UNIVERSITY OF
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The ABC of Computational Text Analysis

#6 Learning Regular Expressions

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Recap last Lecture

- well-solved assignment #1 🎊

  example solution

- counting words 🔢

  particular words or entire vocabulary

- preprocessing and cleaning 🧼

Outline

- introducing regular expression ✨
- practicing the writing of patterns 🎢

Text as Pattern

Formal Search Patterns

How to extract all email addresses in a text collection?

```
Please contact us via info@organization.org.
---
For specific questions ask Mrs. Green (a.green@mail.com).
---
Reach out to support@me.ch
```

👉 **Solution:** Write a single pattern to match any valid email adress

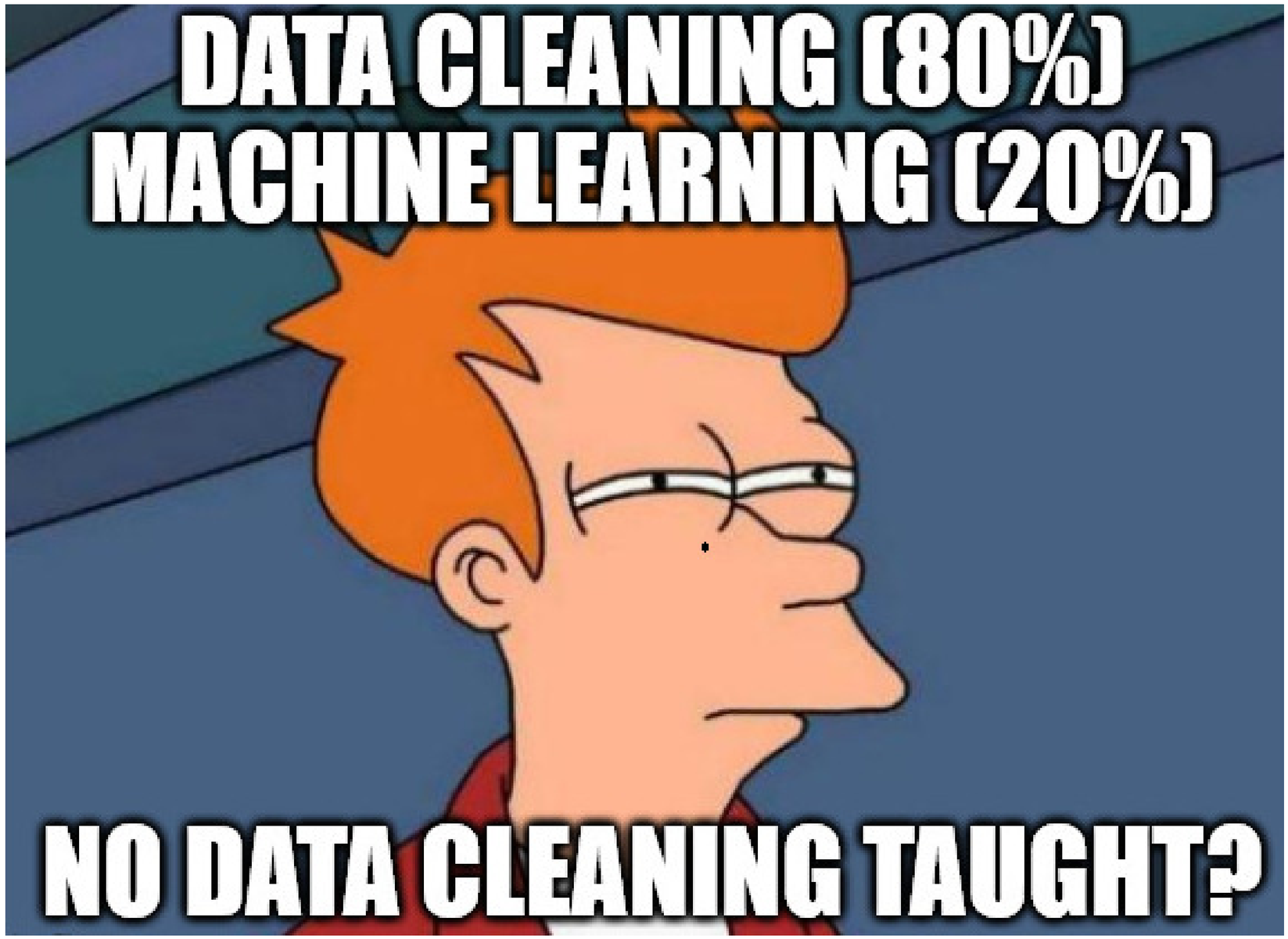
```
[A-Z0-9._%+-]+@[A-Z0-9.-]+\.[A-Z]{2,}   # match any email address
```

What are patterns for?

- finding 🔍
- extracting 🛠️
- removing/cleaning 🗑️
- replacing 🔁

… specific parts in texts

Data Cleaning is paramount!



What are Regular Expressions (RegEx)?

RegEx builds on two classes of symbols

- **literal** characters and strings

  letters, digits, words, phrases, dates etc.

- **meta** expressions with special meaning

  e.g., `\w` represents alphanumeric characters

  `[Cc]o+l` → Col, col, Cool, coool ...

- akin to regular languages

Finding + Extracting

extended globally search for regular expression and print (egrep)

- tool to filter/keep matching lines only

```
# check a regular expression quickly
echo "check this pattern" | egrep "pattern"

egrep "yes" file.txt          # search in a specific file
egrep -r "yes" folder         # search recursively within folder

egrep "yes" *.txt             # keep lines containing pattern (yes) a
egrep -i "yes" *.txt          # dito, ignore casing (Yes, yes, YES .
egrep -v "noisy" *.txt        # do NOT keep lines containing noisy

# extract raw match only to allow for subsequent counting
egrep -o "only" *.txt         # print match only instead of entire li
egrep -h "only" *.txt         # suppress file name
```

Quantifiers

repeat preceding character X times

- ? zero or one
- + one or more
- * zero or any number
- {n}, {m,n} a specified number of times

```
1 egrep -r "Bundesrath?es"          # match old and new spelling
2 egrep -r "a+"                     # match one or more "a"
3 egrep -r "e{2}"                   # match sequence of two "e"
```

⚠️ Do not confuse regex with Bash wildcards!

Character Sets

- `[...]` any of the characters between brackets

  any vowel: `[auoei]`

  any digit: `[0-9]`

  any letter: `[A-Za-z]`

- `[^...]` any character but none of these (negation)

  anything but the vowels: `[^auoei]`

```
# match the capitalized and non-capitalized form
egrep -r "[Gg]rüne"

# match sequences of 3 vowels
egrep -r [aeiou]{3}

# extract all bigrams (sequence of two words)
egrep -rohi "[a-z]+ [a-z]+"
```

Special Symbols

- `.` matches any character (excl. newline)
- `\` escapes to match literal
  - `\.` means the literal `.` instead of “any symbol”
- `\w` matches any alpha-numeric character
  - same as `[A-Za-z0-9_]`
- `\s` matches any whitespace (space, newline, tab)
  - same as `[ \t\n]`

```
1 # match anything between brackets
2 egrep -r "\(.*\)"
```

The power of `.*` ...

matches ***any character any times***

More Complex Examples

```
# extract basename of URLs
egrep -ro "www\.\w+\.[a-z]{2,}"

# extract valid email adresses (case-insensitive)
egrep -iro "[A-Z0-9._%+-]+@[A-Z0-9.-]+\.[A-Z]{2,}" **/*.txt
```

Combining RegEx with Frequency Analysis

something actually useful

```
1 # count political areas by looking up words ending with "politik"
2 egrep -rioh "\w*politik" **/*.txt | sort | uniq -c | sort -h
3
4 # count ideologies/concepts by looking up words ending with "ismus"
5 egrep -rioh "\w*ismus" **/*.txt | sort | uniq -c | sort -h
```


Start simple,
add complexity
subsequently.

In-class: Exercise

1. Use the command line to navigate to the local copy of the Github repository KED2023 and make sure it is up-to-date with `git pull`. Change in to the directory `materials/data/swiss_party_programmes/txt`.
2. Use `egrep` to extract all uppercased words like `UNO, OECD, SP` and count their frequency.
3. Use `egrep` to extract all plural nouns with female endings e.g. `Schweizerinnen` (starting with an uppercase letter, ending with `innen`, and any letter in between). Do the same for the male forms. Is there a qualitative or a quantitative difference between the gendered forms?

```
# Some not so random hints
piping with |
sort
uniq -c
egrep -roh **/*.txt
```

In-class: Solution

1. Use `egrep` to extract all uppercased words like `UNO, OECD, SP` and count their frequency.

   ```
   egrep -roh "[A-Z]{2,}" **/*.txt | sort | uniq -c | sort -h
   ```

2. Use `egrep` to extract all plural nouns with female endings e.g. `Schweizerinnen` (starting with an uppercase letter, ending with `innen`, and any letter in between). Do the same for the male forms. Is there a qualitative or a quantitative difference between the gendered forms?

   ```
   egrep -roh "[A-Z][a-z]+innen\b" **/*.txt | sort | uniq -c | sort -h
   ```

   ```
   egrep -roh "[A-Z][a-z]+er\b" **/*.txt | sort | uniq -c | sort -h
   ```

   (there is no way with regular expression to extract only nouns of the male form but not `Wasser` and the like. For this, you have to use some kind of machine learning.)

Replacing + Removing

stream editor (sed)

- advanced find + replace using regex

```
sed "s/WHAT/WITH/g" file.txt
```

- `sed` replaces any sequence, `tr` only single symbols

```
1 echo "hello" | sed "s/llo/y/g"       # replace "llo" with a "y"
2
3 # by setting the g flag in "s/llo/y/g",
4 # sed replaces all occurences, not only the first one
```

Contextual Replacing

reuse match with grouping

- define a group with parentheses `(group_pattern)`
- `\1` equals the expression inside first pair of parentheses
- `\2` expression of second pair
- ...

```
# swap order of name (last first -> first last)
echo "Lastname Firstname" | sed -E "s/(.+) (.+)/\2 \1/"

# matching also supports grouping
# match any pair of two identical digits
egrep -r "([0-9])\1"
```

More Meta-Symbols

- `\b` matches word boundary

  `word\b` does not match `words`

- `^` matches begin of line and `$` end of line

  `^A` matches only `A` at line start

- `|` is a disjunction (OR)

  `(Mr|Mrs|Mr\.|Mrs\.) Green` matches alternatives

Greediness Trap

- greedy ~ match the longest string possible
- quantifiers `*` or `+` are greedy
- non-greedy by excluding some symbols `[^EXCLUDE_SYMBOLS]` instead of `.*`

```
1 # greedy: an apple, other apple
2 echo "an apple, other apple" | egrep "a.*apple"
3
4 # non-greedy: an apple
5 echo "an apple, other apple" | egrep "a[^,]*apple"
```

Assignment #2 ✍️

- get/submit via OLAT

  starting tomorrow

  deadline 15 April 2023, 23:59

- use forum on OLAT

  subscribe to get notifications

- ask friends for support, not solutions

In-class: Exercises I

1. Use `egrep` to extract capitalized words and count them. What are the most frequent nouns?
2. Use `egrep` to extract words following any of these strings: `der die das`. Hint: Use a disjunction.
3. Do the self-check on the next slide.
4. Use `sed -E` to remove the table of content, the footer and the page number in the programme of the Green Party. Check the corresponding PDF to get a visual impression and test your regular expression with `egrep` first to see if you match the correct parts in the document.

In-class: Solution I

1. Use `egrep` to extract capitalized words and count them. What are the most frequent nouns?

   ```
   egrep -roh "[A-Z][a-z]+" **/*.txt | sort | uniq -c | sort -h
   ```

2. Use `egrep` to extract words following any of these strings: `der die das`. Hint: Use a disjunction.

   ```
   egrep -roh "(der|die|das) \w+" **/*.txt
   ```

3. Use `sed -E` to remove the table of content, the footer and the page number in the programme of the Green Party. Check the corresponding PDF to get a visual impression and test your regular expression with `egrep` first to see if you match the correct parts in the document.

   ```
   cat gruene_programme_2019.txt | sed "1,192d" | sed -E
   "s/^Wahlplattform.*2023$//g" | sed -E "s/^[0-9]+$//g"
   ```

In-class: Self-Check

equivalent patterns

```
1 a+ == aa*                    # "a" once or more than once
2 a? == (a|_)                  # "a" once or nothing
3 a{3} == aaa                  # three "a"
4 a{2,3} == (aa|aaa)           # two or three "a"
5 [ab] == (a|b)                # "a" or "b"
6 [0-9] == (0|1|2|3|4|5|6|7|8|9)  #any digit
```

In-class: Exercise II

1. Count all the bigrams (sequence of two words) using character sets and quantifiers. What about trigrams (three words)?
2. Extract the words following numbers (also consider numbers like: `1'000`, `1,000` or `5%`). Then, count all the words while excluding the numbers themselves. Hint: Pipe another grep to remove the digits.
3. You are ready to come up with your own patterns…

In-class: Solution II

1. Count all the bigrams (sequence of two words) using character sets and quantifiers. What about trigrams (three words)?

```
egrep -hoir "\b[a-z]+ [a-z]+\b" | sort | uniq -c | sort -h
egrep -hoir "\b[a-z]+ [a-z]+ [a-z]+\b" | sort | uniq -c | sort -h
```

2. Extract the words following numbers (also consider numbers like: `1'000`, `1,000` or `5%`). Then, count all the words while excluding the numbers themselves. Hint: Pipe another grep to remove the digits.

```
egrep -rhoi "[0-9][0-9,'%]+ [a-z]+" | egrep -io "[a-z]+" | sort | uniq -c | sort -h
```

Alternative: `egrep -rhoi "[0-9][0-9,'%]+ [a-z]+" | sed -E "s/[0-9][0-9,'%]+//g" | sort | uniq -c | sort -h`

In-class: Exercise III

1. Since you know about RegEx, we can use a more sophisticated tokenizer to split a text into words. What is the difference between the old and new approach? Test it and check the helper page with `man`.

```
# new, improved approach
cat text.txt | tr -sc "[a-zäöüA-ZÄÖÜ0-9-]" "\n"

# old approach
cat text.txt | tr " " "\n"
```

More Resources

required

- Ben Schmidt. 2019. Regular Expressions.
- Cheatsheet of this course

highly recommended

- Nikolaj Lindberg. egrep for Linguists.

online regular expression editor

Questions?