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Portfolio A0: An Overview of NLP

In my own words, NLP or Natural Language Processing (Human Language Technologies / Computational Linguistics) is defined as the combination of linguistics and computer science as a discipline/process because it involves creating and giving machines the ability to "understand" / process human languages (this includes text, and spoken words) and to do "something" with or to those words. Simply put, NLP is concerned with designing machines that understand the human language just like regular people do. NLP can involve actions such as translating text, executing an action after a human gives a command, summarizing/shortening long news articles, and more ("What Is Natural Language Processing?").

Artificial intelligence is defined as "intelligent machines" where systems act/think rationally and like humans ("What is artificial intelligence?"). And NLP tries to process the human language so it is a subset of AI. NLP also overlays many other subsets that are also in AI such as Machine Learning (ML) and Deep Learning (DL). ML are "systems that can learn from experience" while DL are "systems that learn from experience on large data sets" ("What's the difference between"). In other words, ML and DL are both subsets of AI and NLP is under AI and overlap with both ML and DL ("What's the difference between"). NLP often utilizes and is intertwined with AI, ML, and DL.

Natural Language Processing (NLP) can be split into 2 branches, natural language understanding (NLU) and natural language generation (NLG). NLU processes voice/text input data from a human and tries to understand the meaning/context of the input by means such as syntactic (structure / grammar) and semantic (meaning) analysis (Kavlakoglu). NLG is the process of producing an output in the form of the human language (text or speech) when given some input data (Kavlakoglu). Both NLU and NLG are subsets of NLP as they seek to enable machines to understand language data by "taking unstructured data and converting it into a structured data format" (Kavlakoglu). However, they differ in that NLU focuses on determining the meaning of a sentence while NLG focuses on the generation or creation of text when given an input.

There is an abundance of modern NLP applications that people often use without even realizing it. NLP applications are not always overtly recognizable. For starters, autocorrect, autocomplete, and spell check are all NLP applications that are commonly used unremarkably. Modern applications of this include Google Search, the grammar and spell check Grammarly, and the predictive and autocorrect keyboard app Microsoft SwiftKey (Sharma). An obvious NLP app is Google Translate, which converts a text in one language to text to another language. Google Translate also has the ability to convert text into speech. A common NLP app everyone thinks of are voice/phone assistants. These include Google Assistant, Apple's Siri, Amazon's Alexa, and Samsung's Bixby. They use speech recognition, NLU, and NLG to understand the verbal instructions of a user and execute that action (Sharma). One last example of a modern NLP app are chatbots. Chatbots are often used for customer service support to guide or to solve a customer's problem. Examples of this include the Nike, Frontier, BestBuy, and Amazon

customer support chatbot which is the first line of defense for customer support before utilizing a real person for support.

The 3 main approaches to NLP are rules-based, statistical and probabilistic, and deep learning. Most NLP applications use a combination of all three of these approaches.

Rules-based is the oldest approach toward NLP. This approach designs an NLP system based on linguistic rules and structures. Human languages have rules, grammar, structure, nouns, verbs, etc. so a rules-based NLP app tries to recognize rules and patterns and rely on techniques like regular expressions and Context-Free Grammar Production Rules (Mazidi). This means it has low precision for generalized cases but high performance specific use cases (Mayo). An example NLP app of this approach is IBM's Eliza, a very basic rules-based therapist chatbot from the 1960s. Eliza used “pattern matching and substitution methodology”, to give canned responses that made “users feel they were talking to someone who understood their input”(“Eliza: A Very Basic”). E.g. a user inputs “Hello Eliza” and a pattern would match “hello” and then the bot would say “hello” back.

The next technique came as statistical and probabilistic or ML based NLP. Classic machine learning algorithms use statistical methods, probabilistic modeling, and learn on moderate/large training data to analyze text, and thus give probabilistic results (Mayo). In other words, this approach finds the probability of words and sequences of words which lead to useful language models for translation systems (Mazidi). An example of this is in language translation where in Farsi, “your mother’s mother” is “mama bozorg” and the literal translation is “big mama” but a probabilistic language model can indicate a better translation is “grandmother” (Mazidi). This is like how Google Translate used to use statistical models to translate text before

switching to a new model (Turovsky). Another example of this is a predictive text / autocomplete app such as a search bar / Microsoft Swiftkey (Mazidi).

And finally deep learning based NLP came from neural networks when very large amounts of training data and processing power became available (Mazidi). Neural Networks is a branch of machine learning that simulates the way human brains work and Deep Learning is called "deep" due to how many interconnected layers there are that perform computation on the input data ("Natural Language Processing: A Guide"). Where raw data input goes through Preprocessing, Dense Embedding, Hidden Layers, and then Output Units which consist of Sentiment, Classification, Entity Extraction, Translation, and Topic Modeling ("Natural Language Processing: A Guide"). A real example of a deep learning based NLP app is Google Translate which introduced "Neural Machine Translation" in 2016 (Turovsky). The system is able to translate "whole sentences at a time, rather than just piece by piece" (Turovsky).

My personal interests in NLP is due to my curiosity and fascination with how many use cases or real world applications that involve the use of such technology. Every time I interact with an application that involves computers understanding the human language, I am amazed at how relatively good it performs its intended purpose/action and I wonder how exactly it works and how people are able to create these interesting machines. I would love to learn more about NLP for both personal projects and professional applications usually by understanding how to build applications such as a customer assistant chat bots (often used as customer support for businesses), online chat bots (often used on sites such as Reddit and Discord), voice assistants (E.g. Siri, Google Assistant, Bixby), or even language translations/manipulations (such as summarizing an article). By learning and building any of these apps as a possible class project,

I'd hope to understand exactly how NLP is used and created, which in turn lets me understand how to build an NLP application in the future either for a personal project or work.

Works Cited

"What Is Natural Language Processing?" IBM, https://www.ibm.com/topics/natural-language-processing. Accessed 28 January 2023.

"What Is Artificial Intelligence (AI)?" IBM, https://www.ibm.com/topics/artificial-intelligence. Accessed 28 January 2023.

Sharma, Abhishek. "Top 10 Applications of Natural Language Processing (NLP)." Analytics Vidhya, 23 July 2021, https://www.analyticsvidhya.com/blog/2020/07/top-10-applications-of-natural-language-processing-nl. Accessed 28 January 2023.

Mayo, Matthew. "The Main Approaches to Natural Language Processing Tasks." *KDnuggets*, Guiding Tech Media, 17 Oct. 2018, https://www.kdnuggets.com/2018/10/main-approaches-natural-language-processing-tasks.html. Accessed 28 January 2023.

Mazidi, Karen Janice. *nlp01-Welcome to Natural Language Processing*. YouTube, 2 Aug. 2020, https://www.youtube.com/watch?v=PcMdvb7jg0w&list=PLfe6IcA_dEWk_OYj4vLz5jBqvLTc7JJOc. Accessed 28 January 2023.

"Eliza: A Very Basic Rogerian Psychotherapist Chatbot." *Eliza, a Chatbot Therapist*, https://web.njit.edu/~ronkowit/eliza.html. Accessed 28 January 2023.

Turovsky, Barak. "Found in Translation: More Accurate, Fluent Sentences in Google Translate." *Google*, Google, 15 Nov. 2016,

https://blog.google/products/translate/found-translation-more-accurate-fluent-sentences-google-translate/. Accessed 28 January 2023.

"Natural Language Processing: A Guide to NLP Use Cases, Approaches, and Tools." AltexSoft, 25 Aug. 2021, https://www.altexsoft.com/blog/natural-language-processing/. Accessed 28 January 2023.

Kavlakoglu, Eda. "NLP vs. NLU vs. NLG: The Differences between Three Natural Language Processing Concepts." Watson Blog, IBM, 12 Nov. 2020, https://www.ibm.com/blogs/watson/2020/11/nlp-vs-nlu-vs-nlg-the-differences-between-three-natural-language-processing-concepts. Accessed 28 January 2023.