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Assignment: Overview of NLP

A Definition of NLP
Natural language processing (NLP) is the field of training computers to recognize and generate natural language, process natural language data, and interact with human users using natural language.

The Relationship Between NLP and AI
NLP is a sub-field of AI, which is a broad field encompassing a wide variety of other topics, including machine learning. NLP, ML, and AI are all related topics; major AI projects may focus on any one of these topics or incorporate all three. A major component of AI is training machines to recognize patterns in data and generate output or make decisions accordingly, and NLP focuses exclusively on patterns in natural, human languages.

Natural Language Understanding & Generation
Natural language involves the cycling of two acts: natural language generation (ie. the formation of spoken responses) and natural language understanding (ie. both parties' comprehension of what was said). The acts of speaking, comprehending what was said, and formulating an appropriate response are highly complex and don't necessarily follow a known set of rules or steps, but do generally follow patterns, thus making the problem of NLP appropriately solvable by AI and machine learning.

Modern NLP Applications
In modern years, many common NLP applications have grown highly advanced, and we interact with them on a daily basis. An extremely mundane example is automated word suggestions, such as searchbar autofill suggestions and email reply suggestions. When we type on our computers or smartphones, often we'll be using an application like Google or Outlook which automates suggestions for what we might want to type next. These suggestions come from countless repetitions of training an NLP algorithm on search and email data, until the algorithm can generate an accurate enough model of what users are likely to want to say next. Another example is machine translations, which translate words between languages. Translation itself is not a simple act that follows easily codified rules either; accurate translations have to take into consideration factors like context, idioms, metaphors, sarcasm, and other figures of speech. An accurate machine translation application has to be trained on large amounts of language data in both languages in order to identify patterns in how one language maps to the other.

The Three Approaches to NLP
There are three general approaches to solving NLP problems. The first and oldest technique is the rules-based approach, which uses sets of rules to analyze and produce grammatically correct sentences. These rules can be implemented through regular expressions with lists of exceptions and context-free grammar production rules. However, this technique doesn't scale well because human language is too complicated to simply be encoded in some rulesets. Even so, approaches of this type form part of the complex systems in modern approaches, too. An example of the rules-based approach is Eliza, which was a therapist chatbot made in the 1960s. Eliza would form sentences by simply following some grammar production rules, or otherwise by outputting preset lines.

The second technique is the statistical and probabilistic approach, which became popular post-1980s. This approach improves upon the rules-based approach and is more mathematical in nature, involving the counting of words and word sequences to determine their probabilities, which leads to the production of better language models and better data to train machine learning algorithms on. The result was the production of accurate word translations, predictive text, and other NLP systems. The ML approach requires only a moderate to large amount of data to perform well, and became popular as more and more language data became available over the decades. In some scenarios, the ML approach may even outperform the DL approach if extremely large amounts of data aren't available. An example of the ML approach is Watson, IBM's famous question-answering (QA) system that uses machine learning to process queries, retrieve and analyze information, and deduce answers. Watson is best known for being so advanced in its ability to answer questions that it won on the quiz show *Jeopardy!* in 2011 [1].

The third and final technique is the deep learning approach. As the amount of available data went from large to huge in modern times, DL approaches like neural networks became more viable. Additionally, the evolution of better GPUs and cloud computing allowed for enough processing power to sustain neural networks. DL algorithms improve on ML algorithms by deriving from neural networks, which are known for their considerable potential to solve many highly complex problems, NLP among them. However, DL algorithms are limited by the fact that they require large amounts of data and the hardware to process it, which not everyone has access to. So due to these limitations, smaller-scale methods are still used in many NLP applications, and typically most NLP projects will incorporate a blend of these 3 approaches. An example of the DL approach is Google's Neural Image Caption application, or NIC, which uses deep learning to combine computer vision and NLP to analyze images and produce meaningful, accurate captions of what is being depicted [2].

About My Interest in NLP

My personal interest in NLP stems from my lifelong fascination with language: I enjoy reading and writing, learning new languages, studying the psychology of healthy communication, and pondering on the similarities and differences between natural human languages and formal programming languages. Additionally, language is a shared interest between my bilingual family members and I, which makes for some endearingly recursive conversations on the topic. When I realized I could combine my passion for language with my profession as a programmer, it was like something clicked for me. My goal is to explore this particular avenue until I can hopefully find a place in the computer science field where I can bring my passion for language to the table.

Sources

[1] Wang, James. "How Much Artificial Intelligence Does IBM Watson Have?" [Online]. *ARK Invest*, 12 July, 2017, https://ark-invest.com/articles/analyst-research/ibm-watson/. [Accessed: 27-Jan-2023].

[2] Hornyak, Tim. "Google Program Can Automatically Caption Photos." [Online]. *PC World New Zealand*, 18 November, 2014, https://www.pcworld.co.nz/article/559886/. [Accessed: 27-Jan-2023].