TEXT MINING

Lecture 03

TEXT MINING PRINCIPLES

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Data Science

Data Science

- Data
  - Record of history
  - Structured data → excel sheet
  - Unstructured data → text, audio, video

- Data Science
  - Mathematics / Statistics → probability, linear algebra, descriptive statistics, inferential statistics, Bayes' theorem
  - Computer science → R, Python, SQL
  - Domain Knowledge

Data Science 1) Value

- Data value
  - Either numerical or non-numerical value

2022

Mathematical computation
Statistical computation

“2022”
“two zero two two”
“two thousand and twenty two”
“twenty hundred and twenty two”

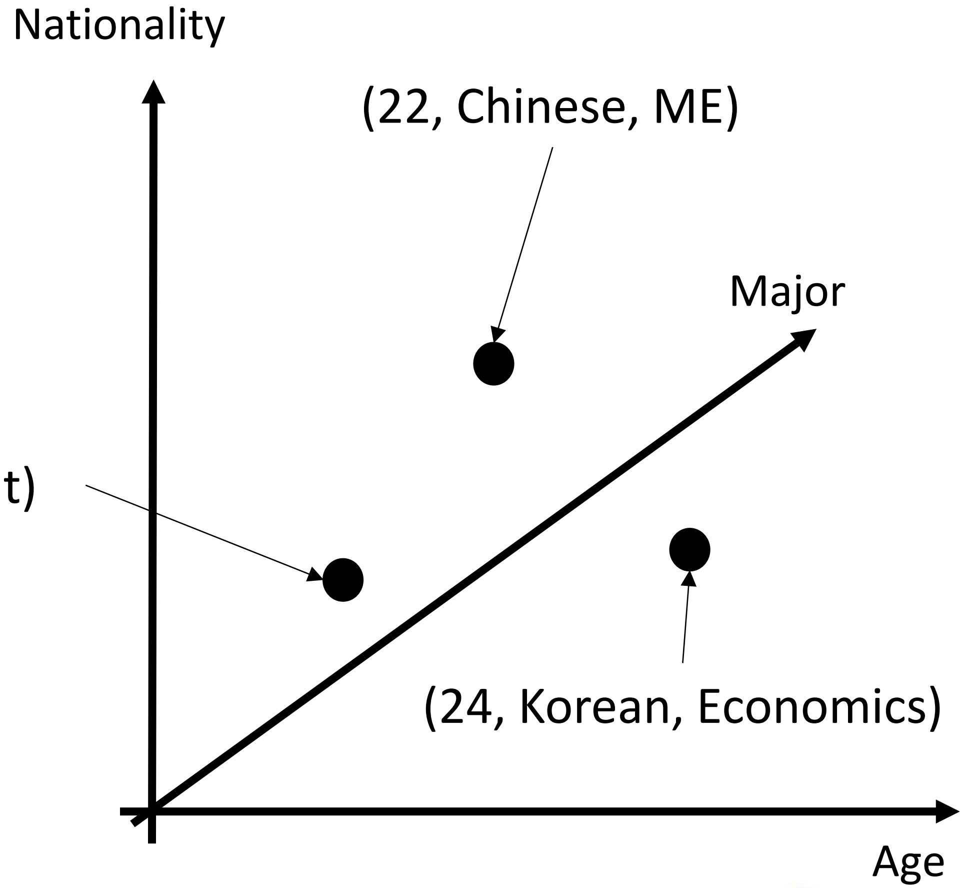
~~Mathematical computation~~
~~Statistical computation~~

1. The meaning of the value that the computer understands is different.
2. The way computers handle values is different.

Data Science 2) Data Dimension

- In Data Science, data is recognized as a “dimension”
  - Big Data: Countless Variables and Countless Observations → Countless Dimensions and Countless Objects
  - Each dimension is "independent"

Name	Age	Nationality	Major
Kim	22	Korean	Management
Lee	24	Korean	Economics
Wang	22	Chinese	Mechanical Engineering



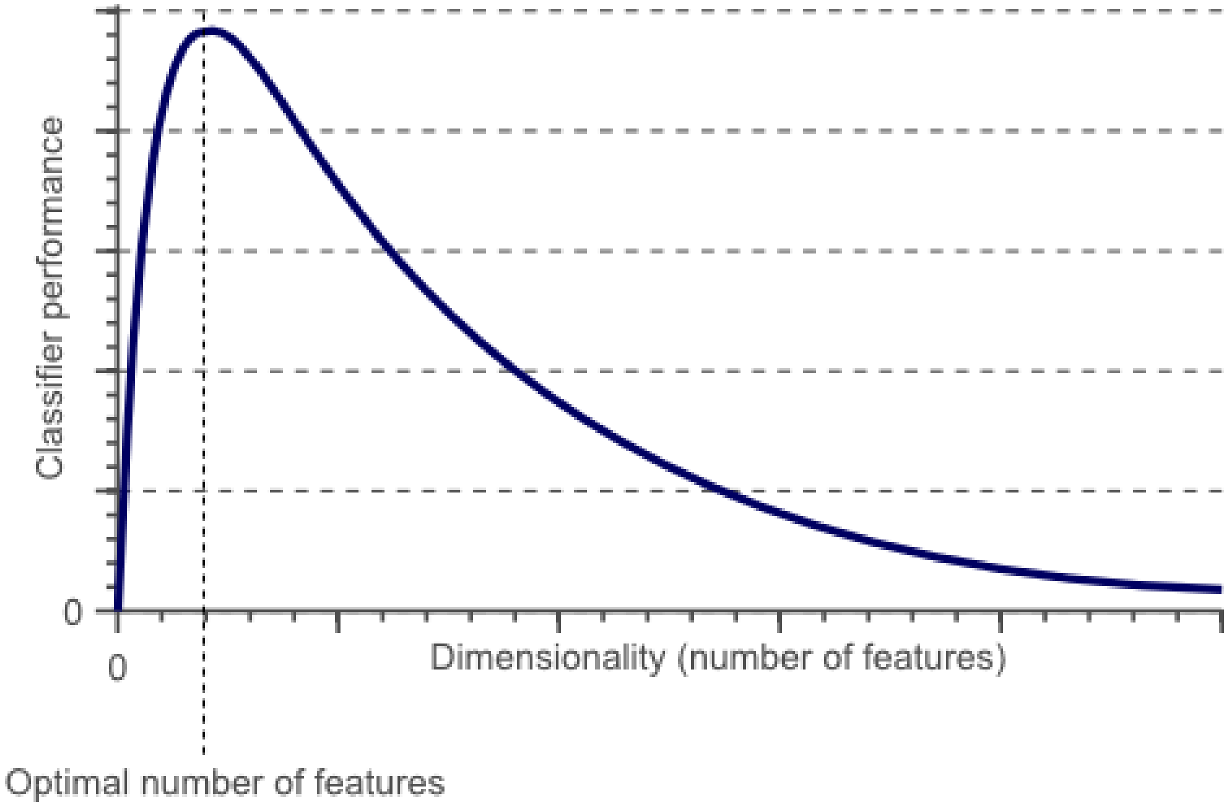
3 people
3 attributes
3 values

→

3 objects
3 axis
3 lengths

Data Science 2) Data Dimension

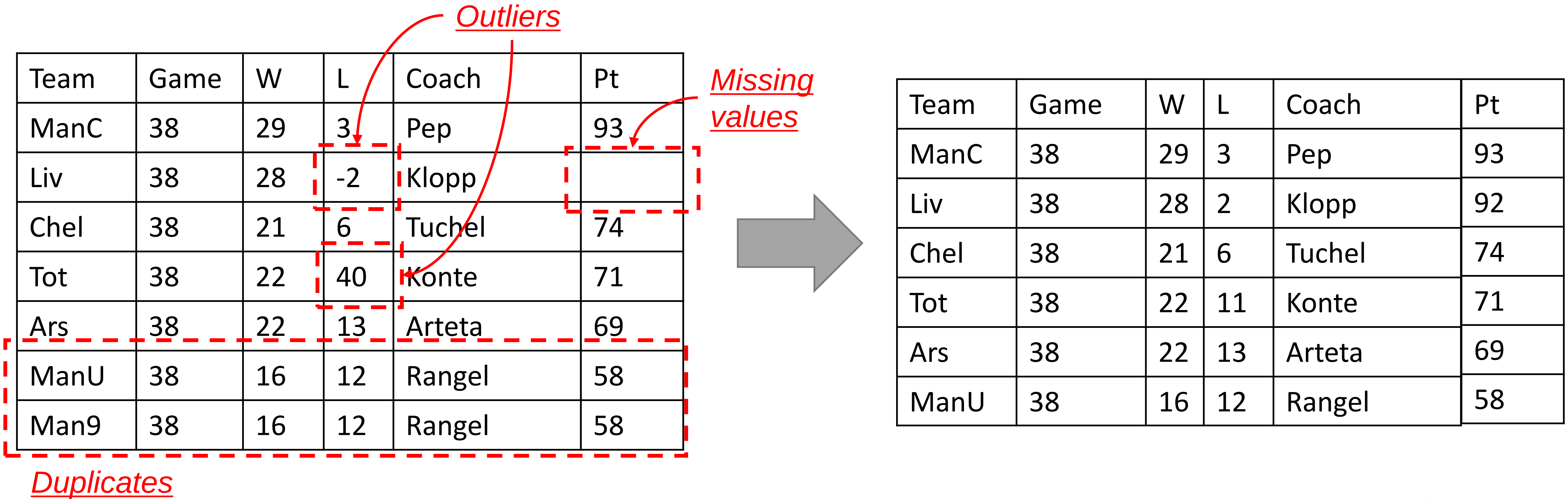
- Dimensional Curse
  - number of objects < number of dimensions
  - Variables increase → More information is available.



Dimensional reduction: PCA (principal component analysis), LSA (Linear Discriminant Analysis), MDS (Multidimensional scaling), SVD (Singular Value Decomposition), LL (Locally-Linear Embedding), Kernel Principal Component Analysis, etc.

Data Science 3) Data Pre-processsing

- Turning data into an “analyzable form”
  - Data processing work tailored to the “input value” of the data analysis methodology to be performed
  - Tidy data: A form in which one row has an independent value



Outliers

Missing values

Team	Game	W	L	Coach	Pt
ManC	38	29	3	Pep	93
Liv	38	28	-2	Klopp	
Chel	38	21	6	Tuchel	74
Tot	38	22	40	Konte	71
Ars	38	22	13	Arteta	69
ManU	38	16	12	Rangel	58
Man9	38	16	12	Rangel	58

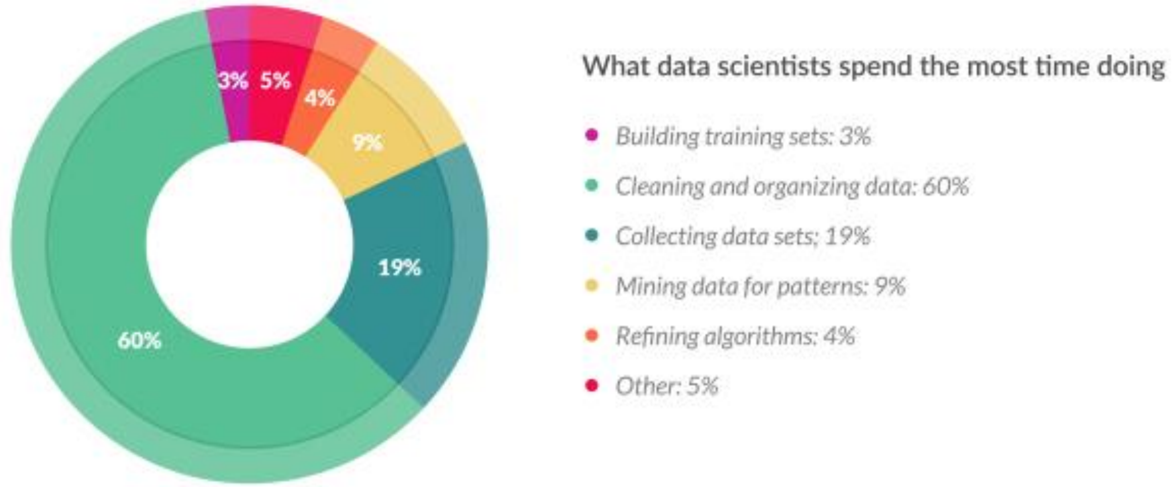
Duplicates

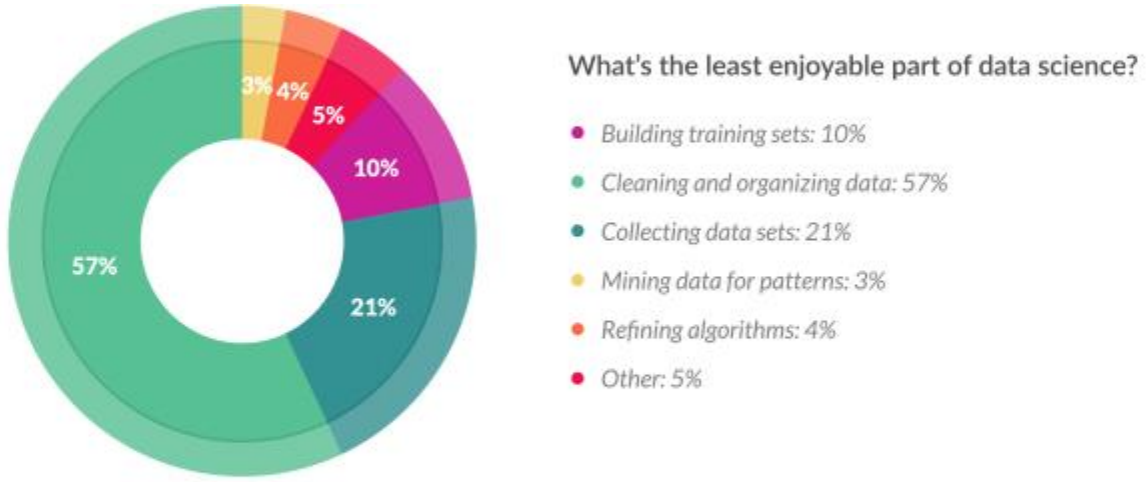
Team	Game	W	L	Coach	Pt
ManC	38	29	3	Pep	93
Liv	38	28	2	Klopp	92
Chel	38	21	6	Tuchel	74
Tot	38	22	11	Konte	71
Ars	38	22	13	Arteta	69
ManU	38	16	12	Rangel	58

Data Science 3) Data Pre-processsing

- In most cases, data sets are imperfect for data analysis
  - Data cleansing decides the “quality” and “performance” of data analysis
  - It takes most times…

- Two purposes
  - Creating a “tidy” data
  - Cleansing a “messy” data





Data Science 4) Uncertainty

- No data is perfect
  - Philosophy of Statistics: I cannot know everything.

N

Size of population
population: all data that I cannot obtain

vs.

n

Size of sample
sample: data that I obtain

Big Data Era
→ The amount and variety of data samples that can be analyzed have grown
→ Big data does not mean perfect data.

Data Science 4) Uncertainty

- No data is perfect

“Is it safe under extreme repetitive conditions?”
→ Removal of uncertainty about new cars

Data ↑

Uncertainty ↓

Consistency ↑

<u>However, uncertainty still exists!!!</u>

https://cmobile.g-enews.com/view.php?ud=202009041807478556e8b8a793f7_1&ssk=search&md=20200907160311_V

Data Science 4) Uncertainty

- No data is perfect

Winning move

=

Unknown information that my algorithm has not experienced yet

https://www.donga.com/news/Inter/article/all/20210518/107001323/2

Text Data

Features of Text Data

- Value of text data is NOT numerical
  - Raw text data cannot be used for calculation, but it is <u>highly compressed.</u>

~~22~~ “22” “Twenty-two” “Two-two”

Text data

WIKIPEDIA
La enciclopedia libre

NAVER 뉴스 TV연예 | 스포츠 | 뉴스스탠드 | 날씨

01.21(목) 인천 -4°C 주요뉴스 › 자동차수리 고객 3명 중 1명 "과다청구 불만"

뉴스홈 속보 정치 경제 사회 생활/문화 세계 IT/과학 오피니언 포토 TV 랭킹뉴스 뉴스 검색 검색

신문 헤드라인 · 저녁 방송 뉴스 ·

이 시각 주요뉴스 최종 2016.01.21. 16:03

작년 500만원이상 고가 월세 거래 43건.. 72% 증가

中 3년만에 73조 투입 경기부양..

효과는? 중국증시3 중국이 대규모 유동성 공급을 통한 경기부양에 나선다. 21일 블룸버그통신에 따르면 이날 중국 인민은행(PBOC)은 …

졸업자는 채용에 불리? 기업들은 "상관안한다"

줄줄 새는 실손보험금…'진료 조작·부풀리기' 병원 36곳 적발

건설현장은 왜 청년 일자리의 무덤이 됐나?

자동차수리 고객 3명 중 1명 "과다청구 불만"

TV연예 TV 포토 스타캐스트

"내가 제일 잘나가" 2NE1 공민지…

"꽃생활 꽃미남"…장근석, 프린…

방송 '한류'도 아시아가 주도…프로그램 수출 9…

'연기 모범생' 박소담의 역주행 행보

스포츠 야구 축구 해외야구 해외축구

김호주 '열정적인 훈련에 더워요'

김병현 '칼 바람을 가르며 달려라!'

선수만 57명…치열한 한화 잔류군 캠프

가와시키, 도전 계속…컵스와 마이너 계약

가장 많이 본 뉴스 더보기

종합 정치 경제 사회 생활/문화

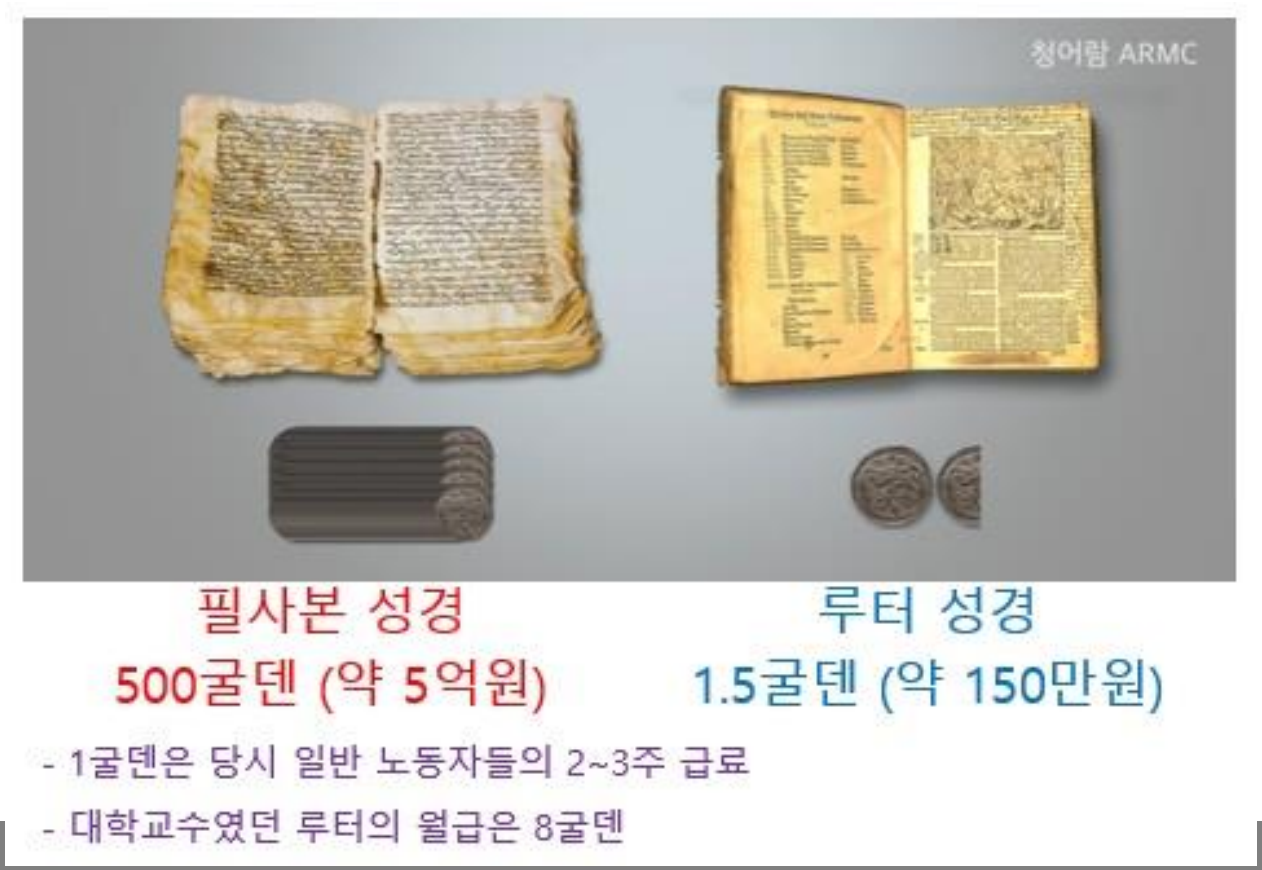
- [정치] 정의화 "선진화법 직권상정 제한…
- [경제] "공짜 미백치료 받으세요" 진료기…
- [사회] "눈물도 없이 머뭇거리지도 않고"…
- [생활/문화] "3억5천에 경매나온 '삼국유…
- [세계] "'쯔위 사건'은 중국인 92공식 오해…
- [IT/과학] "명왕성 너머 9번째 행성 있다"…
- [연예] [단독] 류준열, '응팔' 차기작은 조…

https://www.donga.com/news/Inter/article/all/20210518/1

knowledge, opinion, philosophy, belief + α

Features of Text Data

- Value of text
  - Value of bible – value of a book? Or value of content?
  - Value of bible as a book → 19,850 won
  - Value of bible as a content → ??



필사본 성경
500굴덴 (약 5억원)

루터 성경
1.5굴덴 (약 150만원)

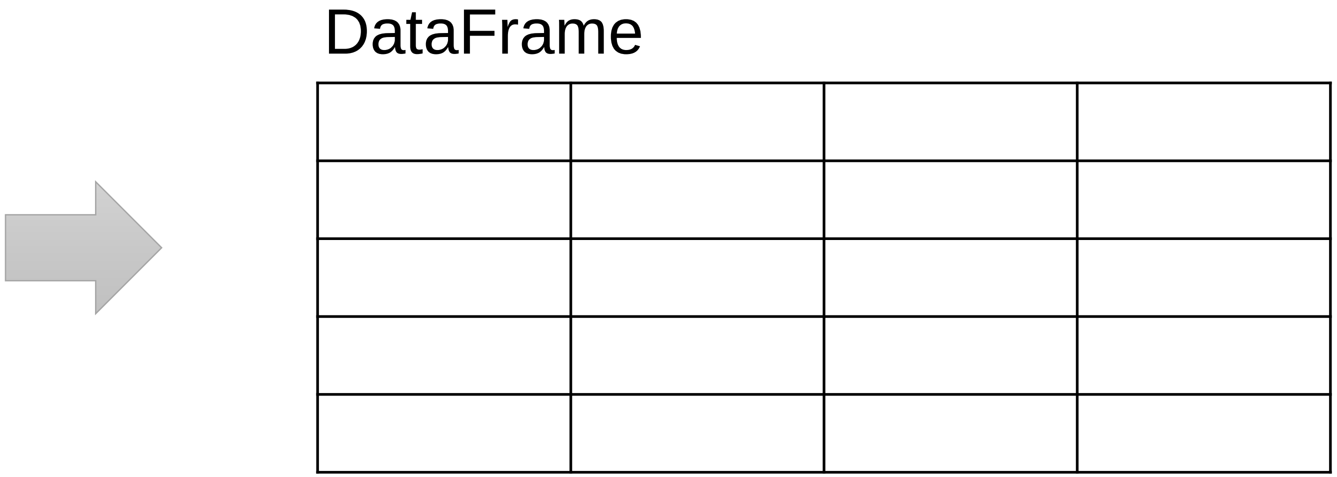
- 1굴덴은 당시 일반 노동자들의 2~3주 급료
- 대학교수였던 루터의 월급은 8굴덴

http://www.acronet.kr/22700

Features of Text Data

- Unstructured format
  - No data structure = No columns and no rows
  - Can’t conduct data analysis with raw text data

“Chelsea and Tottenham managers were both sent off after contentious 2-2 draw.”



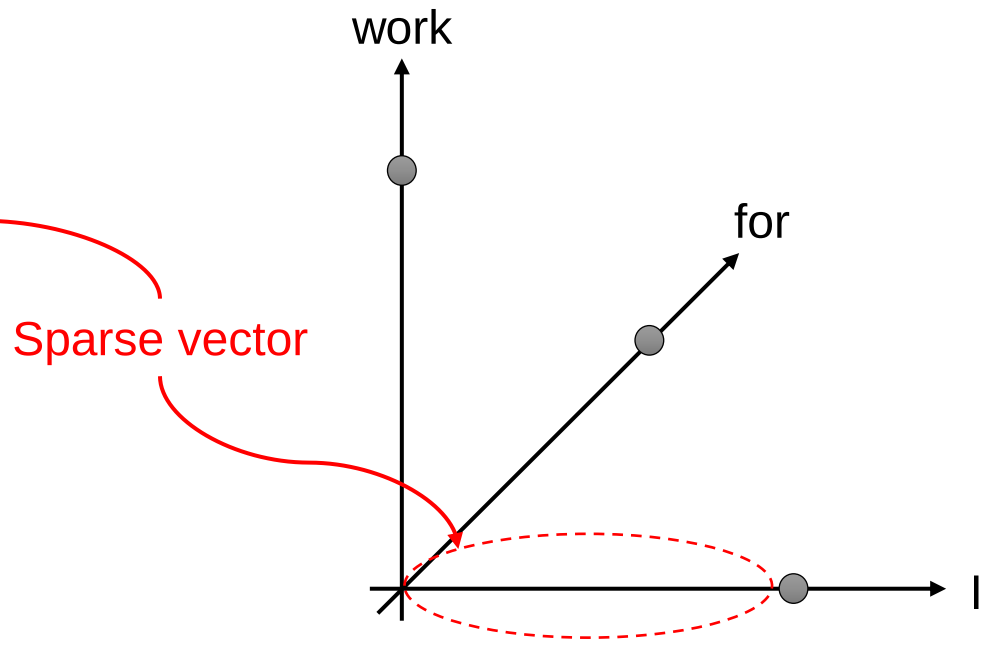
DataFrame

Features of Text Data

- Unstructured format
  - Cannot compute mathematical operations with text variables → text encoding?
  - Text encoding: converting text into a numerical value
  - The problem is that the encoded text does not have any meaning

	I	work	for	hyundai	motors
I	1	0	0	0	0
work	0	1	0	0	0
for	0	0	1	0	0
hyundai	0	0	0	1	0

I = [1, 0, 0, 0, 0]
work = [0, 1, 0, 0, 0]
for = [0, 0, 1, 0, 0]
hyundai = [0, 0, 0, 1, 0]



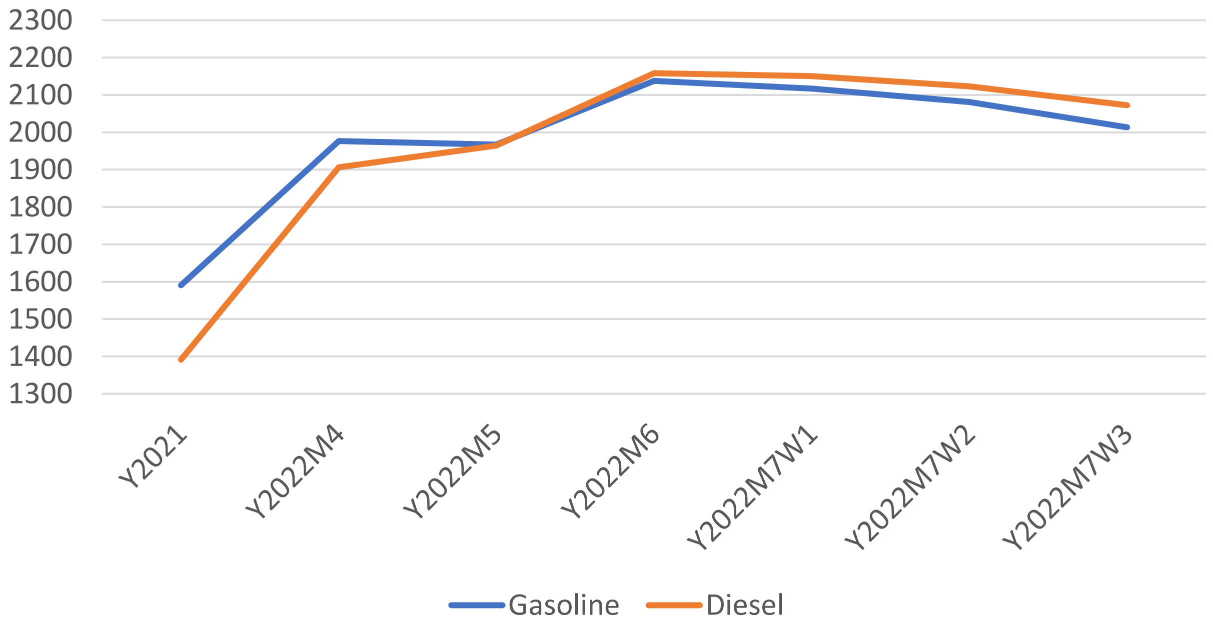
Features of Text Data

- Ambiguity 모호성
  - Ambiguity means the capability of being understood in two or more possible senses or ways.
  - Contextual background matters

Data without context 2013.1

Data with context

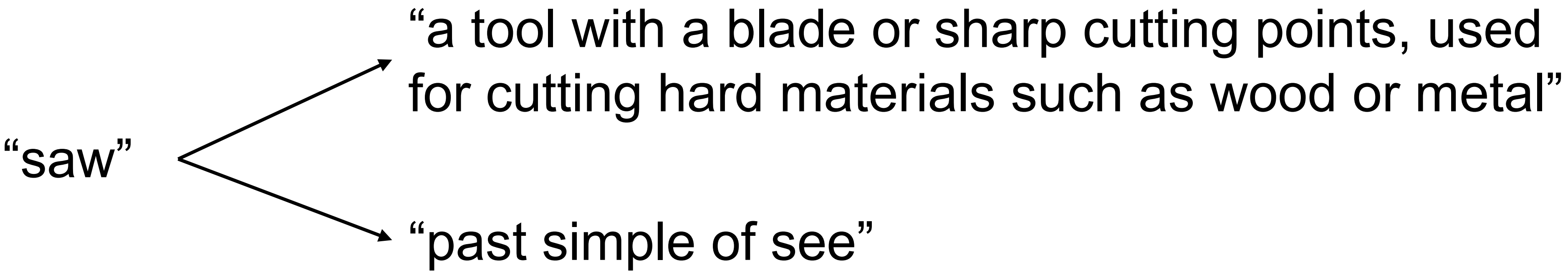
	Gasoline	Diesel
Y2021	1590.6	1391.4
Y2022M4	1976.53	1906.42
Y2022M5	1967.07	1964.28
Y2022M6	2137.7	2158.2
Y2022M7W1	2116.8	2150.4
Y2022M7W2	2080.7	2123.3
Y2022M7W3	**2013.1**	2072.5



https://www.opinet.co.kr/user/ofdoptd/getOfdoptdSelect.do

Features of Text Data

- Ambiguity 모호성
  - Lexical ambiguity: a word with multiple meaning

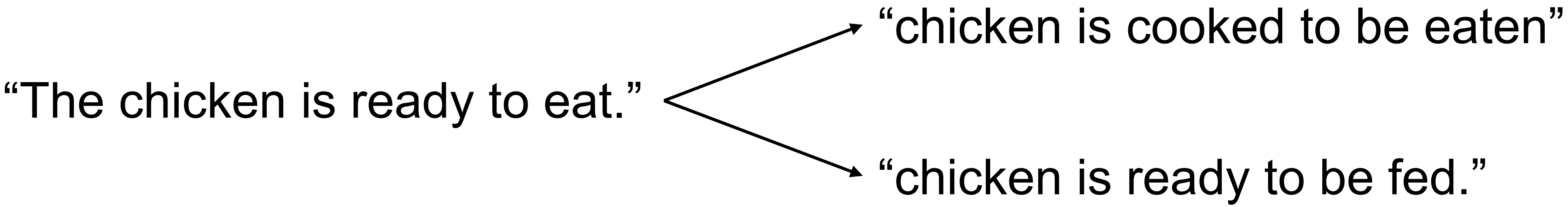


"saw"

"a tool with a blade or sharp cutting points, used for cutting hard materials such as wood or metal"

"past simple of see"

  - Syntactic ambiguity: a sentence with multiple meanings due to the relationship between words or sentences



"The chicken is ready to eat."

"chicken is cooked to be eaten"

"chicken is ready to be fed."

Features of Text Data

- Ambiguity types
  - Homonym 동형어: A word that has the same form but has a different meaning. different etymology. 형태는 같으나 뜻이 다른 단어. 어원이 다름

  ➔ pitcher: baseball pitcher or bowl

  ➔ 배: 과일 or 신체 부위

  - polysemy 다의어: A word in which one form of a word has several related meanings. 한 형태의 단어가 여러 관련된 의미를 갖는 단어

  ➔ mouth: body mouth or entrance

  ➔ 저녁: 저녁 시간 or 저녁 밥

Features of Text Data

- Ambiguity types
  - Synonym 동의어: A word in different forms but with the same meaning 다른 형태이지만 의미가 같은 단어

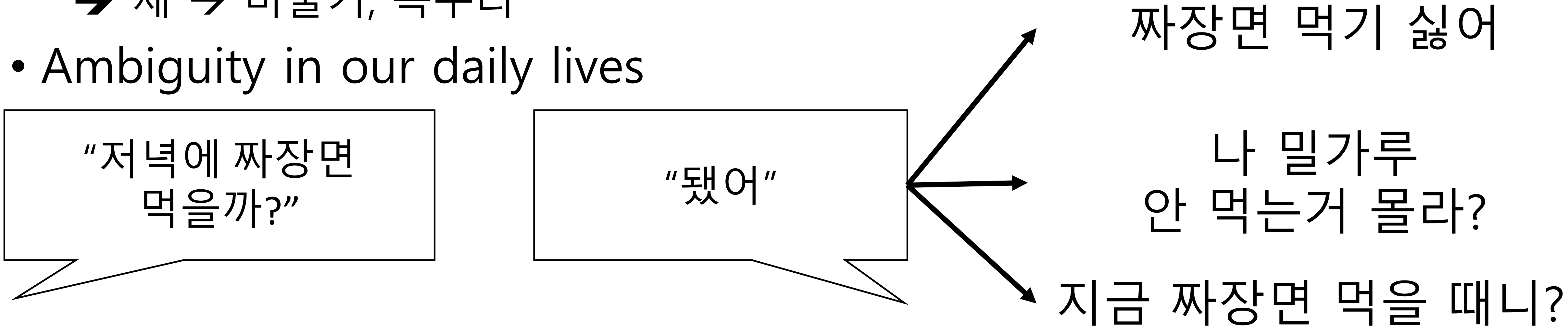
  ➔ tired or sleepy

  ➔ 아기, 유아

  - Hypernym 상위어 Hyponym 하위어: A word of a higher concept or lower concept 상위 개념 혹은 하위 개념의 단어

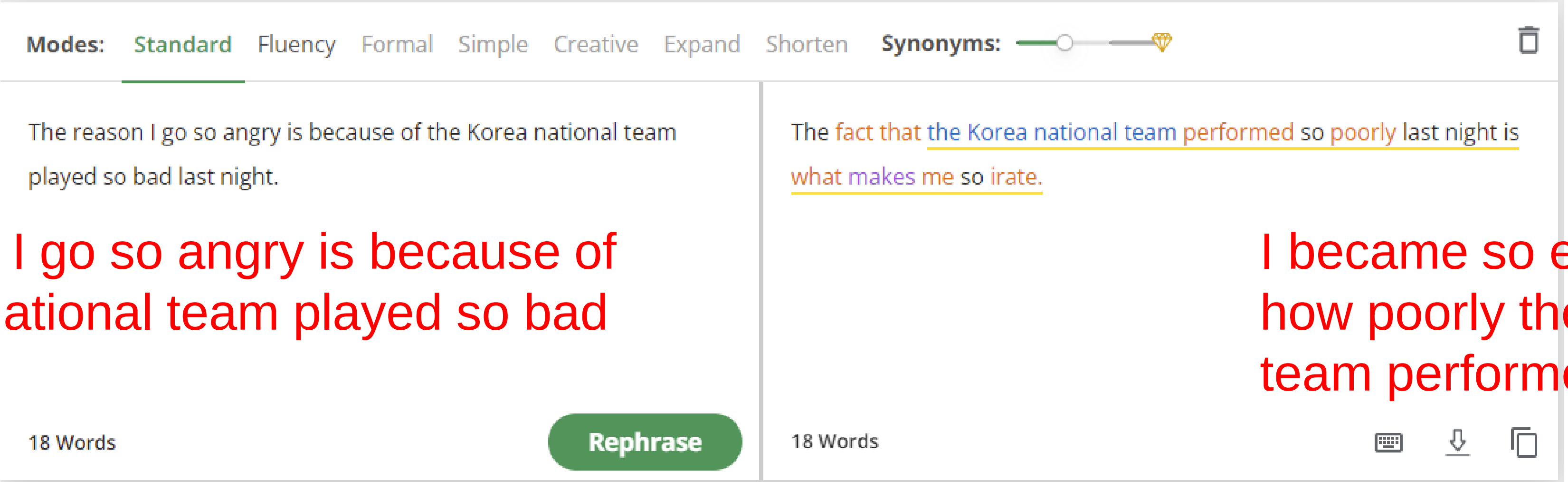
  ➔ Bird → pigeon, eagle

  ➔ 새 → 비둘기, 독수리
- Ambiguity in our daily lives



Features of Text Data

- Paraphrase 의역
  - Restatement or rewording of a paragraph or text
  - Synonym restatement, structure change, etc.
  - One meaning, numerous ways to express it


Modes: Standard Fluency Formal Simple Creative Expand Shorten
Synonyms:
Rephrase

The reason I go so angry is because of the Korea national team played so bad last night.

18 Words

The fact that the Korea national team performed so poorly last night is what makes me so irate.

18 Words

The reason I go so angry is because of the Korea national team played so bad last night.

I became so enraged because of how poorly the Korea national team performed last night.

The fact that the Korea national team performed so poorly last night is what makes me so irate.

- High freedom of expression = Many possible answers

https://quillbot.com/?utm_medium=paid_search&utm_source=google&utm_campaign=sitelinks&campaign_type=extension

Text Mining Overview

Text Mining

- “A process where an interesting pattern or a useful value is discovered in unstructured Big Data.”
  - Collection
  - Preprocessing
  - Analysis
  - Summarization
- With text mining, we can find certain patterns from the unstructured text data.

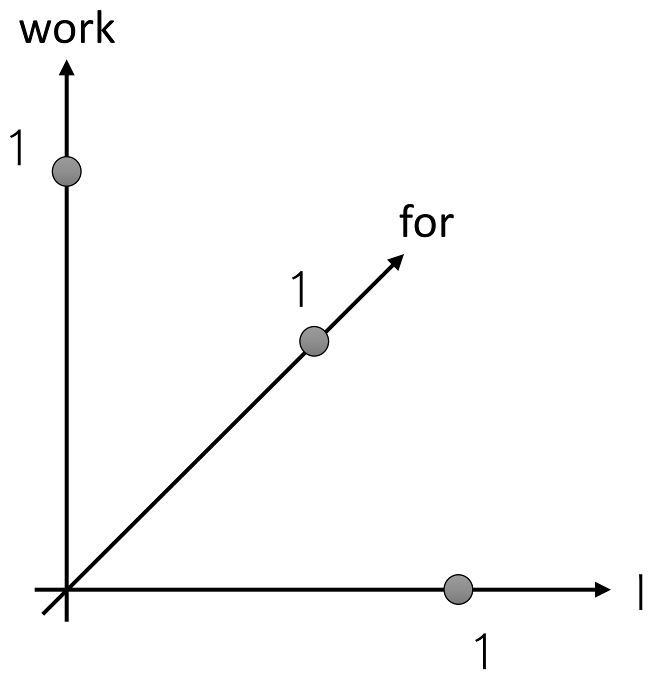
- “text-as-data approach”

Text Mining - Value

- Encoding (one-hot encoding vector)
  - Turning text data into “numbers”
  - Sparse vector (spare representation)
  - “Meaning” is not considered

	I	love	Handong
I	1	0	0
love	0	1	0
Handong	0	0	1

I	= [1, 0, 0]
work	= [0, 1, 0]
Handong	= [0, 0, 1]



Text Mining - Format

- Considering “text” as a data set
    - Matrix or Data.Frame or Numerical array (in encoded)

<Original text>
Ferguson) “Twitter is a waste of time.”
Kim) “Cyworld is a full of joy.”

Doc	Text
Ferguson	“Twitter is …”
Kim	“Cyworld is …”

Wide format

Doc	X1	X2	X3	X4	X5	…
Ferguson	Twitter	is	a	waste	of	…
Kim	Cyworld	is	a	full	of	…

Long format

Doc	Text
Ferguson	Twitter
Ferguson	is
Ferguson	…

Text Mining – Unit of Analysis

- Considering “text” as “data” means that text is non-numeric data with a hierarchical structure

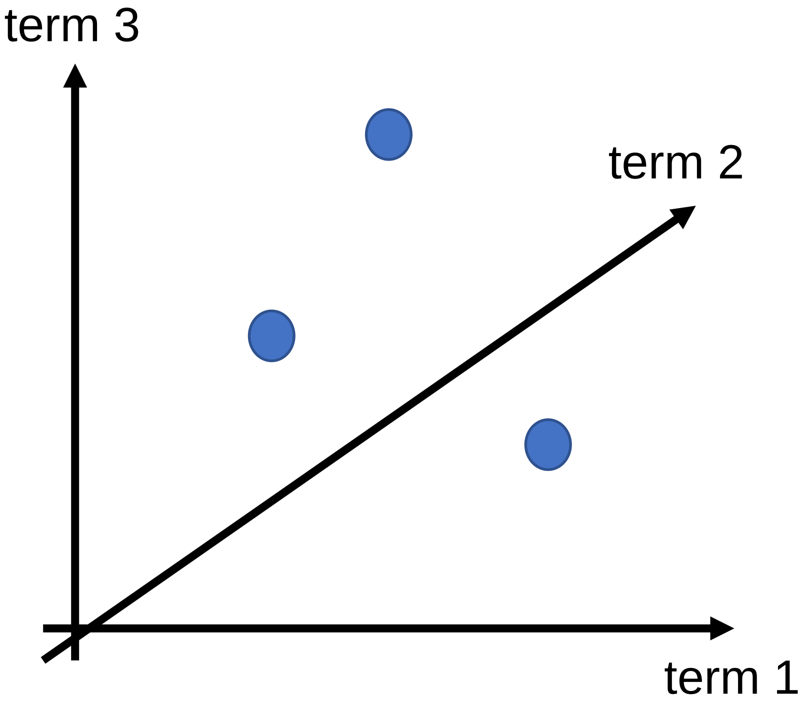
Corpus > Document > Paragraph > Sentence > Word > Morpheme

- Corpus: a set of documents
- Morpheme: the smallest unit of language that has its own meaning (part of a word)

- In general, corpus > document > word is used. This is similar to sample > observation > variable in conventional data analysis.
- Depending on the “unit of text analysis”, the whole concept of text mining analysis changes.
- Remember that the unit of text analysis and the level of hierarchical structure depends on the researcher’s interest.

Text Mining – Dimension

- Text dimension
  - Similar to the concept of data dimension, text data can also be described with an n-dimension
  - Text is ‘high-dimensionality’ data



Number of dimension:

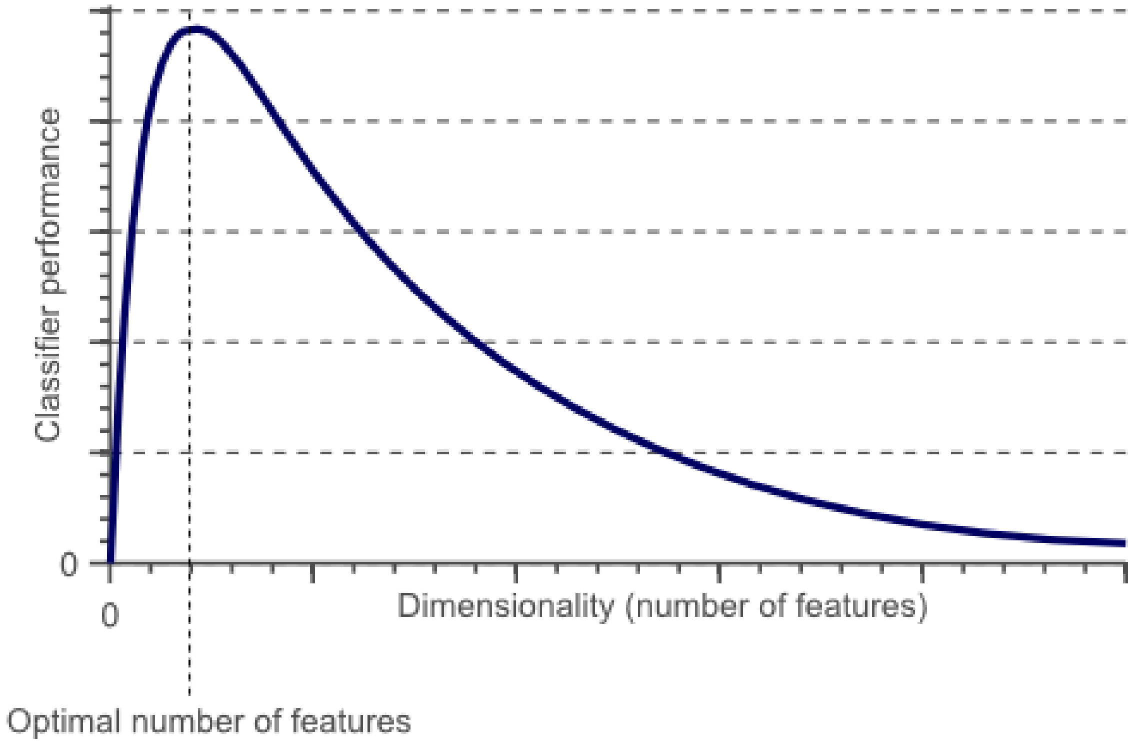
Number of unique terms:

Number of objects:

Number of sentences (or documents):

Text Mining – Dimension

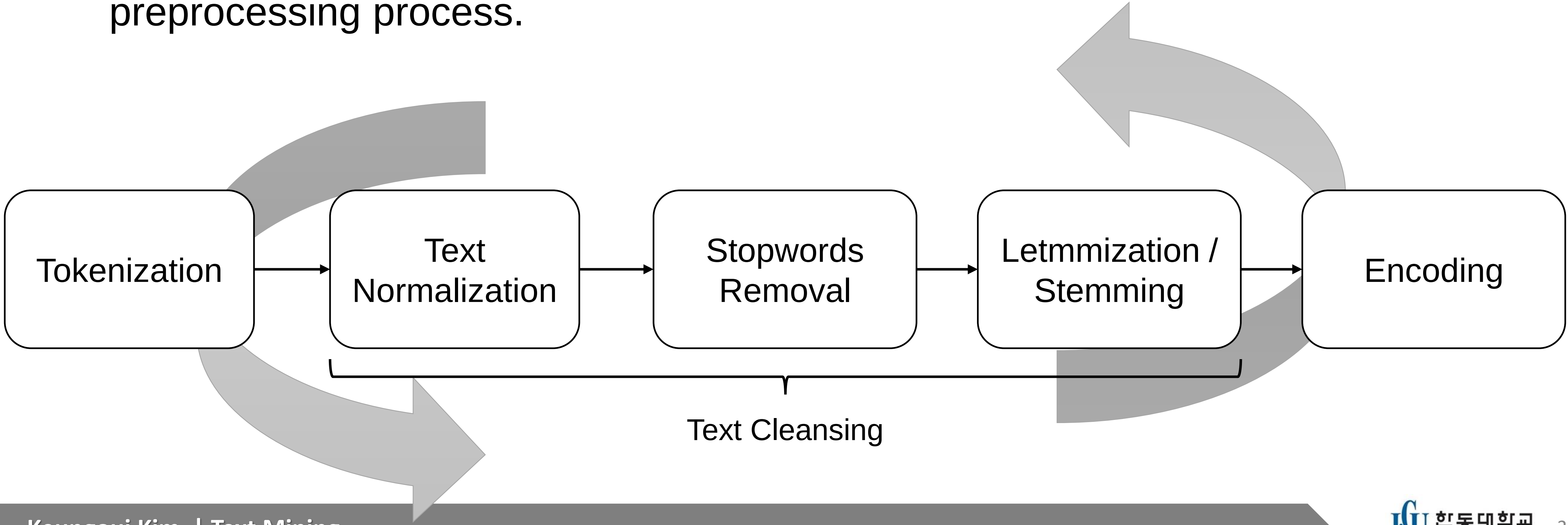
- High Dimensionality
  - Assuming that each word is considered as a “dimension”, text data is a data set with very high dimension. Hundreds? Thousands?
  - Curse of dimensionality: Explosive nature of increasing data dimensions and its resulting exponential increase in computational efforts required for its processing and/or analysis



https://www.visiondummy.com/2014/04/curse-dimensionality-affect-classification/

Text Mining – Pre-processing

- Text data pre-processing process
  - Due to the nature of text data, text preprocessing is completed after several iterations rather than all at once.
  - The key to text data preprocessing is to 1) transform the text to fit the “researcher's purpose” and 2) minimize data distortion or loss during the preprocessing process.



Text Mining – Analysis

- Text Mining analysis includes methods being used to “understand” text data and “extract” the hidden meaning from it
  - Always think : 1) “what sort of data am I dealing with? 2) “what do I want to find from the analysis?”
  - Selecting the proper analytic method is more important than anything

- Text Mining analysis
  - Word cloud
  - Cluster analysis
  - Network analysis
  - Sentiment analysis
  - Topic modelling

Text Mining & Natural Language Processing

- Natural Language Processing (NLP)
  - Linguistic
  - Text Mining*
  - Artificial Intelligence
  - Domain knowledge

- Text Mining is often used as a prerequisite technique needed for proceeding to NLP
- While most Text Mining relies on “discrete representation,” NLP focuses on “distributional (or continuous) representation”

Text Mining Approaches

Text Mining Principles

- Basic principals
  - “People express themselves through language and want to be approved”

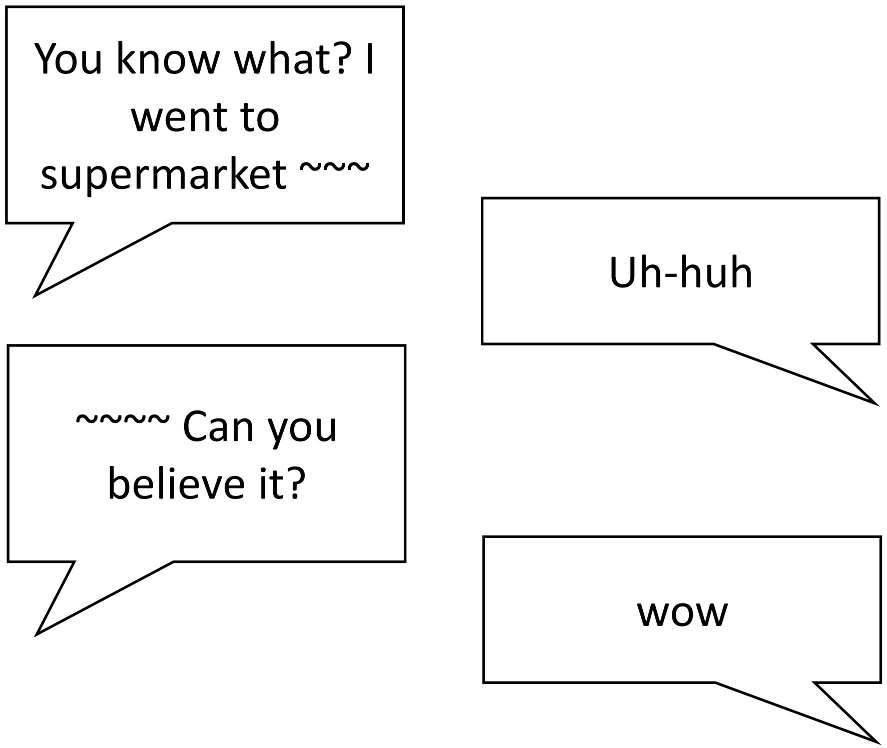
  → There is 'something' in language that researchers need to focus on

- Three approaches
  - Conversation analysis
  - Discourse analysis
  - Critical discourse analysis

Conversation Analysis

- Conversation analysis
  - An approach to the study of social interaction, embracing both verbal and non-verbal conduct, in situations of everyday life [Wikipedia]
  - Used to understand “how speakers work together to make the conversation happen” → “how speakers talk” & “how sentences are structured”

- Conversation
  - Communication between two people including “turn-taking”, “backchanneling”, “pauses”, “interruptions” + “gesture”, “pitch”, etc.



You know what? I went to supermarket ~~~

Uh-huh

~~~~ Can you believe it?

wow
~~~~

Discourse Analysis

- Discourse analysis
  - An approach to the analysis of written, vocal, or sign language use, or any significant semiotic event [Wikipedia]
  - Interested in 'naturally occurring' language use
  - Used to understand "how speakers use language to construct meaning and identity"
- Tannen (2008)'s studies on women's discourse on their sisters
  - Small n-narratives: accounts of ***specific events*** or interactions that speakers said that had occurred with their sisters
  - Big n-narratives: ***themes*** speakers developed in telling the interviewee about their sisters, and in support of which they told the small-n narratives
  - Master narratives: ***culture-wide ideologies*** shaping the big-N Narratives.

Tannen, Deborah. 2008. We've never been close, we're very different: Three narrative types in sister discourse

Critical Discourse Analysis

- Critical perspective
  - Views social problems as institutionalized
  - Challenges unjust professional discourse
  - Seeks social change
- Critical discourse analysis: Critical perspective + Discourse analysis
  - 3 dimensions of text, discourse practice, and social practice
  - Text: The stage of describing the linguistic properties in the text, paying attention to vocabulary, tone, sentences, grammar, dialogue order, and newspaper article structure.
  - Discourse practice: The stage of interpretation involving various aspects of the process by which texts are produced and consumed.
  - Social practice: Analysis of social and cultural practices or relationships outside the text is an analysis of the relationship between texts' social practice practices and social structures.

Content Analysis

- Content analysis
  - Method used to determine the presence of certain words, themes, or concepts within some given data, such as books, newspapers, magazines, speeches, interviews, web contents, etc.
  - Identifying “patterns” in recorded communication

  - Quantitative approach: counting and measuring
  - Qualitative approach: interpreting and understanding

  - Steps: (1) Categorize (or code) words, themes, and concepts within the text.

    (2) Then, analyze.

Learning Types

- Like a typical data analysis, text analysis can be divided into two types based on the learning type

- Supervised learning
  - If the classification, label, or meaning of the text is known
  - Sentimental analysis, document classification, etc.

- Unsupervised learning
  - If the meaning of the text is unknown
  - clustering, topic modeling, etc.

Methodologies

- Descriptive analysis
  - Text analysis with descriptive features (Text frequency, co-occurrence rate)
  - The result of descriptive analysis is intuitive and easy to understand
  - Using descriptive analysis, we can understand the characteristics of unstructured data (Ex. number of reviews, mentions, comments, etc.)

- Predictive analysis
  - Goal of machine learning is “prediction”
  - Pretrained text analysis model can be used for prediction
  - Text is sequential data → applicable for prediction?

Word Representation

Word Representation

- From computer’s perspective, text is just a “symbol”

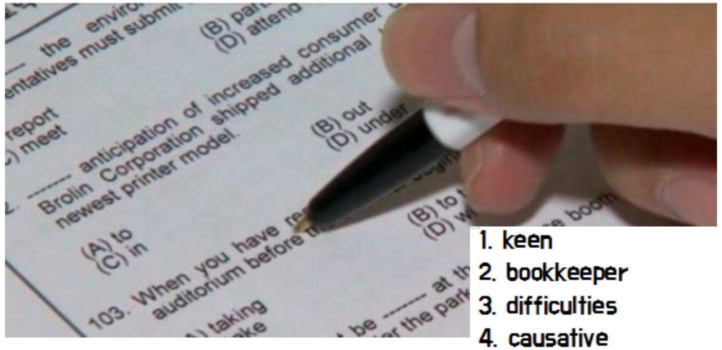
- The goal of Text Mining is to convert a text into a form that a computer can understand (or CALCULATE)

- Two ways of word representation
  - Discrete representation
  - Distributed representation

Discrete Representation

- Discrete representation
  - Also known as local representation
  - Count based approach
  - One-hot encoding vector

- Related techniques
  - Bag of Words
  - Document-Term Matrix (DTM)
  - Term-Document Matrix (TDM)
  - Term Frequency-Inverse Document Frequency (TF-IDF)
  - N-gram language model



ETS TOEIC®

1. keen	1. 예리한
2. bookkeeper	2. 회계 장부 담당자
3. difficulties	3. 말썽, 곤란
4. causative	4. 원인이 되는, 야기 시키는
5. affected	5. 영향을 받는
6. athletics	6. 체육, 육상 경기
7. affection	7. 감정, 감동
8. marginal	8. 최저의, 한계의
9. release	9. 양도하다, 놓아주다
10. historic site	10. 유적지
11. conduction	11. 전도
12. even-numbered	12. 짝수의
13. demonstration	13. 입증, 설명, 시연
14. undisclosed	14. 나타나지 않은
15. undetermined	15. 미확인의
16. record	16. 이력, 경력
17. association	17. 협회, 연계, 연관
18. ballroom	18. 무도회장
19. witness	19. 직접보다, 목격하다
20. stringently	20. 엄격하게, 용서 없이
21. bring together	21. 모으다, 합치다
22. recognize	22. 표창하다, 인정하다
23. expedition	23. 여행, 탐험
24. remote	24. 외딴, 외진
25. serve as	25. ~의 역할을 하다
26. isolated	26. 외딴, 고립된
27. vessel	27. 선박, 배
28. therapeutic	28. 치료법의
29. contraction	29. 수축, 축소
30. metabolism	30. 신진대사

Discrete Representation

- Limitations of Discrete Representation
  - Can't figure out the nuances of words
  - Subjective issue
  - Expensive labeling
  - Difficult to calculate the similarity between words

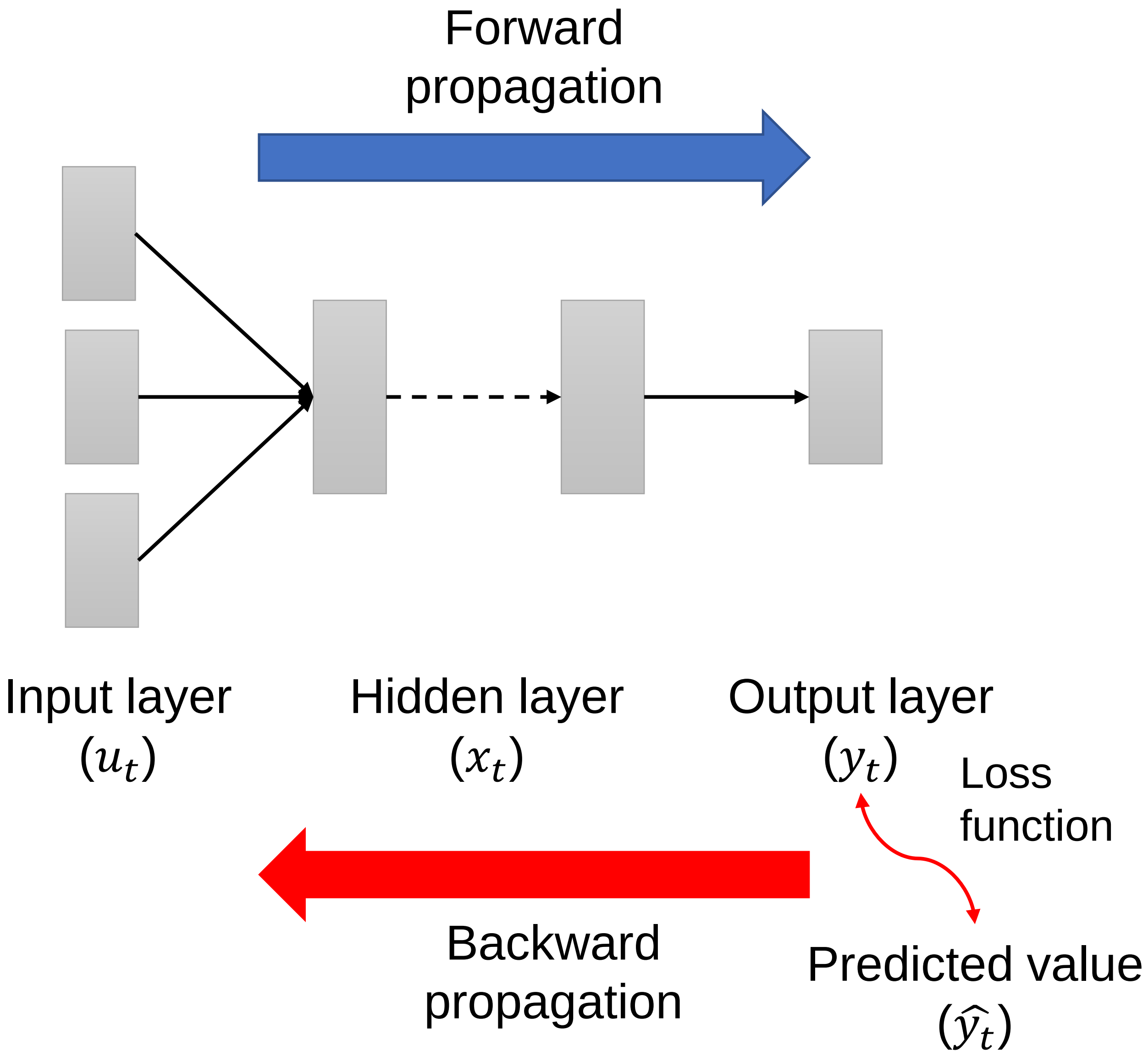
- It starts from the simple truth that “frequency matters,” but that is not the way we understand the text!

Distributional Representation

- Distributional (or continuous) representation
  - Vector expression that can understand the ‘meaning of words’ (ex. RGB)
- Distributional Hypothesis
  - The word itself has no meaning, and the context in which it is used forms the meaning
  - ‘The meaning of a word is its conjugation in that language.’
  - Context of a word = words around it in a sentence
- Embedding vector
  - Word2Vec
  - GloVe
  - FastText
  - Deep Learning language model (BERT, GPT, LLaMA, etc.)

Distributional Representation

- Neural network language model (NNLM)
  - Language model: probability distribution over the sequence of words
  - RNN
  - LSTM
  - BERT
  - GPT

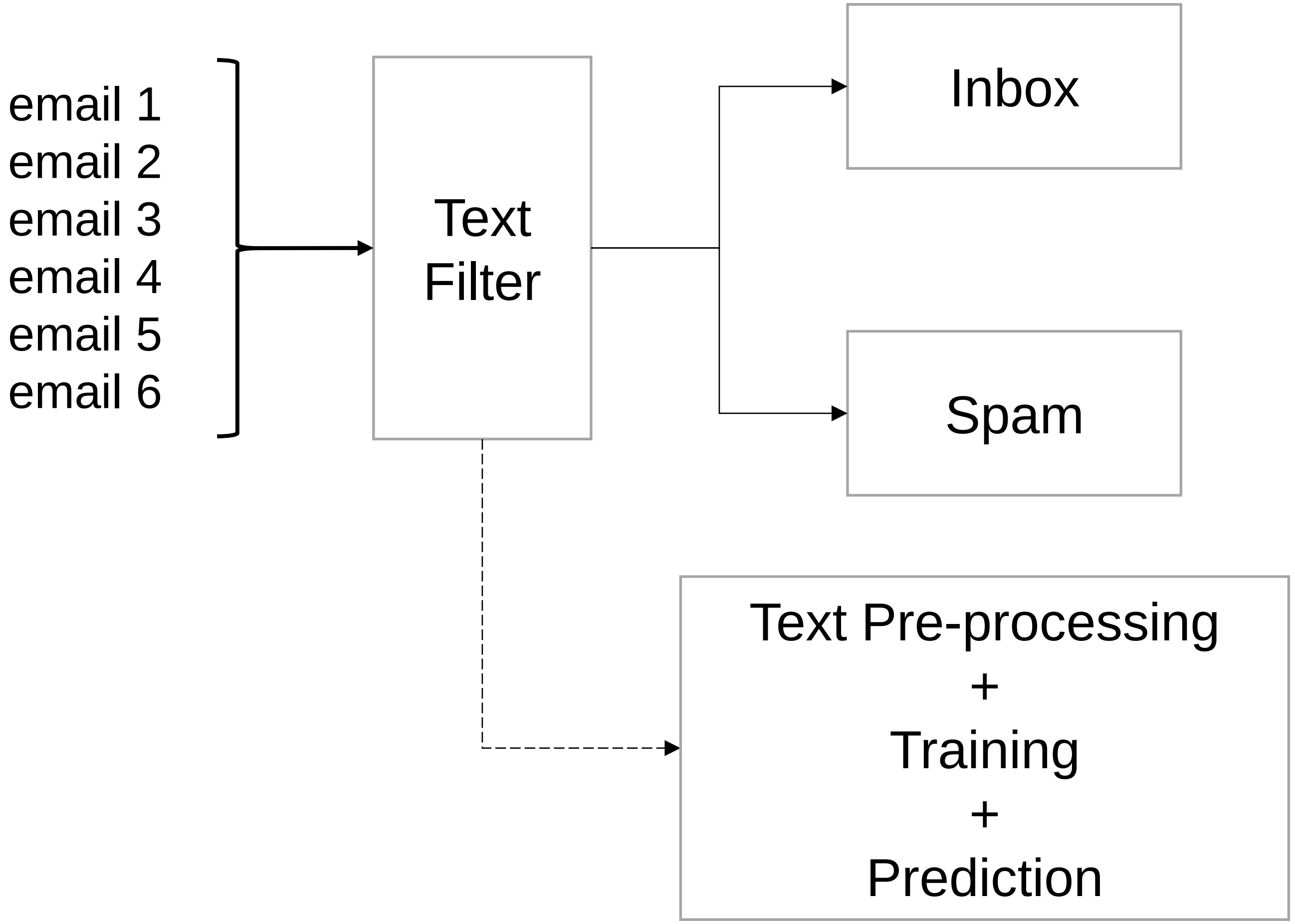


Text Mining Applications

Text Filtering

- Spam email detection
  - Binary classification problem
  - Filter by word or word embedding

- Bad word detector
  - Classification problem
  - Filter by word or word embedding

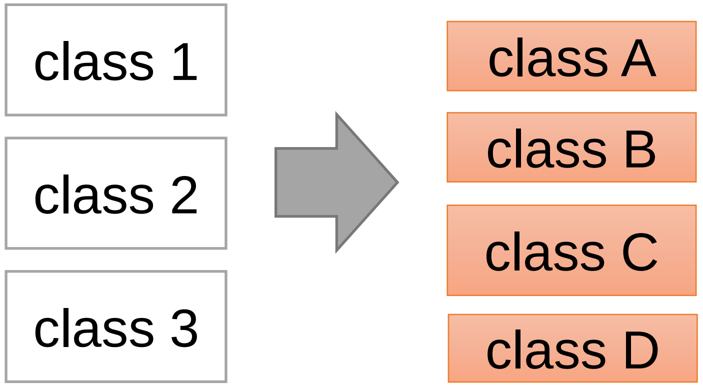


Classification Development

- Classification
  - Used to manage and support diverse research or tasks
  - Industry classification (Standard Industrial Classification, SIC; International Standard Industrial Classification of All Economic Activities, ISIC; Statistical Classification of Economic Activities in the European Community, NACE)
  - Technology classification (International Patent Classification, IPC; Cooperative Patent Classification, CPC)
- Classification based on text analysis

<Existing Classification>

- Based on the opinions of experts, classification systems such as industries and technologies are established and periodically revised
- Limitations in dealing with new or fusion taxonomy
- Intervention by subjective opinion

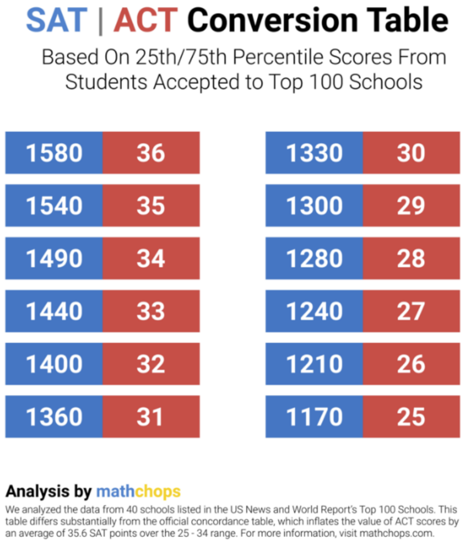


<Text analysis-based Classification>

- Establish a new classification based on the text data
- Ability to reflect change faster and proactively

Data Matching

- Matching different data sets
  - To combine multiple data sets into one, a concordance table is often used.
  - Concordance table: a table combining two tables arranged in a sequence



SAT | ACT Conversion Table

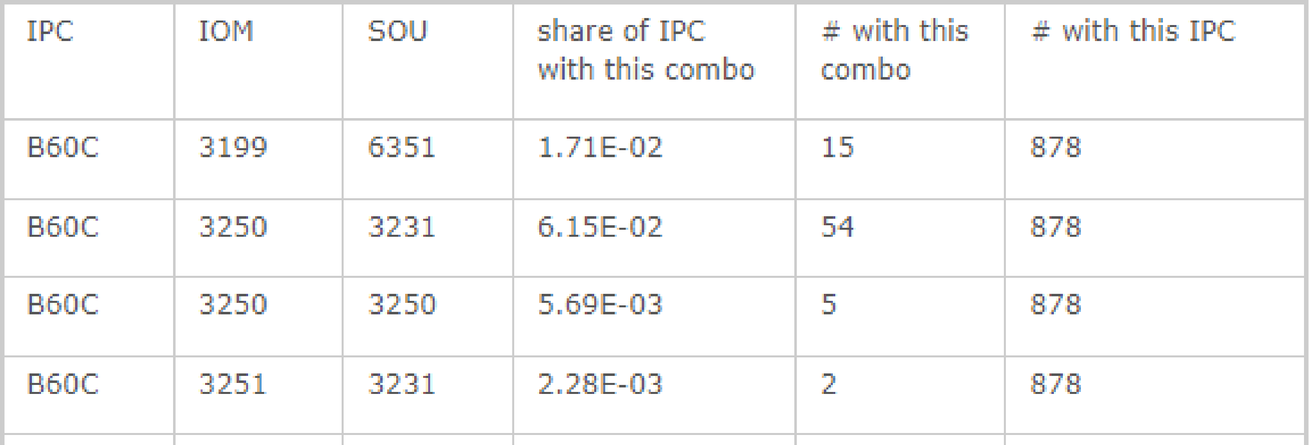
Based On 25th/75th Percentile Scores From Students Accepted to Top 100 Schools

1580	36	1330	30
1540	35	1300	29
1490	34	1280	28
1440	33	1240	27
1400	32	1210	26
1360	31	1170	25

Analysis by mathchops

We analyzed the data from 40 schools listed in the US News and World Report's Top 100 Schools. This table differs substantially from the official concordance table, which inflates the value of ACT scores by an average of 35.6 SAT points over the 25 - 34 range. For more information, visit mathchops.com.

https://www.nyctestprepadvice.com/blog/2021/6/10/actsat-conversion-table-based-on-college-acceptances



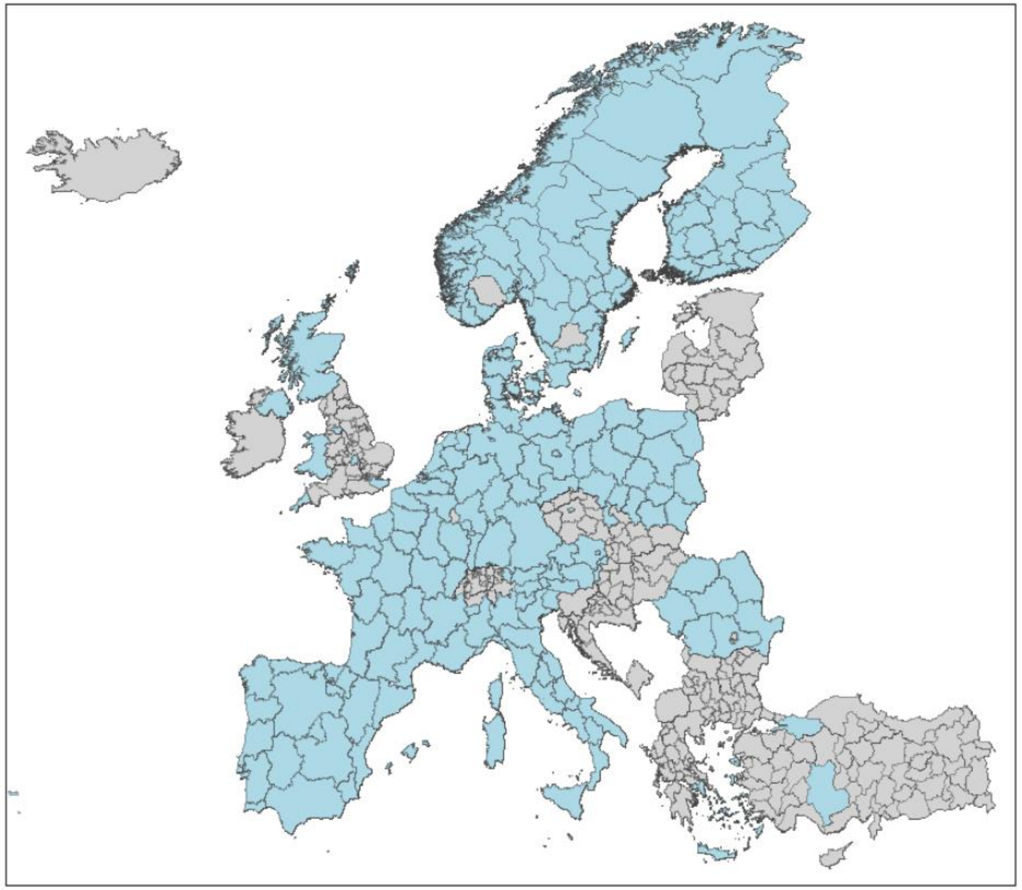
IPC	IOM	SOU	share of IPC with this combo	# with this combo	# with this IPC
B60C	3199	6351	1.71E-02	15	878
B60C	3250	3231	6.15E-02	54	878
B60C	3250	3250	5.69E-03	5	878
B60C	3251	3231	2.28E-03	2	878

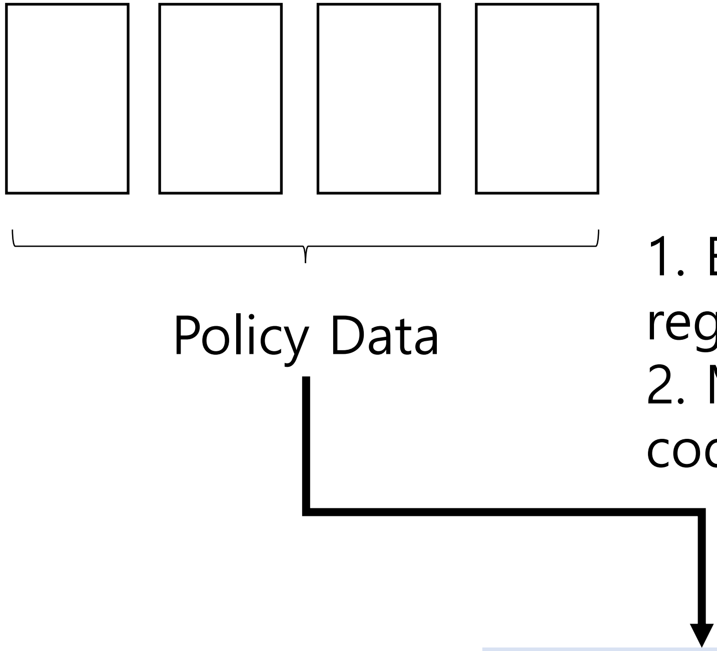
https://paranmir.wordpress.com/2010/11/08/%EA%B8%B0%EA%B3%A0-%EC%82%B0%EC%97%85%EB%B3%84%EB%A1%9C-%EC%82%B4%ED%8E%B4%EB%B3%B8-%ED%95%9C%EA%B5%AD%EA%B3%BC-%EB%AF%B8%EA%B5%AD%EC%9D%98-%ED%8A%B9%ED%97%88%EB%8F%99%ED%96%A5/

- If there's no suitable concordance table, a text analysis method can be implemented
  - Matching with the name → (Company data) Hyundai Motors, Hyundai Motors Group, Hyundai LTD, etc.

Text Mining + Policy Evaluation

- Smart specialization policy (SSP)
  - An approach in which a country or region identifies and invests in priorities based on “comparative advantage”
    - Are SSPs implemented in Europe based on regional “comparative advantage”?





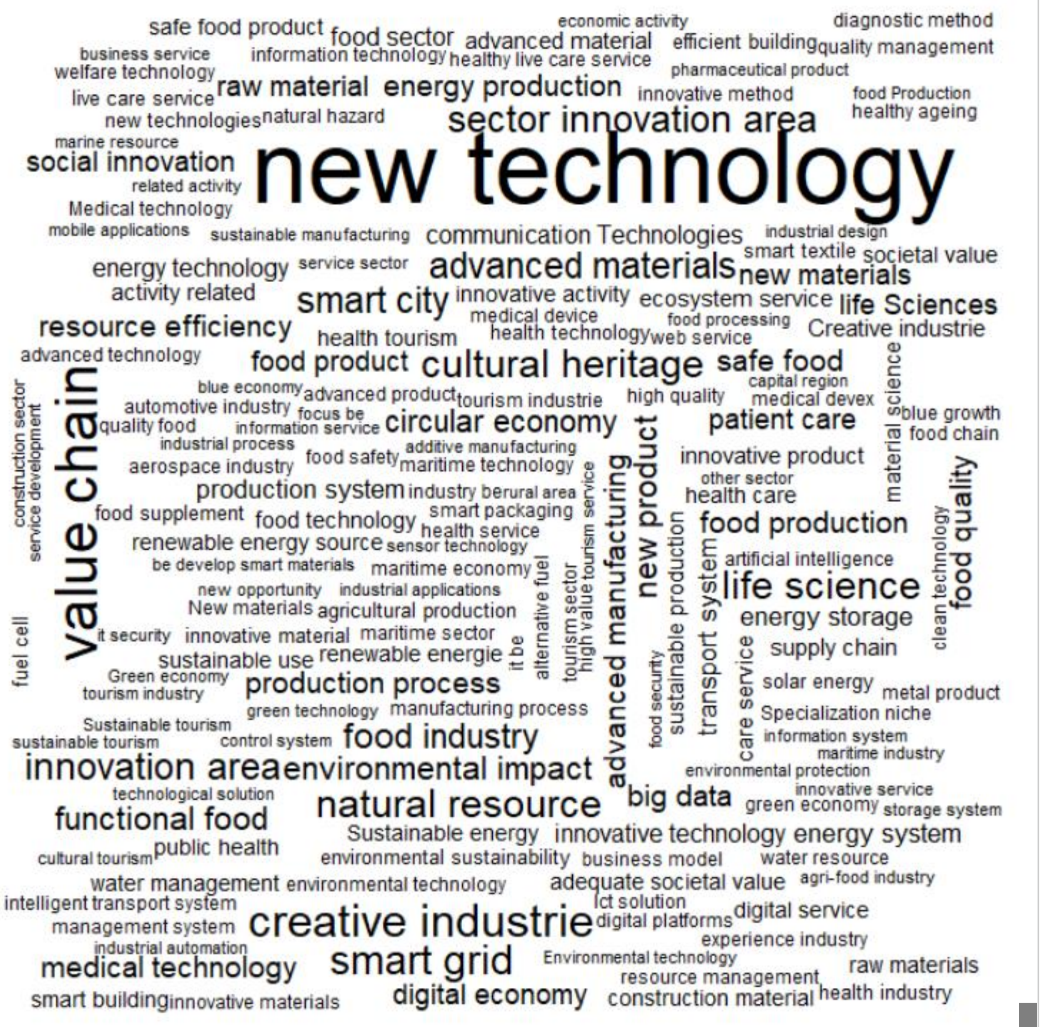
Policy Data

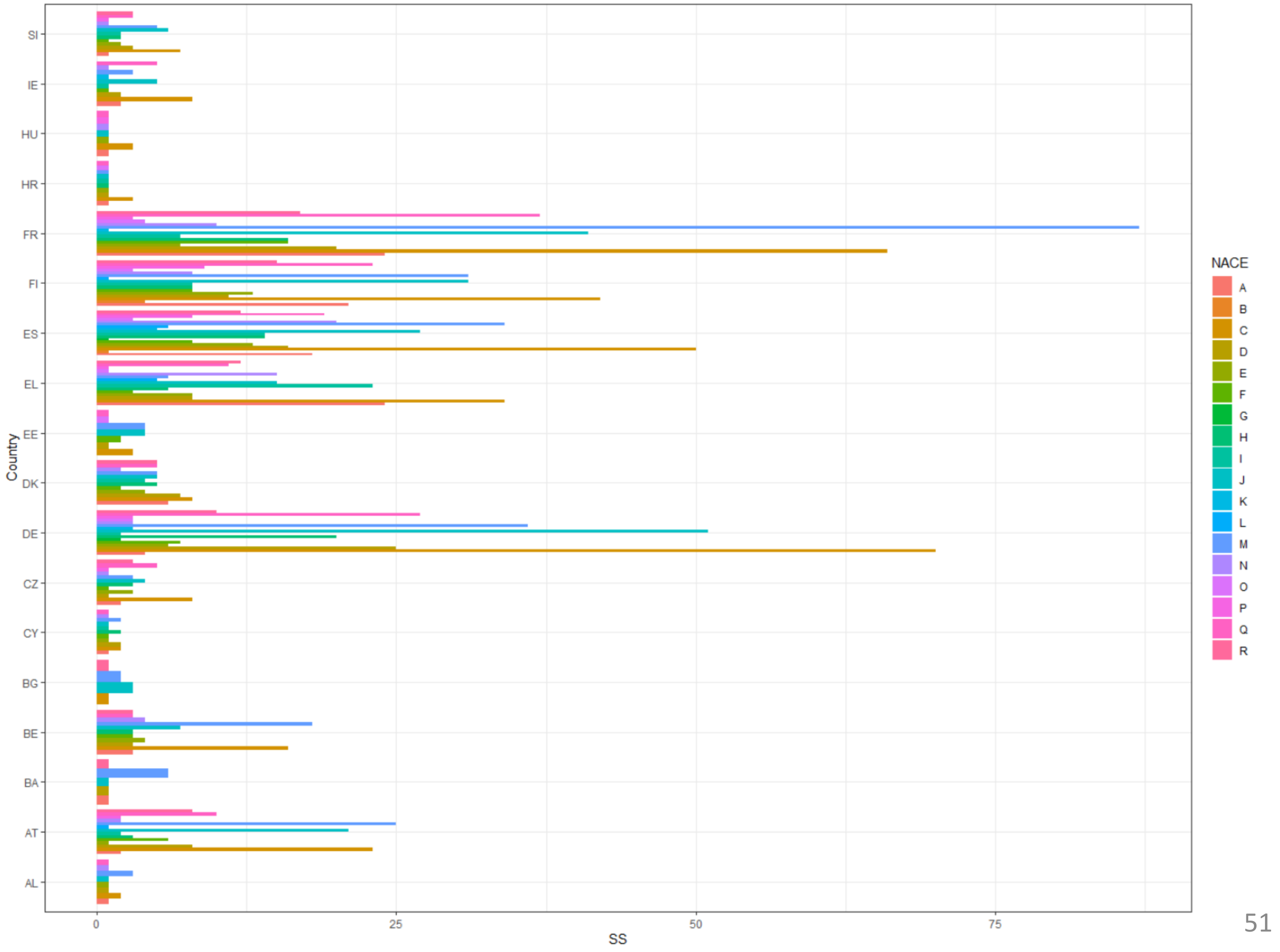
1. Extract keyword from regional policy
2. Match keywords to industry codes

Region – Policy – Industry Code – Patent Code

Text Mining + Policy Evaluation

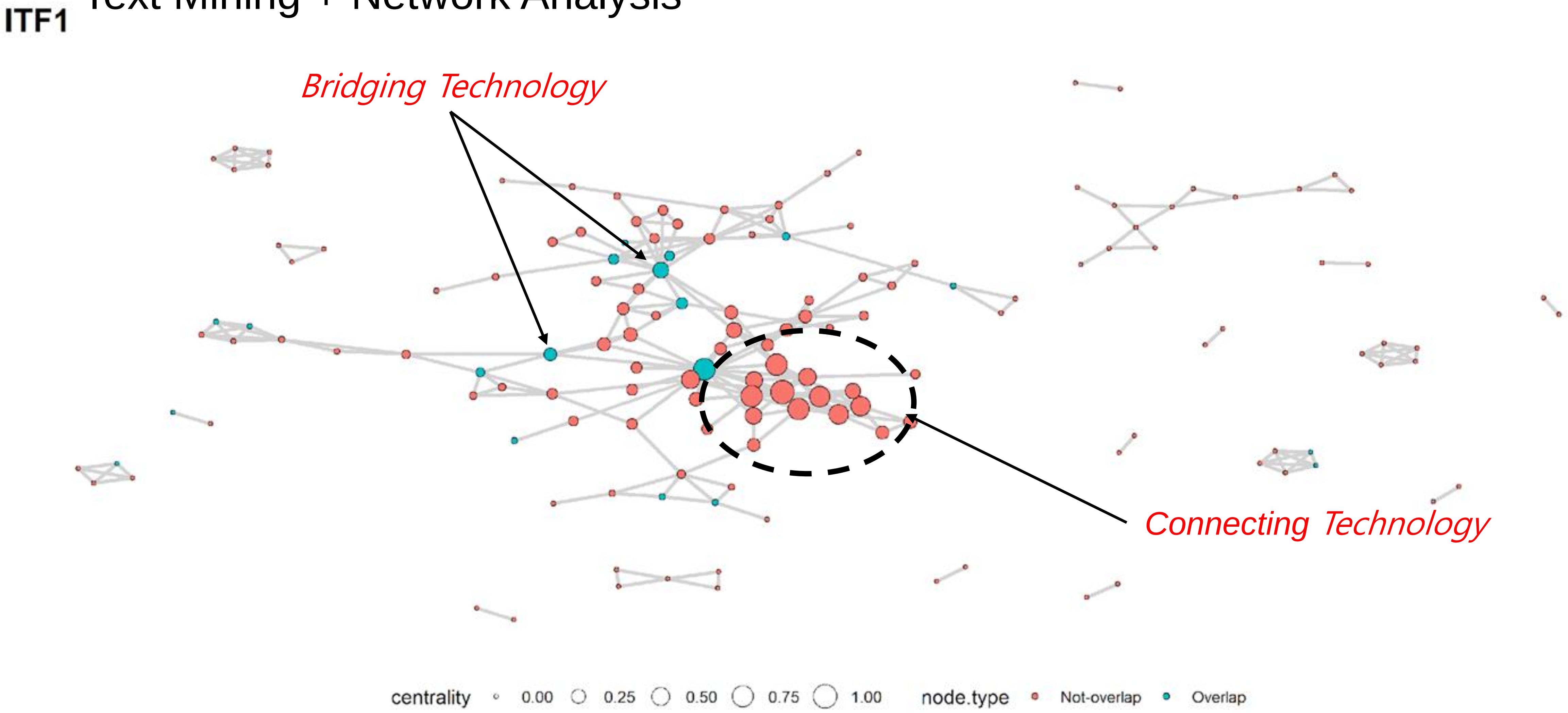
- Finding the main keyword
- Evaluating the industry distribution of the country’s SSP





Text Mining + Policy Evaluation

- Analyzing region’s knowledge structure and SSP status
  - Weighted degree centrality / betweenness centrality
  - Text Mining + Network Analysis

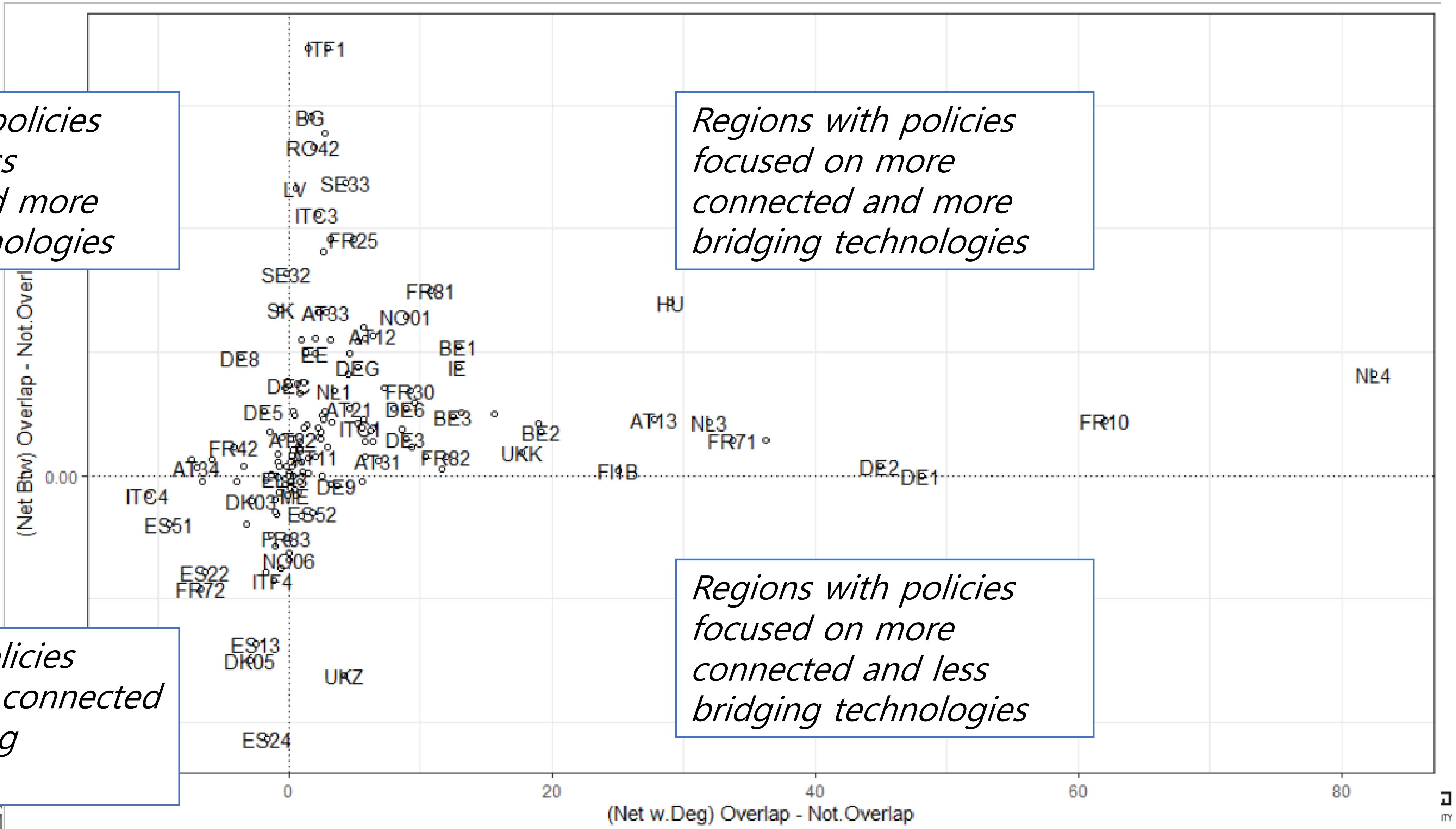


Bridging Technology

Connecting Technology

Text Mining + Policy Evaluation

- Evaluation of smart specialization policy with connectivity and brokerage



Regions with policies focused on less connected and more bridging technologies

Regions with policies focused on more connected and more bridging technologies

Regions with policies focused on less connected and less bridging technologies

Regions with policies focused on more connected and less bridging technologies