

Introduction to Natural Language Processing

Artificial Intelligence has integrated in our lives, and its technology has grown quickly in the past few years. Natural Language Processing (NLP) is a branch of Artificial Intelligence (AI) in which a computer simulates language comprehension similar to that of a human. This simulation is accomplished by the use of a combination of rules-based approaches, statistical-based approaches, and usually incorporates Deep Learning models taken from the Machine Learning (ML) branch of AI. Thus, ML and NLP are separated entities within AI, and NLP utilizes ML models to produce computer AI. Herein, a basic overview of NLP.

As noted previously, AI has been incorporated in our lives, and NLP is available in many of our normal day activities. From simple spam detection to Personal Assistants (such as Apple™ Siri, Google™ Assistant, and Amazon™ Alexa), NLP is a useful tool that can be leverage to help humanity. NLP, in general, has two domains: that of speech/text understanding and speech/text generation. Starting with speech recognition, vocal language is converted to text. Once as text, the language input may be processed via: sentence and/or word tokenization, parts of speech (parts of speech tagging), named entity recognition (NER) and various other preprocessing to which statistical methods can be drawn. Prediction analysis with ML models assists in sentiment analysis, and recognition of language meaning. As such, this is considered Natural Language Understanding (NLU) by which computers take in input of speech or text and are able to comprehend the input [1]. Google and spam detection are prime examples of NLU in the modern world. Utilizing ML pipelines, machine translations and response generation, applications such as Chat GPT and chatbots are a possibility. Producing language response or output via text or speech is Natural Language Generation (NLG) [2], which is the other subdivision of NLP. Thus, the text generated by Chat GPT or the voice response of electronic personal assistant (such as Alexa and Siri) are modern world applications and examples of NLG.

As noted, NLP has three approaches by which the end response is obtained. First is the rules-based approach of NLP. Language by its nature has certain rules by which form the syntax and structure of the language. Converting these rules into code provides a foundation in which computers could fundamentally understand or comprehend language. Rules-based approaches is considered the first element of NLP, and in part, may be the foundation upon which NLP started and extended. As noted in Class, ELIZA is one of the first implementation of rules-based approach to simulate a Rogerian psychotherapist. [3] Rules-based approaches powers many of the spelling and grammar checkers seen in word-processing applications, as well as some language translation applications.

The next step in the progression of NLP was with Statistical based approaches. Utilizing mathematical distributions and statistical methods, NLP is given the ability to predict meaning, words and sentiment. Humans do similarly without noting the mathematical detail. For instance, if someone shows expressions of sadness and communicate these expressions, one can infer or guess the next words that the person might communicate. Also, one can at least determine that they might be in a depressed state, or not in a jovial mood. Statistical Based approaches provide the means for a computer to have this ability to infer and makes logical suggestions. This methodology is seen in auto-completion technology in some websites and word processing applications. Similarly, this technology is utilized (at least in part) in sentiment detection bots that have been proposed and utilized by some companies and theorized academically [4] .

Finally, the last approach in NLP is ML Deep Learning Techniques. One of the fundamental tools in ML is the concept of the neural net, which in essence is an encoded simulated human neuron. These neurons take in data (input), and weighs these inputs. After reaching a certain threshold computed by mathematical models, the neuron is activated-- thus simulating a biological neuron. Coupled with Gradient Descent and other linear algebra models, an approximation based on a trained model is generate. Once the neuron is coupled with other neurons (also known as a perceptron) a connection of inputs and weights are created. Utilizing the concept of backpropagation in which the weights are adjusted to be closer to a pretrained model, a neural network is formed. These networks of neurons and backpropagation are the basis of convoluted neural networks (CNN). CNNs in their inception had limitations of the amount of data that it could process. Due to these limitation, Recurrent Neural Networks were conceived to take in multiple inputs and make multiple inference, which leads to the concept of Deep Learning. [5] With the foundation of Deep Neural Networks and Deep Learning, NLP has the means for computer cognition that is utilized in Chat GPT™, and as well as the predictive aspect of spam detection.

In conclusion, NLP has three fundamental approaches that are used in modern technology and applications. These include Rules-based, Statistical-based, and ML/Deep Learning - approaches. NLP will play a major role in the development of technologies that will interact and hopefully aid humanity. As a side note, my interest in this field was introduced in a ML course, and I found the project in that class was interesting. At the time, I had never been exposed to the power of language/communication and equally the power that NLP can wield. In many ways, NLP crosses many discipline—to which I too share a multi-disciplined background and thus my interest in the field. There are many interests within the applications of NLP (such as chat-bot generation, text completion, and language translation) which are outside of my profession. However, but I believe that this could be utilized in a humanitarian project (such as to aid refugees of war or help immigrants). With the basic NLP fundamentals, it is my belief that this technology can be utilized in a utilitarian way to better humanity.

Works Cited

- [1] Wikipedia, "Natural Language Understanding," Wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Natural-language_understanding. [Accessed 25 January 2023].
- [2] Wikipedia, "Natural Language Generation," Wikipedia, [Online]. Available: https://en.wikipedia.org/wiki/Natural_language_generation. [Accessed 25 January 2023].
- [3] K. Ronkowitz, "ELIZ a very basic Rogerian Chatbot," [Online]. Available: <https://web.njit.edu/~ronkowitz/eliza.html>. [Accessed 27 01 2023].
- [4] J. P. Dickerson, V. Kagan and V. Subrahmanian, "Using sentiment to detect bots on Twitter: Are humans more opinionated than bots?," in *2014 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM 2014)*, Beijing, 2014.
- [5] M. Ekrman, *Learning Deep Learning*, Boston: Addison Wesley, 2022.