LECTURER: Nghia Duong-Trung

ARTIFICIAL INTELLIGENCE

TOPIC OUTLINE

History of AI

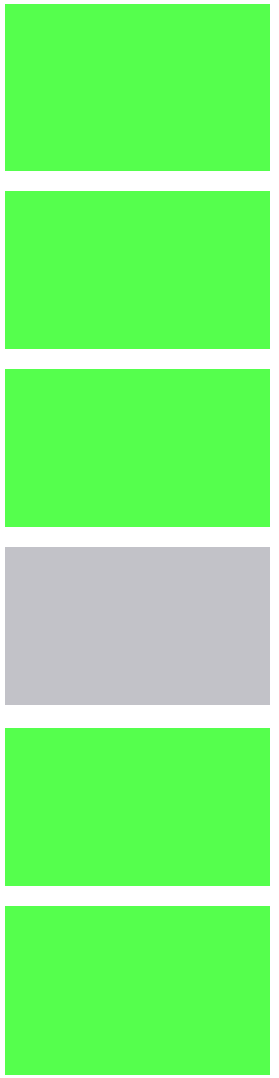
Modern AI Systems

Reinforcement Learning

Natural Language Processing – Part 1

Natural Language Processing – Part 2

Computer Vision



- Course book: Artificial Intelligence_DLBDSEAIS01, provided by IU, myStudies
- Reading list provided by IU, myStudies
- The amount of slides content is based on the course book.
- Additional teaching materials:

https://github.com/duongtrung/IU-ArtificialIntelligenceCourse

DISCLAIMER

- This is the modified version of the IU slides.
- I used it for my lectures at IU only.

UNIT 4

NATURAL LANGUAGE PROCESSING

PART 1

STUDY GOALS

— On the completion of this unit, you will be able to…

… identify the subdomains of NLP.

… explain the historical background of NLP.

… name the most important areas of application.

EXPLAIN SIMPLY

1. What are the three subdomains of NLP?

2. How did NLP develop?

3. What are the most important application areas for NLP?

SUBDOMAINS OF NLP

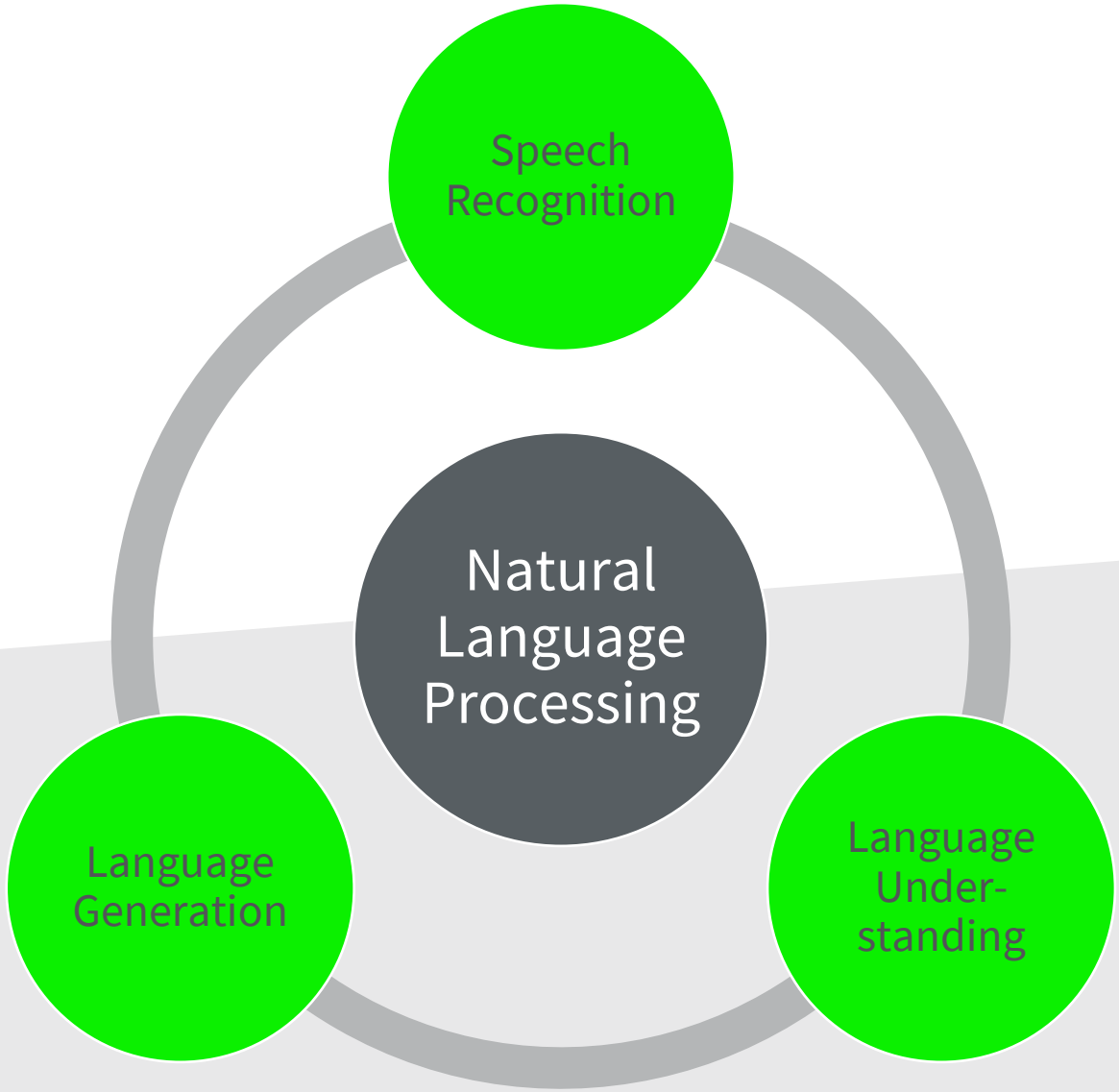


Image Source: Custom Depiction

SPEECH RECOGNITION

- Speech Recognition is a subfield of computational linguistics dealing with the recognition and translation of spoken language into text by computers, a process known as “speech to text” in some cases.
- The phrase “speech recognition” refers to the process of converting spoken words into text in general; however, subfields such as voice recognition and speaker identification specialize in identifying both the spoken content and the speaker’s identity.

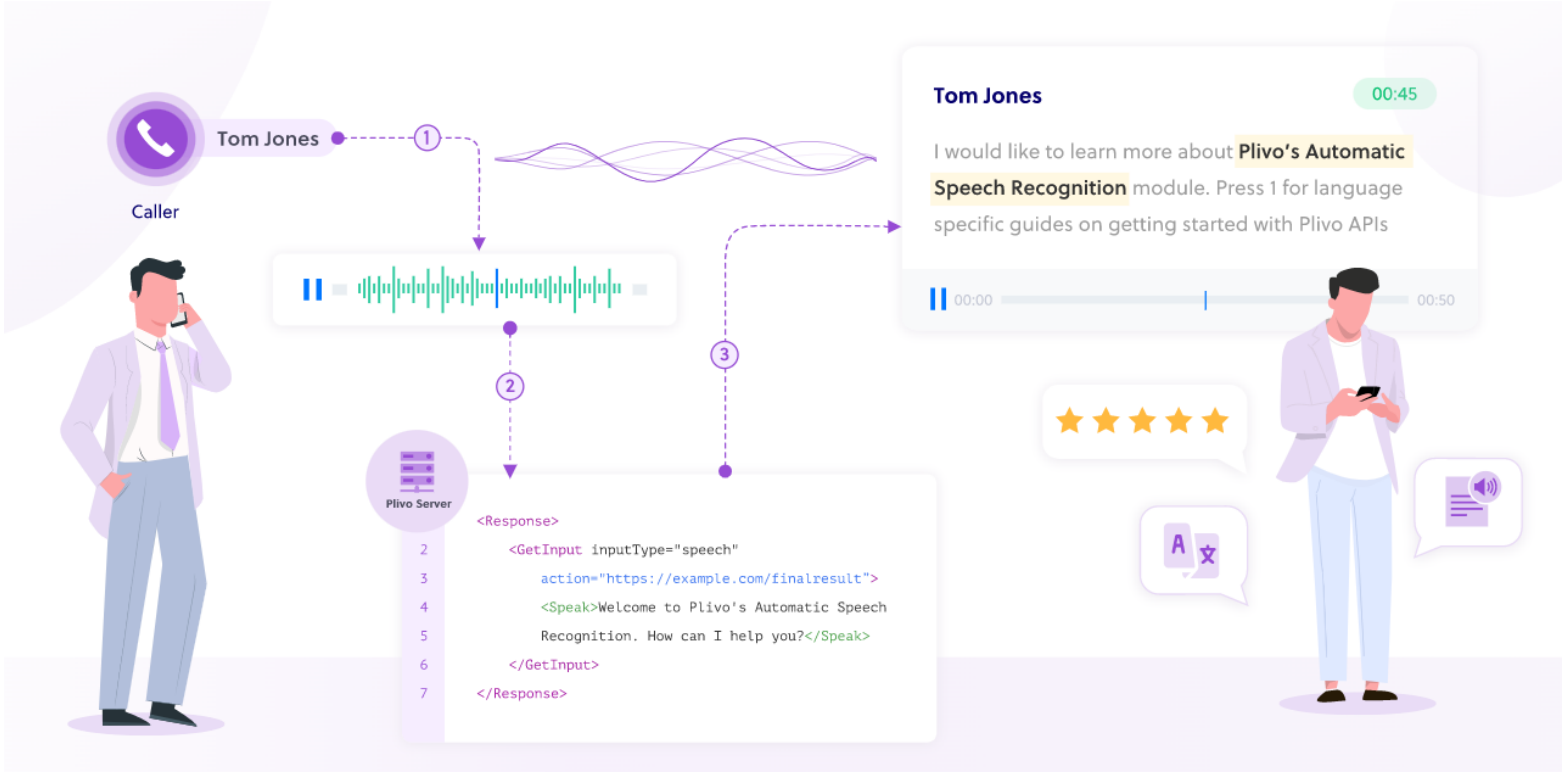


Image Source: Medium.com, Plivo.com

There are two types of speech recognition systems, speaker-dependent, and speaker-independent

- Speaker-dependent systems are designed in such a way that training is required. This works by having a speaker read text into the system or a succession of discrete vocabulary. The algorithm will then analyze the vocal recordings and link them to the text collection.
- Speaker independent systems are speech recognition systems that do not rely on vocal training.

There are two types of models used in speech recognition systems:

- Acoustic Model: A file containing statistical representations of each of the various sounds that make up a word is known as an acoustic model. A phoneme is a label given to each of these statistical representations. There are approximately 40 distinct sounds in the English language that is suitable for speech recognition, resulting in 40 separate phonemes.

- Language Model: To discriminate between words that sound similar, sounds are matched with word sequences. We presume our audio sample is grammatically and semantically sound, even if it is not grammatically perfect or has skipped words. As a result, incorporating a language model into decoding can enhance ASR accuracy.

Steps involved in the process of speech recognition:

- **Analog-to-Digital Conversion**: In most cases, speech is recorded and available in analog format. To convert analog voice to digital utilizing sampling and quantization techniques, standard sampling techniques or devices are available. A one-dimensional vector of voice samples, each of which is an integer, is typically used to represent digital speech.
- **Speech Pre-processing**: Background noise and long periods of quiet are common in a recorded conversation. Identification and removal of silent frames, as well as signal processing techniques to reduce/eliminate noise, are all part of speech pre-processing. Following pre-processing, the speech is divided into 20-second frames for subsequent feature extraction stages.
- **Feature Extraction**: It is the conversion of speech frames into a feature vector that specifies which phoneme or syllable is being spoken.
- **Word Selection**: The sequence of phonemes/features is translated into the spoken word using a language model/probability model.

SPEECH RECOGNITION & NATURAL LANGUAGE PROCESSING (NLP)

- The combination of linguistics and machine learning (ML) is known as Natural Language Processing (NLP). To produce actionable results, NLP seeks to understand human-human and human-computer interactions in the form of language (voice or text). NLP is an ML application in which machines “learn” to understand the natural language from millions of example datasets.
- Speech recognition is concerned with turning speech input into text, whereas NLP is concerned with “understanding” language in order to feed subsequent activities
- Applications
  - Automatic subtitle with speech recognition
  - Mobile telephony, including mobile email
  - People with disabilities
  - Home automation
  - Virtual assistant
  - Dictation

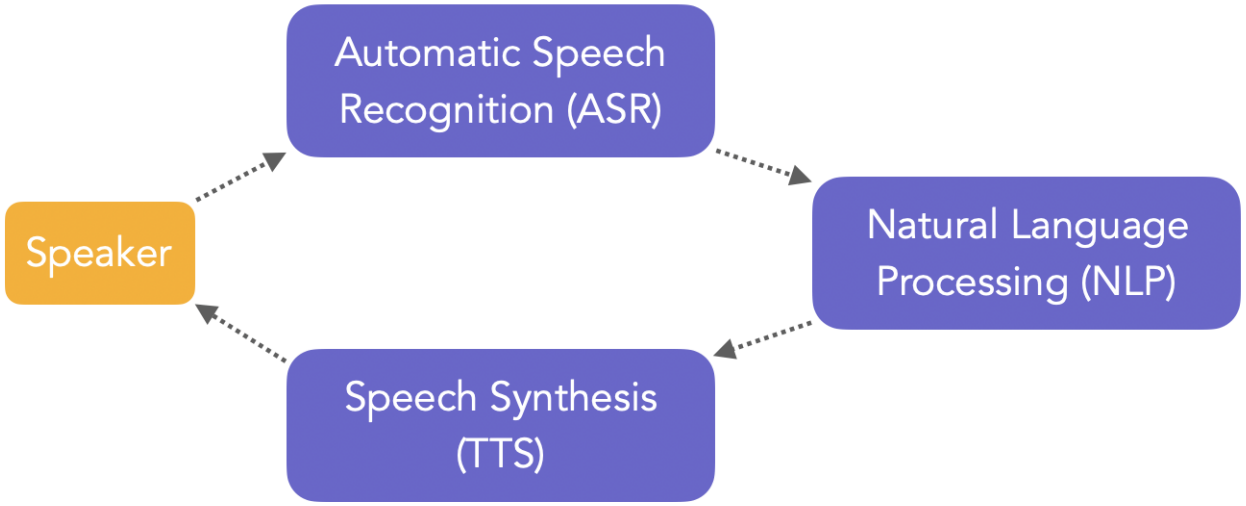


Image source: Medium.com

(NATURAL) LANGUAGE GENERATION

- Natural language generation (NLG) is a software process that produces natural language output.
- NLG is characterized as "the subfield of artificial intelligence and computational linguistics that is concerned with the construction of computer systems than can produce understandable texts in English or other human languages from some underlying non-linguistic representation of information".
  - Common applications of NLG methods include the production of various reports, for example weather and patient reports; image captions; and chatbots.

(NATURAL) LANGUAGE GENERATION

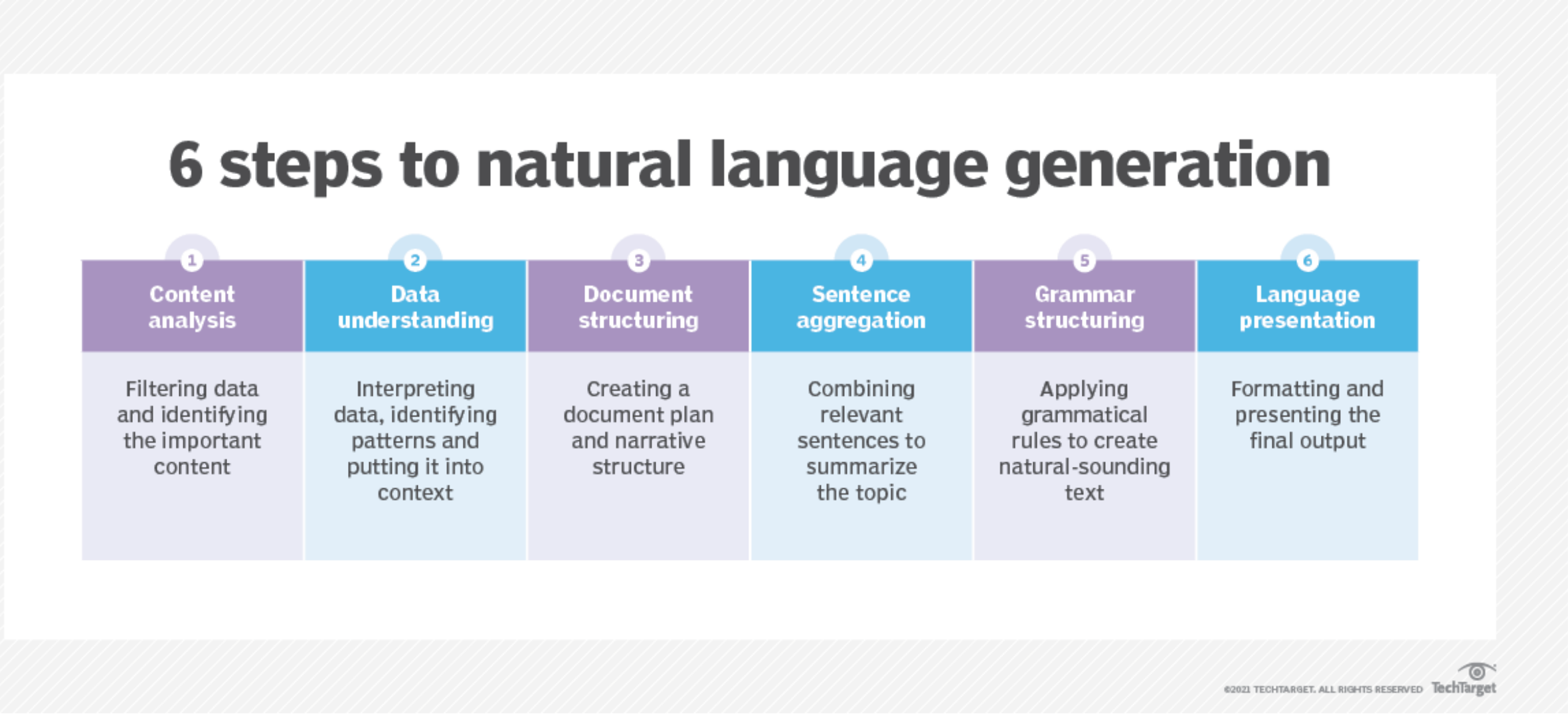


Image source: techtarget.com

(NATURAL) LANGUAGE GENERATION

Natural language generation is being used in an array of ways. Some of the many uses include the following:

- generating the responses of chatbots and voice assistants such as Google's Alexa and Apple's Siri;
- converting financial reports and other types of business data into easily understood content for employees and customers;
- automating lead nurturing email, messaging and chat responses;
- personalizing responses to customer emails and messages;
- generating and personalizing scripts used by customer service representatives;
- aggregating and summarizing news reports;
- reporting on the status of internet of things devices; and
- creating product descriptions for e-commerce webpages and customer messaging.

(NATURAL) LANGUAGE GENERATION

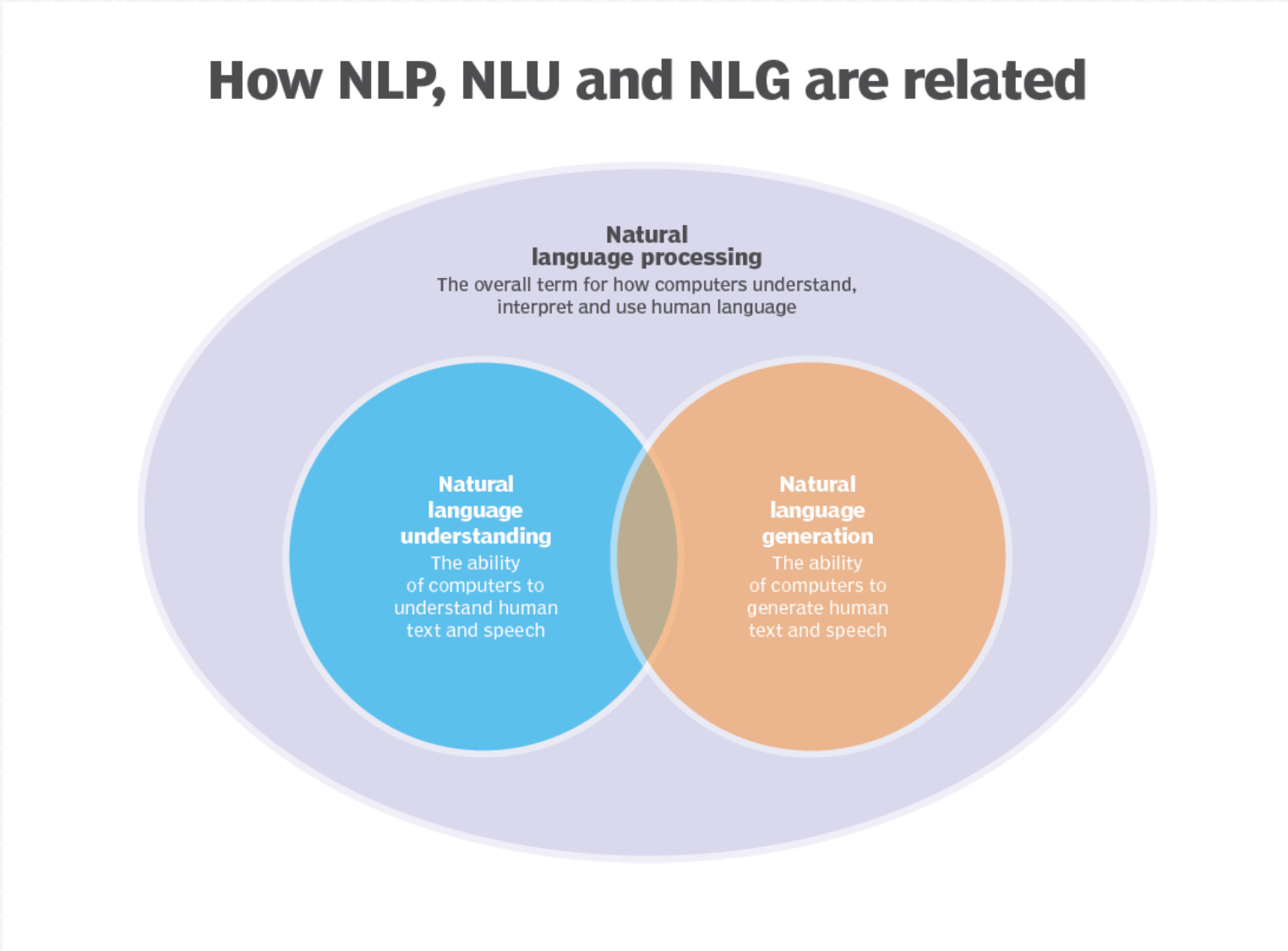


Image source: techtarget.com

(NATURAL) LANGUAGE GENERATION

NLG relies on machine learning algorithms and other approaches to create machine-generated text in response to user inputs. Some of the methodologies used include the following:

- Recurrent neural network
- Long short-term memory
- Transformer
  - Generative pre-trained transformer (GPT)
  - Bidirectional encoder representations from transformers (BERT)
  - XLNet

Image source: techtarget.com

(NATURAL) LANGUAGE UNDERSTANDING OR NATURAL-LANGUAGE INTERPRETATION (NLI)

- Natural-language understanding (NLU) or natural-language interpretation (NLI) is a subtopic of natural-language processing in artificial intelligence that deals with machine reading comprehension. Natural-language understanding is considered an AI-hard problem.
  - what human language means, rather than simply what individual words say.
  - comprehend and respond accurately to the sentiments expressed in natural language text.
  - Natural Language Understanding deconstructs human speech using trained algorithms until it forms a structured ontology, or a set of concepts and categories that have established relationships with one another.
  - computational linguistics

(NATURAL) LANGUAGE UNDERSTANDING OR NATURAL-LANGUAGE INTERPRETATION (NLI)

Extract information from the data source

- “ICE ticket Berlin to München” 15.11, 9am”
  - ICE: type of train in Germany
  - Ticket: intent to buy a train ticket
  - Berlin, München: locations
  - 15.11, 9am: date and time

NLU deconstructs human speech/text using trained algorithms until it forms a structured ontology, or a set of concepts and categories that have established relationships with one another.

- Intent recognition, entity recognition

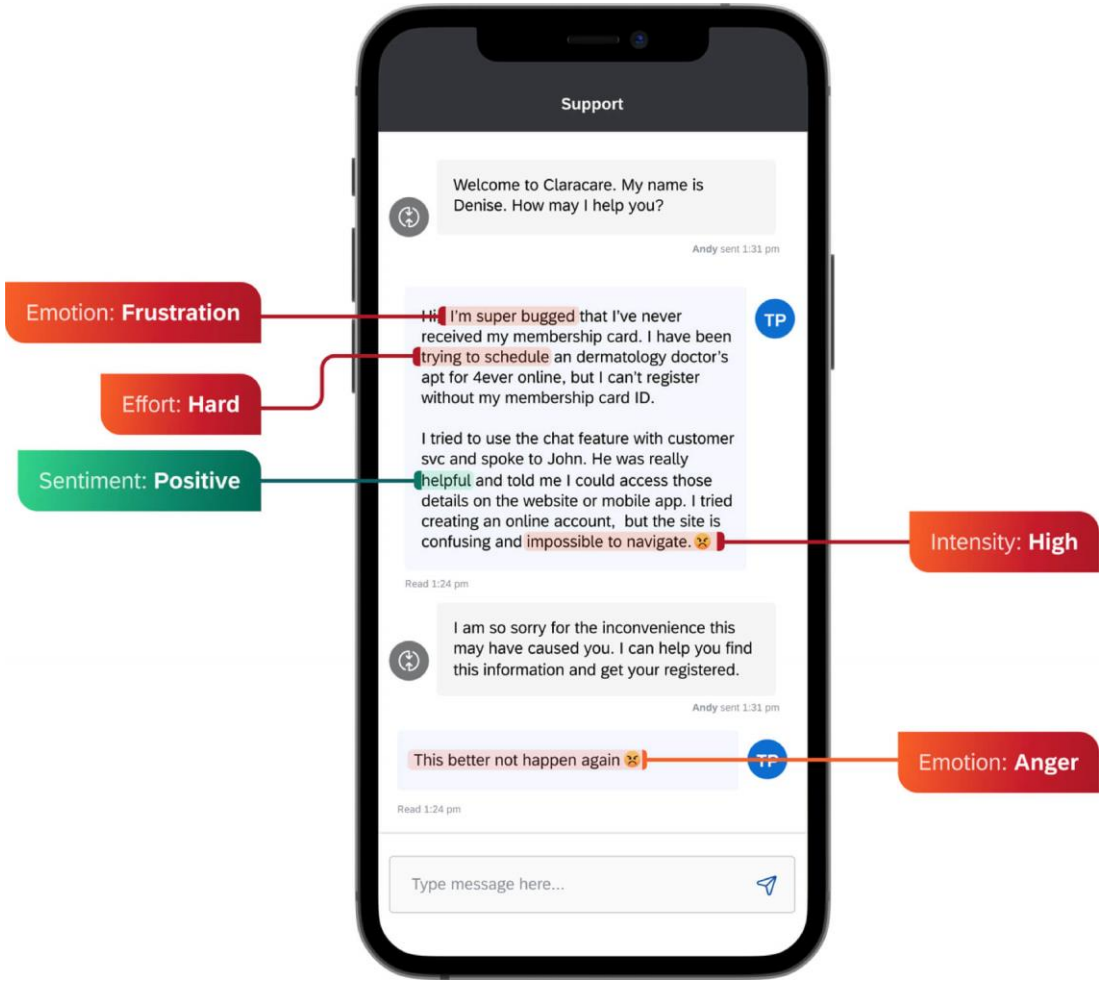
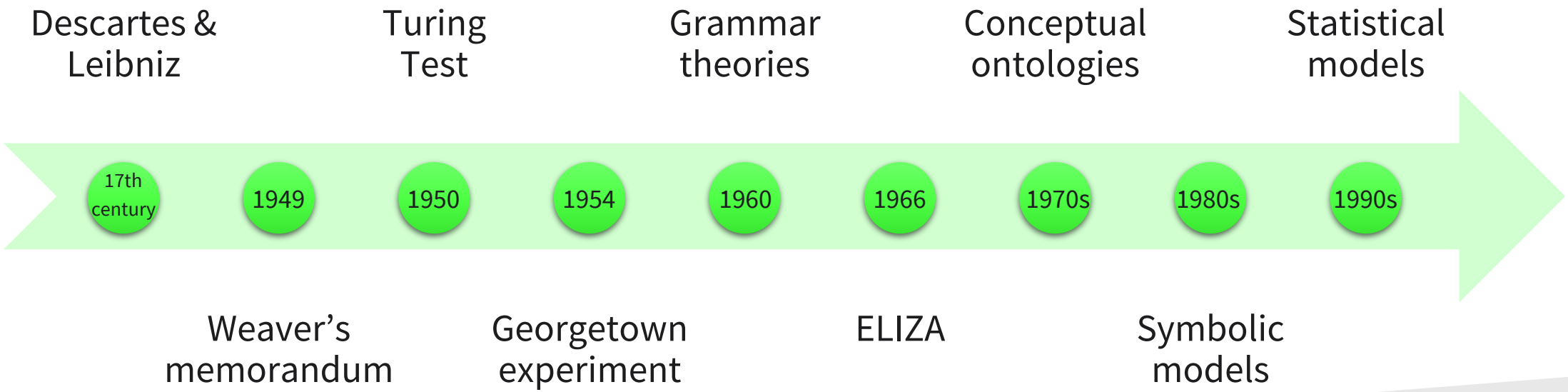
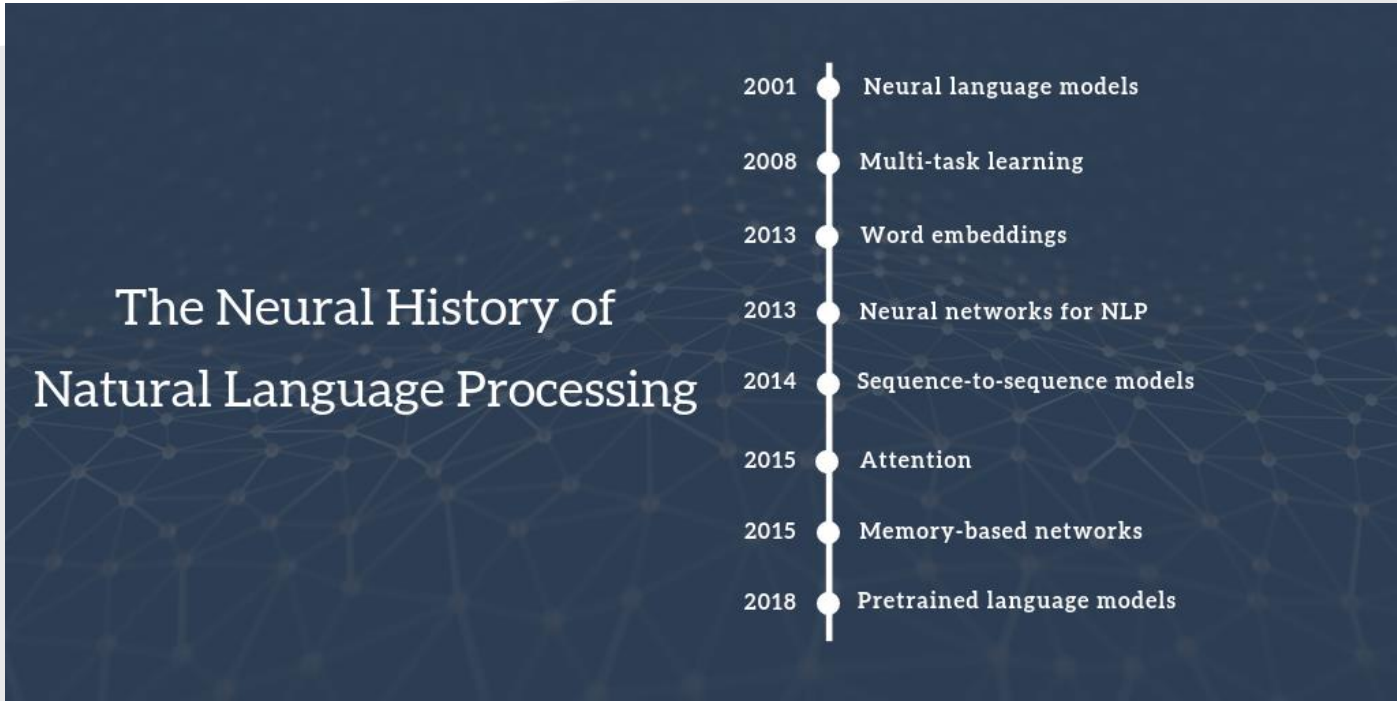


Image source: Qualtrics.com

HISTORICAL BACKGROUND



https://aylien.com/blog/a-review-of-the-recent-history-of-natural-language-processing



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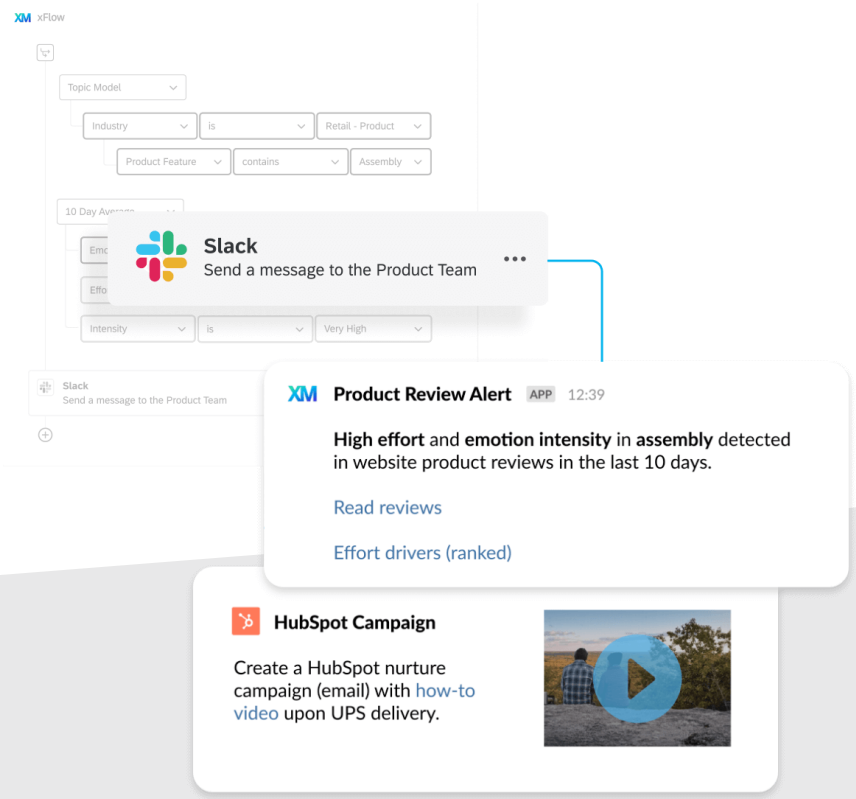
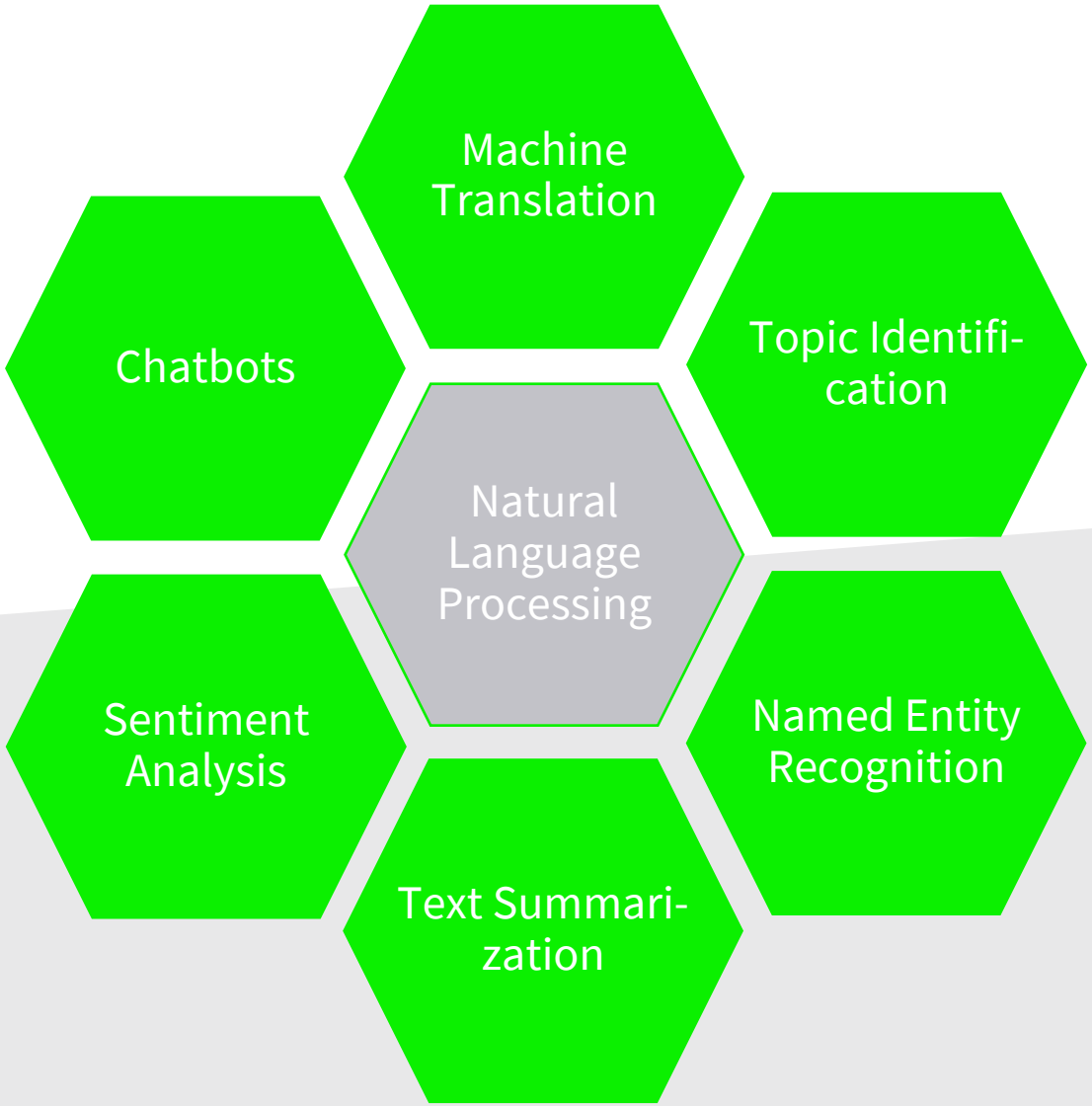
TYPICAL AREAS OF APPLICATION FOR NLP





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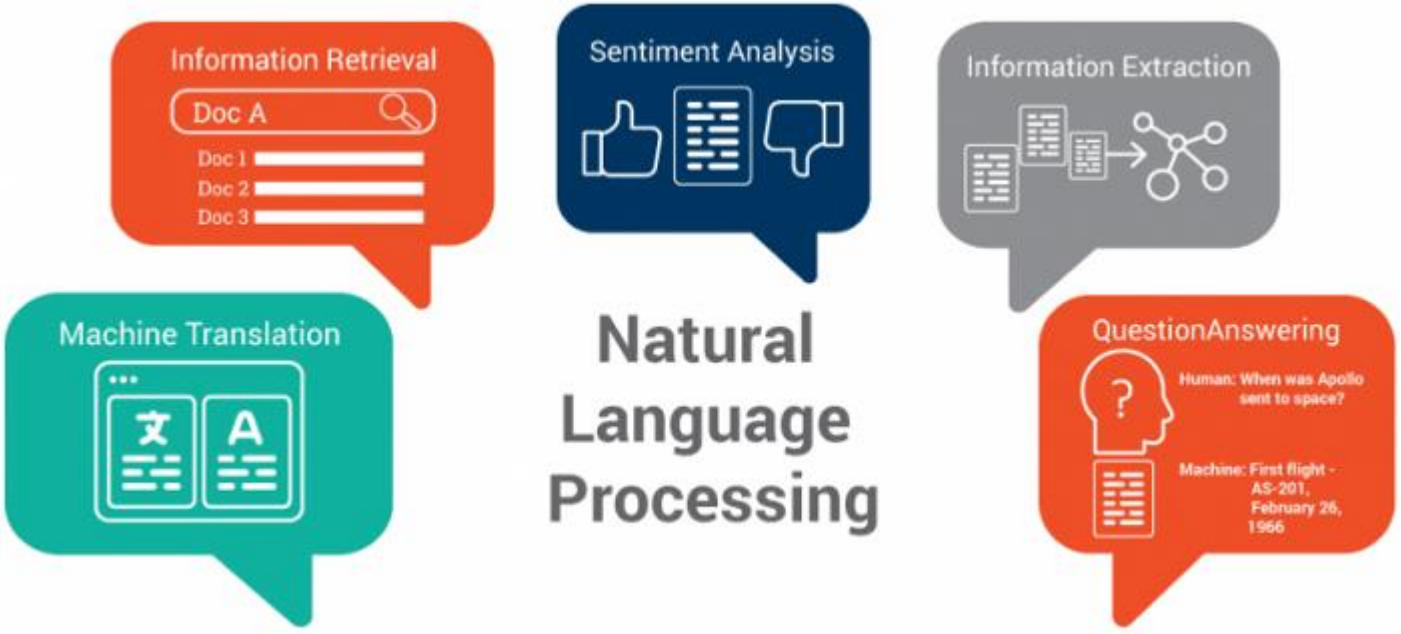
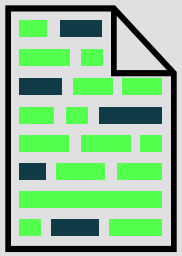
STATISTICS

Worldwide revenue from the natural language processing (NLP) market is forecast to increase rapidly in the next few years. The NLP market is predicted be almost 14 times larger in 2025 than it was in 2017, increasing from around three billion U.S. dollars in 2017 to **over 43 billion in 2025**. Natural language processing (NLP) is a branch of artificial intelligence (AI) that helps computers understand, interpret and manipulate human language. (https://www.statista.com/statistics/607891/worldwide-natural-language-processing-market-revenues/#:~:text=The%20NLP%20market%20is%20predicted,interpret%20and%20manipulate%20human%20language.)



TOPIC IDENTIFICATION



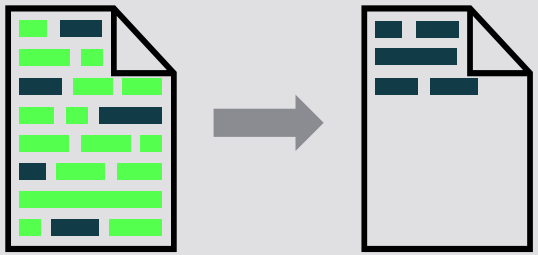
→ <topic>

"One quick way to summarize the milestones in AI history is to list the Turing Award winners: Marvin Minsky (1969) and John McCarthy (1971) for defining the foundations of the field based on representation and reasoning; Allen Newell and Herbert Simon (1975) for symbolic models of problem solving and human cognition" (Russell & Norvig, 2021, p. 35).

→ history

Text Source: Russell, S., & Norvig, P. (2021), p. 35.
Image Source: Custom Depiction.

TEXT SUMMARIZATION

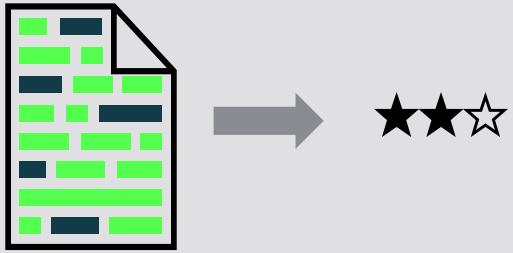


"Mr and Mrs Dursley, of number four, Privet Drive, were proud to say that they were perfectly normal, thank you very much. They were the last people you'd expect to be involved in anything strange or mysterious, because they just didn't hold with such nonsense" (Rowling, 1998, p. 1).

Mr and Mrs Dursley were perfectly normal. They were the last people to be involved in anything mysterious.

Text Source: Rowling (1998), p. 1.
Image Source: Custom Depiction.

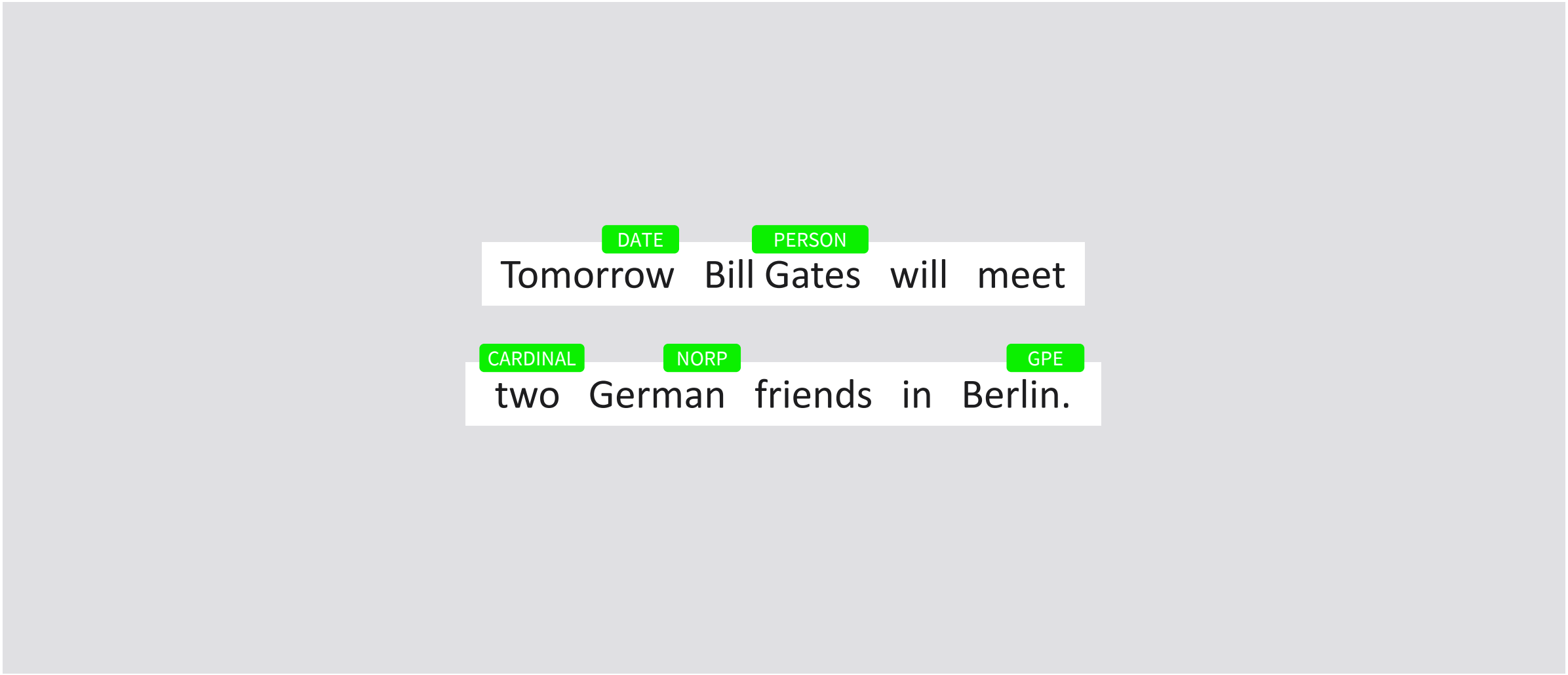
SENTIMENT ANALYSIS



“Exactly what I thought it would be. Perfect early Father's Day gift for my husband – we had so much fun playing ping pong at a resort recently I just had to get it for him.”

Text Source: Jay, L. (2016).
Image Source: Custom Depiction.

NAMED ENTITY RECOGNITION



CHATBOTS

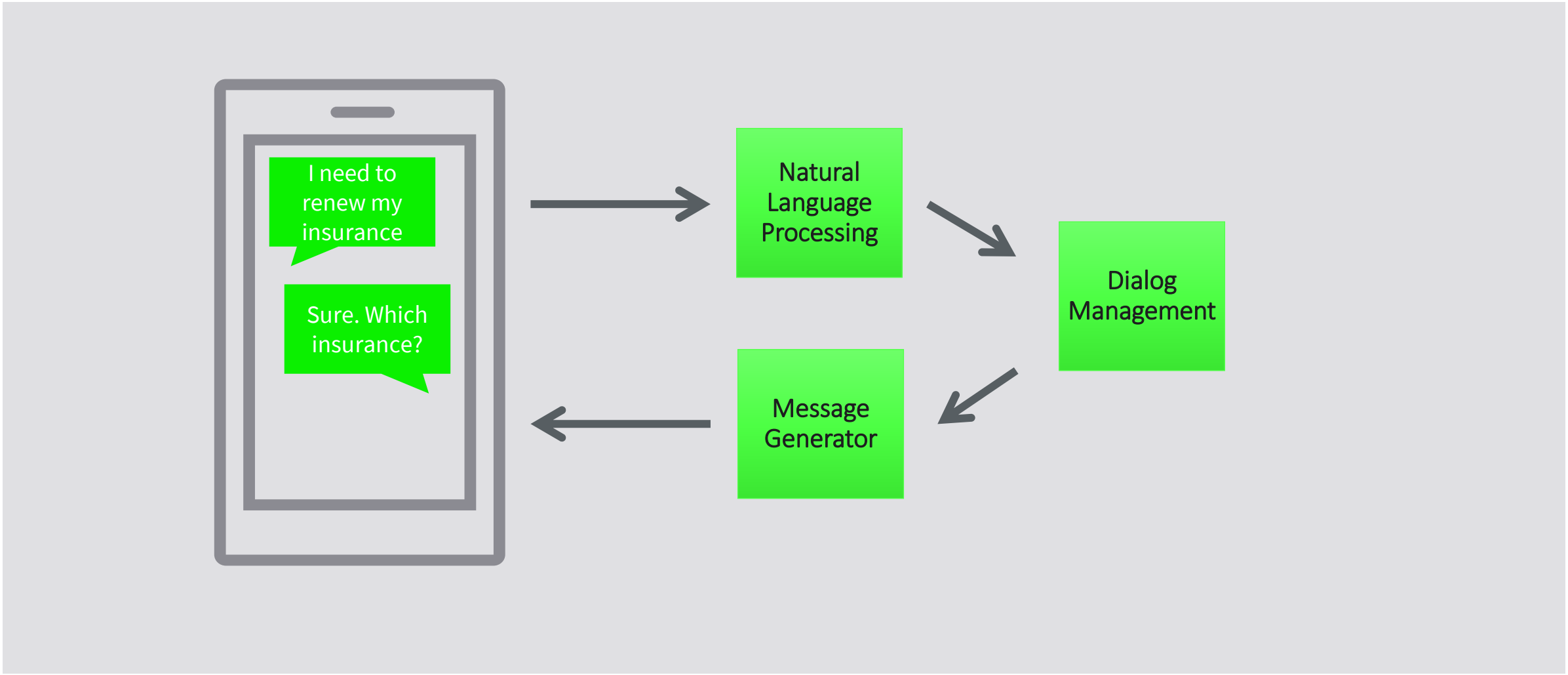


Image Source: Custom Depiction.

MACHINE TRANSLATION

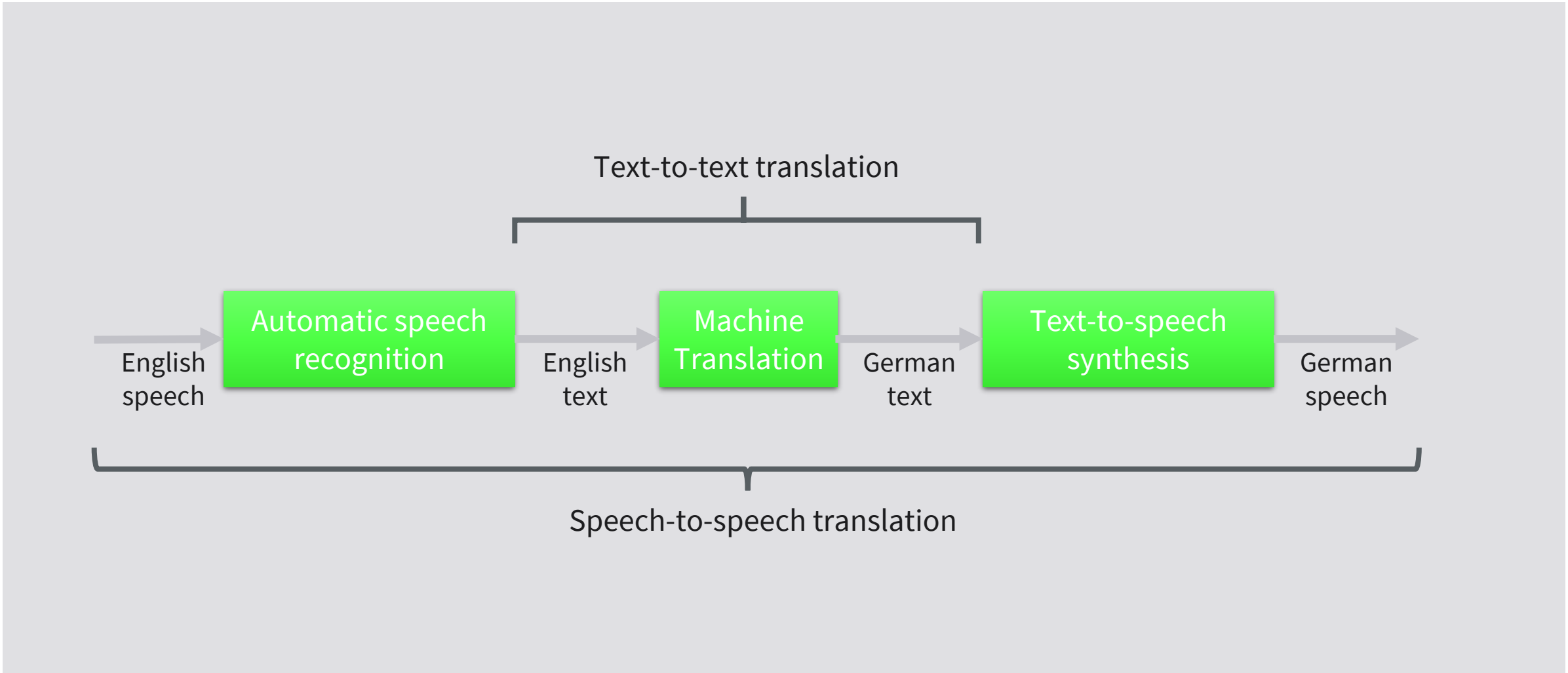


Image Source: Custom Depiction.

REVIEW STUDY GOALS

- On the completion of this unit, you will be able to…

  … identify the subdomains of NLP.

  … explain the historical background of NLP.

  … name the most important areas of application.

SESSION 4

TRANSFER TASK

1. Describe how NLP can be used for marketing purposes.

2. Assume you want to build a system that simultaneously translates language from a Spanish speaker for a French speaking audience.

a) Which components are required for this system?
b) Which data do you need to train the system?

TRANSFER TASK

3. Learn and self-practice on Generative AI and Generative AI Studio.

- https://www.youtube.com/watch?v=G2fqAlgmoPo
- https://www.youtube.com/watch?v=-7nf5EJ2Fsc
- https://www.youtube.com/playlist?list=PLtUo3ajIIgYNLtP_PCFzit_TQRF_ltydP

TRANSFER TASK
PRESENTATION OF THE RESULTS

Please present your results.

The results will be discussed in plenary.

1. Examples for NLP in Marketing:

- Get insights about topics that might be interesting for the customers using topic identification
- Aggregate relevant news using text summarization
- Find out the customers' attitude towards a product using sentiment analysis
- Using chatbots to capture new leads
- Automatically translate customer requests

2.

a) Components of the system

- Spanish Speech-to-text converter
- Text-to-text translation from Spanish to French
- French text-to-speech converter

2.

b) Data corpora

- Spanish data corpus for natural language understanding
- Bilingual data corpus for the translation from Spanish to French
- Data corpus for the generation of French speech

1. Which type of approaches were used in early NLP?

a. Statistical-based approaches

b. Neural networks

c. Rule-based approaches

d. Logical inference

2. What aspects of a text does sentiment analysis deal with?

a. Subjective aspects
b. Objective aspects
c. Spoken aspects
d. Linguistic aspects

3. Which of the following statements is true?

a. Speech-to-speech translation is a part of text-to-text translation.
b. Speech-to-Speech translation is a part of machine translation.
c. Text-to-text translation requires a component for automatic speech recognition.
d. Text-to-text translation is a part of speech-to-speech translation.

Solutions

1. Rule-based approaches
2. Subjective aspects
3. Text-to-text translation is a part of speech-to-speech translation.

LIST OF SOURCES

Jay, L. (2016, June 17). Perfect early Father‘s Day gift for my husband [Review of the product *JOOLA midsize compact table tennis table great for small spaces and apartments – multi-use free standing table - compact storage fits in most closets - net set included - no assembly required*]. Amazon.com. https://www.amazon.com/review/R25UZZH51JWYF5/ref=cm_cr_srp_d_rdp_perm?ie=UTF8&ASIN=B0012QJZTI

Rowling, J. K. (1998). *Harry Potter and the sorcerer's stone*. Scholastic.

Russell, S., & Norvig, P. (2021). *Artificial intelligence: A modern approach* (4th ed.). Pearson.