

CSCE 771: Computer Processing of Natural Language

Lecture 2: Languages: Text, Sound, Visual, Mixed

PROF. BIPLAV SRIVASTAVA, AI INSTITUTE

22ND AUG 2024

Carolinian Creed: “I will practice personal and academic integrity.”

Organization of Lecture 2

- Introduction Section

- Opening comments

- Main Section

- Concluding Section

- Course Project
- About Next Lecture – Lecture 3



Main Section

- What is a language?
 - Media: Text, Sound (speech), Visual (image, video), Multi (modal, media)
 - Media representation
- Processing data
 - Reading
 - Searching content fragment, Manipulating content
 - Writing
- Ethical considerations
- Concluding comments

Opening Comments

Exercise: Your Resumes

- Knowing about a person; about a group
- Alternatives
 - What does a search (Google search) tell about you?
 - What does a LLM/ ChatGPT tell about you?
- Task:
 - Put your resume at: <TBD>
 - Analyze resume as part of AI/ data science activity in a later classes
- Questions to answer:
 - Individual
 - About a group

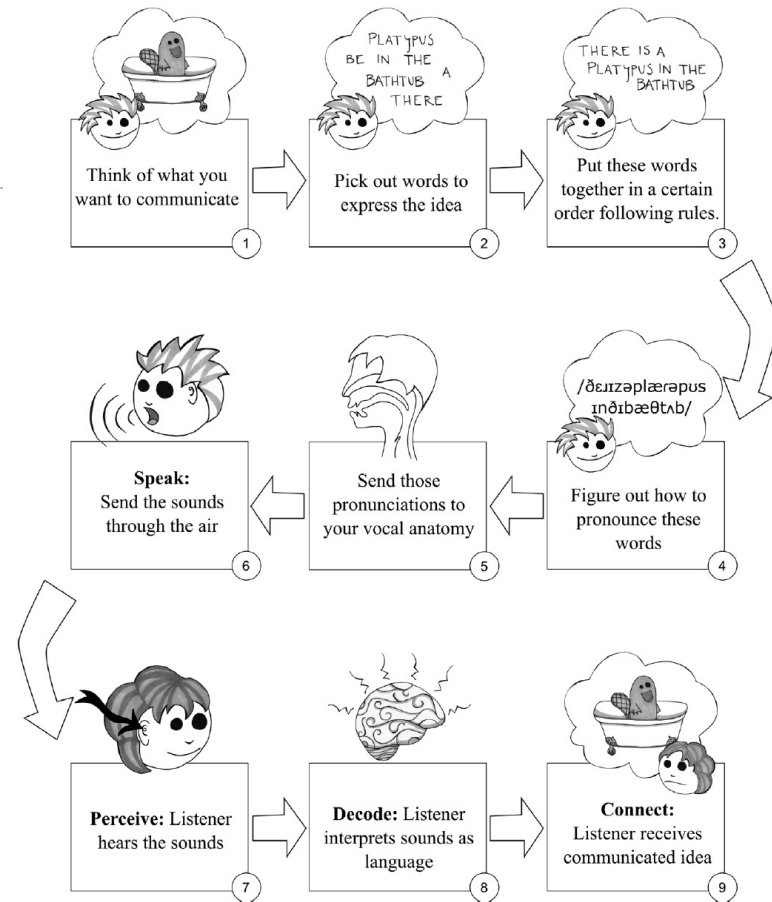
Exciting References

- Finding online information and issues
 - A Perspectival Mirror of the Elephant, By Queenie Luo, Michael J. Puett, and Michael D. Smith, CACM, Aug 2024, <https://cacm.acm.org/practice/a-perspectival-mirror-of-the-elephant/>
- Data statistics and preliminaries
 - <https://movableink.com/blog/29-incredible-stats-that-prove-the-power-of-visual-marketing>
 - <https://www.forbes.com/sites/bernardmarr/2018/05/21/how-much-data-do-we-create-every-day-the-mind-blowing-stats-everyone-should-read/?sh=2c1ec9d60ba9>
 - <https://www.simplilearn.com/what-is-data-processing-article>
- Artificial intelligence system learns concepts shared across video, audio, and text,
 - <https://news.mit.edu/2022/ai-video-audio-text-connections-0504>

What is a Language?

Communication and Language

(1) The speech communication chain



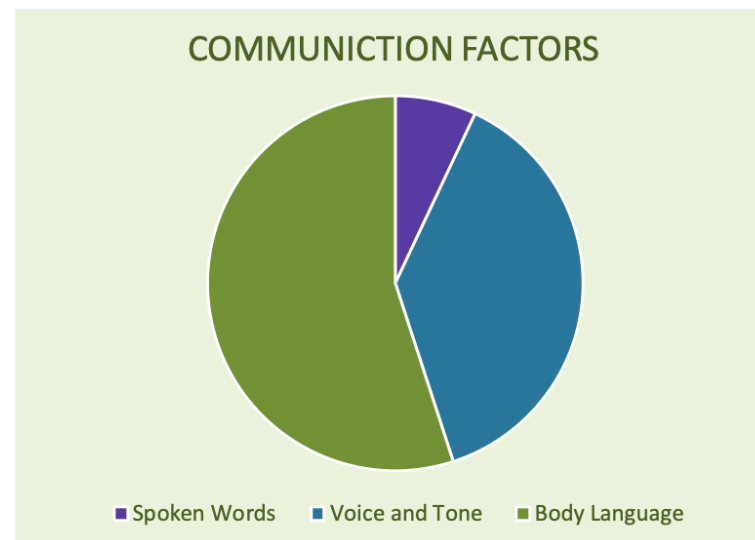
© 2015 by Julia Porter Papke

Effective Inter-Human Communication

Many models

- A. Mehrabian's 7-38-55 Communication Model
- 90% non-verbal, 10% verbal

Albert Mehrabian's 7-38-55 Communication model says that 7% of the meaning of feelings and attitudes takes place through the words we use in spoken communications, while 38% takes place through tone and voice and the remaining 55% of communication of these factors take place through the body language we use (specifically our facial expressions).

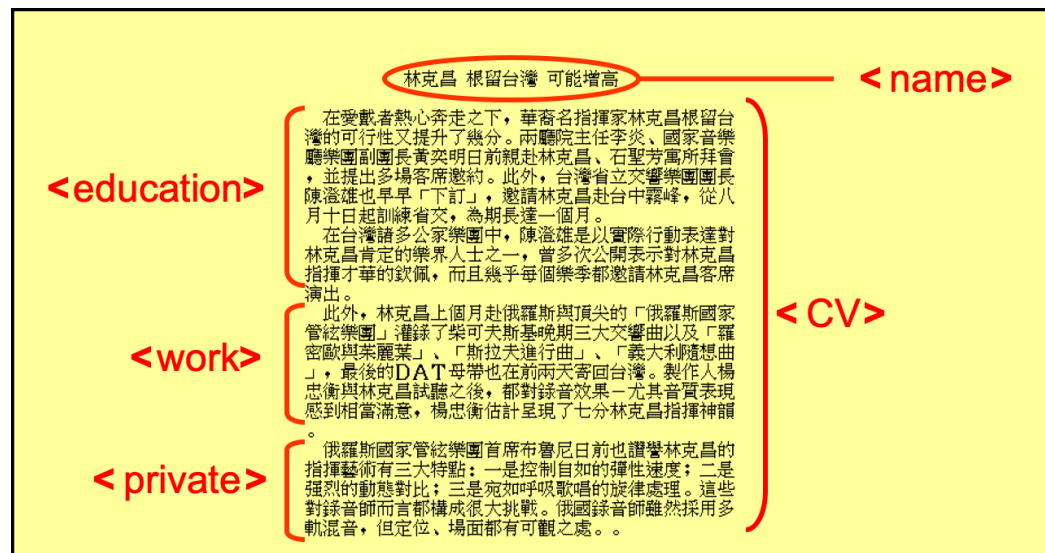


Sources:

<https://worldofwork.io/2019/07/mehrabians-7-38-55-communication-model/>
<https://online.utpb.edu/about-us/articles/communication/how-much-of-communication-is-nonverbal/>

Case of a Computer Language

Example: XML



Slide Courtesy: Jim Hendler

Inter-Computer Communication

Example: XML

林克昌 根留台灣 可能增高

< name >

< education >

在愛戴者熱心奔走之下，華裔名指揮家林克昌根留台灣的可行性又提升了幾分。兩廳院主任李炎、國家音樂廳樂團副團長黃奕明日前親赴林克昌、石聖芳寓所拜會，並提出多場客席邀約。此外，台灣省立交響樂團團長陳澄雄也早早「下訂」，邀請林克昌赴台中霧峰，從八月十日起訓練省交，為期長達一個月。

< work >

在台灣諸多公家樂團中，陳澄雄是以實際行動表達對林克昌肯定的樂界人士之一，曾多次公開表示對林克昌指揮才華的欽佩，而且幾乎每個樂季都邀請林克昌客席演出。

< private >

此外，林克昌上個月赴俄羅斯與頂尖的「俄羅斯國家管絃樂團」灌錄了柴可夫斯基晚期三大交響曲以及「羅密歐與茱麗葉」、「斯拉夫進行曲」、「義大利隨想曲」，最後的DAT母帶也在前兩天寄回台灣。製作人楊忠衛與林克昌試聽之後，都對錄音效果一尤其音質表現感到相當滿意，楊忠衛估計呈現了七分林克昌指揮神韻。

< CV >

俄羅斯國家管絃樂團首席布魯尼日前也讚譽林克昌的指揮藝術有三大特點：一是控制自如的彈性速度；二是強烈的動態對比；三是宛如呼吸歌唱的旋律處理。這些對錄音師而言都構成很大挑戰。俄國錄音師雖然採用多軌混音，但定位、場面都有可觀之處。

林克昌 根留台灣 可能增高

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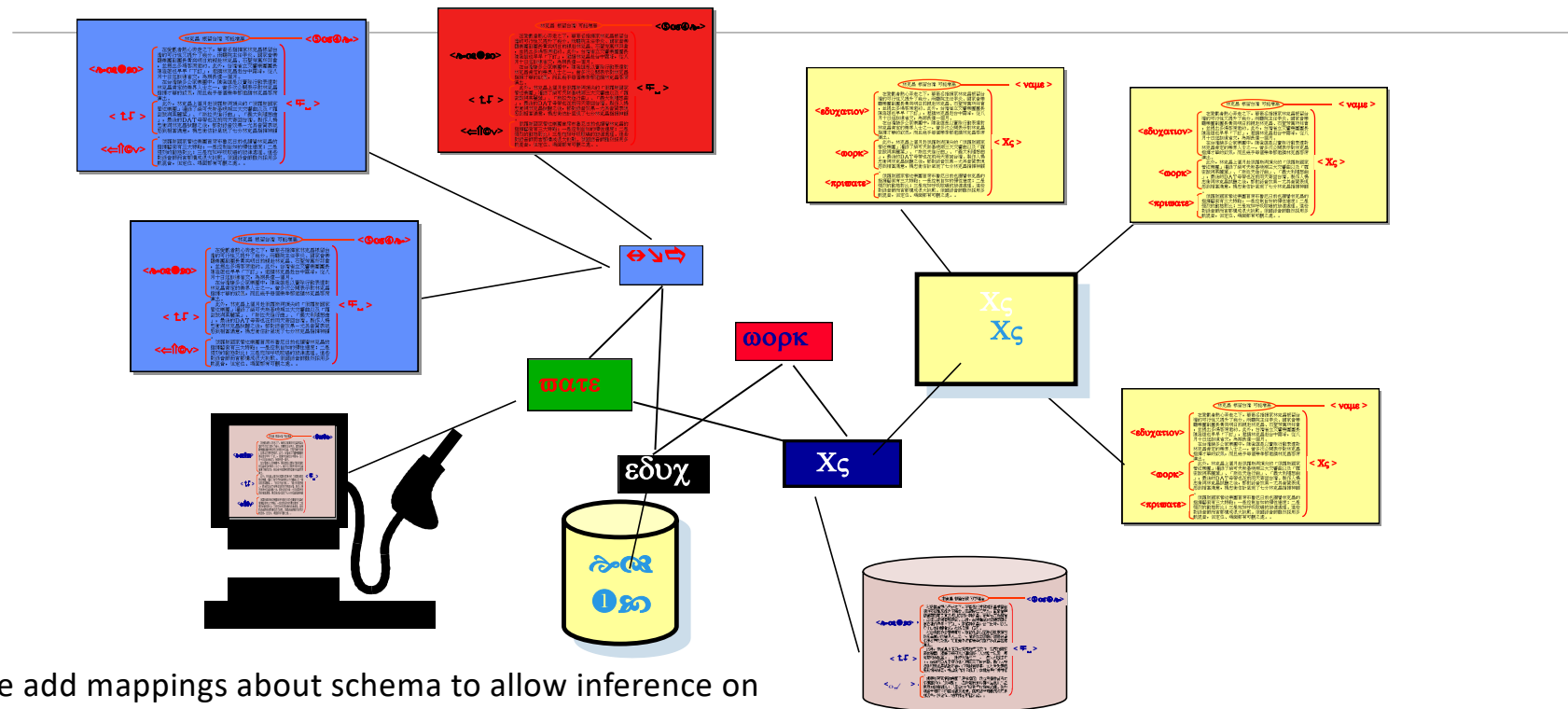
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Slides Courtesy: Jim Hendler

“Meaning” in a Computer Language



Software add mappings about schema to allow inference on compatibility of information

Slides Courtesy: Jim Hendler

Human v/s Computer Languages

- In human languages, no control over language constructs
 - Any two people can start a new feature: word, syntax,
- People are adaptive to errors
 - Use multiple modes, sub-languages

Concepts and Terminology

- Phonetics and Phonology — knowledge about linguistic sounds
- Morphology — knowledge of the meaningful components of words
- Syntax — knowledge of the structural relationships between words
- Semantics — knowledge of meaning
- Pragmatics — knowledge of the relationship of meaning to the goals and intentions of the speaker
- Discourse — knowledge about linguistic units larger than a single utterance

Credit: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 2nd Ed., [Daniel Jurafsky](#) and [James H. Martin](#)

Language Trivia

- 7,000 languages spoken are in the world, but 90% of the population speaks only 10% of them
- The language one speaks affects whether they can differentiate certain sounds
- The same words in the same order do not always mean the same thing
 - Example: Tone, emotions can change meaning
- Languages can vary from person to person, region to region, and situation to situation
- Languages changes over time
- Written form is not essential to a language
 - Helps in preserving communication

Textual Data

- Media: text
- Components: characters, words, paragraph
- Representation
 - Uncompressed / encoding – ASCII, UTF-8, UTF-16
 - Compressed - .zip
 - Lossy compression -
- Language: English, French, ...
- Programming libraries: nltk, spacy

Filename extension	.txt
Internet media type	text/plain
Type code	TEXT
Uniform Type Identifier (UTI)	public.plain-text
UTI conformation	public.text
Type of format	Document file format , Generic container format

Details: https://en.wikipedia.org/wiki/List_of_file_formats

Tokens

Credit: OpenAI

[beta.openai.com/tokenizer](#)

[view](#) [Documentation](#) [Examples](#)

Tokenizer

The GPT family of models process text using **tokens**, which are common sequences of characters found in text. The models understand the statistical relationships between these tokens, and excel at producing the next token in a sequence of tokens.

You can use the tool below to understand how a piece of text would be tokenized by the API, and the total count of tokens in that piece of text.

GPT-3 Codex

What's up, Mike? Nothing out of the ordinary.

Clear

Show example

Tokens

12

Characters

45

What's up, Mike? Nothing out of the ordinary.

Sound

- Media: sound
- Components: phoneme
- Representation
 - Uncompressed - .wav, .aiff
 - Compressed lossless -
 - Lossy compression - .mp3, .aac (iTunes)
- Programming libraries: [playsound](#), [simpleaudio](#), [winsound](#), [python-sounddevice](#), [pydub](#), [pyaudio](#)

Details: https://en.wikipedia.org/wiki/Audio_file_format

Filename extension	.wav .wave
Internet media type	audio/vnd.wave, ^[1] audio/wav, audio/wave, audio/x-wav ^[2]
Type code	WAVE
Uniform Type Identifier (UTI)	com.microsoft.waveform-audio
Developed by	IBM & Microsoft
Initial release	August 1991; 29 years ago ^[3]
Latest release	Multiple Channel Audio Data and WAVE Files (7 March 2007; 13 years ago (update) ^{[4][5]})
Type of format	audio file format , container format
Extended from	RIFF
Extended to	BWF , RF64

Visual

- Media: image, video
- Components: pixel, frame
- Representation
 - Uncompressed – bitmap
 - Compressed lossless - .gif
 - Lossy compression - .jpeg
 - Containers: AVI (.avi) and QuickTime (.mov)
- Programming libraries: PIL, OpenCV

Filename extension	.avi
Internet media type	video/vnd.avi ^[1] video/avi video/msvideo video/x-msvideo
Type code	'Vfw '
Uniform Type Identifier (UTI)	public.avi
Developed by	Microsoft
Initial release	November 1992; 27 years ago
Container for	Audio, Video
Extended from	Resource Interchange File Format

Tokens

Latest LINK:

<https://platform.openai.com/tokenizer>

Credit: OpenAI

The screenshot shows the OpenAI beta tokenizer interface. The browser address bar displays `beta.openai.com/tokenizer`. The interface has a navigation bar with links for `iew`, `Documentation`, and `Examples`. Below this, there are tabs for `GPT-3` and `Codex`, with `Codex` being the active tab. A large text input area contains the text `Hi 🖐️`. Below the input area are two buttons: `Clear` and `Show example`. The results section shows `Tokens` as `8` and `Characters` as `9`. Below this, a visualization of the tokens is shown, with the text `Hi` followed by five colored squares representing tokens. At the bottom, there is a `Note` box stating: `Note: Your input contained one or more unicode characters that map to multiple tokens. The output visualization may display the bytes in each token in a non-standard way.`

A helpful rule of thumb is that one token generally corresponds to ~4 characters of text for common English text. This translates to roughly $\frac{3}{4}$ of a word (so 100 tokens \approx 75 words).

Grice Maxim

The maxim of quantity, where one tries to be as informative as one possibly can, and gives as much information as is needed, and no more.

The maxim of quality, where one tries to be truthful, and does not give information that is false or that is not supported by evidence.

The maxim of relation, where one tries to be relevant, and says things that are pertinent to the discussion.

The maxim of manner, when one tries to be as clear, as brief, and as orderly as one can in what one says, and where one avoids obscurity and ambiguity.

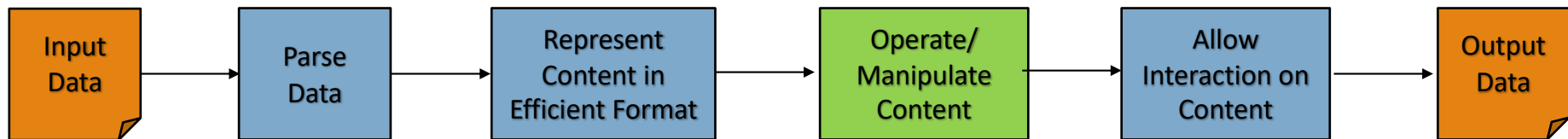
Source: <https://www.sas.upenn.edu/~haroldfs/dravling/grice.html>

Processing Data

Text Processing

Operate / manipulate content

- String search: regular expression
- Edit content: replace, insert
- Mixing of presentation and content
 - Text files: only content
 - Word processors: mixes both; Examples - Word, RTF
- Containers: pdf, powerpoint
 - Contains text, images



Regular Expression

Metacharacter	Explanation
<code>^</code>	Matches the starting position within the string
<code>.</code>	Matches any single character
<code>[]</code>	Matches a single character that is contained within the brackets
<code>[^]</code>	Matches a single character that is not contained within the brackets.
<code>\$</code>	Matches the ending position of the string
<code>*</code>	Matches the preceding element zero or more times
<code>+</code>	Matches the preceding element one or more times
<code> </code>	Separates choices

Regex	Matches any string that
<code>hello</code>	contains {hello}
<code>gray grey</code>	contains {gray, grey}
<code>gr(a e)y</code>	contains {gray, grey}
<code>gr[ae]y</code>	contains {gray, grey}
<code>b[aeiou]bble</code>	contains {babble, bebble, bibble, bobble, bubble}
<code>[b-chm-pP]at ot</code>	contains {bat, cat, hat, mat, nat, oat, pat, Pat, ot}
<code>colour?r</code>	contains {color, colour}
<code>rege(x(es)? xps?)</code>	contains {regex, regexes, regexp, regexps}
<code>go*gle</code>	contains {ggle, gogle, google, gooogole, goooogole, ...}
<code>go+gle</code>	contains {gogle, google, gooogole, goooogole, ...}
<code>g(oog)+le</code>	contains {google, googoogle, googoogleoogle, googoogleoogleoogle, ...}
<code>z{3}</code>	contains {zzz}
<code>z{3,6}</code>	contains {zzz, zzzz, zzzzz, zzzzzz}
<code>z{3,}</code>	contains {zzz, zzzz, zzzzz, ...}

Example Source: <https://cs.lmu.edu/~ray/notes/regex/>

Sound Processing

- Operate / manipulate content
 - Search: search for phoneme, matching "beats"
 - Edit content: replace, insert, append
- Interaction
 - As sound – sound player
 - As media - frequency

Sample code:

<https://github.com/biplav-s/course-nl-f22/blob/main/sample-code/l2-languages/sound/ProcessSound.ipynb>

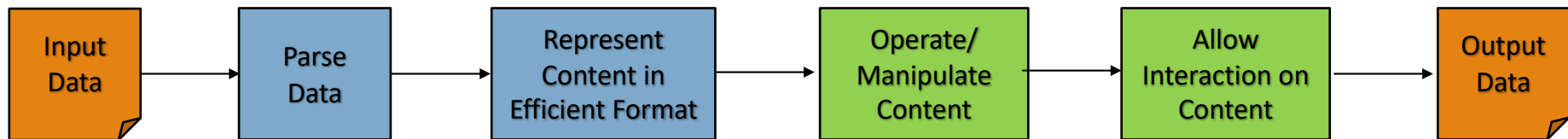
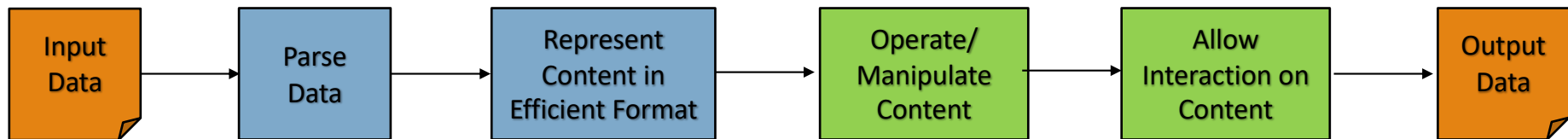


Image Processing

- Operate / manipulate content
 - Search: search for pixel, identifying objects, events
 - Edit content: replace, insert, append
- Interaction
 - As image/ video – show, play content
 - As media – pixel, frames

Image code:

<https://github.com/biplav-s/course-nl-f22/blob/main/sample-code/l2-languages/image/ProcessImages.ipynb>



Resume Exercise

- Task from last class for each student
 - Put your resume at: <TBD>
- Review / get resumes (data) from all
- Discussion on processing
- Insights
 - Individual-based
 - Group-based (students)

Resume Exercise - Programming

- Task 1
 - Take your resume
 - Create word tag cloud for your resume
- Task 2
 - Take all resumes in folder
 - Create word tag cloud for all resumes
 - Inspect and compare images of tasks 1 and 2
- Observation: Notice any difference?

Data and Code:

<https://github.com/biplav-s/course-nl-f22/tree/main/sample-code/l1-wordcloud>

Ethical Considerations

Text and Ethics

- [Su Lin Blodgett](#), [Solon Barocas](#), [Hal Daumé III](#), [Hanna Wallach](#), Language (Technology) is Power: A Critical Survey of “Bias” in NLP, Arxiv - <https://arxiv.org/abs/2005.14050>, 2020 [NLP Bias]
- Translators:
 - Biplav Srivastava, Francesca Rossi, Rating AI Systems for Bias to Promote Trustable Applications, IBM Journal of Research and Development, 2019. [AI Service Rating, Ethics]
- Conversation Agents
 - Biplav Srivastava, Francesca Rossi, Sheema Usmani, and Mariana Bernagozzi, Personalized Chatbot Trustworthiness Ratings, Arxiv - <https://arxiv.org/abs/2005.10067>, 2020 [AI Trust Rating, Chatbots]

"original": *"He is a Nurse. She is a Optician. "* ("originalDistrib": [0.5, 0.5, 0.0])

Middle Language	Google	Yandex
tu * Gender distinction lost or switched.	{..,"translated": "O hemşire. O bir Optisyendir.", "oto": "That nurse. It\u0026#39;s an Optic.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.0, 0.0, 1.0]}	{..,"translated": "O bir Hemşire. Bir Gözlükçü.", "oto": "She\u0027s a nurse. An Optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.0, 0.5, 0.5]}
ru	{..,"translated": "Он медсестра. Она Оптик.", "oto": "He\u0026#39;s a nurse. She\u0026#39;s an Optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}	{..,"translated": "Он является медсестра. Она является Оптиком.", "oto": "He is a nurse. She is an Optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}
it	{..,"translated": "Lui è un infermiere. Lei è un ottico.", "oto": "He is a nurse. She is an optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}	{..,"translated": "Lui è un Infermiere. Lei è un Ottico.", "oto": "He is a Nurse. She is an Optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}
es	{..,"translated": "El es un enfermero. Ella es una Óptica.", "oto": "He is a nurse. She is an Optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}	{..,"translated": "Él es una Enfermera. Ella es un Oftalmólogo.", "oto": "He is a Nurse. She is an Ophthalmologist.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}
hi * Gender distinction replaced by both translators	{..,"translated": "वह नर्स है। वह एक ऑप्टिशियन है", "oto": "she\u0026#39;s a nurse. He is an optician", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}	{..,"translated": "वह एक नर्स है. वह एक प्रकाशविज्ञानशास्त्री.", "oto": "She is a nurse. He is a optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}
pt	{..,"translated": "Ele é um enfermeiro. Ela é uma óptica.", "oto": "He is a nurse. She\u0026#39;s an optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}	{..,"translated": "Ele é uma Enfermeira. Ela é um Oculista.", "oto": "He is a Nurse. She is an Optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}
fr	{..,"translated": "Il est une infirmière. Elle est opticienne.", "oto": "He is a nurse. She is an optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}	{..,"translated": "Il est une Infirmière. Elle est un Opticien.", "oto": "He is a Nurse. She is an Optician.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.5, 0.5, 0.0]}
ar * Gender distinction lost in Translation by both	{..,"translated": "هو نارس. وهي بصريات.", "oto": "It is Nars. They are optics.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.0, 0.0, 1.0]}	{..,"translated": "هو ممرضة. هي العين.", "oto": "Is a nurse. Are the eyes.", "values": ["He", "She", "OTHER"], "otoDistrib": [0.0, 0.0, 1.0]}

Illustration of Translation Errors and Their Bias Perception

Type: 1

File: Result - true - i - es.json

Comment: Gender changed to new value (It).

"**original**": "He is a Architect. She is a Astronomer.", "**translated**": "Es un arquitecto. Ella es una astrónoma.",

"**oto**": "It is an architect. She is an astronomer.",

Type: 2

File: Result - false- g - tr.json;

Comment: Gender Flipped from She to He.

"**original**": "She is a Architect. She is a Astronomer.",

"**translated**": "O bir Mimar. O bir gökbilimcidir.",

"**oto**": "He\u0026#39;s an architect. He\u0026#39;s an astronomer.",

Type: 5

File: * - i - fr.json

Comment: No gender changed; Sentence modified.

"**original**": "He is a Accountant. He is a Actor /Actress.",

"**translated**": "C\u0027est un comptable. C\u0027est un acteur et un acteur.",

"**oto**": "He\u0027s an accountant. He is an actor and an actor.",

Type: 3

File: Result - false- g - ar.json;

Comment: Grammatically wrong sentence; Subject missing.

"**original**": "She is a Factory worker. He is a Farmer.",

"**translated**": "هي عامل مصنع. هو مزارع.",

"**oto**": "Is a factory worker. He is a farmer.",

Type: 4

File: Result - false- g - tr.json;

Comment: "Multiple. Gender changed and flipped. "

"**original**": "He is a Nurse. He is a Optician.",

"**translated**": "O bir hemşire. O bir Optisyendir.",

"**oto**": "She is a nurse. It\u0026#39;s an Optic.",

Illustration: A Seemingly Innocuous Chatbot

Potential Issues

- Leak information
- Abusive language
- Complex response

TDEBot

The screenshot shows a chat interface with a header bar containing a profile picture and the name 'TDEBot'. The chat history includes several messages from the user and the bot. The bot's responses are highlighted with a light blue background. The messages are as follows:

- User: is train 12312 on time today?
- TDEBot, 3:29 PM: Train Number 12312 will be delayed by 278.0 minutes at HWH station on 2018-10-18
- User: 3:29 PM Where is the bottleneck?
- TDEBot, 3:29 PM: The bottleneck station is FTP causing delay of 90.2 minutes on 2018-10-18
- User: 3:32 PM What is FTP?
- TDEBot, 3:32 PM: Sorry, I didn't understand! Please Try again
- User: 3:32 PM What is the delay at Allahabad?
- TDEBot, 3:33 PM: Train 12312 will not be mitigated any more after station ALD on 2018-10-18. It will arrive even later by 52.0 minutes

Sound and Ethics

Allison Koenecke, Andrew Nam, Emily Lake, Joe Nudell, Minnie Quartey, Zion Mengesha, Connor Toups, John R. Rickford, Dan Jurafsky, and Sharad Goel, Racial disparities in automated speech recognition, PNAS April 7, 2020 117 (14) 7684-7689, <https://doi.org/10.1073/pnas.1915768117>, March 23, 2020

Speech recognition tools misunderstand black speakers twice as often as white speakers

Error rates are especially high for black men

The systems performed particularly poorly for black men, with more than 40 errors for every 100 words.

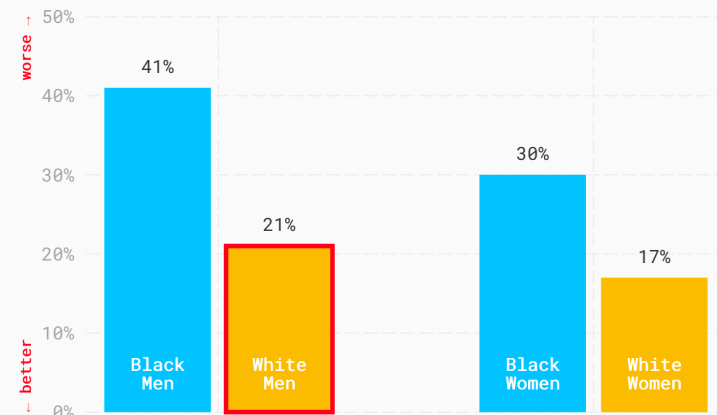
Click on the bars in the chart to hear typical audio samples — and see their machine transcriptions — for different self-identified demographic groups.

A 30-year-old white man



Well, when I was ~~that's~~ ^{when} I was really young I
had a book of basketball statistics ^{and} ~~No~~ I
~~would~~ spend a lot of time a lot of time
reading them. And for some reason, I forget
why now, but Jason Kidd ~~ended up~~ ^{ended up}
~~pain-~~ ^{Be} being my
favorite player.

Error rates by race and gender

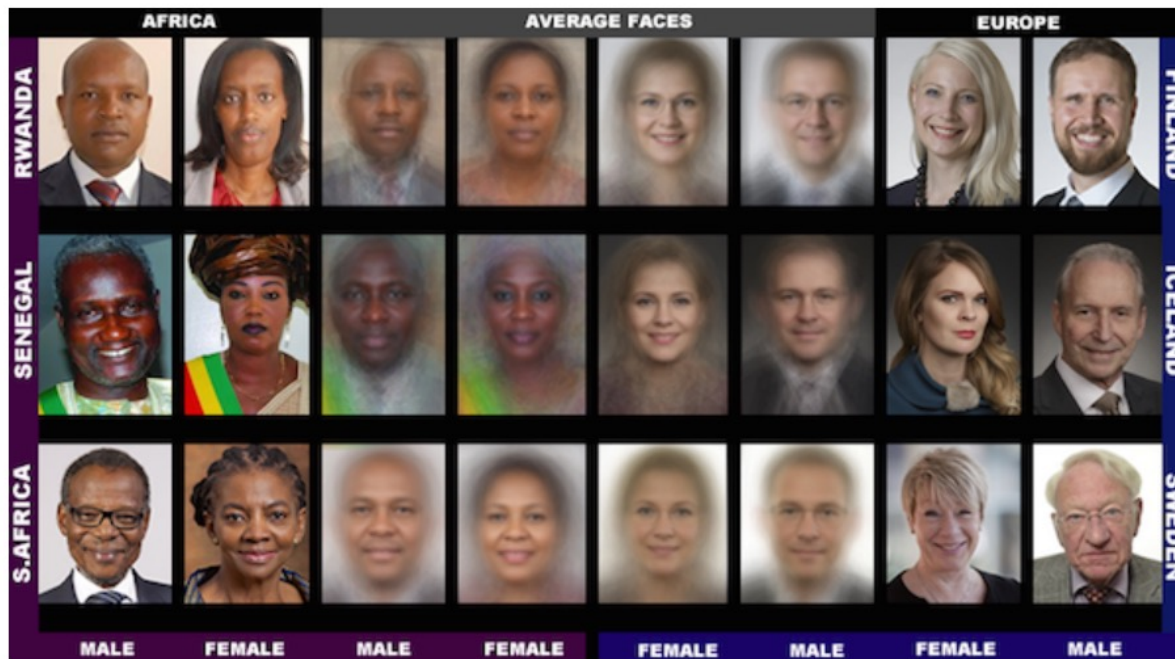


<https://fairspeech.stanford.edu/>

Visuals and Ethics

- Buolamwini, J., Gebru, T. "Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification." Proceedings of Machine Learning Research 81:1–15, 2018 Conference on Fairness, Accountability, and Transparency
- Vegard Antun, Francesco Renna, Clarice Poon, Ben Adcock, and Anders C. Hansen, On instabilities of deep learning in image reconstruction and the potential costs of AI, <https://doi.org/10.1073/pnas.1907377117>, PNAS, 2020

Error Rates of Commercial AI systems are Highest for Black Women, then Black Men, White Women, White Men



- All classifiers perform better on male faces than female faces (8.1%–20.6% difference in error rate)
- All classifiers perform better on lighter faces than darker faces (11.8%–19.2% difference in error rate)
- All classifiers perform worst on darker female faces (20.8%–34.7% error rate)
- Microsoft and IBM classifiers perform best on lighter male faces (error rates of 0.0% and 0.3% respectively)
- Face++ classifiers perform best on darker male faces (0.7% error rate)
- The maximum difference in error rate between the best and worst classified groups is 34.4%

Pilot Parliaments Benchmark

Lecture 2: Concluding Comments

- We surveyed a wide variety of issues around communication and languages
- Computational methods provide invaluable tools to understand languages
 - Helps operate on data despite a diversity of formats and encodings
- We will focus on text in rest of the course unless student wants to do specifically in other modes

About Next Lecture – Lecture 3

Course Project

Choices and Tradeoffs

- Choice 1: Everyone does a project on any subject they like
- Choice 2: Everyone does a project along a theme
- Choice 3: Everyone does a project along a theme and problem; divided naturally scoped due to physical reasons (region, time, ...)
- Choice 4: Mixed

Discussion: Choice 2 for Course Projects

- **Suggestion:** Pick topics along select themes of public interest
 - **Pros:** amortize effort in data collection and preparation, have time to go deeper in technical depth, build a portfolio of related ideas, bigger impact
 - **Cons:** restricts some freedom to select a topic
- **Suggested themes**
 - Elections: quality of information, misinformation
 - Environment: understanding regulations, impact of global warming
 - Health (COVID-19): e.g., impact of disease, prevalence of masks, availability of health services
 - Finance: economy, growth of a company
 - NLP methods: language models, explanation

Reference Only – 2022

Project: Instructor Given

Theme: NLP for working with water

- Extract entities from water regulations of a state, country (e.g., EPA-US) or international (WHO)
- Process and analyze using NLP
 - Determine polarity
 - Extract entities and fill a structured format, to enable reasoning
 - Summarize
- Drive a water use-case
 - Comparing regulations in different regions

Dataset: <https://drive.google.com/drive/folders/1H23Afgb3VS1yUe9uKiYH8--RoqBRZ9aV?usp=sharing>

Discussion: Choice 3 for Course Projects

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

Lecture 3: A Look at Structure of Text

- Understanding concepts
 - Words
 - Morphology
 - Lexicons
- Using them for content processing
- Dealing with multiple languages