

Applications of Natural Language Processing

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ABSTRACT

Natural language processing (NLP) is about teaching computers to actually understand and work with our everyday language. It stands at the intersection of computer science, artificial intelligence, and linguistics, serving as the critical bridge between human communication and machine understanding. The primary objective of NLP is to enable computers to process, interpret, and generate natural language in a manner that is both meaningful and contextually accurate. NLP is the technology that helps computers make sense of that flood of words. It is already changing how we live and work. This paper explores the various applications of NLP, highlighting its impact on business, healthcare, and society.

KEYWORDS: *natural language processing, NLP, computational linguistics, applications.*

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INTRODUCTION

Natural language processing (NLP) refers to the application of computational techniques to the understanding and generation of human language. It involves the study of mathematical and computational modeling of various aspects of language. It implies the development of a wide range of systems such as spoken language systems that integrate speech and natural language, multilingual interfaces, and machine translation. This capability has revolutionized numerous industries, streamlining operations, enhancing decision-making, and improving user experiences. NLP systems perform useful roles, such as correcting grammar, converting speech to text, and automatically translating between languages [1].

Imagine that you can talk to your phone and get things done. Or that your phone can talk back to you. Imagine typing a message and watching autocorrect fix a misspelled word before you hit send. This has become a pretty normal thing these days with Siri, Alexa, Google Assistant, etc. All of this is accomplished using natural language processing.

Natural language processing allows your device to hear what you say, then understand the hidden meaning in your sentence, and finally act on that meaning. From email and search engines to customer support tools and accessibility features, NLP plays a large role in how we communicate, work, and interact with technology. Every time you type a document and your software highlights a misspelled word or suggests a grammar fix, you are experiencing a natural language processing application. NLP supports many forms of digital communication, including email, online chat, messaging platforms, social media, search engines, and voice-enabled tools [2].

FUNDAMENTALS OF NLP

Natural language processing is a subfield of artificial intelligence that empowers computers to understand, interpret, and generate human language. It is a technique where machine can become more human and thereby making human to communicate with the machine easily. NLP seeks to make software intelligent enough to process a natural language as

humans. For example, imagine a machine that takes instructions by voice.

NLP analysis generally consists of the following three levels [3]:

- *Syntax*, the study of sentence structure. Syntax deals with the formation of a sentence from individual words. Syntax alone suggests the proper interpretation of “Jimmy loves Lucy.”
- *Semantics*, the study of context-independent meaning. This derives the meaning of a sentence based on the meanings of the words/phrases. For example, semantics determines whether the word “bank” refers to a river bank or to a financial institution.
- *Pragmatics*, the study of context-dependent meaning. Pragmatics deals with how meaning changes in the presence of a specific context and how the contexts affect the meaning of the sentences. This level is concerned with the purposeful use of language in situations.

As a foundational pillar of modern artificial intelligence, NLP encompasses a wide array of tasks, including speech recognition, text classification, natural language understanding (NLU), and natural language generation (NLG). NLP encompasses a wide range of tasks, such as information retrieval (IR), named entity recognition (NER), relation extraction, text classification, topic modeling, semantic textual similarity, machine translation, and question answering (QA).

Recently, large language models (LLMs) have shown their ability in learning universal language representations, text understanding and generation. LLMs refer to a model with a large number of parameters, vast training data, and substantial compute, enabling it to capture complex language patterns. In LLM-based NLP, pre-processing is followed by prompt engineering, which guides LLMs to produce outputs that align with extraction requirements during inference without altering the model’s parameters. Models like GPT are pushing the boundaries of language understanding, enabling nuanced and context-aware applications. The GPT (Generative Pretrained Transformer) is a large-scale language model developed by OpenAI that consists of multiple layers of transformer blocks, each with a self-attention mechanism and a forward neural network [4]. GPT-based systems can summarize complex reports or generate creative content like essays, making them versatile in both academic and professional environments. ChatGPT uses NLP techniques to understand prompts. When you enter a prompt, the chatbot comprehends it and provides relevant replies.

HISTORICAL BACKGROUND

NLP (also known as computational linguistics) is a interdisciplinary field involving computer science, linguistics, logic, and psychology. Over the past seven decades, the field has undergone a profound transformation, evolving from rigid, rule-based systems to highly sophisticated, data-driven neural architectures that power today's most advanced AI applications. NLP has a long history dating back to the 1950s. The objective is to make computers understand and generate text, in particular, in two principal tasks: natural language understanding (NLU) and natural language generation (NLG). Since then, NLP research has been focusing on tasks such as machine translation, information retrieval, text summarization, question-answering, information extraction, and opinion mining [5]. The late 1980s witnessed a revolution in NLP with the introduction of machine learning algorithms and statistical techniques for language processing. Machine learning approaches extract statistical information from large amounts of documents and learn the rules of language without explicitly listing them.

The history of natural language processing is generally categorized into three distinct eras: the symbolic era, the statistical era, and the neural era. Each phase represents a paradigm shift in how researchers approached the challenge of teaching machines to comprehend human language. Figure 1 shows the development and application of NLP [4].

APPLICATIONS

NLP is important because of the wealth of potential applications. NLP is commonly used for text mining, machine translation, and automated question-answering. Applications of NLP include interfaces to expert systems and database query systems, machine translation, text generation, story understanding, automatic speech recognition, and computer-aided instruction. Figure 2 portrays some applications of NLP [6]. Common applications of NLP include the following [2,7-12]:

1. *Chatbots*: Chatbots are a prominent NLP application that simulates human-like conversations and interacts with users conversationally. They are a form of artificial intelligence that are programmed to interact with humans in such a way that they sound like humans themselves. They are created using natural language processing and machine learning, which means that they understand the complexities of the English language and find the actual meaning of the sentence and they also learn from their conversations with humans and become better with time.

2. *Voice Assistants*: These days voice assistants are everywhere and have made life much easier. Whether it is Siri, Alexa, or Google Assistant, almost everyone uses one of these to make calls, place reminders, schedule meetings, set alarms, surf the Internet, etc. They use a complex combination of speech recognition, natural language understanding, and natural language processing to understand what humans are saying and then act on it. The long term goal of voice assistants is to become a bridge between humans and the Internet and provide all manner of services based on just voice interaction. Figure 3 shows an example of voice command [13].
3. *Machine Translator*: Want to translate a text from English to Hindi but do not know Hindi? Well, Google Translate is the tool for you. Although it is not exactly 100% accurate, it is still a great tool to convert text from one language to another. Language translator use sequence to sequence modeling which is a technique in natural language processing. Tools like Google Translate have advanced significantly thanks to neural networks and large data sets, making translation more accurate and accessible for global communication. Figure 4 shows an example of language translation [13].
4. *Grammar Checkers*: Grammar and spelling is a very important factor while writing professional reports. Grammar and spell checkers can not only correct grammar and check spellings but also suggest better synonyms and improve the overall readability of your content. They utilize natural language processing to provide the best possible piece of writing. The NLP algorithm is trained on millions of sentences to understand the correct format.
5. *Text Classification*: Text classification allows systems to automatically categorize large volumes of text. It is commonly used in survey analysis, spam filtering, topic labeling, genre classification, and language detection. Text classification can save organizations significant time compared to manual review.
6. *Text Summarization*: Text summarization creates a concise version of a long document. This will automatically summarize a block of text, extracting topic sentences, and ignoring the rest. Opinion summarization focuses on the opinionated parts, while traditional summarization focuses on extracting informative parts and getting rid of redundancy.
7. *Market Intelligence*: NLP supports market intelligence by analyzing unstructured data such as reviews, social media posts, and competitor content. Marketers can use the resulting insights to identify trends, refine messaging, and better understand consumer behavior.
8. *Speech Recognition*: This involves transcribing spoken language into text. Speech recognition systems power applications like virtual assistants and automated transcription tools. For example, virtual meeting platforms use it to provide live captions for participants. Voice-to-text tools, such as transcription software and real-time captioning systems, rely on NLP to convert spoken language into written text.
9. *Voice Recognition*: These techniques powered by natural language processing allow companies to develop intelligent voice-driven services and interfaces for any product and service. Narrowing the communication gap between machines and human is the most critical and necessary step to increasing the grip on artificial intelligence.
10. *Spell Checking*: Spell checking is a fundamental aspect of natural language processing (NLP) that identifies and rectifies misspelled words within a text. It plays a vital role in ensuring written content's precision and readability. Spell-checking algorithms scrutinize the input text, cross-referencing each word against a pre-existing lexicon or dictionary. When an incorrect spelling is detected, the algorithm suggests a list of potential corrections based on similarity metrics and contextual information. NLP has significantly elevated written communication's overall quality and professionalism in today's digital landscape.
11. *Text-to-Speech (TTS)*: TTS is an innovative NLP application that transforms written text into spoken audio outcomes. Using sophisticated algorithms, TTS systems analyze the input text, interpret its linguistic structure, and generate corresponding speech with natural intonation and pronunciation. NLP enables TTS to handle diverse languages and accents, adapt to different contexts, and convey emotions effectively.
12. *Sentiment Analysis*: Sentiment analysis in customer service allows businesses to detect customer emotions in real-time, enabling support teams to tailor their approach and prioritize escalations effectively. It is a task in which NLP automatically identifies the sentiment of a text based on the opinions or feelings written in the text. This can be used to identify the feeling, opinion, or belief of a statement. The main issue in sentiment analysis is to identify how sentiments are expressed in texts and whether the

expressions indicate positive or negative opinions toward the subject. For example, sentiment analysis of an online videogame can provide game designers with insights into what the users consider as favorable or unfavorable about the game.

13. *Content Generation*: While humans are still best at creative writing, natural language processing applications are becoming increasingly capable of generating various types of text automatically. Advanced NLP models, often based on large language models (LLMs), are trained on massive datasets of text. They learn to predict the next word in a sequence, allowing them to generate coherent and contextually relevant sentences, paragraphs, or even entire articles. Content generation can automate routine writing tasks, freeing up human writers for more creative work.
14. *Fraud Detection*: In industries like banking and insurance, fraud is a significant concern. Fraud detection is another critical application where NLP analyzes communication patterns to identify inconsistencies and emotional manipulation that may indicate fraudulent activities. This capability is vital for safeguarding financial transactions and protecting consumers. It helps businesses protect themselves and their customers from financial crime.
15. *Spam Detection*: One of the very first and still most useful NLP applications is spam detection. NLP algorithms analyze the content of emails. They look for patterns, keywords, and phrases commonly found in spam. This includes things like suspicious links, certain sales pitches, or unusual sender addresses. This NLP application saves us countless hours. It protects us from phishing scams and keeps our communication channels clear. Figure 5 shows spam detection [14].
16. *Recruitment and HR*: The hiring process can be time-consuming. Natural language processing applications are making it more efficient for HR departments. This NLP application helps companies quickly find qualified candidates. It saves time for recruiters and improves the matching process, leading to better hires. Figure 6 shows how NLP works in recruitment and HR [14].
17. *Named Entity Recognition (NER)*: NER is an NLP technique that identifies and classifies names of people, places, organizations, dates, and amounts in text. It is essential for search, content recommendation, and data analysis. NER is

essential for tasks like information retrieval and document summarization. For example, an email filtering system can identify names and dates to highlight important calendar events. By automating this process, NER plays a vital function in different applications, like information recovery, document summarization, and knowledge graph construction.

Applications for processing large amounts of texts require NLP expertise. These include classifying text into categories, indexing, automatic translation, speech understanding, information extraction, automatic summarization, knowledge acquisition, games, opinion mining, spell-checking, context-based thesaurus, and genre-based word prediction, and text generations [15]. Some of NLP applications involve generation as well as analysis of the language. Over the years, a significant number of NLP software have been developed; some of these are available freely, while others are available commercially

EXAMPLES OF NLP

Natural language processing has emerged as a transformative technology with far-reaching applications across industries. It has great potential in healthcare, finance, customer service, mobile technology, cloud computing, virtual reality, election, social work, education, government, and social networking. Common example of NLP include the following [16-18]:

- *Healthcare*: NLP is important to health. In the healthcare sector, NLP plays a pivotal role in transforming how medical data is managed and utilized. NLP clinical systems can be used to represent clinical knowledge and clinical decision support interventions in standardized formats. They have been developed to process unstructured text and transform it into a desired coded form to support several healthcare-related activities. Such systems require a higher degree of accuracy as results are incorporated into critical decisions related to patient care. There is also NLP-based approach to extract information from patient records.
- *Finance*: The financial industry leverages NLP to improve customer service, detect fraud, and inform investment strategies. In customer service, AI-powered chatbots, exemplified by Bank of America's Erica, handle routine inquiries, significantly reducing operational costs and boosting customer satisfaction. These chatbots can answer frequently asked questions, provide account balance information, and assist with money transfers.

- *Social Media Monitoring:* The role of social media in people's lives is becoming significant. Natural language processing is one of the most promising avenues for social media data processing. Social media monitoring is a prominent NLP application that tracks and analyzes conversations on various social media platforms. NLP algorithms can process large volumes of unstructured textual data, extracting valuable insights and sentiments from posts, comments, and mentions.
- *Customer Service:* NLP-powered chatbots are becoming increasingly popular in customer service. These intelligent bots are trained to understand and respond to customer queries, providing quick and accurate solutions. NLP-powered chatbots enhance responsiveness by handling a high volume of queries with accuracy. Sentiment analysis tools assess customer satisfaction and identify areas for improvement.
- *Marketing:* Analyzing user-generated content can lead to insights into brand perception and customer sentiment. NLP helps marketers analyze customer feedback, social media trends, and online reviews to gain valuable insights into customer preferences. Marketers can tailor their campaigns and advertisements accordingly, ensuring maximum impact and customer engagement.
- *Education:* In education, NLP is used to develop intelligent tutoring systems. These systems analyze student responses and provide personalized feedback, enhancing the learning experience. NLP also aids in automated essay grading, saving valuable time for educators. It supports language learners with tools that provide instant feedback on grammar and pronunciation.
- *Government:* Integration of technology and governance is already being used as an electronic governance system. For example, DARPA (Defense Advanced Research Projects Agency) has developed a program called DEFT (Deep Exploration and Filtering of Text) that uses natural language processing to extract relevant information. Unstructured data. This information is further used in analytical procedures to derive insights from the data. Because in a multilingual country like India, NLP can be a game changer.

BENEFITS

NLP allows machines to understand, interpret, and generate human language in a valuable and meaningful way. The ultimate goal of NLP is to create systems that understand language in a way that

is both smart and useful to people, effectively bridging the gap between human communication and computer understanding. NLP enhances our communication, bridges language barriers, aids in data interpretation, and revolutionizes educational assessments. Other benefits of NLP include the following [10,17]:

- *Automation:* One of the most significant benefits of NLP lies in its capacity to automate and streamline tasks that traditionally require human linguistic comprehension. In business, NLP-powered systems can handle repetitive yet crucial operations such as data entry, document processing, and information extraction, thereby minimizing manual effort and reducing the incidence of human error. Automation not only boosts operational efficiency but also leads to substantial cost savings for enterprises.
- *Improved Decision-making:* The digital age has led to an explosion of unstructured textual data, from emails and social media posts to patient records and financial reports. This data, often rich in valuable insights, remains largely untapped without advanced analytical tools. NLP provides the key to unlocking this information, transforming raw text into structured, actionable intelligence. Its ability to bridge the communication gap between humans and machines has transformed industries, improved decision-making processes, and enhanced the overall quality of life.
- *Multilingual NLP:* While NLP has predominantly focused on English-language processing, there is a growing emphasis on multilingual NLP. Researchers are developing models that can understand and generate text in multiple languages, enabling seamless communication across linguistic barriers.
- *Contextual Understanding:* Context is crucial for understanding language, and NLP research is increasingly focused on developing models that can comprehend and generate text in context. This contextual understanding enables machines to generate more relevant and natural-sounding responses, making human-computer interactions more seamless.

CHALLENGES

Despite their fluency, modern NLP models often struggle with deep comprehension and logical reasoning. One of the most pervasive issues is the phenomenon of "hallucinations," where models confidently generate plausible but entirely fabricated information. This is particularly problematic in high-

stakes domains such as healthcare and scientific research. The challenges facing NLP are substantial, but they are not insurmountable. Other challenges of NLP include the following [10]:

- *Ethical Concerns:* With great power comes great responsibility. Ethical considerations are becoming increasingly important in NLP research. The ethical considerations of using NLP primarily revolve around privacy, bias, and transparency. As NLP systems become deeply integrated into societal infrastructure, the ethical implications of their deployment have taken center stage.
- *Data Privacy:* Security and privacy also present formidable challenges. The massive datasets required to train frontier models often contain sensitive personal information. Preventing models from inadvertently memorizing and regurgitating this data is a critical privacy concern. Additionally, the susceptibility of models to adversarial attacks, such as prompt injection or jailbreaking, exposes systems to manipulation and misuse.
- *Bias:* NLP models can inherit societal biases embedded in their training data, resulting in unfair outcomes. Researchers are actively developing debiasing techniques and fairness evaluation tools to mitigate these effects. Models trained on vast, uncurated datasets inevitably absorb and amplify the biases present in that data. This can result in unfair or discriminatory outcomes, particularly for marginalized groups or speakers of minority dialects. Ensuring fairness requires rigorous auditing, diverse training data, and the implementation of alignment techniques that prioritize equitable performance across all demographics.
- *Interpretability:* Interpretability—the ability to understand how a model arrives at a specific decision—remains elusive. Without transparent mechanisms to trace outputs back to their source data or internal logic, debugging errors and ensuring accountability become arduous tasks.
- *Universal Access:* The success of NLP is heavily skewed toward high-resource languages, primarily English. While models achieve human parity in translation for the top 20 language pairs, performance degrades precipitously for the thousands of other languages spoken globally. This linguistic divide creates a significant barrier to universal access and utility.

FUTURE OF NLP

The field of NLP is continuously evolving, with several emerging trends shaping its future. The rise of large language models (LLMs) has significantly advanced capabilities in content generation, summarization, and translation, promising even more sophisticated applications across industries. The industry's growing emphasis on alignment, safety, and open-source governance will be crucial in building NLP systems that are not only intelligent but also trustworthy and equitable. By acknowledging and actively addressing these technical, linguistic, and ethical challenges, the AI community can steer the technology toward a future where it serves as a reliable, inclusive, and beneficial tool for all of humanity [10].

Natural language processing (NLP) has come a long way in recent years, and its future looks brighter. With advancements in machine learning and AI, NLP is poised to revolutionize the way we interact with technology and communicate with each other. With exciting advances like LLMs, NLP's future looks bright and promising. As we continue to innovate, NLP will remain a vital tool in bridging the gap between human language and computational power.

CONCLUSION

Natural language processing (NLP) is a popular technique of artificial intelligence for extracting the elements of concerns from raw plain text information. It has emerged as a transformative technology, revolutionizing how humans interact with machines and how organizations derive insights from vast quantities of textual data. It deals with how to program computers to fruitfully process large amounts of natural language data. It is a multidisciplinary field that is related to linguistics, cognitive science, psychology, philosophy, and logic. It acts as a bridge between human language and computers, allowing machines to comprehend, interpret, and produce human-like language.

NLP is changing the way we interact with technology. From voice assistants to tools that analyze customer opinions, it is making life easier and businesses smarter. From sentiment analysis and machine translation to chatbots and speech recognition, NLP finds its way into various domains, revolutionizing customer support, virtual assistants, healthcare, and social media. More information about NLP can be found in [19-22].

REFERENCES

- [1] M. N. O. Sadiku, Y. Zhou, and S. M. Musa, "Natural language processing," *International Journal of Advances in Scientific Research and*

- Engineering*, vol. 4, no. 5, May 2018, pp. 68-70.
- [2] S. Lee, “12 Applications of natural language processing,” <https://www.wgu.edu/blog/12-applications-natural-language-processing2108.html>
- [3] J. Hirschberg, B. W. Ballard, and D. Hindle, “Natural language processing,” *AT&T Technical Journal*, Jan./Feb. 1988, vol. 67, no. 1, 1988.
- [4] X. Jiang et al., “Applications of natural language processing and large language models in materials discovery,” *NPJ Computational Materials*, vol. 11, no.79, 2025.
- [5] E. Cambria and B. White, “Jumping NLP curves: A review of natural language processing research,” *IEEE Computational Intelligence Magazine*, May 2014, pp. 48-57
- [6] “Top 8 applications of natural language processing (NLP),” October 2024, <https://medium.com/@eastgate/top-8-applications-of-natural-language-processing-nlp-54cefce03d1f>
- [7] “Natural-language processing,” Wikipedia, the free encyclopedia https://en.wikipedia.org/wiki/Natural-language_processing
- [8] T. Nasukawa and J. Yi, “Sentiment analysis: Capturing favorability using natural language processing,” Proceedings of the 2nd International Conference on Knowledge capture, October 2003, pp. 70-71.
- [9] J. P. Zagal, N. Tomuro, and A. Shepitsen, “Natural language processing in game studies research: An overview,” *Simulation & Gaming*, vol. 43, no. 3, 2012, pp. 356–373.
- [10] <https://manus.im>
- [11] “Top 7 applications of NLP (Natural Language Processing),” July 2025, <https://www.geeksforgeeks.org/nlp/top-7-applications-of-natural-language-processing/>
- [12] “15 Natural language processing examples: NLP applications,” February 2025, <https://www.weetechsolution.com/blog/15-natural-language-processing-examples-nlp-applications/>
- [13] M. Madnani, “What is NLP used for? Practical applications in everyday life,” January 2025, <https://www.udacity.com/blog/2025/01/what-is-nlp-used-for-practical-applications-in-everyday-life.html>
- [14] “20 Natural language processing applications to watch now,” https://www.intellspot.com/natural-language-processing-applications/#google_vignette
- [15] S. M. Chandhana, “Natural language processing future,” *Proceedings of International Conference on Optical Imaging Sensor and Security*, Tamil Nadu, India, July 2-3, 2013.
- [16] C. Friedman, T. C. Rindfleisch, and M. Corn, “Natural language processing: State of the art and prospects for significant progress, a workshop sponsored by the National Library of Medicine,” *Journal of Biomedical Informatics*, vol. 46, 2013, pp. 765–773
- [17] A. P. Sudhakar, “How NLP works: The power of natural language processing,” January 2026, <https://botpenguin.com/blogs/how-nlp-works>
- [18] J. Kaur, “Applications of natural language processing for businesses,” March 2025, <https://www.xenonstack.com/blog/natural-language-processing-nlp>
- [19] C. D. Manning and H. Schütze, *Foundations of Statistical Natural Language Processing*. Cambridge, MA: The MIT Press, 1999.
- [20] D. Jurafsky and J. H. Martin, *Speech and Language Processing*. Englewood Cliffs, NJ: Prentice Hall, 2000.
- [21] S. Bird, E. Klein, and E. Loper, *Natural Language Processing with Python*. O’Reilly Media, 2009.
- [22] J. Olive, C. Christianson, and J. McCary (eds.), *Handbook of Natural Language Processing and Machine Translation: DARPA Global Autonomous Language Exploitation*. Springer, 2011.

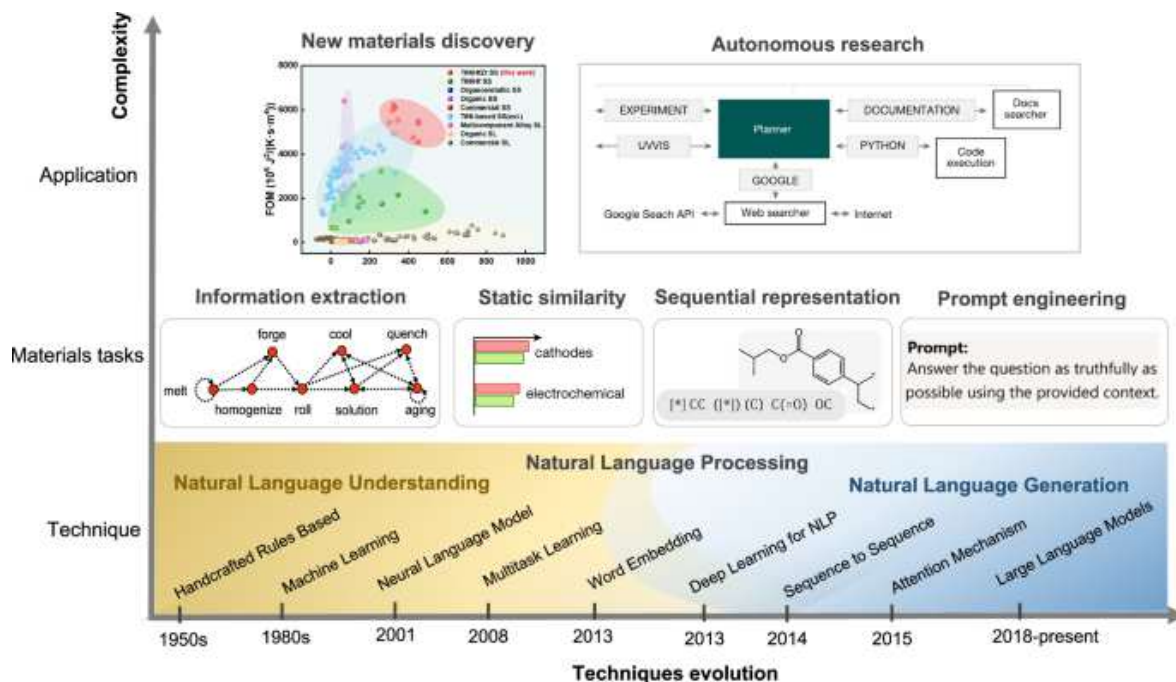


Figure 1 The development and application of NLP [4].

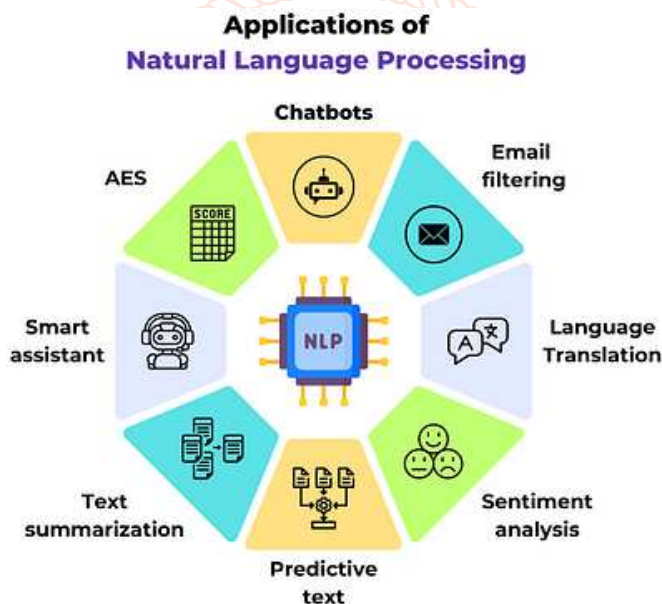


Figure 2 Applications of NLP [6].

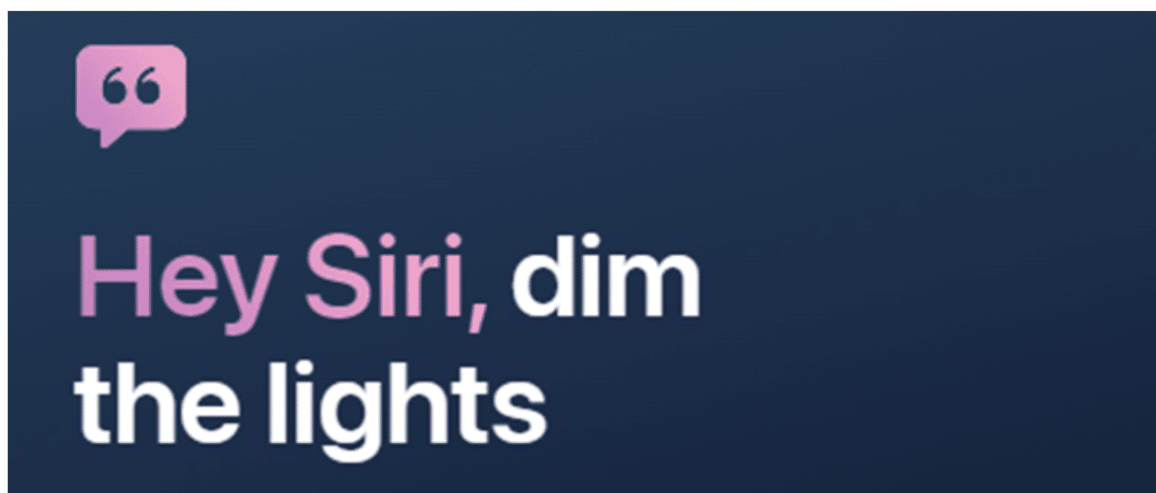


Figure 3 An example of voice command [13].

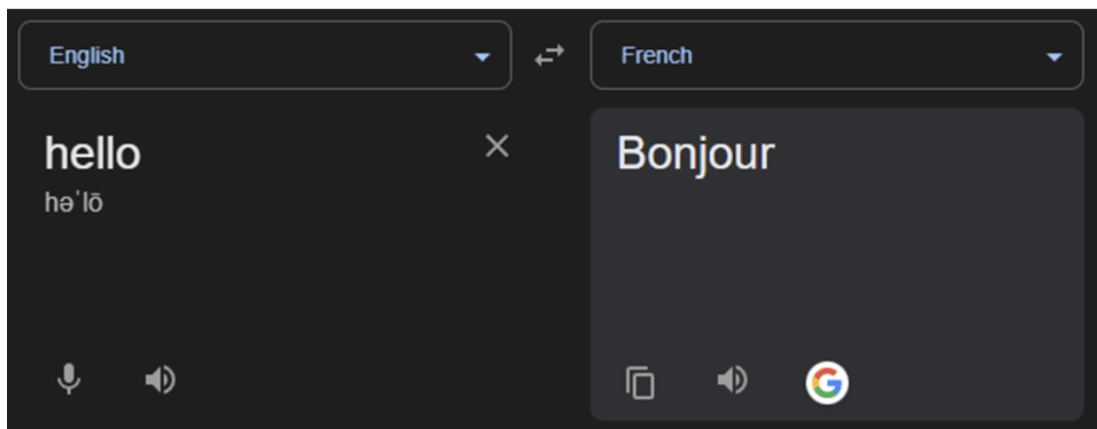


Figure 4 An example of language translation [13].

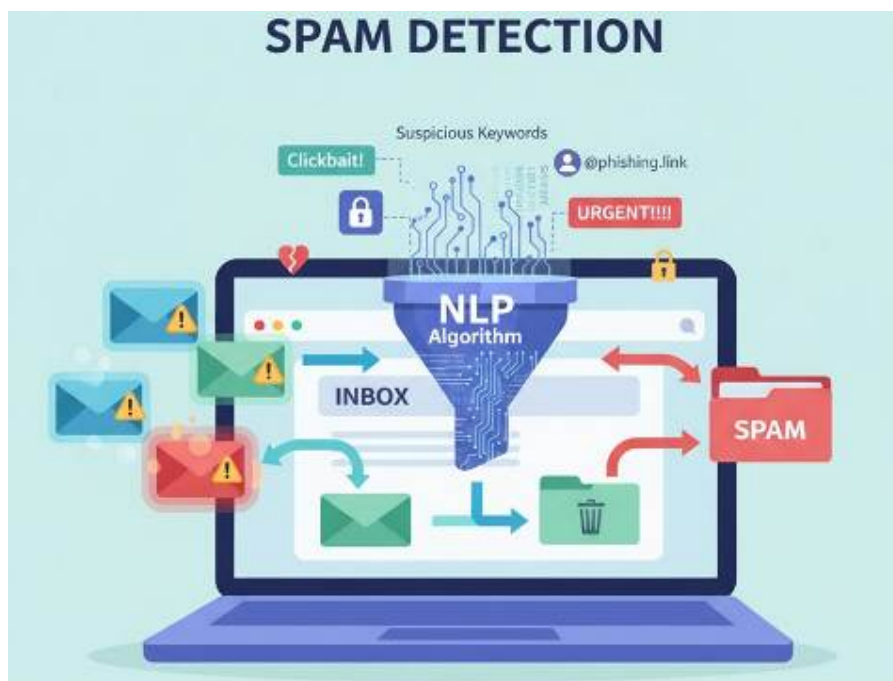


Figure 5 Spam detection [14].



Figure 6 How NLP works in recruitment and HR [14].