition, and part-of-speech (POS) tagging. The process begins with data collection, where Malayalam text is gathered from online sources using web scraping techniques. This collected text is then cleaned to remove any irrelevant information, errors, or special characters.

Language filtering is applied in the cleaning phase to ensure the text is in Malayalam. Following data cleaning, the text undergoes preprocessing, which includes tokenization to break the text into individual words or tokens. Stemming is then applied to reduce inflected words to their base form, simplifying the text for analysis. A crucial step is building a training corpus of preprocessed Malayalam text labeled with the desired information, such as sentiment labels, named entities, and part-of-speech tags. Features are extracted from the preprocessed text and serve as inputs to the machine learning model. A suitable machine learning model is selected and trained on the extracted features and labeled training data. The model's performance is evaluated on a separate set of data to assess its accuracy and effectiveness on new, unseen data. Finally, the trained model is used to process new Malayalam text, tagging it with sentiment labels, named entities, part-of-speech tags, or other relevant information. Linguists can add custom rules to refine the model's output for better accuracy.

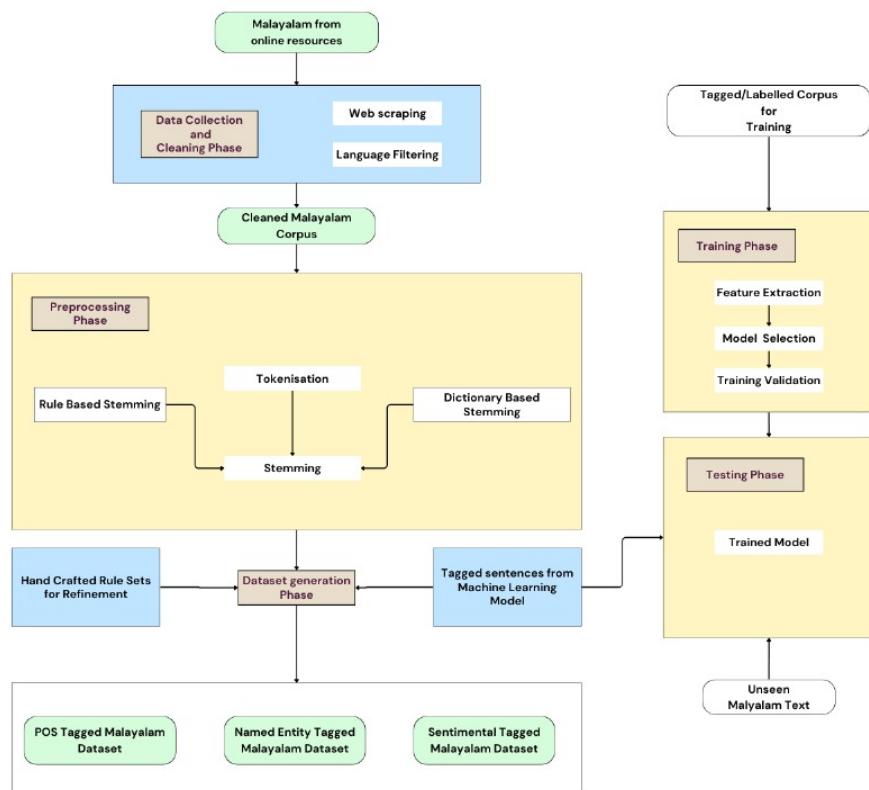
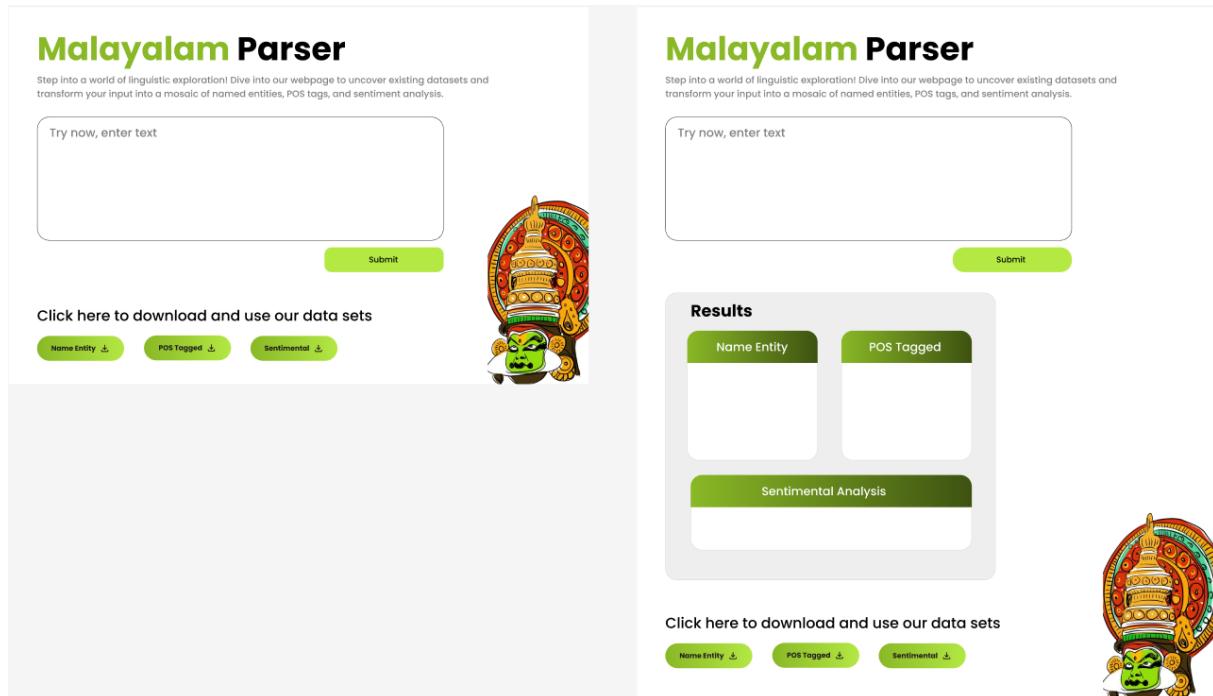


Figure 3.1: Architecture diagram

### 3.2 User Interface Design



# Malayalam Parser

Step into a world of linguistic exploration! Dive into our webpage to uncover existing datasets and transform your input into a mosaic of named entities, POS tags, and sentiment analysis.

Try now, enter text

Submit

[Click here to download and use our data sets](#)

Name Entity ↴

POS Tagged ↴

Sentimental ↴



Figure 3.2: Landing page

# Malayalam Parser

Step into a world of linguistic exploration! Dive into our webpage to uncover existing datasets and transform your input into a mosaic of named entities, POS tags, and sentiment analysis.

Try now, enter text

Submit

## Results

Name Entity

POS Tagged

Sentimental Analysis



[Click here to download and use our data sets](#)

Name Entity ↴

POS Tagged ↴

Sentimental ↴

Figure 3.3: Result page

### **3.3 Description of Implementation Strategies**

The implementation strategies for the project are as follows:

- Data Acquisition and Cleaning:

1. Web Scraping:

- Utilize libraries like BeautifulSoup or Scrapy (Python) to scrape relevant Malayalam websites.
- Define target URLs and develop scraping logic for text extraction.
- Implement techniques to handle pagination or dynamic content loading (if applicable).

2. Language Filtering:

- Implement language detection using libraries like langdetect or textblob (Python) to identify non-Malayalam text.
- Set a threshold or confidence score to filter out content below a certain level of Malayalam probability.

- Data Preprocessing:

1. Tokenization: Choose a suitable tokenization method (word-based, sentence-based, etc.) using libraries like NLTK or spaCy (Python).
2. Handling Non-Textual Elements: Develop logic for managing emojis or other non-textual elements (e.g., removal, special token representation).
3. Stop Word Removal: Implement stop word removal based on a created or located Malayalam stop word list.
4. Stemming or Lemmatization: Use libraries like NLTK or spaCy for stemming (reducing words to root forms) or lemmatization (finding dictionary base forms). Explore specific stemming/lemmatization algorithms if necessary for Malayalam.

- Sentiment Analysis:

1. Model Selection (if applicable): Consider factors like data size, desired accuracy, and computational resources when choosing a model (e.g., Logistic Regression, Naive Bayes, SVM, RNNs).
  2. Data Splitting (if applicable): Split the preprocessed data into training, validation, and testing sets for model development.
  3. Model Training and Tuning (if applicable): Implement hyperparameter tuning to optimize model performance during training.
  4. Evaluation (if applicable): Evaluate the trained sentiment analysis model's performance on the unseen testing data set. Analyze the results and identify areas for improvement in data quality or model architecture.
- Additional Considerations:
    1. Data Storage and Management: Consider implementing data loading/saving functions for various formats (text files, CSV, etc.) if needed for further analysis.
    2. Version Control: Utilize a version control system (e.g., Git) to track code changes and facilitate collaboration.
    3. Testing: Implement unit tests for critical functions and integration tests to ensure the entire NLP pipeline functions as expected.
    4. Logging: Implement logging functionalities to track code execution progress and identify potential issues.

### 3.4 Module Division

- Module 1: Data Collection and Preprocessing (Mohammed Basil)
  - Data Acquisition: Collect Malayalam text data from various sources such as websites, documents, or databases.
  - Data Cleaning: Preprocess collected data to remove noise, inconsistencies, or irrelevant information.
  - Language Identification: Determine the language of the text to ensure only Malayalam language text is processed.

- Tokenization: Divide the preprocessed text into individual tokens or words following Malayalam language rules and conventions.
- Module 2: UI Design (Godwin Gino)
  - User Interface Components: Design and implement user interface elements such as input fields, buttons, text areas, and output displays.
  - Interaction Logic: Manage user interactions, including event handling, input validation, and feedback mechanisms.
  - Layout and Styling: Define layout structure, visual design, and styling for an intuitive and aesthetically pleasing user experience.
- Module 3: Rule Set Generation (Fathima Jennath)
  - Rule Extraction: Extract linguistic rules and patterns from annotated data or linguistic resources specific to Malayalam language parsing.
  - Rule Representation: Represent extracted rules in a formal format suitable for integration into the parsing module.
  - Rule Validation and Optimization: Validate generated rules for accuracy and completeness, optimizing them for efficient parsing of Malayalam text.
- Module 4: Machine Learning and Dataset Generation (Gautham C Sudheer)
  - Dataset Collection and Annotation: Acquire or generate a dataset of Malayalam text samples, annotating them with linguistic information.
  - Feature Extraction: Identify relevant features or attributes from the annotated dataset using techniques like bag-of-words or word embeddings.
  - Model Training and Evaluation: Train machine learning models for tasks such as part-of-speech tagging or named entity recognition, evaluating their performance using metrics like accuracy.

### 3.5 Work Schedule - Gantt Chart

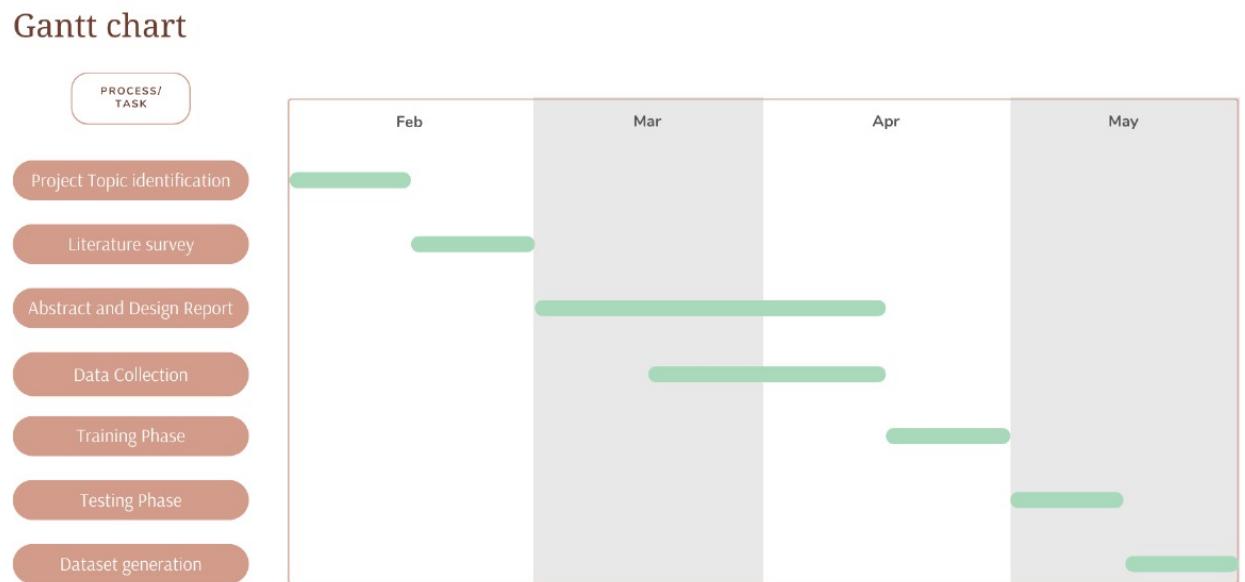


Figure 3.4: Work Schedule-Gantt chart

# Chapter 4

## Results and Discussions

### 4.1 Overview

Our project provides three essential datasets for Malayalam text analysis: POS-tagged, named entity labeled, and sentiment labeled. We include POS tag information along with dataset examples to enhance understanding. The implementation of the parser involved the use of the translation method. Although efforts to improve accuracy with rules and machine learning were not integrated due to accuracy concerns, this remains a future goal. Overall, the project has established a foundation for processing and analyzing Malayalam text, with potential implications for advancing NLP applications in Malayalam.

### 4.2 Testing

**Malayalam Parser**

Step into a world of linguistic exploration! Dive into our webpage to uncover existing datasets and transform your input into a mosaic of named entities, POS tags, and sentiment analysis.

മലയാളം നാമവാക്യങ്ങൾ വാച്ചിനും പദങ്ങളിൽ സ്വർഗ്ഗവാക്യം കൊണ്ട് വിവരങ്ങൾ തുറന്നുവരുന്നതിന് മുൻഭേദ സഹായം ചെയ്യുന്നു।

Entity	Tag
സ്വർഗ്ഗവാക്യം	Organization
കൊണ്ട്	Person

Token	POS Tag
സ്വർഗ്ഗവാക്യം	Proper Noun
കൊണ്ട്	Verb
സ്വർഗ്ഗവാക്യം	Noun
കൊണ്ട്	Verb
കൊണ്ട്	Proper Noun
കൊണ്ട്	Pronoun
സ്വർഗ്ഗവാക്യം	Adjective
കൊണ്ട്	Verb
കൊണ്ട്	Adverb

Sentimental Analysis
Positive

[Click here to download and use our data sets](#)

[Named Entity](#) [POS Tagged](#) [Sentimental](#)



Figure 4.1: Malayalam Parser Output

## Malayalam Parser

Step into a world of linguistic exploration! Dive into our webpage to uncover existing datasets and transform your input into a mosaic of named entities, POS tags, and sentiment analysis.

Mary was awarded the best student at Rajagiri College.



Entity	Tag
Mary	Person
Rajagiri College	Organization

Token	POS Tag
Mary	Proper Noun
was	Auxiliary
awarded	Verb
the	Determiner
best	Adjective
student	Noun
at	Adposition
Rajagiri	Proper Noun
College	Proper Noun
.	Punctuation

Sentimental Analysis
Positive

[Click here to download and use our data sets](#)

[Named Entity ↴](#)

[POS Tagged ↴](#)

[Sentimental ↴](#)

Figure 4.2: English Parser Output

## Malayalam Parser

[Explore More](#)

### NOUN

A noun is a word that names a person, place, thing, or idea. It's like a label we use for everything around us. For example, "dog," "cat," "house," and "love" are all nouns. Nouns can be common, like "book" or "table," which are general things, or they can be proper, like "Mary" or "London," which are specific names. In a sentence, nouns can be the subject (the thing doing the action) or the object (the thing receiving the action). They help us talk about the world and communicate with others.

### നാമം

നാമം എന്നും, സ്വാഹാ, ഗാന്ധി അദ്ദേഹിക്ക അനുഭവിക്കുന്നതു, നാമങ്ങൾ, സ്വാധാരണ പരമ്പരാഗത പരാശ്രാംക പരാശ്രാംക (ഉന്നതാനോന്തിൻ, പ്രാശ്രാംക, ദാനിൾ), നാലുപ്പതിൽ ഒന്പത് മാര്യ, മെരുക്കളുടെ പരാശ്രാംക (അനുഭവാന്തിൻ, മരി, മാരാട്) എന്നീവയാണ്. നാമങ്ങൾ ദാനുത്തിൻ (പ്രധാന അനുഭവാന്ത പരാശ്രാംക കാര്യം വിശദിക്കുന്നു. അഥവാ ദാനു (വൈജ്ഞാനിക അനുഭവാന്ത പരാശ്രാംക (വിശദിക്കുന്നു. എന്തു ഫോറിനേറേഷൻ ഉപയോഗിച്ചും, നാമങ്ങൾ നമ്മുടെ ആഖ്യാനങ്ങളും അനുഭവാന്തകളുമുണ്ട്. പ്രധാനമായി സാഹചര്യക്കാനുള്ള പരാശ്രാംകമുണ്ട്. വൈജ്ഞാനിക

### ഉദ്ദേശ്യസംബന്ധം

- അനുഭവാന്ത
- പിരി
- മഹി
- മാരാട്
- പാശ്രാംക
- ദാനിൾ



Figure 4.3: Description of POS tags(eg-Noun)

30

# Malayalam Parser

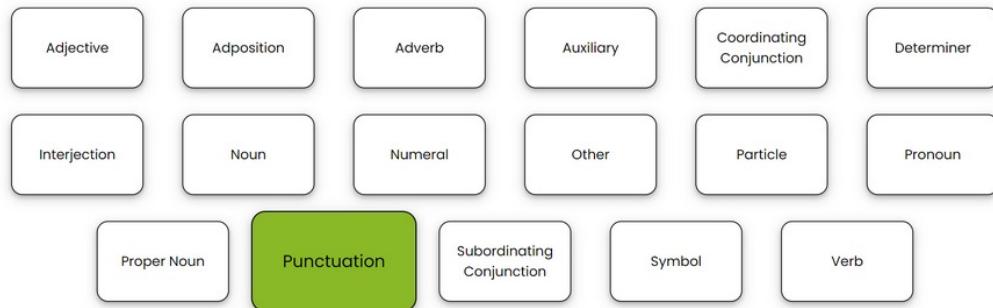


Figure 4.4: Different POS tags

Figure 4.5: POS tagged malayalam dataset

### 4.3 Discussion

The project has developed a Malayalam Parser for Dataset Creation. However, due to timing constraints, integrating the rule-based and machine learning-based approach remains a future enhancement.

The project's deviation from its initial goal of integrating rules and machine learning underscores the challenges in accurately processing Malayalam text. Factors such as the

language's linguistic complexities and the limited availability of annotated data likely contributed to this deviation. Nevertheless, creating valuable datasets represents a significant step toward overcoming the shortage of resources for NLP in Malayalam.

# **Chapter 5**

## **Conclusion**

### **5.1 Conclusion**

The project aimed to develop a Malayalam Parser for Dataset Creation, focusing on tasks such as part-of-speech tagging, named entity recognition, and sentiment analysis. The main goal was to create annotated datasets for Malayalam NLP applications, which are currently scarce. The system provides POS-tagged, named entity labeled, and sentiment labeled datasets. It has a user-friendly interface for inputting Malayalam text and getting analyzed results. This parser helps with various applications, including sentiment analysis, translation, and summarization, making it easier to work with Malayalam text in technology. It also supports research and learning in NLP and Malayalam linguistics, offering valuable resources for scholars and developers.

The creation of this Malayalam Parser is a significant step forward in developing linguistic tools for the Malayalam language. By providing annotated datasets and robust analysis capabilities, the project not only preserves and promotes Malayalam but also opens new opportunities for technology applications in Malayalam-speaking regions. Future work includes improving accuracy by refining machine learning models and integrating them with handcrafted rules, expanding the dataset with more diverse examples, and handling complex linguistic structures in Malayalam. This project lays a strong foundation for future enhancements and broader applications, ensuring Malayalam remains a vital part of the technological landscape.

## **5.2 Future Scope**

In future developments, the Malayalam parser project could explore advanced parsing techniques such as dependency parsing or deep learning to enhance accuracy and robustness. Implementing a rule-based parsing approach specific to Malayalam, with defined grammatical rules and patterns, could further improve parsing accuracy. A hybrid approach that combines rule-based and machine learning techniques could be beneficial, leveraging the strengths of both methodologies. Implementing error correction mechanisms to handle inaccuracies in parsing results, along with user feedback options to improve the parser's quality, and engaging with linguists, researchers, and the local community for feedback and validation, will be essential for prioritizing future development efforts.

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## **Appendix A: Presentation**



# **Malayalam Parser for Dataset Creation**

Guided by:  
Dr. Mary Priya Sebastian

Fathima Jennath  
Gautham C Sudheer  
Godwin Gino  
Mohammed Basil



## **Contents**

- Introduction
- Problem Definition
- Objectives
- Scope and Relevance
- System Design
- Work Division – Gantt Chart
- Software/Hardware Requirements
- Results
- Conclusion
- Future Enhancements
- References

## Introduction

---

- Importance of Natural Language Processing (NLP) in regional languages
- Focus on the specific relevance of Malayalam in the context of NLP applications.
- Challenges associated with the scarcity of annotated datasets.
- Analyze both the syntactic and semantic structures of Malayalam sentences
- Applications such as sentiment analysis, named entity recognition, etc.
- Potential impact on advancing research and applications specific to the Malayalam

## Problem Definition

---

To create a Malayalam Parser for dataset creation, involving data collection, preprocessing, manual annotation, and training using various parsing approaches to address the scarcity of annotated datasets in Malayalam for NLP applications.

## Objectives

---

- Data Collection
  - a) Gather text data from diverse sources in Malayalam language
  - b) Aim for a sufficient volume of data to represent the language's usage patterns adequately
- Data Preprocessing
  - a) Perform tokenization, normalization, and cleaning of the collected data
  - b) Handle any inconsistencies or noise in the data to ensure quality

## Objectives

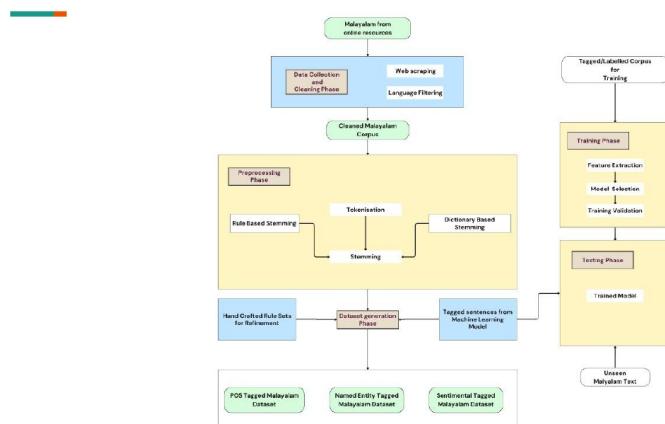
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- Manual Annotation
  - a. Annotate a representative subset of the preprocessed data with grammatical and syntactic information
  - b. Employ linguistic experts or proficient annotators to ensure accurate annotations.
- Parser Development
  - a. Train the parser using the annotated dataset to understand Malayalam syntax and semantics

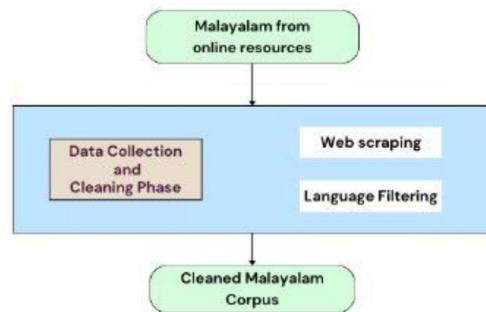
## Scope and Relevance

- Address the scarcity of annotated datasets in the Malayalam language for Natural Language Processing (NLP) applications.
- Analysis of grammatical structures in Malayalam text data.
- Contributing to the overall improvement of Malayalam language processing technologies.
- Does not include specific application development for sentiment analysis, named entity recognition, or machine translation.

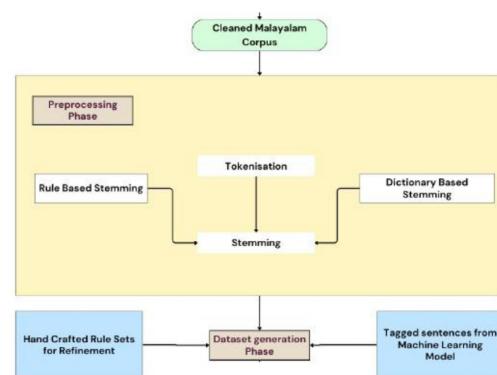
## System Design



## Data Collection and Cleaning Phase



## Data Preprocessing



Prepositions- (?:\b(?:ഉപസർഗങ്ങൾ)\b)

Conjunctions- \b(?:ഉം|അരല്ലുകിൽ|അമവാ|അല്ല|അതിനും|അങ്ങേനെ)\b

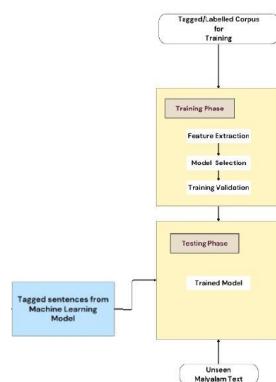
Determiners - \b(?:

ഈ|അത്|അതിന്റെ|ഇവയ്ക്ക്|അവയ്ക്ക്|ആ|അവന്റെ)\b

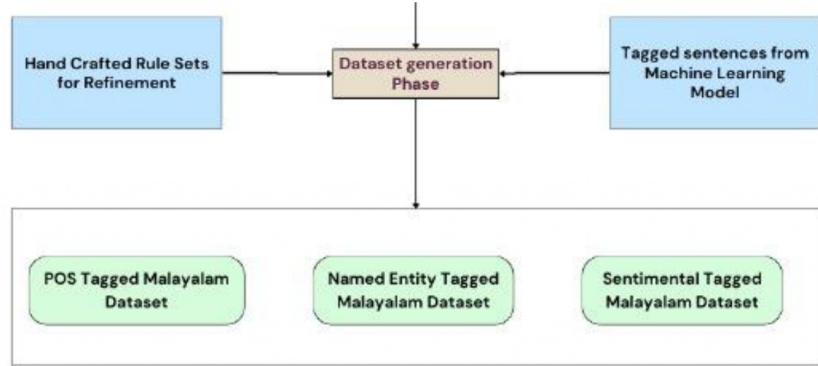
Pronouns-\b(?)

തൊൻ്റീ|നീ|അവൻ|അവൾ|അത്|തെങ്ങൾ|അവർ|എന്തേ|നിന്തേ|അവർക്ക്|എന്തേ|അവർക്ക്|ആർ|എത്തോന്തെ|എത്താണ്ട്)\b

## Training and Testing

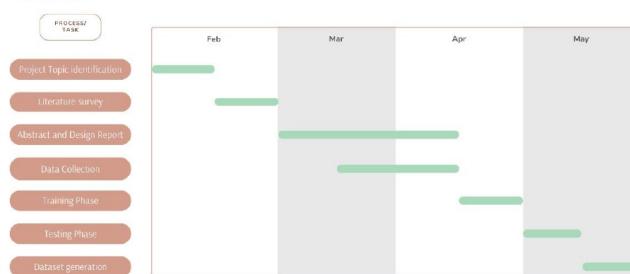


## Output



## Work Division

Gantt chart



## Software / Hardware Requirements

- Windows 10 or later
- MacOS 10.13 High Sierra or later
- Ubuntu 18.04 LTS or later
- A modern processor (e.g., Intel Core i5 or equivalent)
- Sufficient RAM (at least 4GB)
- Available storage space for software installation
- Python (version 3.6 or later)
- Other programming languages and frameworks suitable for NLP development like NLTK, spaCy, scikit-learn, TensorFlow, etc. may be necessary

## Results

### Malayalam Parser

Step into a world of linguistic exploration! Dive into our webpage to uncover existing datasets and transform your input into a mosaic of named entities, POS tags, and sentiment analysis.

മന്ത്രി	Entity	Tag
മന്ത്രി		Organization
കെ.എസ്		Person
കെ.എസ്	Token	POS Tag
മന്ത്രി		Proper Noun
കെ.എസ്		Verb
കെ.എസ്		Noun
കെ.എസ്		Verb
കെ.എസ്		Proper Noun
കെ.എസ്		Pronoun
കെ.എസ്		Adjective
കെ.എസ്		Verb
കെ.എസ്		Adverb
Sentimental Analysis		
Positive		



Click here to download and use our data sets

[Named Entity ↴](#) [POS Tagged ↴](#) [Sentimental ↴](#)

## Results

## Malayalam Parser

Step into a world of linguistic exploration! Dive into our webpage to uncover existing datasets and transform your input into a mosaic of named entities, POS tags, and sentiment analysis.

Mary was awarded the best student of Rajagiri College.		Submit
Entity		Tag
Mary		Person
Rajagiri College		Organization
Token		POS Tag
Mary		Proper Noun
was		Auxiliary
awarded		Verb
the		Determiner
best		Adjective
student		Noun
of		Adposition
Rajagiri		Proper Noun
College		Proper Noun
.		Punctuation
Sentimental Analysis		
Positive		



## Results

## Malayalam Parser

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## NOUN

A noun is a word that names a person, place, thing, or idea. It's like a label we use for everything around us. For example, "dog," "cat," "house," and "love" are all nouns. Nouns can be common, like "book" or "table," which are general things, or they can be proper, like "Mary" or "London," which are specific names. In a sentence, nouns can be the subject (the thing doing the action) or the object (the thing receiving the action). They help us talk about the world and communicate with others.

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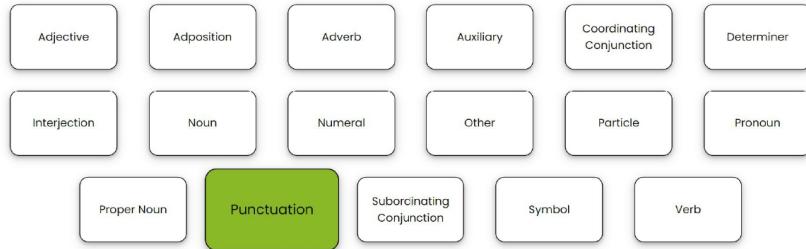


ଓଡ଼ିଆ

- നാട്ടുവാസി
  - വീട്
  - കുടി
  - ദാനാദാർ
  - പല്ല
  - രംഗാചാരൻ

## Results

### Malayalam Parser



## Results

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- Implemented basic functionality for processing Malayalam text, including extracting entities, part-of-speech (POS) tags, and sentiment analysis
- Integration with external services such as Google Translator and TextBlob has enabled language translation and sentiment analysis capabilities
- Detect whether the input text is in Malayalam or English, enabling appropriate processing based on the language
- Processed data, including entities, POS tags, and sentiment analysis results, are stored in CSV files for further analysis and reference.

## Results

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- A basic user interface (UI) is provided through a Django web application, allowing users to input text and receive processed results
- Includes educational resources that provide descriptions and examples for various parts-of-speech (POS) tags in the Malayalam language. These pages serve as valuable reference materials for users interested in understanding the linguistic nuances of Malayalam text

## Future Enhancements

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- Explore and implement more advanced parsing techniques, such as dependency parsing or deep learning, to enhance the accuracy and robustness
- Implementing a rule-based parsing approach that involves defining grammatical rules and patterns specific to the Malayalam language to improve parsing accuracy and coverage
- Exploring a hybrid approach that combines rule-based and ML techniques to leverage the strengths of both methodologies. For example, using rule-based parsing for deterministic tasks and ML models for probabilistic tasks to achieve a balance between accuracy and flexibility.

## Future Enhancements

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- Implement error correction mechanisms to handle inaccuracies in the parsing results and provide users with feedback options to report errors and improve the quality of the parser over time
- Incorporate language-specific features and linguistic resources tailored to Malayalam, such as lexicons, morphological analyzers, and syntactic parsers
- Engaging with linguists, researchers, and the local community to gather feedback, validate parsing results, and prioritize future development efforts

## Conclusion

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A comprehensive Malayalam language processing tool facilitating accurate linguistic analysis and dataset generation for NLP applications.

- Parsing and analysis of Malayalam text, enabling identification of linguistic components and determination of grammatical structure, syntax, and semantics
- Generates part-of-speech tagged, named entity, and sentiment-tagged datasets
- Contribute significantly to the advancement of language processing technologies in Malayalam.

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

**DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING  
RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)  
RAJAGIRI VALLEY, KAKKANAD, KOCHI, 682039  
(Affiliated to APJ Abdul Kalam Technological University)**



## **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**

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

#### **CO1:**

Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)

**CO2:**

Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)

**CO3:**

Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)

**CO4:**

Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)

**CO5:**

Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)

## **Appendix C: CO-PO-PSO Mapping**

## COURSE OUTCOMES:

After completion of the course the student will be able to

<b>SL. NO</b>	<b>DESCRIPTION</b>	<b>Blooms' Taxonomy Level</b>
CO1	Identify technically and economically feasible problems (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO2	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO3	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions of minimal complexity by using modern tools & advanced programming techniques (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO4	Prepare technical report and deliver presentation (Cognitive Knowledge Level: Apply)	Level 3: Apply
CO5	Apply engineering and management principles to achieve the goal of the project (Cognitive Knowledge Level: Apply)	Level 3: Apply

## CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PS O3
C O1	3	3	3	3		2	2	3	2	2	2	3	2	2	2
C O2	3	3	3	3	3	2		3	2	3	2	3	2	2	2
C O3	3	3	3	3	3	2	2	3	2	2	2	3			2
C O4	2	3	2	2	2			3	3	3	2	3	2	2	2
C O5	3	3	3	2	2	2	2	3	2		2	3	2	2	2

3/2/1: high/medium/low

## JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
101003/CS6 22T.1-PO1	<b>HIGH</b>	Identify technically and economically feasible problems by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS6 22T.1-PO2	<b>HIGH</b>	Identify technically and economically feasible problems by analysing complex engineering problems reaching substantiated conclusions using first principles of mathematics.
101003/CS6 22T.1-PO3	<b>HIGH</b>	Design solutions for complex engineering problems by identifying technically and economically feasible problems.
101003/CS6 22T.1-PO4	<b>HIGH</b>	Identify technically and economically feasible problems by analysis and interpretation of data.
101003/CS6 22T.1-PO6	<b>MEDIUM</b>	Responsibilities relevant to the professional engineering practice by identifying the problem.
101003/CS6 22T.1-PO7	<b>MEDIUM</b>	Identify technically and economically feasible problems by understanding the impact of the professional engineering solutions.
101003/CS6 22T.1-PO8	<b>HIGH</b>	Apply ethical principles and commit to professional ethics to identify technically and economically feasible problems.
101003/CS6 22T.1-PO9	<b>MEDIUM</b>	Identify technically and economically feasible problems by working as a team.
101003/CS6 22T.1-PO10	<b>MEDIUM</b>	Communicate effectively with the engineering community by identifying technically and economically feasible problems.
101003/CS6 22T.1-P011	<b>MEDIUM</b>	Demonstrate knowledge and understanding of engineering and management principles by selecting the technically and economically feasible problems.
101003/CS6 22T.1-PO12	<b>HIGH</b>	Identify technically and economically feasible problems for long term learning.
101003/CS6 22T.1-PSO1	<b>MEDIUM</b>	Ability to identify, analyze and design solutions to identify technically and economically feasible problems.
101003/CS6 22T.1-PSO2	<b>MEDIUM</b>	By designing algorithms and applying standard practices in software project development and Identifying technically and economically feasible problems.
101003/CS6 22T.1-PSO3	<b>MEDIUM</b>	Fundamentals of computer science in competitive research can be applied to Identify technically and economically feasible problems.
101003/CS6 22T.2-PO1	<b>HIGH</b>	Identify and survey the relevant by applying the knowledge of mathematics, science, engineering fundamentals.

101003/CS6 22T.2-PO2	<b>HIGH</b>	Identify, formulate, review research literature, and analyze complex engineering problems get familiarized with software development processes.
101003/CS6 22T.2-PO3	<b>HIGH</b>	Design solutions for complex engineering problems and design based on the relevant literature.
101003/CS6 22T.2-PO4	<b>HIGH</b>	Use research-based knowledge including design of experiments based on relevant literature.
101003/CS6 22T.2-PO5	<b>HIGH</b>	Identify and survey the relevant literature for getting exposed to related solutions and get familiarized with software development processes by using modern tools.
101003/CS6 22T.2-PO6	<b>MEDIUM</b>	Create, select, and apply appropriate techniques, resources, by identifying and surveying the relevant literature.
101003/CS6 22T.2-PO8	<b>HIGH</b>	Apply ethical principles and commit to professional ethics based on the relevant literature.
101003/CS6 22T.2-PO9	<b>MEDIUM</b>	Identify and survey the relevant literature as a team.
101003/CS6 22T.2-PO10	<b>HIGH</b>	Identify and survey the relevant literature for a good communication to the engineering fraternity.
101003/CS6 22T.2-PO11	<b>MEDIUM</b>	Identify and survey the relevant literature to demonstrate knowledge and understanding of engineering and management principles.
101003/CS6 22T.2-PO12	<b>HIGH</b>	Identify and survey the relevant literature for independent and lifelong learning.
101003/CS6 22T.2-PSO1	<b>MEDIUM</b>	Design solutions for complex engineering problems by Identifying and survey the relevant literature.
101003/CS6 22T.2-PSO2	<b>MEDIUM</b>	Identify and survey the relevant literature for acquiring programming efficiency by designing algorithms and applying standard practices.
101003/CS6 22T.2-PSO3	<b>MEDIUM</b>	Identify and survey the relevant literature to apply the fundamentals of computer science in competitive research.
101003/CS6 22T.3-PO1	<b>HIGH</b>	Perform requirement analysis, identify design methodologies by using modern tools & advanced programming techniques and by applying the knowledge of mathematics, science, engineering fundamentals.
101003/CS6 22T.3-PO2	<b>HIGH</b>	Identify, formulate, review research literature for requirement analysis, identify design methodologies and develop adaptable & reusable solutions.

101003/CS6 22T.3-PO3	<b>HIGH</b>	Design solutions for complex engineering problems and perform requirement analysis, identify design methodologies.
101003/CS6 22T.3-PO4	<b>HIGH</b>	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS6 22T.3-PO5	<b>HIGH</b>	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools.
101003/CS6 22T.3-PO6	<b>MEDIUM</b>	Perform requirement analysis, identify design methodologies and assess societal, health, safety, legal, and cultural issues.
101003/CS6 22T.3-PO7	<b>MEDIUM</b>	Understand the impact of the professional engineering solutions in societal and environmental contexts and Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions.
101003/CS6 22T.3-PO8	<b>HIGH</b>	Perform requirement analysis, identify design methodologies and develop adaptable & reusable solutions by applying ethical principles and commit to professional ethics.
101003/CS6 22T.3-PO9	<b>MEDIUM</b>	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS6 22T.3-PO10	<b>MEDIUM</b>	Communicate effectively with the engineering community and with society at large to perform requirement analysis, identify design methodologies.
101003/CS6 22T.3-PO11	<b>MEDIUM</b>	Demonstrate knowledge and understanding of engineering requirement analysis by identifying design methodologies.
101003/CS6 22T.3-PO12	<b>HIGH</b>	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by analysis, identify design methodologies and develop adaptable & reusable solutions.
101003/CS6 22T.3-PSO3	<b>MEDIUM</b>	The ability to apply the fundamentals of computer science in competitive research and prior to that perform requirement analysis, identify design methodologies.
101003/CS6 22T.4-PO1	<b>MEDIUM</b>	Prepare technical report and deliver presentation by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS6 22T.4-PO2	<b>HIGH</b>	Identify, formulate, review research literature, and analyze complex engineering problems by preparing technical report and deliver presentation.

101003/CS6 22T.4-PO3	<b>MEDIUM</b>	Prepare Design solutions for complex engineering problems and create technical report and deliver presentation.
101003/CS6 22T.4-PO4	<b>MEDIUM</b>	Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions and prepare technical report and deliver presentation.
101003/CS6 22T.4-PO5	<b>MEDIUM</b>	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and Prepare technical report and deliver presentation.
101003/CS6 22T.4-PO8	<b>HIGH</b>	Prepare technical report and deliver presentation by applying ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
101003/CS6 22T.4-PO9	<b>HIGH</b>	Prepare technical report and deliver presentation effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.
101003/CS6 22T.4-PO10	<b>HIGH</b>	Communicate effectively with the engineering community and with society at large by prepare technical report and deliver presentation.
101003/CS6 22T.4-PO11	<b>MEDIUM</b>	Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work by prepare technical report and deliver presentation.
101003/CS6 22T.4-PO12	<b>HIGH</b>	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change by prepare technical report and deliver presentation.
101003/CS6 22T.4-PSO1	<b>MEDIUM</b>	Prepare a technical report and deliver presentation to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas.
101003/CS6 22T.4-PSO2	<b>MEDIUM</b>	To acquire programming efficiency by designing algorithms and applying standard practices in software project development and to prepare technical report and deliver presentation.
101003/CS6 22T.4-PSO3	<b>MEDIUM</b>	To apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs by preparing technical report and deliver presentation.
101003/CS6 22T.5-PO1	<b>HIGH</b>	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
101003/CS6 22T.5-PO2	<b>HIGH</b>	Identify, formulate, review research literature, and analyze complex engineering problems by applying engineering and management principles to achieve the goal of the project.

101003/CS6 22T.5-PO3	<b>HIGH</b>	Apply engineering and management principles to achieve the goal of the project and to design solutions for complex engineering problems and design system components or processes that meet the specified needs.
101003/CS6 22T.5-PO4	<b>MEDIUM</b>	Apply engineering and management principles to achieve the goal of the project and use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
101003/CS6 22T.5-PO5	<b>MEDIUM</b>	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools and to apply engineering and management principles to achieve the goal of the project.
101003/CS6 22T.5-PO6	<b>MEDIUM</b>	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities by applying engineering and management principles to achieve the goal of the project.
101003/CS6 22T.5-PO7	<b>MEDIUM</b>	Understand the impact of the professional engineering solutions in societal and environmental contexts, and apply engineering and management principles to achieve the goal of the project.
101003/CS6 22T.5-PO8	<b>HIGH</b>	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice and to use the engineering and management principles to achieve the goal of the project.
101003/CS6 22T.5-PO9	<b>MEDIUM</b>	Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings and to apply engineering and management principles to achieve the goal of the project.
101003/CS6 22T.5-PO11	<b>MEDIUM</b>	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 and to apply engineering and management principles to achieve the goal of the project.
101003/CS6 22T.5-PO12	<b>HIGH</b>	Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change and to apply engineering and management principles to achieve the goal of the project.
101003/CS6 22T.5-PSO1	<b>MEDIUM</b>	The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas. Apply engineering and management principles to achieve the goal of the project.

101003/CS6 22T.5-PSO2	<b>MEDIUM</b>	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 and to apply engineering and management principles to achieve the goal of the project.
101003/CS6 22T.5-PSO3	<b>MEDIUM</b>	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 and apply engineering and management principles to achieve the goal of the project.

