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A Survey on Natural Language Processing and its Applications

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***Abstract*— Advancements in technologies and the internet help to pave the way to collect and store unstructured data which includes voice, etc. The use of unstructured data in an efficient manner helps to understand the insight of the data and make a decision based on the data. To analyse the unstructured data, natural language processing (NLP) is applied. NLP referred to a subcategory of AI that mainly focus on computers understanding, and interpreting human being language. NLP is developed by combing different fields like linguistics, and computer science which helps the computer to perform as a human does in process in speech and text data. NLP is mostly applied in the application areas like content categorization, contextual extraction, sentiment analysis, document summarization, Machine translation, etc. The objective of the research is to perform an in-depth study about the NLP, its methodology, and applications area with pros and cons. Further, this survey helps new researchers to easily understand the underlying concepts of NLP and its terms.**

Keywords*— *Natural Language Processing, Natural Language Components, Artificial Intelligence, Text, Data

I. INTRODUCTION

Computer science and artificial intelligence's field of natural language processing (NLP) aims to develop methods that will allow machines to recognise, comprehend, and produce human language. The goal of the field of research known as "natural language processing" (NLP) is to educate computers how to understand and communicate with human language **[1]**. When computational linguistics researchers tried to utilise computers to process and analyse human language, NLP was born in the 1950s. The creation of rule-based systems, which aimed to capture both the structure of language and the way that words may be joined to make sentences, was one of the first attempts at natural language processing. In its history, Natural Language Processing (NLP) has seen a remarkable transformation, driven by advancements in computer hardware, software, and linguistic theories. The most significant turning points in the development of NLP include the following: The first rule-based systems were in the 1950s and 1960s, academics developed rule-based systems to imitate the syntax and rules of language. These rule-based systems were referred to be "early" methods based on statistics. In the 1980s, statistical methods became more and more prevalent in the field of natural language processing (NLP), notably in applications like voice recognition and machine translation. Learning by Machine: The importance of learning by machine approaches in the field of natural language processing (NLP) grew in the 1990s and 2000s. Researchers created models that are capable of automatically deciphering patterns and rules from enormous volumes of data rather than depending on expert-crafted rules. Deeper Learning: Deep learning technologies, most notably deep neural networks, were introduced in the decade of the 2010s, beginning to change natural language processing. These models may acquire more intricate patterns and representations from unstructured text input, which has the potential to significantly enhance fields like language modelling, sentiment analysis, and machine translation. In recent years, the field of natural language processing (NLP) has seen a rise in popularity of pre-trained language models like GPT and BERT **[2]**. These models may be adjusted for a variety of tasks and are trained on enormous volumes of text data, yielding state-of-the-art results on several benchmarks for natural language processing. Natural language processing (NLP) has developed throughout time to include a variety of strategies and techniques, including those based on machine learning and statistical analysis. NLP has become an essential part of many contemporary technologies, including search engines, chatbots, and virtual assistants, as a result of the growth in the availability of vast volumes of text data and the development of more complex algorithms. Some of the most significant benefits of using NLP are the ones listed below: 1. Increased effectiveness 2. Increased accuracy 3. Additional viewpoints 4. Increased dialogue 5. Accessibility. NLP is mostly applied in the application areas like content categorization, contextual extraction, sentiment analysis, document summarization,

Machine translation, etc. [4]. The purpose is to know about natural language processing, its methods, applications, and advantages and disadvantages is the aim of the study. The remainder of the article is structured. 2. NLP components, 3. NLP applications, 4. NLP challenges, and 5. Concluding remarks.

II. COMPONENTS OF NLP

The natural language processing components can be classified into two types; one is Natural Language understanding and the other one is Natural Language Generation. In NLU, it contains Phonology, Morphology, Pragmatics, Syntax and semantics. Likewise in NFG, it contain Natural language Text. These structured representations may be put to use in a variety of downstream applications, including text summarization, sentiment analysis, chatbots, and many more [5].

A. Natural Language Understanding(NLU)

Natural language understanding (NLU) is a tough area since it requires dealing with the complexity and ambiguity of natural language, which can change significantly based on the context, cultural references, and idiomatic phrases. On the other hand, developments in NLU are propelling considerable progress in the creation of intelligent conversational agents and enhancing the precision and effectiveness of a wide variety of text-based applications.

a) Phonology:

Phonology is a discipline of linguistics that studies language sound organization. This discipline studies linguistic phonemes and their distribution and trends. Phonology is more concerned with the conceptual representation of language sounds than their real properties. This includes the study of phonemes, which are a language's smallest sound units that may change a word's meaning. Phonemes are language's tiniest sounds. In English, "cat" and "bat" vary by /k/, whereas "bat" differs by /b/. Phonology also studies phonotactics. Phonotactic principles govern how phonemes may be joined to create new sounds. In English, the phoneme /ng/ may only come at the end of a syllable, as in "sing." Phonology also involves studying phonological processes, which are systematic sound changes in a language. Aspiration makes the letter "p" in "spin" sound different from "pin." Such as. Speech therapy, language learning, and NLP employ phonology. Phonology analyses voice sounds in natural language processing. These qualities are utilized to distinguish and transcribe spoken language and in text-to-speech synthesis, which uses the language's sound system to pronounce words and phrases.

b) Morphology

Morphology, a linguistics discipline, studies word structure and creation. Morphemes—language's smallest meaningful units—are its emphasis. Morphemes create words. Morphology studies word structure and the principles for combining morphemes to form new words. "Unhappy" is formed by adding the prefix "un-," which means "unhappy," to "happy." Morphology also studies inflection, a word's form change to indicate grammatical variations like tense, number, and gender. Words undergo inflection. The English verb "walk" may be inflected to signify several tenses, such as "walked" (past tense) and "walking" (present participle). Morphology also studies morphological processes, which combine morphemes to form words. Most morphological processes involve compounding, inflection, or derivation. By adding prefixes and suffixes to a parent word, derivation creates a new word with a separate meaning. As said, inflection alters a word's shape to better express grammatical distinctions. Compounding creates new words by combining two or more words. Compound words include "bookshelf" and "blueberry." Morphology has several uses in linguistics, including lexicography, natural language processing, and language instruction. Morphology studies word structure and morphemes. Voice recognition and machine translation employ morphology.

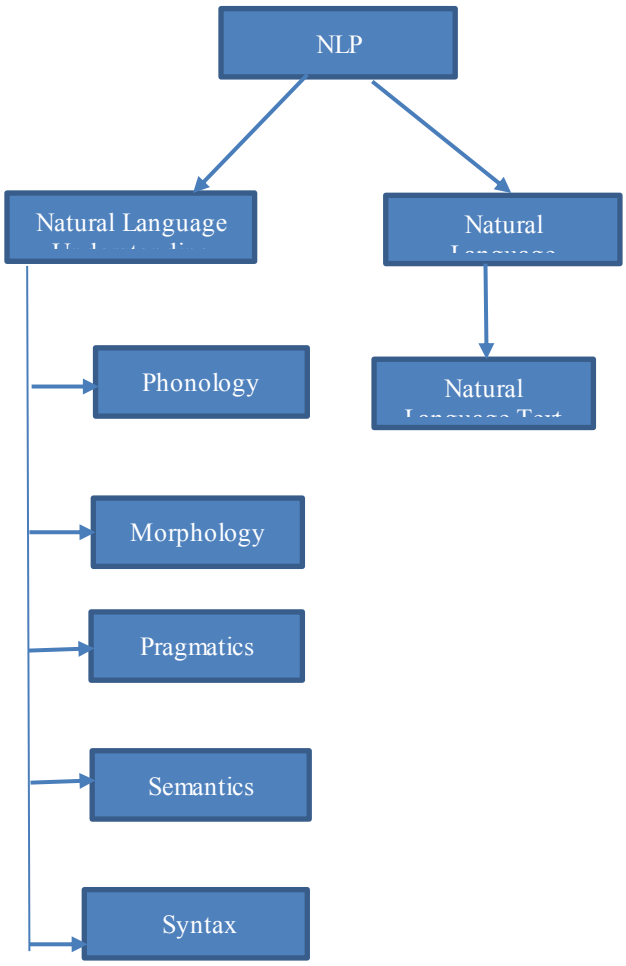

Figure 1: Classification of NLP

c) Lexical

The work of analyzing individual words and the meanings they communicate is accomplished at the lexical level of natural language processing (NLP). It is common standard to use a process known as part-of-speech tagging, which assigns the most probable part-of-speech tag to each sentence based on the surrounding context. It is also feasible

to use semantic representations instead of words with a single meaning. At the lexical level, words may be represented using a number of different semantic theories. The first stage in lexical analysis is to break down the text into paragraphs, then phrases, and lastly individual words. Words with the potential for more than one part of speech are classified according to the tag that is most likely to apply given the context. Another technique to improve semantic representation is to apply the correct POS tag. Linguistic techniques like stop word removal, stemming, and lemmatization may be employed for cleaning and feature extraction. Stop words are removed from the equation since they offer nothing significant to the interpretation and their prominence indicates that they may slow down the computation process. Lemmatization considers the surrounding text to find the proper basic form to return, while stemming removes suffixes from words to reduce them to their root form. For example, "driven" would be abbreviated to "driv," but depending on the context, "drive" or "driven" would be returned through lemmatization.

d) Syntactic:

Syntactic Natural Language Processing (NLP) emphasizes sentence accuracy by analyzing its grammatical structure. This involves forming phrases, clauses, and sentences from words. This needs phrase-grouping. The goal is to find phrases that are more significant than their component words and show structural dependency between sentence parts. "Parsing" is another word for this process. Syntactic analysis considers word order, stop words, morphology, and word occurrence. Unlike the lexical level, this level examines phrase-word relationships. As illustrated by the examples "Ram beats Shyam in a competition" and "Shyam beats Ram in a competition," rearranging the words may affect the meaning. Syntactic analysis doesn't remove stop words since it could change the phrase's meaning. However, lemmatization and stemming are not supported since they may affect sentence syntax. Syntactic analysis, which focuses on the phrase, aims to find the proper PoS for each word in a sentence. "Frowns" is a noun when it occurs in "Frowns on his face," but it is a verb when it appears in "He frowns." Syntactic analysis produces a sentence that uses grammatical structure to convey meaning.

e) Semantic

The semantic level of natural language processing (NLP) focuses on phrase meaning. Humans use words and concepts to communicate, whereas robots use alternative methods. Semantic processing analyses a phrase's logical structure to identify which words are most important and how they interact. The semantic level may detect a remark about movies based on related concepts like "actor," "actress," "conversation," or "script" even if it does not include the term "movies." This level also requires semantic interpretation of multi-meaning words. "Bark" may mean a dog's voice or a tree's covering. Semantically, one either searches up words in the dictionary or infers their meaning from their usage in a sentence. "Krishna is a nice and noble person" might refer to Lord Krishna or a person with the given name "Krishna." The rest of the sentence helps comprehend this term.

f) Pragmatic

Pragmatic analysis in natural language processing examines how context affects language interpretation. Pragmatics studies language meaning and usage. Sociolinguistics examines how humans use language to achieve goals and convey meaning beyond the literal meaning of words. Pragmatic analysis considers the speaker's and listener's previous knowledge and presumptions, as well as the language's social context. Pragmatics involves understanding the speaker's intentions and how they affect the message. It also requires awareness of the listener's preconceptions and expectations and how these affect their perception of what is being communicated. "Can you give me the salt?" is a literal inquiry. It may also mean "pass the salt" at a formal dinner party. The term means this. Pragmatic analysis enhances language understanding in natural language processing. When they incorporate context, natural language processing algorithms can better understand what people mean and provide more accurate responses. Natural language production requires pragmatic analysis since the system must analyse the context in which language is used to generate appropriate responses.

B. Natural Language Generation(NLG)

NLG is the NLU equivalent. Natural language comprehension uses writing to find meaning. However, natural language generation creates text from structured data or other input. NLG systems use data or information to generate human-like text. NLG systems generate reports, product descriptions, weather forecasts, and news stories **[6]**. They can also generate bespoke messages, Chatbot responses, and full storylines. NLG systems usually have three stages: content determination, text planning, and surface realization. "Determining the content" involves selecting relevant information for the text. Planning a text involves organizing the content into paragraphs and giving each sentence or phrase its own phrase. Surface realization involves writing the text's words and phrases while considering syntax, style, and tone. Deep learning methods like neural networks have improved natural language generation (NLG) with high-quality text. NLG still struggles to write natural, meaningful language, particularly for complex or abstract concepts.

a) Speaker and Generator

The speaker, which is responsible for giving the general structure and direction for the language output, and the generator, which is responsible for creating the exact text that is outputted, are both crucial components of a Natural Language Generation system.

b) Component and level of Representation

The term "Natural Language Generation" (NLG) refers to the process of producing texts or vocal output in natural language from structured data. It often entails a succession of activities that are connected to one another, such as the selection of content, the structuring of textual material, the use of linguistic resources, and the actualization of the content. The process of picking the appropriate information to be included in the output is known as "content selection."

This information has to be broken down into its constituent parts and arranged in a logical fashion before it can be used. It's possible that some pieces of the material need to be cut out, while others may need some expansion. Textual organization entails arranging the information in accordance with the rules of the grammar of the language being used. This may include sorting the material chronologically as well as in terms of linguistic connections such as modifications. The selection of pertinent words, idioms, and syntactic constructions to enable the actualization of the information is an example of linguistic resources in action. To do this, you need to have an understanding of the context, the audience, and the intended style. Realization entails bringing together all of the elements that have been picked and structured in order to produce a text or voice output that is consistent and sounds natural. This entails producing speech output with the right grammar, syntax, and discourse structure, in addition to prosodic elements like intonation, rhythm, and emphasis **[7]**.

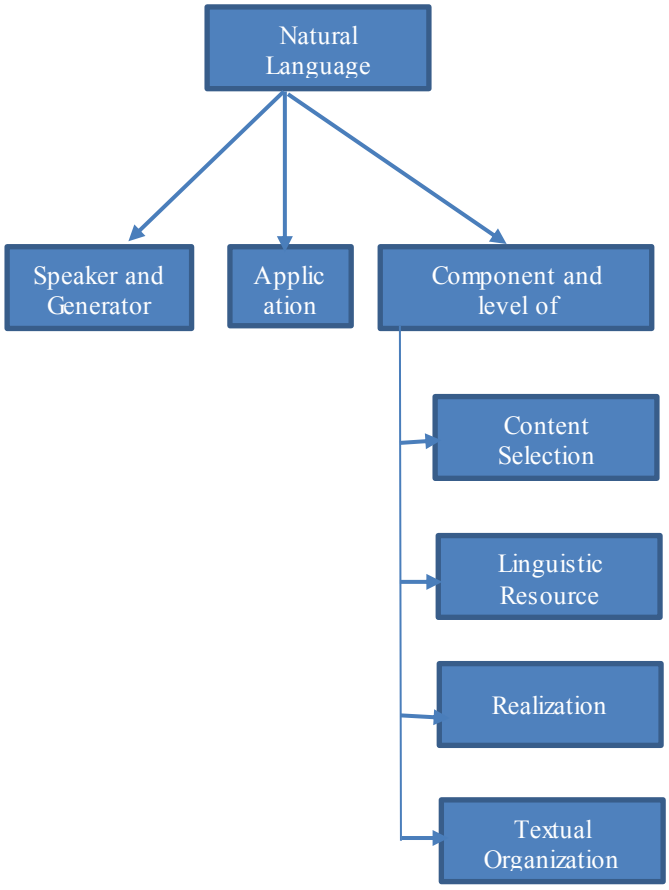

Figure 2: Natural Language Components

III. APPLICATIONS OF NLP

A. *Chatbots and Virtual Assistants*

Chatbots and other virtual assistants are a prominent use of natural language processing. AI-powered conversational bots can mimic human conversations in natural language. Chatbots are used in customer service, internet shopping, healthcare, and even personal assistants. Chatbots help customers solve problems, answer commonly asked inquiries, and provide basic information. They handle several inquiries at once and are accessible 24/7. Customer satisfaction, response times, and operational efficiency may improve. Online retailers may recommend products, help customers find them, and speed the buying process using chatbots. They may use natural language processing to understand user preferences, purchasing history, and other data to personalize the experience. In the healthcare business, chatbots and virtual assistants help patients, answer medical questions, and schedule appointments. They also monitor symptoms and alert patients to potential health issues. Siri, Alexa, and Google Assistant help consumers with daily chores via natural language processing. These include scheduling, playing music, and presenting information. Personal assistants inform and play music [8].

B. *Sentiment Analysis*

Sentiment analysis is another frequent usage of natural language processing (NLP). Sentiment analysis may classify text as good, negative, or neutral. It may be used for social media posts, product reviews, customer comments, news articles, and more. Sentiment analysis may aid in the following situations: Sentiment analysis may help marketers understand how customers feel about a brand or product. With this data, firms may improve their marketing tactics and better tailor their messages to their target customers. Customer service: Sentiment analysis may help enhance customer service by analyzing customer comments and reviews. This may assist organizations identify client needs and improve service quality. Sentiment analysis may be used to assess public opinion on political issues, leaders, and policy. This data may aid political campaigns and politicians seeking public opinion on many issues. Sentiment analysis of social media posts and news about a company or industry may be used in stock market analysis. This data can anticipate stock prices and investment decisions [9].

C. *Machine Translation*

Machine translation is one of several NLP applications. For this exercise, text is translated using computer software. Machine translation systems utilize complex algorithms to assess source text and translate it into the destination language. Machine translation software falls into two main categories: rule-based and statistical. Rule-based systems use pre-defined rules and grammatical structures to translate text, whereas statistical systems use statistical models to find the best translation from huge multilingual text data. Rule-based systems predominate. Language training, international trade, and government agencies employ machine translation. It removes linguistic barriers and promotes global understanding by enabling people to communicate regardless of language or culture. Machine translation research continues. It can handle linguistic ambiguity, cultural variety, and complex syntax and grammar. Thus, machine translation systems must be constantly improved to enhance accuracy and efficiency **[10]**.

D. Speech Recognition

Speech recognition is another prominent NLP application. Computers can interpret spoken language and transcribe it into text. Medical, financial, and telecommunications areas employ this technology. Speech recognition technology is used in voice assistants like Siri and Alexa to let people talk to their electronics in their native language. Voice recognition technology can transcribe doctor-patient conversations, which may subsequently be analyzed for patient care and treatment insights. Speech recognition may be used for voice biometrics in finance to verify an individual's identity using their unique voice patterns. Voice recognition technology is also utilized in contact centers to transcribe client conversations, helping staff respond quicker and more accurately **[11]**.

E. Text Summarization

Text summarization is another popular NLP application. The development of digital content necessitates automatic summaries of long texts, articles, and news reports. Summarizing the text involves condensing it without losing its significance. Extractive and abstractive summaries exist. Extractive summarizing selects and reproduces the most important sentences or phrases from the source material. Sentence rating algorithms, which assign points to sentences based on their textual importance, underpin this concept. Algorithms score sentences. However, abstractive summarizing involves creating a summary without using the same terms and phrases as the original text. By reducing needless information. Instead, it emphasizes understanding the text and writing a summary that simplifies the key points. Journalism, research, and social media use summing texts. News organizations use it to provide quick news summaries for readers. Text summary is used in research to quickly examine large literature and acquire vital information. Social media postings are summarized using text summaries **[12]**.

F. Named Entity Recognition

NLP is vital for recognizing and extracting named entities from unstructured text. NER is a major NLP application. Named entities are real-world items like people, places, organizations, dates, and times. NER can aid question-answering systems, information extraction, text classification, and sentiment analysis. NER involves tokenization, part-of-speech tagging, and dependency parsing. These procedures will help find the text context of the recognized item. After setting the context, a classifier or rule-based system isolates the desired elements. The application or domain may categorize retrieved entities. NER can extract names, places, and organizations from a news story. Manually or automatically. Market research, social media analysis, and trend analysis may benefit from this data. In a similar manner, NER may be used in a medical report to extract the names of the illnesses, medications, and symptoms that are discussed in the report. This data may aid medication research, clinical trial analysis, and medical diagnostics. NER helps extract useful information from unstructured text data and has many applications in commercial, healthcare, and educational sectors **[13]**.

G. Information Retrieval

Information extraction (IE) automatically extracts structured information from unstructured or semi-structured text input. Information extraction extracts entities, connections, events, and facts from a text document. This includes facts, connections, events, and entities. Extraction of information is used in a wide number of disciplines, including corporate intelligence, finance, healthcare, analysis of news stories, and scientific research, amongst others. It can extract data from legal documents, academic papers, social media posts, and news reports. Information extraction uses statistical analysis, machine learning, and rules. Information extraction often includes named item identification, event extraction, connection extraction, and summary generation. Information extraction may automate the process of extracting relevant information from vast volumes of text data, saving time and resources for businesses and people that need to evaluate or make choices based on text documents. This may help companies examine and make choices based on text materials **[14]**.

IV. CHALLENGES IN NLP

Researchers and practitioners of NLP are still confronted with a number of obstacles, despite the substantial progress that has been made in the field. Among these difficulties are the following:

Since natural languages are inherently ambiguous, it may be difficult to determine the meaning that a particular word or phrase is intended to convey when it is used in a sentence. Because of this, effectively extracting facts or feelings from language may be a tough endeavor.

Domain-specific language: The language that is used in particular fields, such as medicine or law, may be very specialized and include jargon or technical terminology that are not used in ordinary English. This kind of language is known as "domain-specific language." Because of this, it is challenging for natural language processing algorithms to correctly comprehend text in various areas.

Insufficient quantities of training data: In order to develop reliable NLP models, you need to have sufficient amounts of training data. Nevertheless, such data may be restricted or not accessible at all for specific languages or domains, making it difficult to construct models that are accurate. This might make the task of developing such models more challenging.

In order to effectively extract meaning from words or phrases, NLP models need to have the ability to comprehend the context in which they are being used. Context, on the other hand, isn't always easy to pin down, especially in situations when a number of different meanings or interpretations might be applicable.

Diversity in both cultures and languages makes it challenging to create natural language processing (NLP) models that are applicable in a variety of contexts, given the wide range of natural language varieties found in the world's regions and civilizations.

NLP models are susceptible to becoming biased because of the training data to which they are exposed. This may lead to models that are less accurate or that perpetuate existing prejudices and inequities in society. Both of these outcomes are undesirable.

Explainability: When NLP models get more sophisticated, it might be difficult to grasp how they arrive at their conclusions or to describe their behaviour to end-users. This is a challenge due to the fact that explainability is directly related to complexity. Because of this, the adoption of and confidence in NLP systems may be hindered **[15]**.

V. CONCULISON

Finally, Natural Language Processing (NLP) has grown in importance as a field of artificial intelligence, with several applications in a variety of sectors. Its capacity to educate computers to comprehend and interpret human language has resulted in the creation of powerful algorithms capable of analyzing data in natural language, allowing tasks such as sentiment analysis, language translation, and chatbot development. While there are still significant accuracy and reliability difficulties to solve, NLP has the potential to revolutionize the way we interact with technology and extract insights from massive volumes of data. As such, it is a fascinating and fast changing area that is expected to expand and develop more in the next years. Here are some possible avenues for future NLP research: Multilingual NLP is growing more vital as the globe grows more linked. Algorithms that comprehend and analyse many languages might improve cross-cultural communication. Explainable NLP: NLP models are hard to understand, raising ethical and prejudice problems. Future research might construct more transparent and explainable NLP models to help us comprehend their results and spot biases. Contextualized NLP: NLP models fail to interpret language in varied settings, resulting in inaccurate analysis. Better context-aware models might improve language analysis in varied contexts in future study. Low-resource languages: Many languages lack NLP tools and resources. Future study might construct NLP models for these languages to improve community communication and analysis. Real-time NLP: Voice assistants and chatbots need rapid and accurate language analysis. Real-time NLP models might improve these applications' efficiency and efficacy in future study. NLP research has great promise to improve language interpretation and analysis. NLP tools and applications will become more accurate and dependable as research and development continue, boosting cross-cultural communication.

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