

# Introduction to NLP

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SCHOOL OF INFOCOMM

# **Need to know**

- **Trainers**

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- **Assessment**

- Written assignment, due 13 Mar 2020

# Learning Objectives

- Describe the principles, concepts and usage of NLP
- Perform text pre-processing activities
- Discuss and use suitable methods for feature engineering of text
- Discuss and use suitable approaches to analysis, classify and compare text
- Explain how deep-learning techniques are used for text generation tasks
- Consume Machine Learning services to build NLP applications
- Use Azure Bot Services to build conversation systems

# Where We're Headed

When	Topics
27 Feb	NLP Introduction Regular Expression Text Pre-processing
28 Feb	Features Engineering Document Classification
02 Mar	Topic Modelling
03 Mar	Word Embedding Text Generation
04 Mar	Google Language Services
05 Mar	Azure Bot Services

# What is Natural Language Processing (NLP)

By “natural language” we mean a language that is used for everyday communication by humans.

Two main components:

- Natural Language Understanding (NLU)
- Natural Language Generation (NLG)

NLP is an Intersection of several fields

- Computer Science
- Artificial Intelligence
- Linguistics

NLP is AI-Complete

- Requires all types of knowledge humans possess → It's hard!

# Ambiguity of Language

- Synonymy – different words, same meaning
- Polysemy – same word, different meaning
- Text and speech are unstructured data
- No fixed structure – Sentence format
- No fixed schema – Grammar
- Misspell, slang, abbreviations

# History of NLP

- NLP has been through (at least) 3 major eras:
  - 1950s-1980s: Linguistics Methods and Rules
  - 1980s-Now: Statistical + Machine Learning Methods
  - Now - ????: Deep Learning
- You're right near the start of a paradigm shift!

# 1950s - 1970s: Linguistics & Rules

- Approach focused on:
  - Linguistics: Grammar rules, sentence structure parsing
  - Handwritten Rules: Huge sets of logical (if/else) statements
  - Phrase structure grammar : conversion of sentences into forms computers can understand
- Problems:
  - Too complex to maintain
  - Cannot scale
  - Cannot generalize

# 1980s - Now: Statistical / Machine Learning Methods

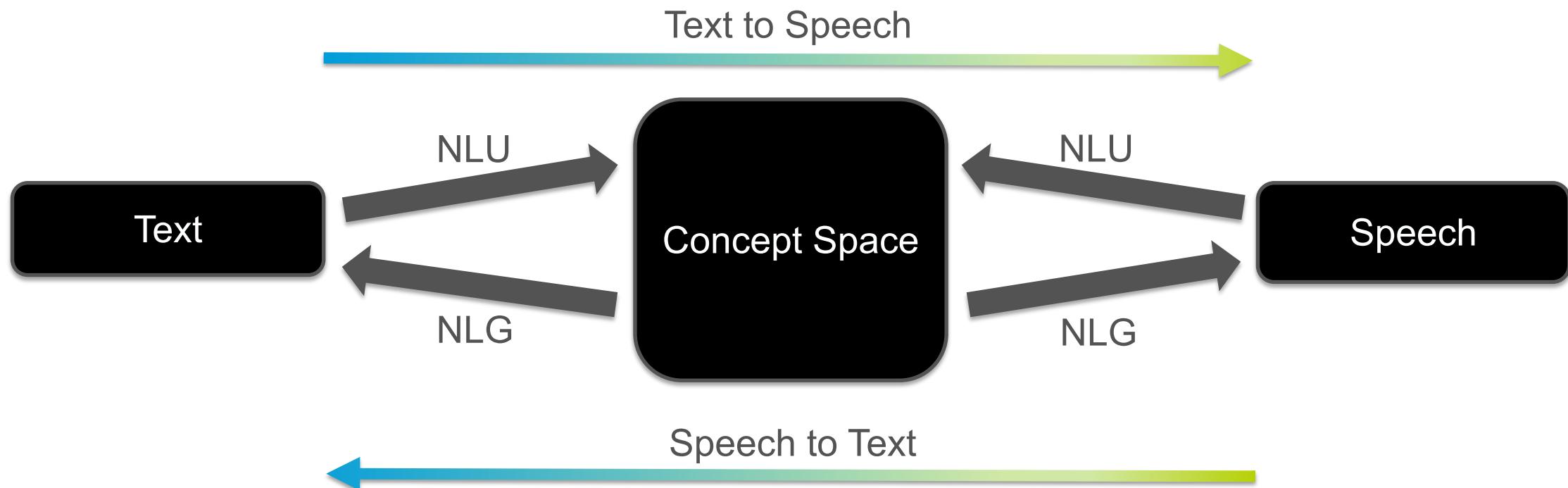
- Approach shifted from linguistics to data-driven
- Increasing computational power and ease to access of text
  - First web page (1991) → discussion forums, blogs, news portal
  - Digital archives
- NLP starts using statistical and probabilistic models
  - Data minding → text mining
- Generic machine learning algorithms applied to NLP tasks
  - Sentiment analysis using logistic regression
  - Language models with Markov models

# Now and future: Deep Learning

- More advances in computing power with parallelization (GPU)
- Availability of large datasets becomes the norm
- CNN
  - Learnt word representation with finite dimensions
  - Capture semantic and relationships among words
- RNN / LSTM
  - Allows sequential processing and learning of text
  - Application into machine translation tasks and questions/answering systems
- Attention-based model
  - A way to place various degree of focus (attention) on different part of the text
  - Break-through in machine translation and text generation tasks

# NLP: Speech vs Text

- Data source can refer to written text or speech
- Goal of both is the same: translate raw data (text or speech) into underlying concepts (NLU) then possibly into the other form (NLG)



# NLU Applications

- Classification
- Natural Language Search
- Document Recommendation
- Topic Modeling
- Language Identification
- Intent matching

# NLU Application: Document Classification

- Classify documents (discrete collections of text) - into categories
  - Classify emails as spam vs not spam
  - Classify product reviews as positive vs negative
  - Assign labels to documents

# NLU Application: Document Recommendation

- Choosing the most relevant document based on some information or "finger print":
  - Show most relevant webpages based on query to search engine
  - Recommend news articles based on past articles liked or read
  - Recommend restaurants based on restaurant reviews

# NLU Application: Topic Modeling

Breaking a set of documents into topics at the word level

See how prevalence of certain topics covered in a magazine changes over time

Find documents belonging to a certain topic

**Election 2015: Parties row over GP out-of-hours cover**

3 hours ago | Election 2015



Figures suggest almost 600 fewer GP surgeries in England open at evenings and weekends than before 2010, Labour has claimed.

Health spokesman Andy Burnham said the coalition had created queues outside practices and diverted people to A&E.

Tory Health Secretary Jeremy Hunt said Labour's numbers were wrong and that out-of-hours cover was being extended.

The Lib Dems also said Labour's figures - obtained through a [parliamentary question](#) - were out of date.

Mr Burnham announced the analysis as his party unveiled a new poster, which reworks the Conservatives' "Labour isn't working" image of 1979 by depicting a huge queue outside a waiting room with the title: "The doctor can't see you now."

Politics or Health?

**Chelsea FC reports a record £18m in annual profit**

13 November 2014 | Business



Business of Sport

Premier League to share £1bn

Adidas unveils Europe factory plan

Fans to protest over ticket prices

Controversial Gatlin gets Nike deal

Business or Sport?

# NLU Application: Intent Matching

Understanding that there are many ways to say or ask for the same thing

Use in conversation systems

*May I know the opening time for the store?*

*Can I come to shop now?*

*What time do you close?*

*Is the mall still open?*

*I can come at 8 pm, is it okay ?*

# NLG Applications

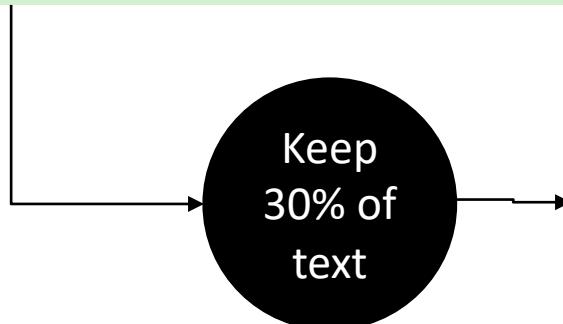
- Machine Translation
- Document Summarization
- Text Generation
- Question Answering
- Image Captioning

Notice NLU is almost a prerequisite for NLG

# NLG Application: Document Summarization

Read less

While the Standard Chartered Singapore Marathon on Saturday night (Nov 30) showcased the fastest running talent in the region and beyond, the road closures involved meant that the traffic in the area could not have been slower. Unlike the past 17 times when the annual event was flagged off in the morning and roads were less busy, Saturday's marathon started at 6pm as organisers sought to raise the event's profile. The changed timing and heavy traffic conditions around that hour led to traffic gridlock and left some drivers furious. While thousands of runners pounded the asphalt, motorists interviewed by TODAY were stuck in traffic for up to 2.5 hours. For some couples holding wedding banquets in town on Saturday, as many as half their guests arrived late, with many no-shows who turned back in frustration. On Nov 27, the police took to Facebook and Twitter to warn commuters of delays during the event. The post gave details of at least 87 changes to usual traffic arrangements, including road closures and the reversal of traffic in some one-way streets. Major roads affected included Republic Avenue, Cantonment Road and Nicoll Highway. Some of the road closures were scheduled for as early as 1.30pm on Saturday. Motorists who had to travel around the affected areas for work, such as wedding planners and performers, were also caught up in the bumper-to-bumper traffic.



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# NLG Application: Document Summarization

Automatically generate text summaries of documents

generate **headlines of news articles**

Input: Article 1st sentence	Model-written headline
metro-goldwyn-mayer reported a third-quarter net loss of dlsr 16 million due mainly to the effect of accounting rules adopted this year	mgm reports 16 million net loss on higher revenue
starting from july 1, the island province of hainan in southern china will implement strict market access control on all incoming livestock and animal products to prevent the possible spread of epidemic diseases	hainan to curb spread of diseases
australian wine exports hit a record 52.1 million liters worth 260 million dollars (143 million us) in september, the government statistics office reported on monday	australian wine exports hit record high in september

Source: <https://ai.googleblog.com/2016/08/text-summarization-with-tensorflow.html>

# NLG Application: Machine Translation

Automatically translate text between language

ENGLISH - DETECTED    ENGLISH    SPANISH

How can I get to the hospital. My son just slipped and has a cut on his chin. He is bleeding badly



JAPANESE    CHINESE (SIMPLIFIED)    ENG

我怎么去医院。 我儿子刚刚滑倒， 下巴上有伤口。 他流血严重

Wǒ zěnme qù yīyuàn. Wǒ érzi gānggāng huá dǎo, xiàbā shàng yǒu shāngkǒu. Tā liúxuè yánzhòng

MALAY    JAPANESE    CHINESE (SIMPLIFIED)

Bagaimana saya boleh mendapatkan hospital. Anak saya hanya tergelincir dan memotong dagunya. Dia berdarah dengan

Example from Google Translate

Reading : <https://ai.googleblog.com/2016/09/a-neural-network-for-machine.html>

# NLG Application: Text Generation

SYSTEM PROMPT  
(HUMAN-WRITTEN)

MODEL  
COMPLETION  
(MACHINE-  
WRITTEN, 10 TRIES)

*In a shocking finding, scientist discovered a herd of unicorns living in a remote, previously unexplored valley, in the Andes Mountains. Even more surprising to the researchers was the fact that the unicorns spoke perfect English.*

The scientist named the population, after their distinctive horn, Ovid's Unicorn. These four-horned, silver-white unicorns were previously unknown to science.

Now, after almost two centuries, the mystery of what sparked this odd phenomenon is finally solved.

Dr. Jorge Pérez, an evolutionary biologist from the University of La Paz, and several companions, were exploring the Andes Mountains when they found a small valley, with no other animals or humans. Pérez noticed that the valley had what appeared to be a natural fountain, surrounded by two peaks of rock and silver snow.

Pérez and the others then ventured further into the valley. "By the time we reached the top of one peak, the water looked blue, with some crystals on top," said Pérez.

Pérez and his friends were astonished to see the unicorn herd. These creatures could be seen from the air without having to move too much to see them – they were so close they could touch their horns.

While examining these bizarre creatures the scientists discovered that the creatures also spoke some fairly regular English. Pérez stated, "We can see, for example, that they have a common 'language,' something like a dialect or dialectic."

Source: <https://openai.com/blog/better-language-models/>

# NLG Application: Question Answering

Question	Generated Answer	Correct	Probability
Who wrote the book the origin of species?	Charles Darwin	✓	83.4%
Who is the founder of the ubuntu project?	Mark Shuttleworth	✓	82.0%
Who is the quarterback for the green bay packers?	Aaron Rodgers	✓	81.1%
Panda is a national animal of which country?	China	✓	76.8%
Who came up with the theory of relativity?	Albert Einstein	✓	76.4%
When was the first star wars film released?	1977	✓	71.4%
What is the most common blood type in sweden?	A	✗	70.6%
Who is regarded as the founder of psychoanalysis?	Sigmund Freud	✓	69.3%
Who took the first steps on the moon in 1969?	Neil Armstrong	✓	66.8%
Who is the largest supermarket chain in the uk?	Tesco	✓	65.3%
What is the meaning of shalom in english?	peace	✓	64.0%
Who was the author of the art of war?	Sun Tzu	✓	59.6%
Largest state in the us by land mass?	California	✗	59.2%
Green algae is an example of which type of reproduction?	parthenogenesis	✗	56.5%
Vikram samvat calender is official in which country?	India	✓	55.6%
Who is mostly responsible for writing the declaration of independence?	Thomas Jefferson	✓	53.3%
What us state forms the western boundary of montana?	Montana	✗	52.3%
Who plays ser davos in game of thrones?	Peter Dinklage	✗	52.1%
Who appoints the chair of the federal reserve system?	Janet Yellen	✗	51.5%

Source: [https://d4mucfpksywv.cloudfront.net/better-language-models/language\\_models\\_are\\_unsupervised\\_multitask\\_learners.pdf](https://d4mucfpksywv.cloudfront.net/better-language-models/language_models_are_unsupervised_multitask_learners.pdf)

# NLG

## Application:

### Question Answering



Image Credit: Amazon

Source:

<https://venturebeat.com/2019/11/25/amazon-researchers-use-nlp-data-set-to-improve-alexa-answers/>

Improving the quality of voice assistants' responses to questions is of interest to tech giants like Google, Apple, and Microsoft, who seek to address shortfalls in their respective natural language processing (NLP) technologies. They've plenty in the way of motivation — more than 50% of U.S. smart speaker owners say they ask questions of their devices, according to a survey conducted last year by Adobe.

# NLG Application: Image Captioning

← → C 🔒 azure.microsoft.com/en-us/services/cognitive-services/computer-vision/ ⋮

Product overview Features Security Pricing Documentation Customer stories FAQs Free account >

The screenshot shows a web interface for the Azure Computer Vision service. On the left, there is a grayscale image of a man performing a skateboard trick. Two pink rectangular boxes highlight specific areas: one around the man's upper body and another around his feet on the skateboard. To the left of the image, the word "person" is labeled. On the right, a table displays the detected features and their values.

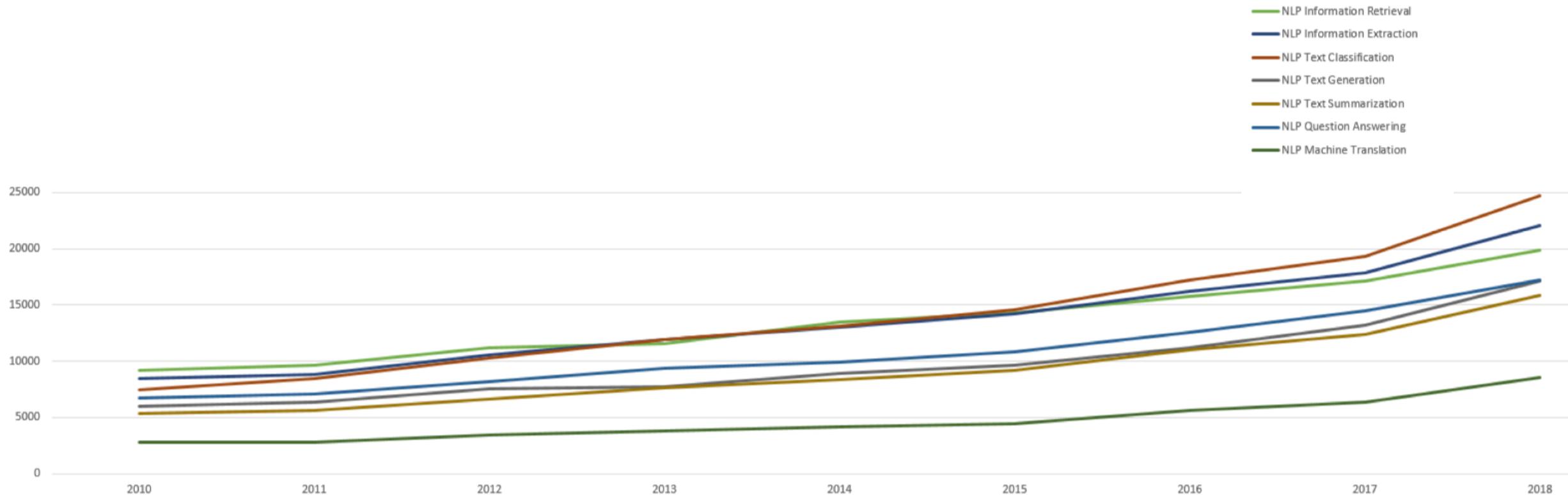
FEATURE	VALUE
NAME:	
Objects	[ { "rectangle": { "x": 238, "y": 299, "w": 177, "h": 117 }, "object": "Skateboard", "confidence": 0.903 }, { "rectangle": { "x": 118, "y": 63, "w": 305, "h": 321 }, "object": "person", "confidence": 0.955 } ]
Tags	[ { "name": "skating", "confidence": 0.999951541 }, { "name": "snowboarding", "confidence": 0.990067363 }, { "name": "sports equipment", "confidence": 0.9774853 }, { "name": "person", "confidence": 0.9605776 }, { "name": "roller skating", "confidence": 0.945730746 }, { "name": "boardsport", "confidence": 0.9242261 }, { "name": "man", "confidence": 0.9199999 } ]

Image URL  Submit

## Demo:

- <https://azure.microsoft.com/en-us/services/cognitive-services/computer-vision/>

# Publications on Applied Areas of NLP



Credit: A Survey of the Usages of Deep Learning for Natural Language Processing , Daniel W. Otter, Julian R. Medina, and Jugal K. Kalita (<https://arxiv.org/pdf/1807.10854.pdf>)

# NLP Benchmark

The General Language Understanding Evaluation (GLUE) benchmark is a collection of resources for training, evaluating, and analysing natural language understanding systems

- Language understanding tasks built on established existing datasets and selected to cover a diverse range **of dataset sizes, text genres, and degrees of difficulty**
- Diagnostic dataset designed to evaluate and analyze model performance with respect to a wide range of **linguistic phenomena** found in natural language
- Leaderboard for **tracking performance** on the benchmark and a dashboard for visualizing the performance of models on the diagnostic set (<https://gluebenchmark.com/leaderboard>)

Further reading: <https://openreview.net/pdf?id=rJ4km2R5t7>

# Regular Expression

```
/[\w._%+-]+@[\\w.-]+\\.\\.[a-zA-Z]{2,4}/
```

# What are Regular Expressions (“RegEx”)?

- To understand text, we need mechanisms for analysing its structure and identifying particular types of constituents
- Regular expressions is the starting point
- A regular expression is a pattern which can match one or more characters strings
- One common outcome of using regular expression is to find some data in text and take actions

# Use Cases for RegEx

Parsing documents with structured layout

- HTML, find all text within <p> tags
- Find body sections of emails

Handling personal identifiable information (PII)

Is there something in the text that looks like NRIC or password?

e.g. Series of digits + character

Find logic "cut point" of huge corpus of document

# Simple examples of regular expressions (1)

## Matching characters

- app - match text containing **app**, such as pineapple, apple, applications
- 1800 – Match to the text 1800

## Character sets [ ]

- [amk] – Match to either a , m or k
- [a-z] – Match any alphabet from a to z
- [7-9] – Match text containing characters with 7, 8, 9
- [A-Z0-9] – Match characters A to Z or 0 to 9
- \d – numbers class (short cut for [0-9])
- \w – character class (e.g. digits, letters but exclude special symbols)

# Simple examples of regular expressions (2)

## OR |

- apple | orange | pineapple – match to either apple, orange or pineapple

## Groups ( )

- Group symbols in the parathesis
- (Mon | Tues | Wednes)day – match to Monday, Tuesday or Wednesday

## Quantifiers. \*. ? + {n , m }

- \* : match zero or more of the previous expression
- ? : Optional match
- + : match 1 or more of previous expression
- {n, m} : match n to m occurrence of previous expression

# Exercise 1

Appreciation of ReEx syntax

[Visit https://regexone.com/](https://regexone.com/)

[Lesson 1: An Introduction, and the ABCs](#)

[Lesson 1½: The 123s](#)

[Lesson 2: The Dot](#)

[Lesson 3: Matching specific characters](#)

[Lesson 4: Excluding specific characters](#)

[Lesson 5: Character ranges](#)

[Lesson 6: Catching some zzz's](#)

[Lesson 7: Mr. Kleene, Mr. Kleene](#)

[Lesson 8: Characters optional](#)

[Lesson 9: All this whitespace](#)

[Lesson 10: Starting and ending](#)

[Lesson 11: Match groups](#)

[Problem 1: Matching a decimal numbers](#)

[Problem 2: Matching phone numbers](#)

[Problem 3: Matching emails](#)

**Instructions:**

Work in pairs.

Complete Lesson 1 to Lesson 11.

Complete Problem 1 to Problem 3.

# Regex Methods in Python

## re.**search**(pattern, string, flags=0)

Scan through *string* looking for the first location where the regular expression *pattern* produces a match, and return a corresponding **match object**. Return `None` if no position in the string matches the pattern; note that this is different from finding a zero-length match at some point in the string.

```
1 import re
2
3 pattern = 'term'
4 string = "The school term starts in Jan and Jun every year"
5
6 result = re.search(pattern, string)
7 if result:
8     print("Search successful.")
9 else:
10    print("Search unsuccessful.")
```

Search successful.

# Regex Methods in Python

## re.match(pattern, string, flags=0)

If zero or more characters at the beginning of *string* match the regular expression *pattern*, return a corresponding **match object**. Return `None` if the string does not match the pattern; note that this is different from a zero-length match.

```
1 import re
2
3 pattern = 'term'
4 string = "The school term starts in Jan and Jun every year"
5
6 result = re.search(pattern, string)
7 if result:
8     print("Search successful.")
9 else:
10    print("Search unsuccessful.")
```

Search successful.

# Regex Methods in Python

`Pattern.match(string[, pos[, endpos]])`

If zero or more characters at the *beginning* of *string* match this regular expression, return a corresponding **match object**. Return `None` if the string does not match the pattern; note that this is different from a zero-length match.

```
1 import re
2
3 pattern = 'term'
4 string = "The school term starts in Jan and Jun every year"
5 compile_pattern = re.compile(pattern)
6
7 result = compile_pattern.match(test_string)
8 if result:
9     print("Match successful.")
10 else:
11     print("Match unsuccessful.")
```

Match unsuccessful.

# Regex Methods in Python

## re.**sub**(pattern, repl, string, count=0, flags=0)

Return the string obtained by replacing the leftmost non-overlapping occurrences of *pattern* in *string* by the replacement *repl*. If the pattern isn't found, *string* is returned unchanged. *repl* can be a string or a function; if it is a string, any backslash escapes in it are processed. That is, `\n` is converted to a single newline character, `\r` is converted to a carriage return, and so forth.

```
1 import re
2
3 pattern = 'term'
4 string = "The school term starts in Jan and Jun every year. The term ends in Apr and Nov"
5 repl = 'semester'
6 re.sub(pattern, repl, string)
```

'The school semester starts in Jan and Jun every year. The semester ends in Apr and Nov'

# Regex Methods in Python

## re.**split**(pattern, string, maxsplit=0, flags=0)

Split *string* by the occurrences of *pattern*. If capturing parentheses are used in *pattern*, then the text of all groups in the pattern are also returned as part of the resulting list. If *maxsplit* is nonzero, at most *maxsplit* splits occur, and the remainder of the string is returned as the final element of the list.

```
1 import re
2
3 pattern = '#'
4 string = "The school term starts in Jan.#The term ends in Apr and Nov.#School if fun"
5
6 re.split(pattern, string)
```

```
['The school term starts in Jan.',  
 'The term ends in Apr and Nov.',  
 'School if fun']
```

# Regex Methods in Python

## re.findall(pattern, string, flags=0)

Return all non-overlapping matches of *pattern* in *string*, as a list of strings. The *string* is scanned left-to-right, and matches are returned in the order found. If one or more groups are present in the pattern, return a list of groups; this will be a list of tuples if the pattern has more than one group. Empty matches are included in the result.

```
1
2 str = 'purple alice@google.com, blah monkey bob@abc.com blah dishwasher'
3 pattern = '[\w\.-]+@[ \w\.-]+'
4
5 emails = re.findall(pattern, str)
6 print (emails)
7
```

```
['alice@google.com', 'bob@abc.com']
```

# Alternatives

## re.compile(pattern, flags=0)

Compile a regular expression pattern into a [regular expression object](#), which can be used for matching using its `match()`, `search()` and other methods, described below.

```
1 import re
2
3 pattern = 'term'
4 string = "The school term starts in Jan and Jun every year"
5 compile_pattern = re.compile(pattern)
6
7 result = compile_pattern.search(test_string)
8 if result:
9     print("Search successful.")
10 else:
11     print("Search unsuccessful.")
```

*Compiled object can be reused and is more efficient when the expression is used multiple times*

# Exercise 2

Using RE library in  
Python

Proceed with Jupyter Notebook

*ex2-regex.ipynb*

# Exercise 3

Use regular  
expression to gain  
preliminary insights  
into a large corpus  
of data

Proceed with Jupyter Notebook

*ex3-regex.ipynb*

# References

- Regular expression in Python, [https://www.w3schools.com/python/python\\_regex.asp](https://www.w3schools.com/python/python_regex.asp)
- Python Regular Expressions, <https://developers.google.com/edu/python/regular-expressions>