Introduction

Introduction to Text Mining with R

Ayoub Bagheri

Contents

Very useful

You can access the course materials quickly from

https://ayoubbagheri.nl/r_tm/

Some guidelines

1- Please keep your microphone off

2- If you have a question, raise your hand or type your question in the chat

3- You may always interrupt me

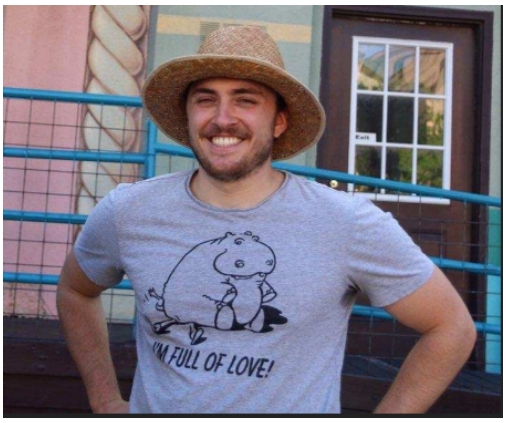
4- We will introduce frequent question breaks

Lecturers and Assistants

José de Kruif

Dong Nguyen

Qixiang Fang



Kevin Patyk

Program

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## Warning in latex_new_row_builder(target_row, table_info, bold, italic,
## monospace, : Setting full_width = TRUE will turn the table into a tabu
## environment where colors are not really easily configable with this package.
## Please consider turn off full_width.

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```

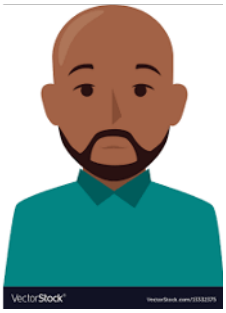
Time	Monday	Tuesday	Wednesday
9:00 - 10:30	**Lecture 1**	**Lecture 3**	**Lecture 5**
	Break	Break	Break
10:45 – 11:45	Practical 1	Practical 3	Practical 5
11:45 – 12:30	Discussion 1	Discussion 3	Discussion 5
	Lunch	Lunch	Lunch
13:45 – 15:15	**Lecture 2**	**Lecture 4**	**Lecture 6**
	Break	Break	Break
15:30 – 16:30	Practical 2	Practical 4	Practical 6
16:30 – 17:00	Discussion 2	Discussion 4	Discussion 6

Goal of the course

- Text data is everywhere!
- A lot of world's data is in unstructured text format
- The course teaches
  - text mining techniques
  - using R
  - on a variety of applications
  - in many domains.

What is text mining?

Text mining in an example



- This is **Garry**!
- **Garry** works at Bol.com (a webshop in the Netherlands)
- He works in the dep of **Customer relationship management**.
- He uses Excel to read and search customers' reviews, extract aspects they wrote their reviews on, and identify their sentiments.
- Curious about his job? See two examples!

This is a nice book for both young and old. It gives beautiful life lessons in a fun way. Definitely worth the money!

+ Educational

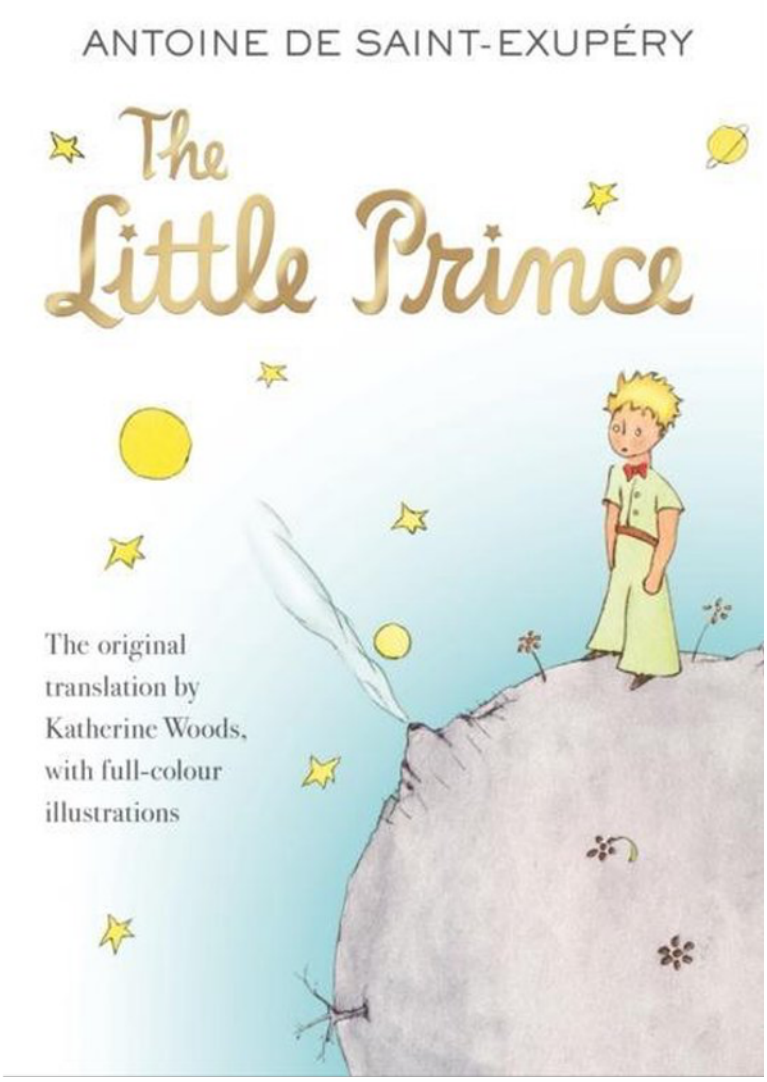
+ Funny

+ Price

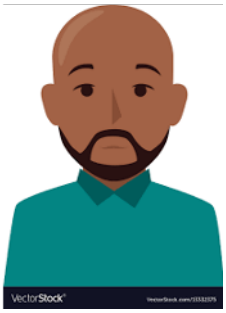
Nice story for older children.

+ Funny

- Readability

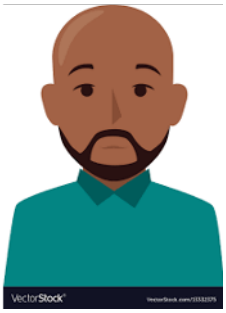


Example



- Garry likes his job a lot, but sometimes it is frustrating!
- This is mainly because their company is expanding quickly!
- Garry decides to hire **Larry** as his assistant.

Example



- Still, a lot to do for two people!
- Garry has some budget left to hire another assistant for couple of years!
- He decides to hire **Harry** too!
- Still, manual labeling using Excel is labor-intensive!

Challenges?

- Can you guess what are the challenges Garry, Larry, and Harry encounter in doing their job, when working with text data?
  - Go to www.menti.com and use the code 9594 3321

Challenges with text data

Challenges with text data

- Huge amount of data
- High dimensional but sparse
  - all possible word and phrase types in the language!!

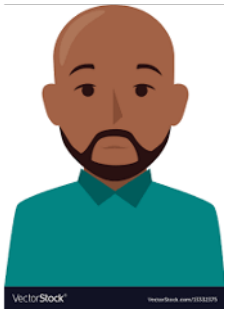
Challenges with text data

- Ambiguity

Challenges with text data

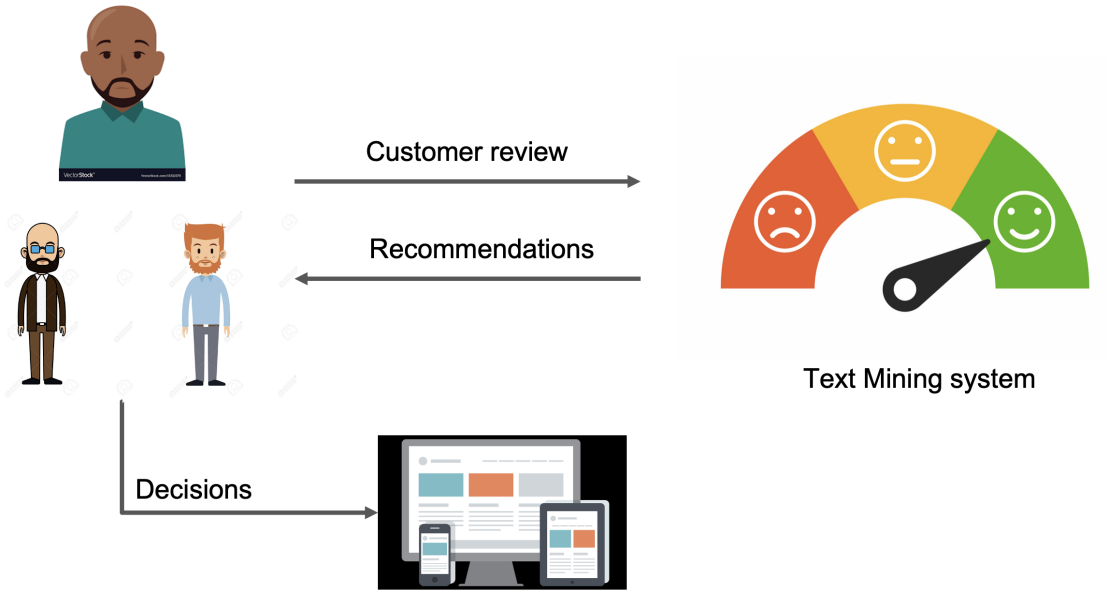
- Noisy data
  - Examples: Abbreviations, spelling errors, short text
- Complex relationships between words
  - "Hema merges with Intertoys"
  - "Intertoys is bought by Hema"

Example



- During one of the coffee moments at the company, **Garry** was talking about their situation at the dep of Customer relationship management.
- When **Carrie**, her colleague from the **Data Science department**, hears the situation, she offers Garry to use Text Mining!!
- She says: "Text mining is your friend; it can help you to make the process way faster than Excel by filtering words and recommending labels."
- She continues : "Text mining is a subfield of AI and NLP and is related to data science, data mining and machine learning."
- After consulting with Larry and Harry, they decide to give text mining a try!

Example



Text mining definition?

- Which can be a part of Text Mining definition?
  - The discovery by computer of new, previously unknown information from textual data
  - Automatically extracting information from text
  - Text mining is about looking for patterns in text
  - Text mining describes a set of techniques that model and structure the information content of textual sources

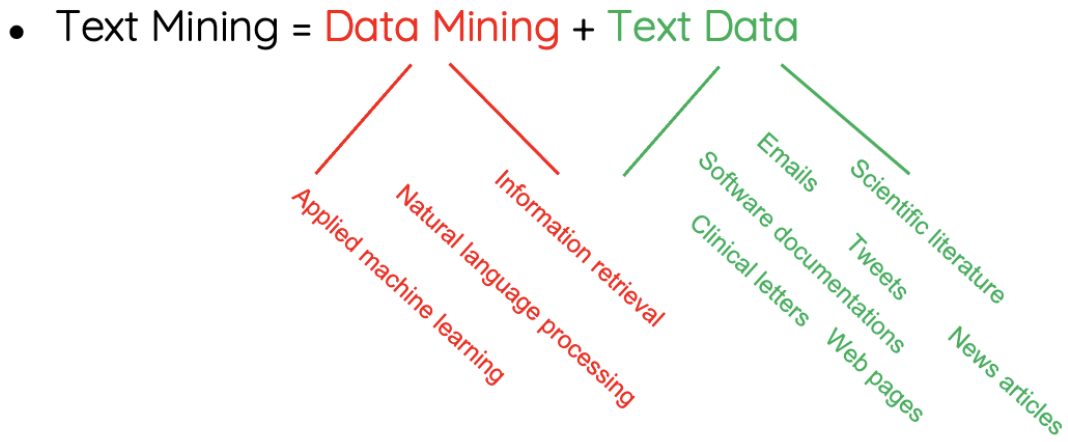
(You can choose multiple answers)

Go to www.menti.com and use the code 9594 3321

Text mining definition

- "the discovery by computer of new, previously unknown information, by automatically extracting information from different written resources" Hearst (1999)
- Text mining is about looking for patterns in text, in a similar way that data mining can be loosely described as looking for patterns in data.
- Text mining describes a set of linguistic, statistical, and machine learning techniques that model and structure the information content of textual sources. (Wikipedia)

Another TM definition



Language is hard

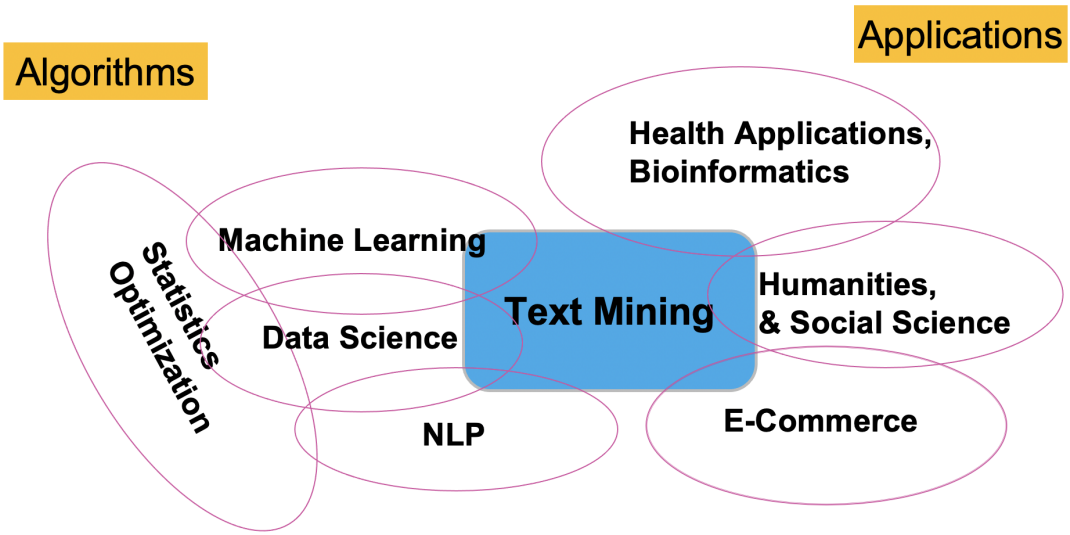
- Different things can mean more or less the same ("data science" vs. "statistics")
- Context dependency ("You have very nice shoes");
- Same words with different meanings ("to sanction", "bank");
- Lexical ambiguity ("we saw her duck")
- Irony, sarcasm ("That's just what I needed today!", "Great!", "Well, what a surprise.")
- Figurative language ("He has a heart of stone")
- Negation ("not good" vs. "good"), spelling variations, jargon, abbreviations
- All the above are different over languages, 99% of work is on English!

Language is hard

- We won't solve linguistics ...
- In spite of the problems, text mining can be quite effective!

Examples & Applications

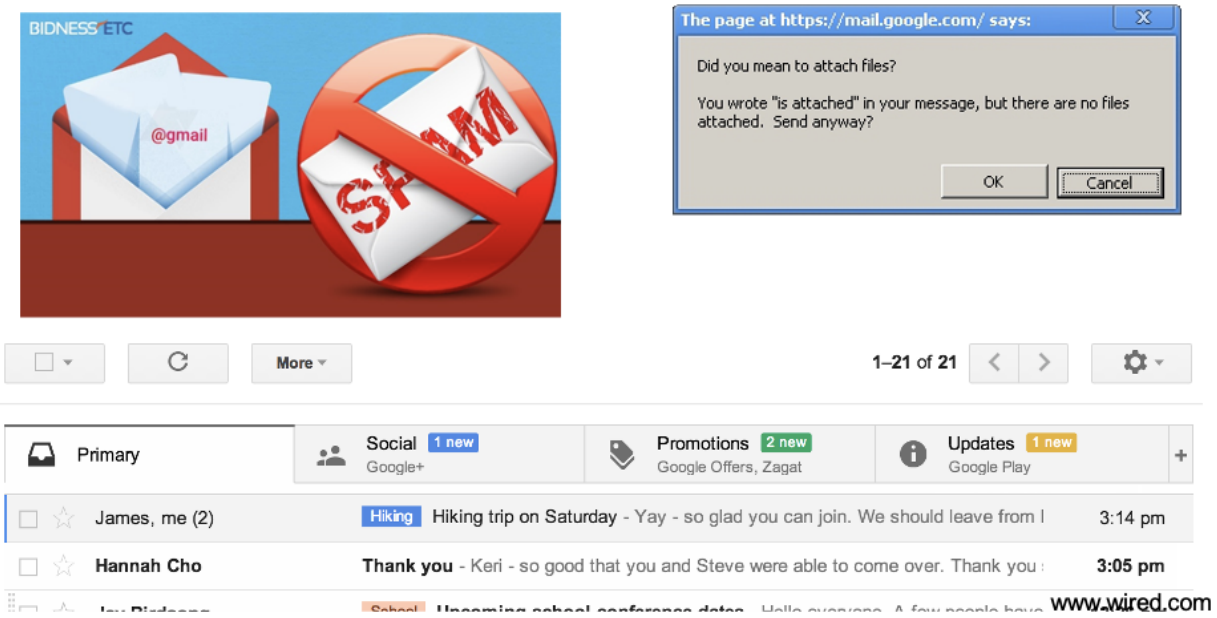
Text mining applications



Who wrote the Wilhelmus?

https://dh2017.adho.org/abstracts/079/079.pdf

Text Classification



Which ICD-10 codes should I give this doctor's note?

Bovengenoemde patiënt was opgenomen op op de voor het specialisme **Cardiologie.**

Cardiovasculaire risicofactoren: Roken(-) Diabetes(-) Hypertensie(?) Hypercholesterolemie (?)

Anamnese. Om 18.30 pijn op de borst met uitstraling naar de linkerarm, zweten, misselijk. Ambulance gebeld en bij aansluiten monitor beeld van acuut onderwandinfarct. AMBU overdracht:.500mg aspegic iv, ticagrelor 180mg oraal, heparine, zofran eenmalig, 3x NTG spray. HD stabiel gebleven. . .Medicatie bij presentatie.Geen..

Lichamelijk onderzoek. Grauw, vegetatief, Halsvenen niet gestuwd. Cor s1 s2 geen souffles.Pulm schoon. Extr warm en slank .

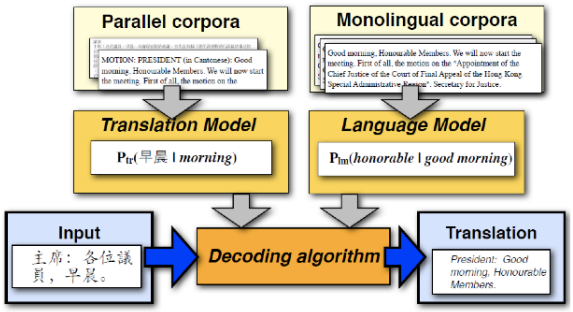
Aanvullend onderzoek. AMBU ECG: Sinusritme, STEMI inferior III)II C/vermoedelijk RCA. Coronair angiografie. (. . .) .Conclusie angio: 1-vatslijden..PCI

Conclusie en beleid Bovengenoemde jarige man, blanco cardiale voorgeschiedenis, werd gepresenteerd vanwege een STEMI inferior waarvoor een spoed PCI werd verricht van de mid-RCA. Er bestaan geen relevante nevenletsels. Hij kon na de procedure worden overgeplaatst naar de CCU van het . ..Dank voor de snelle overname. ..Medicatie bij overplaatsing. Acetylsalicylzuur dispertablet 80mg ; oraal; 1 x per dag 80 milligram ; .Ticagrelor tablet 90mg ; oraal; 2 x per dag 90 milligram ; .Metoprolol tablet 50mg ; oraal; 2 x per dag 25 milligram ; .Atorvastatine tablet 40mg (als ca-zout-3-water) ; oraal; 1 x per dag 40 milligram ; **Samenvatting** Hoofddiagnose: STEMI inferior wv PCI RCA. Geen nevenletsels. Nevendiagnoses: geen. Complicaties: geen Ontslag naar: CCU .

Which ICD-10 codes should I give this doctor's note?

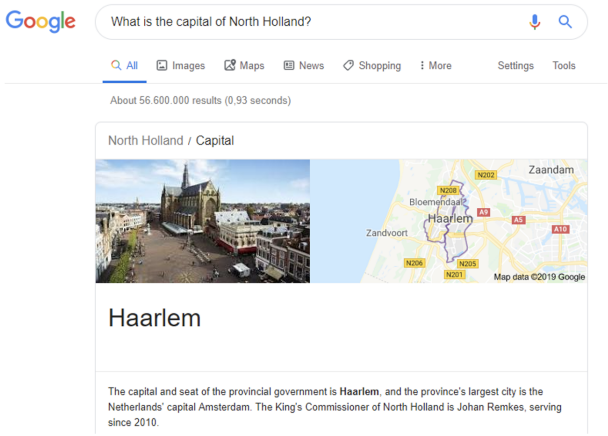
Sentiment Analysis / Opinion Mining

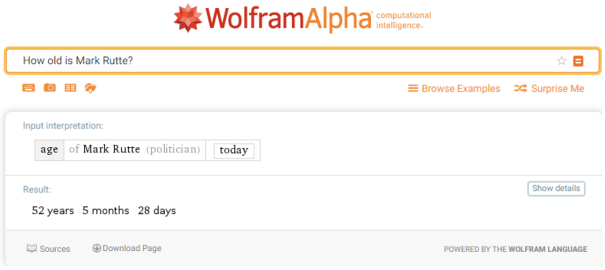
Statistical Machine Translation



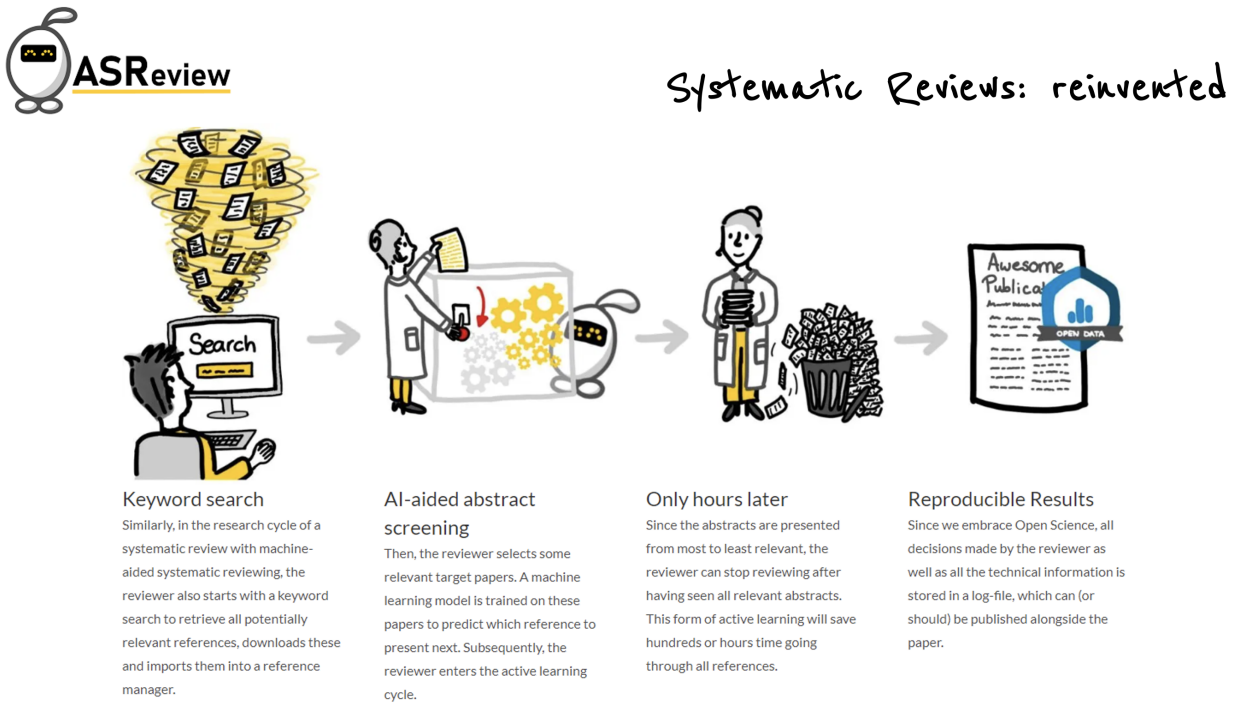
Dialog Systems

Question Answering | Go beyond search





Which studies go in my systematic review?



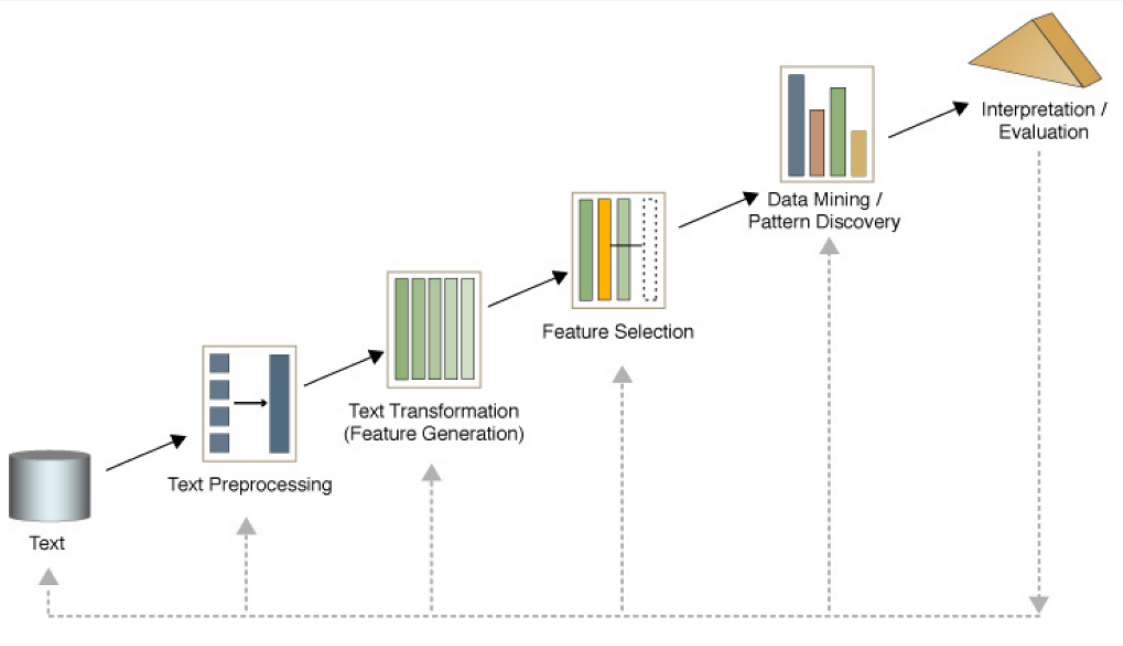
https://asreview.nl/

And more ...

- Automatically classify political news from sports news
- Authorship identification
- Age/gender identification
- Language Identification
- ...

Process & Tasks

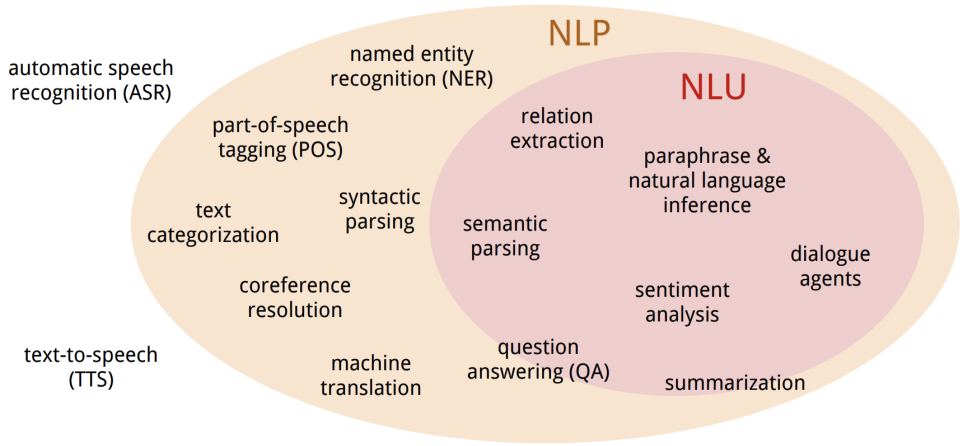
Text mining process



Text mining tasks

- Text classification
- Text clustering
- Sentiment analysis
- Feature selection
- Topic modelling
- Word embedding
- Deep learning models
- Responsible text mining
- Text summarization

And more in NLP



source: https://nlp.stanford.edu/~wcmac/papers/20140716-UNLU.pdf

Regular Expressions

Regular Expressions

Really clever "wild card" expressions for matching and parsing strings.

http://en.wikipedia.org/wiki/Regular_expression

Regular Expressions

In computing, a regular expression, also referred to as "regex" or "regexp", provides a concise and flexible means for matching strings of text, such as particular characters, words, or patterns of characters. A regular expression is written in a formal language that can be interpreted by a regular expression processor.

http://en.wikipedia.org/wiki/Regular_expression

In R

The primary R functions for dealing with regular expressions are:

- `grep()`, `grepl()`: Search for matches of a regular expression/pattern in a character vector
- `regexpr()`, `gregexpr()`: Search a character vector for regular expression matches and return the indices where the match begins; useful in conjunction with `regmatches()`
- `sub()`, `gsub()`: Search a character vector for regular expression matches and replace that match with another string
- The `stringr` package provides a series of functions implementing much of the regular expression functionality in R but with a more consistent and rationalized interface.

Understanding Regular Expressions

- Very powerful and quite cryptic
- Fun once you understand them
- Regular expressions are a programming language with characters
- It is kind of an "old school" language

Regular expressions

- A formal language for specifying text strings
- How can we search for any of these?
  - netherland
  - netherlands
  - Netherland
  - Netherlands

Some simple regex searches

RE	Example Patterns Matched
/woodchucks/	"interesting links to woodchucks and lemurs"
/a/	"Mary Ann stopped by Mona's"
/!/	"You've left the burglar behind again!" said Nori

Disjunction

The use of the brackets to specify a disjunction of characters:

RE	Match	Example Patterns
/[wW]oodchuck/	Woodchuck or woodchuck	"Woodchuck"
/[abc]/	'a', 'b', *or* 'c'	"In uomini, in soldati"
/[1234567890]/	any digit	"plenty of 7 to 5"

The pipe sympol | is also for disjunction:

Pattern	Matches
groundhog|woodchuck	
yours|mine	yours mine
a|b|c	= [abc]

Brackets and dash

The use of the brackets [] plus the dash - to specify a range:

RE	Match	Example Patterns Matched
`/[A-Z]/`	an upper case letter	"we should call it 'Drenched Blossoms' "
`/[a-z]/`	a lower case letter	"my beans were impatient to be hoed!"
`/[0-9]/`	a single digit	"Chapter 1: Down the Rabbit Hole"

Negation

The caret ^ for negation or just to mean ^:

RE	Match (single characters)	Example Patterns Matched
`/[^A-Z]/`	not an upper case letter	"Oyfn pripetchik"
`/[^Ss]/`	neither 'S' nor 's'	"I have no exquisite reason for't"
`/[^.]/`	not a period	"our resident Djinn"
`/[e^]/`	either 'e' or '^'	"look up ^ now"
`/a^b/`	the pattern 'a^b'	"look up a^ b now"

Question and period marks

The question mark ? marks optionality of the previous expression:

RE	Match	Example Patterns Matched
`/woodchucks?/`	woodchuck or woodchucks	"woodchuck"
`/colou?r/`	color or colour	"color"

The use of the period . to specify any character:

RE	Match	Example Matches
`/beg.n/`	any character between *beg* and *n*	begin, beg'n, begun

Anchors

RE	Match
`^`	start of line
`\$`	end of line
`\b`	word boundary
`\B`	non-word boundary

Common sets

Aliases for common sets of characters:

RE	Expansion	Match	First Matches
\d	[0-9]	any digit	Party␣of␣5
\D	[^0-9]	any non-digit	Blue␣moon
\w	[a-zA-Z0-9_]	any alphanumeric/underscore	Daiyu
\W	[^\w]	a non-alphanumeric	!!!!
\s	[␣\r\t\n\f]	whitespace (space, tab)	
\S	[^\s]	Non-whitespace	in␣Concord

The backslash for escaping!

Operators for counting

RE	Match
*	zero or more occurrences of the previous char or expression
+	one or more occurrences of the previous char or expression
?	exactly zero or one occurrence of the previous char or expression
{n}	*n* occurrences of the previous char or expression
{n,m}	from *n* to *m* occurrences of the previous char or expression
{n,}	at least *n* occurrences of the previous char or expression
{,m}	up to *m* occurrences of the previous char or expression

- Patterns are **greedy**: In these cases regular expressions always match the largest string they can, expanding to cover as much of a string as they can.
- Enforce non-greedy matching, using another meaning of the ? qualifier.
  - The operator *? is a Kleene star that matches as little text as possible.
  - The operator +? is a Kleene plus that matches as little text as possible.

Other

Some characters that need to be backslashed:

RE	Match	First Patterns Matched
*	an asterisk "*"	"K*A*P*L*A*N"
\.	a period "."	"Dr. Livingston, I presume"
\?	a question mark	"Why don't they come and lend a hand?"
\n	a newline	
\t	a tab	

Operator precedence hierarchy

Parenthesis	()
Counters	* + ? {}
Sequences and anchors	the ^my end$
Disjunction	|

Example

- Find all instances of the word "the" in a text.

the

Misses capitalized examples

[tT]he

Incorrectly returns words such as other or Netherlands

[^a-zA-Z][tT]he[^a-zA-Z]

Still not compeletly correct! What is missing?

Example

```
txt <- "The other the Netherlands will then be without the"
r   <- gregexpr("[^a-zA-Z][tT]he[^a-zA-Z]", txt)
print(regmatches(txt, r))
```

```
## [[1]]
## [1] " the "
```

```
r   <- gregexpr("(^|[^a-zA-Z])[tT]he($|[^a-zA-Z])", txt)
print(regmatches(txt, r))
```

```
## [[1]]
## [1] "The "  " the " " the"
```

Errors

- The process we just went through was based on fixing two kinds of errors
  - Matching strings that we should not have matched (**the**re, Ne**the**rlands)
    - False positives (Type I)
  - Not matching things that we should have matched (The)
    - False negatives (Type II)

Errors cont.

- In NLP we are always dealing with these kinds of errors.
- Reducing the error rate for an application often involves:
  - Increasing precision (minimizing false positives)
  - Increasing recall (minimizing false negatives).

Quiz 1

Given the text "this Summer School is utrecht summerschool", which RE finds all the summer school mentions?

- (^|[^a-zA-Z])[sS]ummer *[sS]chool($|[^a-zA-Z])
- (^|[^a-zA-Z])[sS]ummer\s[sS]chool($|[^a-zA-Z])
- (^|[^a-zA-Z])[sS]ummer *[sS]chool($|[^a-zA-Z])
- [^a-zA-Z][sS]ummer\s[sS]chool($|[^a-zA-Z])

Go to www.menti.com and use the code 9594 3321

Solution

```
txt <- "this Summer   School is utrecht summerschool"
r <- gregexpr("(^|[^a-zA-Z])[sS]ummer *[sS]chool($|[^a-zA-Z])", txt)
#r <- gregexpr("(^|[^a-zA-Z])[sS]ummer\\s*[sS]chool($|[^a-zA-Z])", txt)

print(regmatches(txt, r))
```

```
## [[1]]
## [1] " Summer   School " " summerschool"
```

Quiz 2

Suppose we want to build an application to help a user buy a car from pdf (text) catalogues. The user looks for any car cheaper than $10,000.00. Which RE will help us to do this?

Assume we are using the following data: txt <- c("Price of Tesla S is $8599.99.", "Audi Q4 is $7000.", "BMW X5 costs $900")

- (^|\W)\$[0-9]{0,4}(\.[0-9][0-9])*
- (^|\W)\$[0-9]{0,3}(\.[0-9][0-9])+
- (^|\W)\$[0-9]{0,4}(\.[0-9][0-9])?
- (^|\W)\$[0-9][0-9][0-9][0-9](\.[0-9][0-9])*

Go to www.menti.com and use the code 9594 3321

Solution

```
txt <- c("Price of Tesla S is $8599.99.",
         "Audi Q4 is $7000.",
         "BMW X5 costs $900")
r <- gregexpr("(^|\\W)\\$[0-9]{0,4}(\\.[0-9][0-9])?", txt)
print(regmatches(txt, r))
```

```
## [[1]]
## [1] " $8599.99"
##
## [[2]]
## [1] " $7000"
##
## [[3]]
## [1] " $900"
```

http://xkcd.com/208/

Summary

Summary

- Text data is everywhere!

- Language is hard!
- Sophisticated sequences of regular expressions are often the first model for any text processing tool
- Regular expressions are a cryptic but powerful language for matching strings and extracting elements from those strings
- The basic problem of text mining is that text is not a neat data set
- One solution: text pre-processing

Practical 1

In a few moments:

- You will be automatically added to a practical session.
- There will be a practical instructor present.
- At the end of the practical, you will be automatically returned to the main meeting.