Natural Languages Understanding and Generation

Introduction

Natural Language Understanding (NLU) and Natural Language Generation (NLG) are two pieces of the puzzle when it comes to Human-Computer Interaction via conversation. To understand exactly how these two processes take part in Human-Computer interaction, we must first understand what Natural Language even means, and then what each piece of the process (NLU & NLP) entail.

Natural Language

- Though its exact definition may vary depending on who you ask, in simple terms, a natural language is a language that has spawned or evolved from humans (Lyons 1991).
- As an example, all world languages, dialects, and variations of said languages constitute natural languages. In contrast, a Constructed Language is one that has been purposefully and thoughtfully put together, instead of having been developed through natural human interaction.
- Relevant examples of Constructed Languages include Programming Languages. This clear distinction is where humans and computers diverge.

The Difference Between Humans and Computers

- To humans, understanding a conversation that involves a natural language seems quite trivial, however, that is far from reality. When listening and understanding even the simplest of phrases, there is a lot of information that we are subconsciously aware of.
- This information not only includes the structure of the language being spoken and how it conveys meaning but more importantly, the context surrounding the phrase is being spoken (Winograd 1973). This context and inherent knowledge allow us to parse communication that strays from any strict rules within a particular language. It is what allows us to communicate despite using slang, speaking in different dialects, and other anomalies we might inject into our speech.
- While we have certainly created Constructed Languages to instruct computers, they inherently lack all of the subconscious knowledge we possess that is required to understand Natural Languages. Therein lies the problem of Natural Language Processing. How do we teach things, which lack this crucial knowledge, to understand how we humans communicate?

Natural Language Processing & Understanding

- Though the two terms are often used interchangeably, Natural Language Processing and Natural Language Understanding are not exactly the same thing.
- Natural Language Understanding, or NLU, is a sub-topic of Natural Language Processing that relates to machine learning comprehension.
- This is a very commercialized technology as it deals with voice recognition, text categorization, question & answer simulation, and archiving. John McCartney first used the term artificial intelligence when he used natural language to show how a computer could interpret algebraic word problems. Further down the road, IBM used machine learning and Natural Language Understanding to classify text. There is a broad scope of applications for Natural Language Understanding.
- The complexity of an NLU program is measured in two ways:
    - Breadth - measured by the size of the vocabulary in the system
    - Depth - measured by the fluency of the system (imagine a novice English as a Second Language student as compared to a native speaker)

Distinction From Speech Recognition

- Speech recognition is often lumped in with Natural Language Processing and Understanding, however, it is important to understand that the two processes are not indeed the same.
- Speech recognition deals with the problem of turning human speech into data that can be interpreted by a machine (Reddy 1976)
- Natural Language Processing and Understanding deal with the problem of actually processing that data and using it to teach a machine how to understand that data.
- It is not always the case that NLP and NLU systems will take data from a speech recognition system. One could type out such data by hand if they wished. However, using the two in conjunction allows us to create a smooth and intuitive system for Human-Computer interaction.

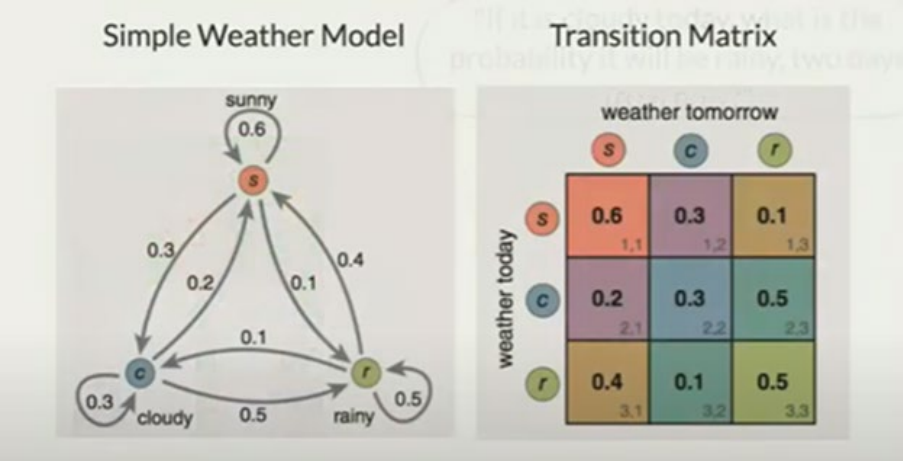
Natural Language Generation

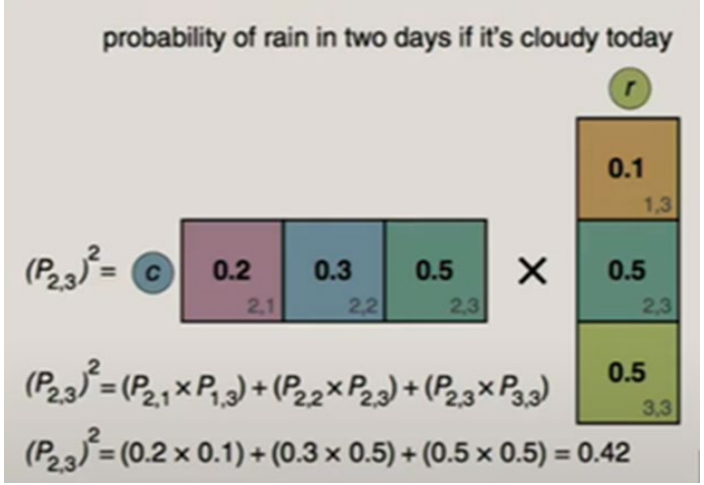
- Natural Language Generation (NLG) - A software process that produces structured data in the form of natural language.
- As noted in Stent et al. (2005), a good generator usually depends on several factors: adequacy, fluency, readability, and variation.
- Two major approaches to language generation
  - Templates creation of documents - a predefined structure that automatically fills in gaps that have a limit because it uses data from a database table entry to fill in the gaps.
  - dynamic creation of documents - creates sentences from representations of the desired linguistic structure.

Markov Chain

- The first algorithm for the natural language generation.
- Markov Chain - It predicts the next word in the sentence that the audience uses and finds the relationship between each word to calculate the next word. It is a mathematical system that transitions from one state to another according to certain probabilistic rules.
- Mostly used in economics, game theory, communication theory, and finance.
- Related to NLG
    - The computer can track a person browsing data and create a Markov chain of state transitions on their application. Depending on how long and how much the person uses the application or website will let the computer know what the person will like and predict what the person will look for in the future.

Markov Chain Example





Source :https://www.youtube.com/watch?v=4q3H_ZN01kk

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Use Cases of Natural Language Understanding

- Natural Language Understanding is key in enabling humans to interact with computers via voice.
- When used in conjunction with Voice Recognition, it can allow direct voice commands to be interpreted by a computer. Because of this, these technologies can be leveraged to solve a plethora of problems that non-technically literate people may have as well as people with disabilities. When a base model smartphone has voice recognition technology it means that a special device for the people is not necessary. Accessibility is a huge benefit of implementing voice recognition.

Use Cases of Natural Language Understanding

- An example of NLP and Voice Recognition working in conjunction to help those with disabilities can be seen in a paper by Tatale et al., where a system is described, implemented, and tested for the educational aid of disabled children, with a heavy emphasis on Natural Language Processing as the backbone for understanding and generating the objects that are to be displayed to a student in a virtual reality space.
- This system allows for students with learning disabilities to interact with a computer through voice in order to create and interact with objects in 3D space. The system takes a voice input query, which is then passed to an NLP engine for processing. Once processed, the system renders out the query in 3D space.

Use Cases of Natural Language Understanding

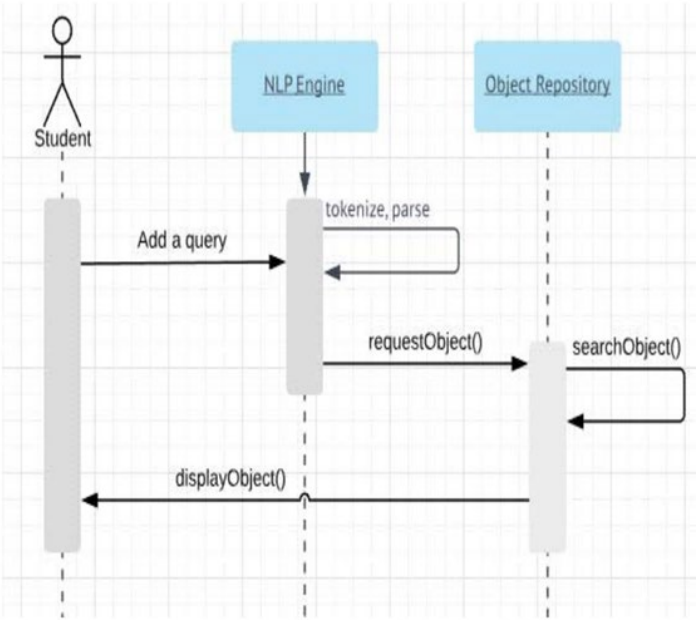

Figure 1.4.1.1; Tatale et al.

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Use Cases of Natural Language Understanding

TABLE I: SYNTAX RULE FOR HUMANOID ACTION MODULE

Sr. No.	Syntax Rule	Example
1.	NNP VBG	Mohan is dancing
2.	(NNP VBG) + (NNP VBG)	Mohan is dancing, and Maya is running
3.	(NNP VBG) + (VBG PRP)	Mohan is dancing and running is being performed by me
4.	(NNP VBG) + (VBG NNP)	Maya is running, and dancing is being performed by Mohan
5.	(NNP VBG) + (NNP VBG) + (PRP VBG)	Akshay is kicking, and Mohan is dancing. On the other hand, I am punching
6.	(PRP VBG) + (NNP VBG) + (NNP VBG) + (VBG NNP)	I am running, and Mohan is dancing. On the other hand, Akshay is punching and rolling is being performed by dadi

Figure 1.4.1; Tatale et al.

TABLE II: SYNTAX RULE FOR DYNAMIC OBJECT GENERATION MODULE

Sr. No.	Syntax Rule	Example
1.	NN JJ JJ	The apple is red in color, and it is big
2.	NN JJ	The apple is on the right/left side
3.	NN	Show me a zebra/computer/spoon etc.
4.	JJ JJ NN JJ	Show me a big red apple which is on the left side
5.	JJ NN JJ	Show me a big apple which is close/closer to me
6.	(NN) + (NN)	Show me an apple and an elephant
7.	(NN) + (JJ NN)	Show me an apple and a big brown table
8.	(JJ NN JJ) + (JJ JJ NN JJ)	Show me a red apple which is on the left side of the big brown table

Figure 1.4.2; Tatale et al.

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Project Summary

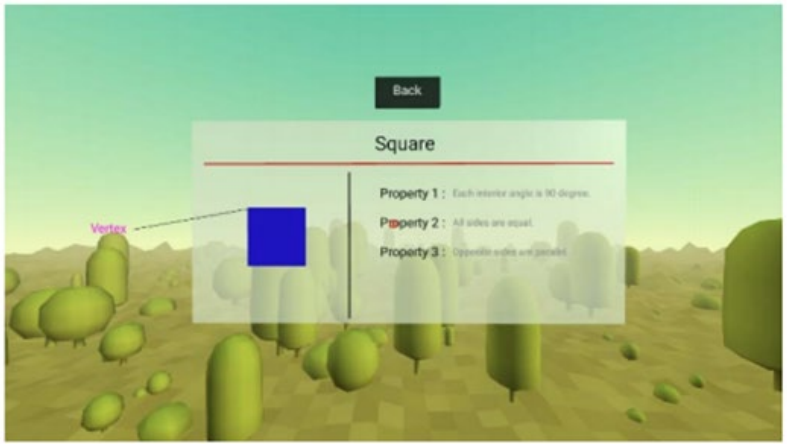

Figure 1.4.3 Courses - Shapes being taught in a 3D World; Tatale et al.

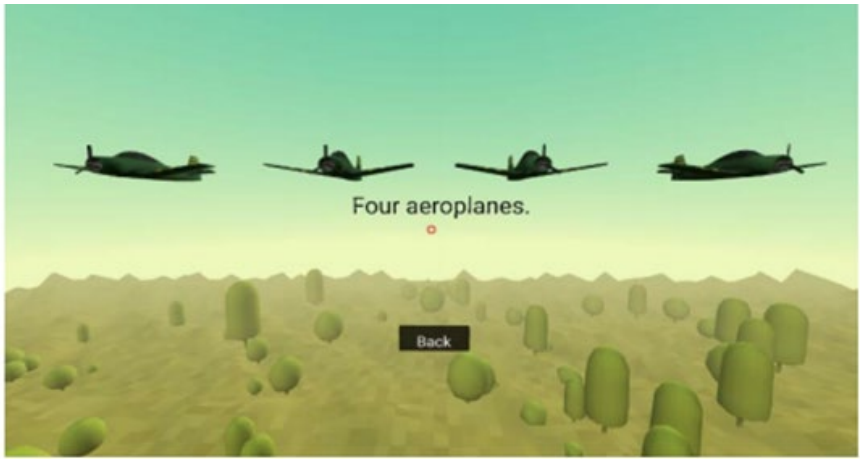

Figure 1.4.4 Courses - Quantity being taught in 3D world; Tatale et al.

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Use Cases of Natural Language Understanding

- NLP also eliminates the need for software to hardcode multiple translations of its text, as it can instead use NLP to handle all translations in the cloud.
- A paper by Padro, L., & Turmo, J. shows this in effect by detailing a system called “TextServer”, a cloud based solution for text related problems, which not only offers multilinguality, but also scalability, replicability, and ease of use. Figure 1.4.5 shows a table of the distribution of services for each TextServer service across 15 languages, which gives an insight into the power and usefulness of a service like this.

Use Cases of Natural Language Understanding

	as	ca	cs	cy	de	en	es	fr	gl	hr	it	nb	pt	ru	sl
language Identification	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Phonetic Transcription			X			X	X								
Tokenization&Splitting	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Morphological Analysis	X	X		X	X	X	X	X	X		X	X	X	X	X
PoS tagging	X	X		X	X	X	X	X	X		X	X	X	X	X
WSD		X				X	X	X	X		X		X		X
NERC		X				X	X						X		
Chunking	X	X				X	X		X				X		
Dependency parsing	X	X			X	X	X		X	X					X
SRL		X			X	X	X								
Coreference resolution						X	X								
Semantic graph generation		X				X	X								

TABLE I. DISTRIBUTION OF LANGUAGES FOR EACH TEXTSERVER SERVICE

Figure 1.4.5 DISTRIBUTION OF LANGUAGES FOR EACH TEXTSERVER SERVICE; Padro, L., & Turmo, J

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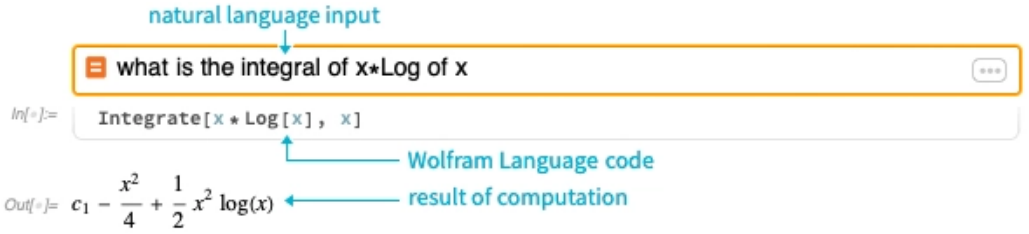
Use Cases of Natural Language Understanding

- Another very important use for Natural Language Understanding is voice recognition in automobiles. Thousands of people die every year due to cell phone use while operating a car. Using voice recognition to render a phone call, navigate to an address, or to change a song can save countless lives. This application allows for hands-free navigation of several interfaces. As Natural Language Understanding improves, so does the quality and swiftness of voice recognition. Because of this, technologies become more intuitive and consequently more powerful.

Project Summary

- Natural Language Understanding is “the comprehension by computers of the structure and meaning of human language (e.g., English, Spanish, Japanese), allowing users to interact with the computer using natural sentences”. (source)
- This technology is a subcategory of Artificial Intelligence. NLU can take an input such as voice or text and interpret it in a computing language then create an output of that computer language into a language that can be understood by humans.
    - Examples of NLU: Google Translate, Siri, and Cortana
- The goal of Natural Language Understanding is to seamlessly translate the human vernacular using computer programs. For example, Siri would be able to tell you the answer to a question regardless of language, tone or slang used. When someone asks their phone, “How hot is it outside?” Natural Language Understanding allows for the program to realize that the person is asking for the temperature, without explicitly inquiring, “How many degrees is it today?”This can also be applicable with calculators such as Wolfram Alpha.



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Project Summary

- Natural Language Understanding and Natural Language Processing are two branches of AI that are often used interchangeably however they have distinct differences.
- Natural Language Understanding is actually a subset of Natural Language Processing. Natural Language Understanding is related to error management in regards to dialects, slang, mispronunciations and phrasing of languages in human interaction. Think of the first time you heard the phrase, “It’s raining cats and dogs”. It doesn’t make a lot of sense to a non-english speaker.
- A huge roadblock of Natural Language Processing is mispronunciations and NLU seeks to minimize the consequences of these errors.

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