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CSCE 771: Computer Processing of Natural Language
Lecture 4: NLP Tasks, NLP for Business

PROF. BIPLAV SRIVASTAVA, AI INSTITUTE

29TH AUGUST, 2024

Carolinian Creed: "I will practice personal and academic integrity."

Organization of Lecture 4

- Opening Segment
  - Recap of Lecture 3
  - Class rules
- Main Lecture

Main Section
- NLP Tasks
- Case Study: NLP for Business

- Concluding Segment
  - Course project
  - About next lecture – Lecture 5

Recap of Lecture 3

- We
  - Looked at structure of building block of text, i.e., words, from an English and non-English perspective
  - Reviewed morphology
  - Looked at useful lexicons that can help simplify language tasks

- Read paper #1-1 - *Contextual Word Representations: Putting Words into Computers* (Full list: https://github.com/biplav-s/course-nl-f24/blob/main/reading-list/Readme-LLMs.md)

- Contranyms
  - Sanction : allow / prevent
  - Bomb : success / failure
  - Break : opportunity / problem
  - Dust: remove or put dust
  - More examples: https://en.wiktionary.org/wiki/Appendix:English_contranyms

Class Rules

- Absence policy
  - Excused absence: If you have a reason to miss, please send me a note BEFORE the class.
  - Non-excused absence: Will be noted in spreadsheet.
  - More than two non-excused absences will lead to a 10% penalty on cumulative score.
- Honor code and plagiarism policy
  - Go through: https://sc.edu/about/offices_and_divisions/student_conduct_and_academic_integrity/instructors/promoting_academic_integrity/index.php
  - On **plagiarism**
    - Acknowledging / giving credits is essential when reusing material
    - Your work cannot be complete reuse by someone else; especially project
    - Will lead to being reported to corresponding office and a D or failed grade

Resume Exercise - WTC

Generate a wordtag cloud for the following three scenarios. Use Python for this assignment.

1. Your individual resume. [WTC1]

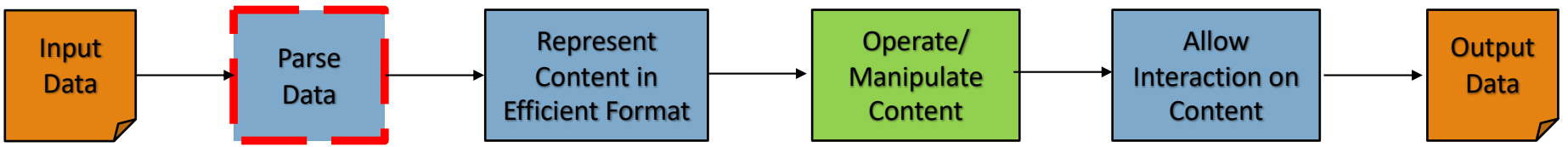
2. The collective resumes of your class (12 students). [WTC2]

3. The collective resumes of another class (30 students). [WTC3]

Additionally, write a 2-page report that includes your observations on which words are most prominently featured in each cloud and why.

Main Lecture

NLP Basic Tasks



Tasks Depends on Applications

- Tokenization – getting tokens for processing
- Normalization - making into canonical form
- Case folding – handling cases
- Lemmatization – handling variants (shallow)
- Stemming – handling variants (deep)

Task - Tokenization: Some Examples

- Example 1
  - **Input**: 'At eight o\'clock on Thursday morning, we will go to school. There is' + \
    'No one there but myself.
  - '**Output**: ['At', 'eight', "o'clock", 'on', 'Thursday', 'morning', ',', 'we', 'will', 'go', 'to', 'school', '.', 'There', 'isNo', 'one', 'there', 'but', 'myself', '.']
- Example 2
  - **Input**: "CSCE 771: Computer Processing of Natural Language " + \
    " Lecture 3: Words, Morphology, Lexicons" + \
    " Prof. Biplav Srivastava, AI Institute 31st Aug 2020 "'
  - **Output**: ['CSCE', '771', ':', 'Computer', 'Processing', 'of', 'Natural', 'Language', 'Lecture', '3', ':', 'Words', ',', 'Morphology', ',', 'Lexicons', 'Prof.', 'Biplav', 'Srivastava', ',', 'AI', 'Institute', '31st', 'Aug', '2020']
- Comments:
  - Does not capture compound words

Tokenization Issue and Practices

- **Penn Treebank** Tokenization
  - Separates clitics - doesn't becomes does plus n't
  - Keeps hyphenated words together
  - Separates out all punctuation

Input: "The San Francisco-based restaurant," they said, "doesn't charge $10".

Output: "␣The␣San␣Francisco-based␣restaurant␣,␣"␣they␣said␣,␣"␣does␣n't␣charge␣$␣10␣"␣.

- Ambiguity while tokenization
  - the book's cover => the book's cover
  - they're => they are
- Practice
  - Deterministic algorithms based on regular expressions compiled into very efficient finite state automata
  - Breaks ambiguity along conventions

Source: Jurafsky & Martin

Tokenization in Other Languages

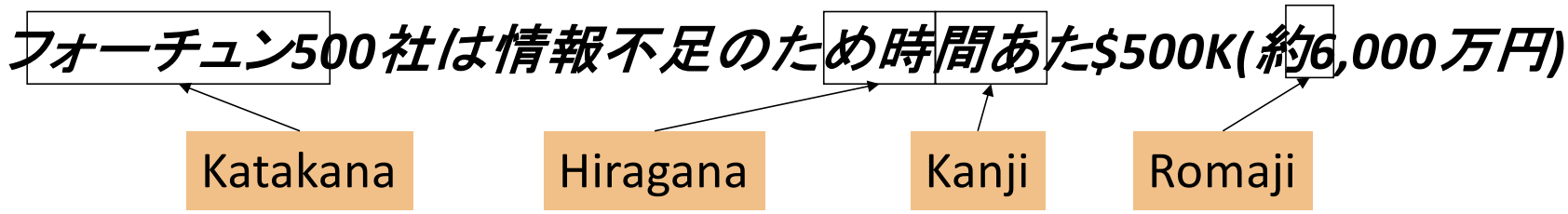
- French
  - ***L'ensemble*** → one token or two?
    - ***L*** ? ***L'*** ? ***Le*** ?
    - Want ***l'ensemble*** to match with ***un ensemble***

- German noun compounds are not segmented
  - ***Lebensversicherungsgesellschaftsangestellter***
  - 'life insurance company employee'
  - German information retrieval needs **compound splitter**

Source: Jurafsky & Martin

Tokenization in Other Languages

- Chinese and Japanese no spaces between words:
  - 莎拉波娃现在居住在美国东南部的佛罗里达。
  - 莎拉波娃 现在 居住 在 美国 东南部 的 佛罗里达
  - Sharapova now lives in US southeastern Florida
- Japanese has alphabets intermingled from other “languages”
  - Dates/amounts in multiple formats



Source: Jurafsky & Martin

Word Tokenization in Chinese

Also called **Word Segmentation**

Chinese words are composed of characters

- Characters are generally 1 syllable and 1 morpheme.
- Average word is 2.4 characters long.

Standard baseline segmentation algorithm:

- Maximum Matching (also called Greedy)

Source: Jurafsky & Martin

(2.5) 姚明 进入 总决赛
YaoMing reaches finals

or as 5 words ('Peking University' segmentation):

(2.6) 姚 明 进入 总 决赛
Yao Ming reaches overall finals

Finally, it is possible in Chinese simply to ignore words altogether and use characters as the basic elements, treating the sentence as a series of 7 characters:

(2.7) 姚 明 进 入 总 决 赛
Yao Ming enter enter overall decision game

Task - Normalization

- Have words/ word phrases in canonical form
- Examples
  - **UoSC** and **USC**
  - ***U.S.A.*** and ***USA***
  - **Window** and **windows**
  - **“Dr. Martin Luther King Jr.”** and **“Dr. M. L. King”**
- Why do it
  - Improve match between query and index
  - Recognize duplicates
- Standards
  - Physical Address - USPS

Task - Case Folding

- Handle case(s) of letter(s)
- Examples
  - Force words to lower case
  - Retain cases of words as entered
    - **US** versus **us** is important
- Case can have important meaning
  - Acronym
  - Useful in sentiment analysis

Source: Jurafsky & Martin

Task - Parts of Speech (POS) Tagging with Homonym

Data

"They refuse to permit us to obtain the refuse permit”

POS

[('They', 'PRP'), ('refuse', 'VBP'), ('to', 'TO'), (**'permit**', 'VB'), ('us', 'PRP'), ('to', 'TO'), ('obtain', 'VB'), ('the', 'DT'), ('refuse', 'NN'), (**'permit**', 'NN')]

Table Source:
https://www.ling.upenn.edu/courses/Fall_2003/ling001/penn_treebank_pos.html

Number	Tag	Description
1.	CC	Coordinating conjunction
2.	CD	Cardinal number
3.	DT	Determiner
4.	EX	Existential there
5.	FW	Foreign word
6.	IN	Preposition or subordinating conjunction
7.	JJ	Adjective
8.	JJR	Adjective, comparative
9.	JJS	Adjective, superlative
10.	LS	List item marker
11.	MD	Modal
12.	NN	Noun, singular or mass
13.	NNS	Noun, plural
14.	NNP	Proper noun, singular
15.	NNPS	Proper noun, plural
16.	PDT	Predeterminer
17.	POS	Possessive ending
18.	PRP	Personal pronoun
19.	PRP$	Possessive pronoun
20.	RB	Adverb
21.	RBR	Adverb, comparative
22.	RBS	Adverb, superlative
23.	RP	Particle
24.	SYM	Symbol
25.	TO	to
26.	UH	Interjection
27.	VB	Verb, base form
28.	VBD	Verb, past tense
29.	VBG	Verb, gerund or present participle
30.	VBN	Verb, past participle
31.	VBP	Verb, non-3rd person singular present
32.	VBZ	Verb, 3rd person singular present
33.	WDT	Wh-determiner
34.	WP	Wh-pronoun
35.	WP$	Possessive wh-pronoun
36.	WRB	Wh-adverb

Task - Parts of Speech (POS) Tagging

Data

"Hola Class! Dost kya kar rahe ho? Let us pay attention."

POS

[('Hola', 'NNP'), ('Class', 'NN'), ('!', '.'), ('Dost', 'NNP'), ('kya', 'VBD'), ('kar', 'JJ'), ('rahe', 'NN'), ('ho', 'NN'), ('?', '.'), ('Let', 'VB'), ('us', 'PRP'), ('pay', 'VB'), ('attention', 'NN'), ('.', '.')]

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Task - Lemmatization

- Reduce inflections or variant forms to base form
  - *am, are, is* → *be*
  - *car, cars, car's, cars'* → *car*
- Examples
  - churches : church
  - rocks : rock
  - children : child
  - focii : focii

See sample code on how to perform

Source: Jurafsky & Martin

Code Sample - NLTK

Notebook:

https://github.com/biplav-s/course-nl-f22/blob/main/sample-code/l4-nlp-basictasks/NLTK%20Basic%20Tasks.ipynb

Task - Stemming

- Reduce terms to their stems in information retrieval
- *Stemming* is crude chopping of affixes
  - language dependent
  - e.g., ***automate(s), automatic, automation*** all reduced to ***automat***.

Complexity
- Multiple senses of words
  - Sense ambiguities: ***ceil-*** is not the stem of ***ceiling***
- Complicated morphological rules
- Part-of-speech
- Irregular words

for example compressed and compression are both accepted as equivalent to compress.

for exampl compress and compress ar both accept as equival to compress

See sample code on how to perform

Source: Jurafsky & Martin

Complexity of Stemming

- Why affixes are added: Grammatical role, tense, derivational morphology
- Complexity reasons
  - Multiple senses of words
    - Sense ambiguities: ***ceil-*** is not the stem of ***ceiling***
  - Complicated morphological rules
  - Part-of-speech
  - Irregular words

Source: NLTK Documentation

Lemmatization and/ or Stemming

- Lemmatization is usually a good idea; reduces variants

- Stemming can cause issues – over and under stemming
  - Use it when doing careful word analysis

- Issue more complicated when doing multi-lingual analysis

Code Sample - Spacy

Notebook:

https://github.com/biplav-s/course-nl-f22/blob/main/sample-code/l4-nlp-basictasks/Spacy%20Basic%20Tasks.ipynb

Reading Assignment

- Paper:
  "Contextual Word Representations: Putting Words into Computers", by Noah Smith, CACM June 2020
- Discussion next week - Tuesday

Clarity: Data-Driven Competitive Analysis

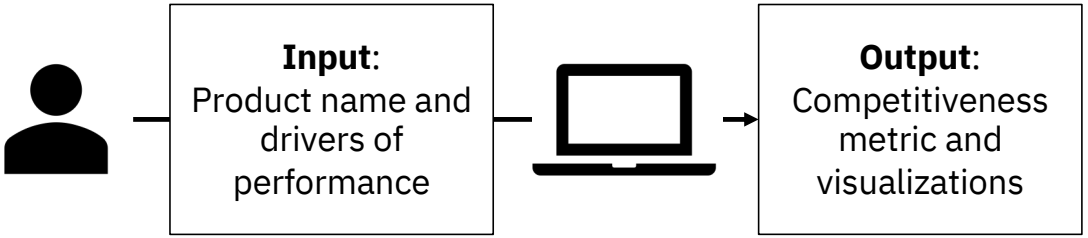
1. Sheema Usmani, Mariana Bernagozzi, Yufeng Huang, Michelle Morales, Amir Sabet Sarvestani, Biplav Srivastava, Clarity: Data-driven Automatic Assessment of Product Competitiveness, IAAI/AAAI 2020, **Deployed Application Award**
2. (Demo paper) Data-driven ranking and visualization of products by competitiveness, Sheema Usmani, Mariana Bernagozzi, Yufeng Huang, Michelle Morales, Amir Sabet Sarvestani, Biplav Srivastava, AAAI 2020
3. Yufeng Huang, Mariana Bernagozzi, Michelle Morales, Sheema Usmani, Biplav Srivastava, Michelle Mullins, Clarity 2.0: Improved Assessment of Product Competitiveness from Online Content. AI Mag. 42(2): 59-70 (2021)

Competitive Analysis: Before & After

Today's Manual Process

- Identify top competitor(s) for product X, e.g. product Y
- Read through thousands of reviews on product X and Y
- Keep track of topics/themes of interest for each product
- Decide whether a mention represented positive/negative feedback by manually annotating each mention
- Use the gathered data to make a decision on whether or not product X is more competitive than product Y, along the dimensions/themes considered.
- **Repeat:** for every data source, theme, and timeframe

New Process

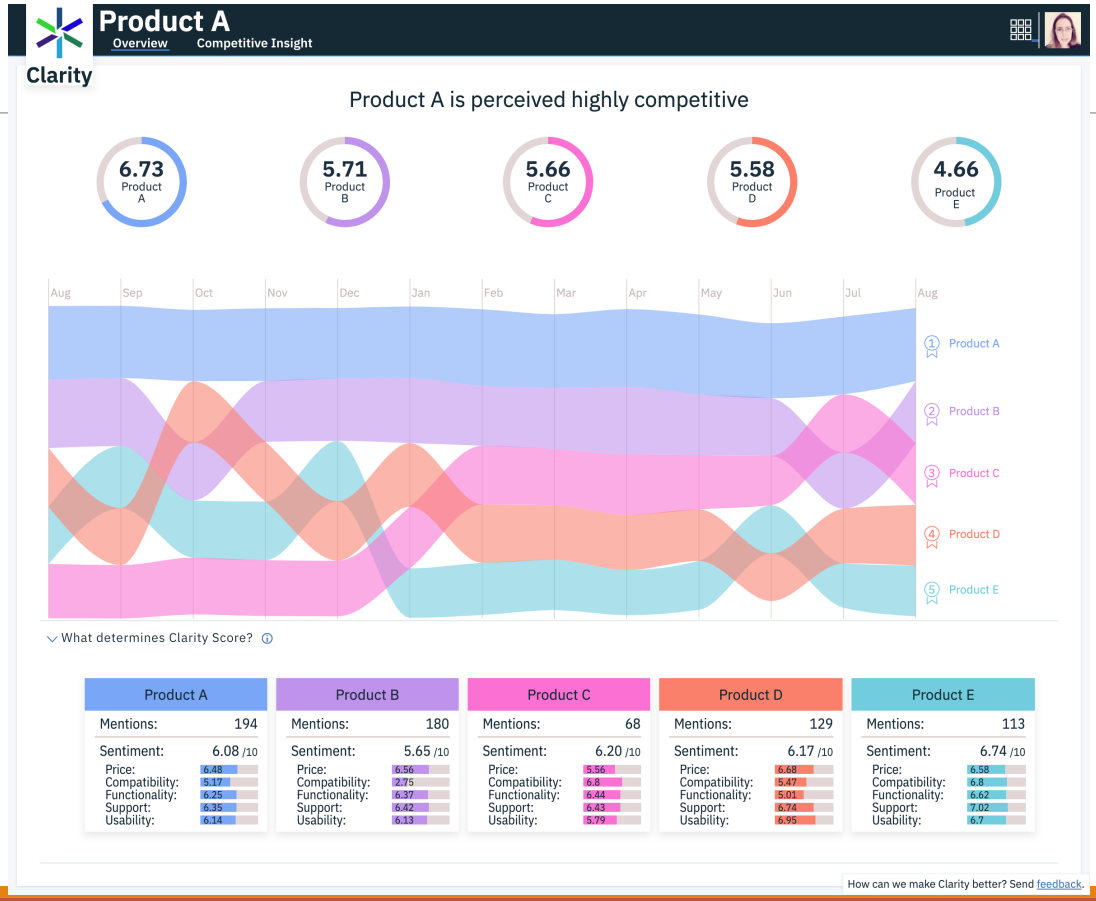


Steps

1. Prepare review data of products p_1 to p_N from sources d_1 to d_M (offline)
2. Process request for analysis for product p_i (online)
3. Visualize analysis results (online, optional)

Illustrative Output

Video demo

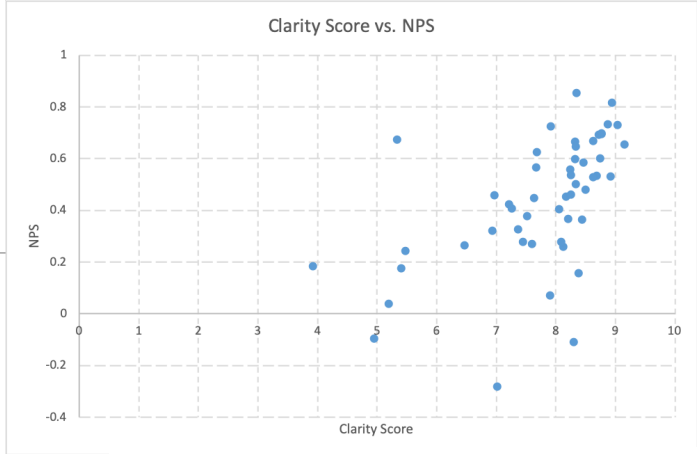


Clarity Score and Trends

Drivers and Raw Scores

Evaluation and Impact

- The system has been running for over two years and used by over 4500 people performing over 200 competitive analyses involving over 1000 products Clarity has been running
- In-field evaluation
  - High user satisfaction
    - Net Promoter Score (NPS) of 52; Scale -100 to 100
- In-lab evaluation
  - Scores consistent with Gartner's Magic Quadrant
    - Products v/s Vendor ranking
  - Clarity scores consistent with Net Promoter Score (NPS) of 50 products



$$\mathcal{CS}(p_L) > \mathcal{CS}(p_C) > \mathcal{CS}(p_N)$$

$$\mathcal{CS}(p_L) > \mathcal{CS}(p_V) > \mathcal{CS}(p_N)$$

Clarity 2.0

We still consider:

- the sentiments on different topics
- the overall rating,
- and the content volume

But change calculation from statistical measures to Bayesian statistics

Model	Precision	Recall	F1 Score
Neural network on sentence	0.40	0.32	0.36
Neural network on words	0.56	0.40	0.47
Neural network based on attention	0.56	0.56	0.56
Human performance	0.75	0.56	0.64

Table 1: Model performance on one of the topics, *product features and functionalities*. Precision, recall, and F1 score are compared for the models described in the *Improved NLP Model in Clarity 2.0* section. It should be noted that the human performance is relative low compared to typical academic datasets. The reason is that practical NLP applications are typically ambiguous, which results in more noise in the results and leads to the overall lower score compared to well-refined academic datasets.

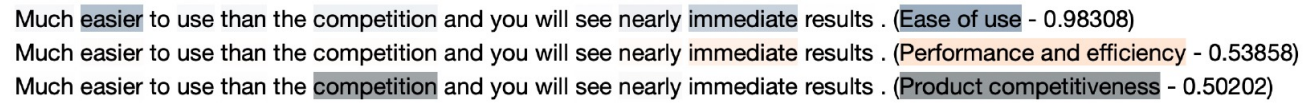


Figure 6: Example of topic classification using the attention mechanism. The example sentence is classified into three topics, *ease of use*, *performance and efficiency*, and *product competitiveness*, with corresponding probabilities, respectively. The darkness of the highlighted keyword is calculated by multiplying the attention weight with the classification probability, which reflects the contribution of the keyword to the classification of a certain topic.

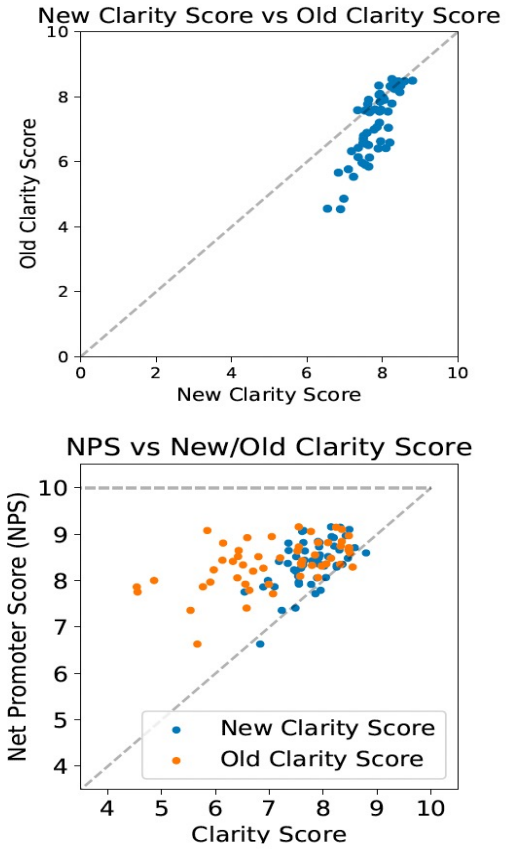


Figure 7: Comparison between NPS, *Clarity Score 1.0*, and *Clarity Score 2.0*. Top: comparison between the old and new *Clarity Scores*. Bottom: comparison between the *Clarity Scores* and NPS.

Improved Performance

Market	Vendor	Product	Gartner Q	*Clarity* score
M_1 = Data Science Machine Learning Platform	$V_1^{M_1}$	$P_1^{V_1M_1}$	Visionary	8.79
	$V_2^{M_1}$	$P_1^{V_2M_1}$	Visionary	8.48
	$V_3^{M_1}$	$P_1^{V_3M_1}$	Challenger	7.93
	$V_4^{M_1}$	$P_1^{V_4M_1}$	Challenger	7.91
	$V_5^{M_1}$	$P_1^{V_5M_1}$	Leader	7.34
M_2 = Data Management Solutions for Analytics	$V_1^{M_2}$	$P_1^{V_1M_2}$	Leader	8.58
	$V_2^{M_2}$	$P_1^{V_2M_2}$	Leader	8.46
	$V_3^{M_2}$	$P_1^{V_3M_2}$	Leader	8.19
	$V_4^{M_2}$	$P_1^{V_4M_2}$	Leader	7.96
	$V_5^{M_2}$	$P_1^{V_5M_2}$	Leader	7.88
M_3 = Data Management Solutions for Analytics	$V_1^{M_3}$	$P_1^{V_1M_3}$	Leader	7.62
	$V_2^{M_3}$	$P_1^{V_2M_3}$	Leader	7.53
	$V_3^{M_3}$	$P_1^{V_3M_3}$	Leader	7.36
M_4 = Operational Database Management Systems	$V_1^{M_4}$	$P_1^{V_1M_4}$	Leader	8.58
	$V_2^{M_4}$	$P_1^{V_2M_4}$	Leader	8.46
	$V_3^{M_4}$	$P_1^{V_3M_4}$	Leader	8.19
M_5 = Analytics and Business Intelligence Platforms	$V_1^{M_5}$	$P_1^{V_1M_5}$	Leader	8.79
	$V_1^{M_5}$	$P_2^{V_1M_5}$	Leader	8.25
	$V_2^{M_5}$	$P_1^{V_2M_5}$	Niche Player	7.92
	$V_3^{M_5}$	$P_1^{V_3M_5}$	Niche Player	7.85

Table 2: Comparison of ratings provided by Gartner vs. *Clarity Score*

Lecture 4: Concluding Comments

- We looked at a variety of NLP tasks
- We looked at evaluation methods
  - For NLP tasks (Precision, Accuracy, Recall)
  - For ML tasks (AUC)

Concluding Segment

Discussion: Course Project

Theme: Analyze quality of official information available for elections in 2024 [in a state]

- Take information available from
  - Official site: State Election Commissions
  - Respected non-profits: League of Women Voters
- Analyze information
  - State-level: Analyze quality of questions, answers, answers-to-questions
  - Comparatively: above along all states (being done by students)
- Benchmark and report
  - Compare analysis with LLM
  - Prepare report

- Process and analyze using NLP
  - Extract entities
  - Assess quality – metrics
    - Content – *Englishness*
    - Content – *Domain* -- election
  - … other NLP tasks
  - Analyze and communicate overall

Major dates for project check

- Sep 10: written – project outline
- Oct 8: in class
- Oct 31: in class // LLM
- Dec 5: in class // Comparative

Review current states chosen by others

Project Discussion

1. Go to Google spreadsheet against your name
2. Enter the **state** you will focus on for course project

1. Create a private Github repository called "CSCE771-Fall2024-<studentname>-Repo". Share with Instructor (biplav-s) and TA (vr25)
2. Create Google folder called "CSCE771-Fall2024-<studentname>-SharedInfo". Share with Instructor (prof.biplav@gmail.com) and TA (rawtevipula25@gmail.com)
3. Create a Google doc in your Google repo called "Project Plan" and have the following by Friday (Aug 30, 2024)

Timeline

1. Title: Analyze quality of official information available for elections in 2024 in <state>
2. Data need:
   1. Official: state's election commission
   2. LWV: https://www.vote411.org/
3. Methods:
4. Evaluation:
5. Milestones
   - Sep 10: written and feedback
   - Oct 8: in class
   - Oct 31: in class
   - Dec 5: in class

Discussion: Course Project

- Expectations
  - Apply methods learned in class or of interest to a problem of interest
  - Be goal oriented: aim to finish, be proactive, be innovative
  - Do top-class work: code, writeup, presentation
- Typical pitfalls
  - Not detailing out the project, assuming data
  - Not spending enough time
- What will be awarded
  - Results and efforts (balance)
  - Challenge level of problem

Review current states chosen by others

Now What – Some Considerations

- Scope: what is the problem?
- Current-state: what happens in the problem today?
- Who cares: who will benefit with the problem being solved?
- Desired-state: what will be the future situation if your project succeeds?
- Resources/ dataset: do you have reasonable data and compute resources to do the work?
- Evaluation: how will we measure goodness of the work?

Discussion: Reading Material

- **Paper**: "Contextual Word Representations: Putting Words into Computers", by Noah Smith, CACM June 2020

- Key Points
  - Different representations of words
    - Characters, one-hot encoding, vectors
  - Determining contexts of words is important
    - Contextual word vectors
    - Bi-, tri-, N-gram representations

About Next Lecture – Lecture 5

Lecture 5:

- Discussion on reading material - Paper:
  "Contextual Word Representations: Putting Words into Computers", by Noah Smith, CACM June 2020
- Parsing
- Projects
  - Review project guidelines in class