Natural Language Processing (NLP)

Observing "Siri-like" models

Alec Moore
Thomas Glasser

April 22th, 2014

Whitworth University Computer Science Department

1 Abstract: Case Study Proposal

Proposal:

We wish to get an in-depth understanding of how voice recognition relates to Artificial Intelligence. The background behind this is that systems such as the famous Apple "Seri", is able to accept voice and recognized different patterns of speech grammar and produce results for the user based off of that recognition. However, our project will incorporate how those systems go about interacting with voice recognition. Thus, we have divided our project into two different parts:

- **Implementation:**

  We wish to build a Windows 8 Desktop Application that incorporates simple voice recognition. Initially, we want to make it a math tutor in which based on specific commands we give the program, it will be able to detect those certain phrases and words and produce a result. For instance, if I requested the sum of two plus two, the program will be able to recognize those keywords (such as "you said two") and produce a result. An overarching goal would be to have the application be able to interact back with the user thus giving way to a more personal app.

- **Research and Presentation:**

  For the research aspect, we will be going more in depth about how voice recognition works in relation to Artificial Intelligence. Through this paper, we will be giving an abstract definition of Artificial Intelligence and how our subject relates to this. For instance, the research will give in-depth analysis of the systems of interactions between the user, the application itself, the server, the cloud, and so forth.

  For the presentation aspect, we would like to combine both the efforts of the implementation and research. For instance, providing a demonstration of our implementation and synthesizing it with our research reflects what we have just presented.

2 Introduction: What is Natural Language Processing?

Natural Language Processing, or NLP, is a field within computer science and Artificial Intelligence that deals with interactions between between computer and human languages. In most cases, NLP is a human-computer interaction involving natural language understanding which "enables" computers to know the purpose and intent behind human language input [4]. Modern algorithms concerned with NLP are based on machine learning, where the machine is able to learn from data, just as how humans learn from daily experiences. Thus, the purpose of NLP is provide an interface that interacts much like a human, being able to have human emotions and thoughts and based on given conditions, can answer in respect to the context of the conversation. Most of the problems and concerns around NLP are around natural language understanding as we will discuss later on. Listed below are some common spoken and textual/interactive systems[1]:

- Make reservations or checking status of transportation plans.
- Navigation systems in cars with satellite-based systems for efficiency.
- Video search companies that provide search services using speech technology.
- Google (translation pages)
- Automated systems to analyze educational material.
- Interactive virtual agents for learning.
- Information retrieval.

These common systems are both of problem and have potential for innovation within NLP. NLP can be problematic in that it is hard to devise appropriate systems that can replicate human interaction. It has potential because NLP is a growing field and many technological advances are helping us cross-culturally connect humans with computers. Research is continually expanding in many tasks of NLP including machine translation, named entity recognition, natural language generation, natural language understanding, parsing, and so forth.

Although these topics are relevant to NLP, for brevity, the paper will be addressing mainly NLP architecture and how it works to communicate with humans.

3 NLP Architecture and Build

Since NLP has the "understanding" component, is important to analyze what what NLP references to in order to determine the context the intent of words and meaning. Language is complex and can be analyzed on several different levels of structures [1]. Key components of this structure includes but are not limited to: **morphology**, the form and structure of a word and its relationship to roots and derivations, **syntax**, how words are put together to form phrases or sentences, **semantics**, the study of meaning in language, **parsing**, breaking down a sentence down into its component parts of speech "with an explanation of the form, function and syntactical relationship of each part", **lexical**, relating to the vocabulary, words or morphemes of a language, **pragmatics**, the use of language in context, and **ellipsis**, omission of portions of sentences that are not necessary[1]. Thus, grammar plays a heavy role in understanding language. The diagram below gives the general flow of NLP processing, which incorporates many of the components from above:

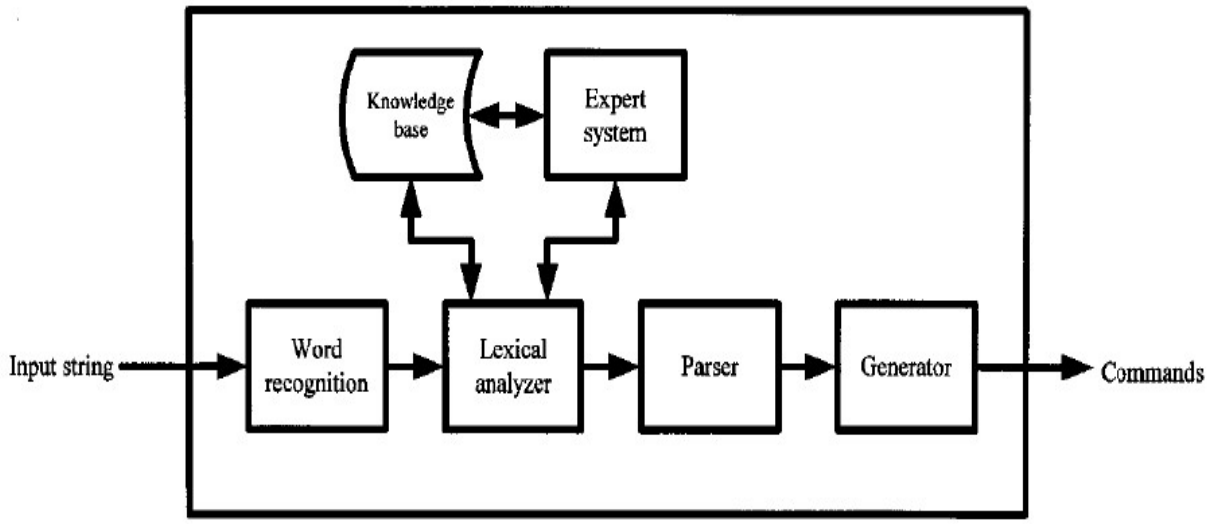

Figure 1: Natural Language Processing Flow. Source: [2]

First, an input string is given into the module. Within the module, several phases and processes occur. The input string is then restructured into a series of nouns, verbs, adjectives, objects, and so forth. Resulting from this, the words and phrases are checked for integrity of the sentence structure and clarifying ambiguities. The lexical analyzer

performs semantic analysis (checking spelling and alternative meanings), the knowledge base stores general knowledge such as words and concepts, and the expert system provides a variety of functionality including deducing ambiguous terms based on context, questions, organizing rules previously defined, and so forth. From here, the words and/or phrases are parsed through a parse tree where their components are broken down to explain its form and function and relationship. A generator then outputs commands based on the meaning deduced previously and the parse tree where the computer executes the commands [2].

4 The Goal

The goal of Natural Language Processing is to "design and build software that will analyze, understand, and generate language the humans use naturally" [3] in order to effectively communicate a computer device as you would a human.

4.1 The Challenges

In order to reach this goal, there are many complexities of language that must be defined and explained in a way that a computer can understand, however the "understanding" aspect is a very challenging task. "Understanding" requires knowing what concepts a word or phrase stands for and how to link the concepts together into something meaningful, and thus a lot of this structure is built on knowing the intent behind a sentence being said. For example, if I asked a vague question or any question relating to morality, how does the computer know how to interpret these meanings and definitions? How do we "code" or build this type of system? Currently, modern machines are able to produce massive parse trees and hold a large database but are still incapable of mastering basic language structure. The main challenge then comes to how much exposure the machine is presented with. Words such as "can" can both be appropriately used as a verb or noun, but how does the machine or rather how should it interpret this meaning[3]. Currently, NLP has many limitations and challenges of language complexity and stucture. Addressing these problems are given in the next section.

4.2 Addressing the Issues

Providing "solutions" would not be the correct term to use in NLP. A more appropriate term to use would be how we as humans can *address* these challenges. Microsoft research uses a mix of "a mix of knowledge-engineered and statistical/machine-learning techniques to disambiguate and respond to natural language input"[3]. Other research looks to parsing more accurately, concentrating on meaning rather than the correct parse of a sentence [1], and more recently, statistical NLP. Servers now compare your speech against a statistical model to estimate, based on sounds you spoke and the order to which you spoke them, what you are trying to say (the intent) [5]. Statistical NLP addresses the problem of the possibility of different parse trees which make it difficult to choose the best parse to interpret or infer meaning of the words and phrases [1]. Statistical NLP assigns probabilities to choosing the best parse tree, and many methods and models have thus become the norm in solving problems addressed in the last section. Addressing the issues in NLP is a long, but plausible process because "in reality, the process [NLP] you just experienced is the culmination of decades of intense interdisciplinary research"[5].

5 Where To Go From Here

. There is much being done to expand the capabilities of Natural Language Processing [1]. As Artificial Intelligence continues to expand and advance its current capabilities and further be capable of addressing current issues and dilemmas, so it will to be able to address the challenges presented by NLP. Much research and money has been invested into NLP, and the current technologies we possess now are proven by that; it also proves that humans are capable of many engineering feats and our progress so far is only little compared to what future holds. Current NLP allows us to simply ask our virtual assistants Siri what the weather is like in Spokane, WA, or Cortana the best route from Chicago, Illinois to Austin, Texas. Even bigger, NLP contains an unfathomably large database having much knowledge of what this world knows. The future of NLP lies within our progressing of truly "understanding" the meaning of words and phrases by context. Only then will we be able to appropriately have a decent conversation with a computer.

6 References

1. Lucci, Stephen, and Danny Kopec. Artificial Intelligence in the 21st Century. Dulles: Mercury Learning and Information LLC, 2013. 398-400,405,410,421. Print.

2. Davis, William S., and David C. Yen. The Information System Consultant's Handbook: Systems Analysis and Design. Boca Raton: CRC Press LLC, 1998. Web. <http://www.hit.ac.il/staff/leonidM/information-systems/ewtoc.html>.

3. "Natural Language Processing." Microsoft Research. Microsoft, n.d. Web. 21 Apr 2014. <http://research.microsoft.com/en-us/groups/nlp/>.

4. Wikipedia contributors. "Natural language processing." Wikipedia, The Free Encyclopedia. 24 March, 2014. <http://en.wikipedia.org/wiki/Natural_language_processing>.

5. Nusca, Andrew. "Say Command: How Speech Recognition Will Change the World." SmartPlanet. SmartPlanet. Web. 21 Apr 2014. <http://www.smartplanet.com/blog/smart-takes/say-command-how-speech-recognition-will-change-the-world/>