Big Data and Automated Content Analysis Part I+II

Week 14 – Wednesday
»Looking back and froward«

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Today

1. Looking back
    - Putting the pieces together
    - A good workflow
2. Looking forward
    - Techniqes we did not cover
    - Neural Networks
3. The INCA project
    - Scaling up Content Analyis
    - The INCA architecture
4. Final steps

Looking back

Putting the pieces together

First: Our epistomological underpinnings

Computational Social Science

Computational Social Science

"It is an approach to social inquiry defined by (1) the use of large, complex datasets, often—though not always— measured in terabytes or petabytes; (2) the frequent involvement of "naturally occurring" social and digital media sources and other electronic databases; (3) the use of computational or algorithmic solutions to generate patterns and inferences from these data; and (4) the applicability to social theory in a variety of domains from the study of mass opinion to public health, from examinations of political events to social movements"

Shah, D. V., Cappella, J. N., & Neuman, W. R. (2015). Big Data, digital media, and computational social science: Possibilities and perils. T*he ANNALS of the American Academy of Political and Social Science, 659*(1), 6–13. doi:10.1177/0002716215572084

Computational Social Science

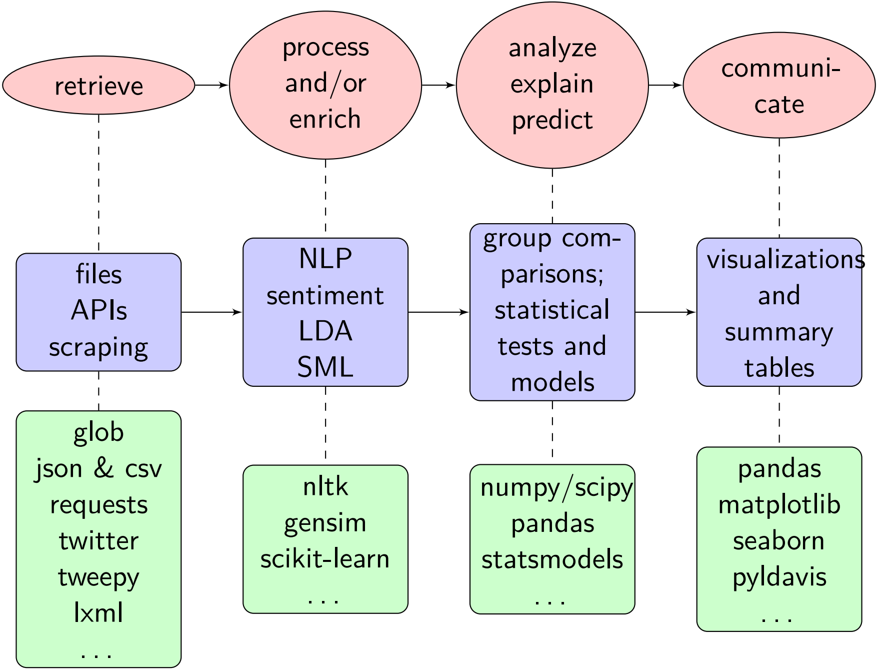
"[. . .] the computational social sciences employ the scientific method, complementing descriptive statistics with inferential statistics that seek to identify associations and causality. In other words, they are underpinned by an epistemology wherein the aim is to produce sophisticated statistical models that explain, simulate and predict human life."

Kitchin, R. (2014). Big Data, new epistemologies and paradigm shifts. *Big Data & Society, 1*(1), 1–12. doi:10.1177/2053951714528481

Steps of a CSS project

We learned techniques for:

- retrieving data
- processing data
- analyzing data
- visualising data


retrieve
process and/or enrich
analyze explain predict
communi- cate
files APIs scraping
NLP sentiment LDA SML
group com- parisons; statistical tests and models
visualizations and summary tables
glob json & csv requests twitter tweepy lxml . . .
nltk gensim scikit-learn . . .
numpy/scipy pandas statsmodels . . .
pandas matplotlib seaborn pyldavis . . .

A good workflow

The big picture

Start with pen and paper

1. Draw the Big Picture

The big picture

Start with pen and paper

1. Draw the Big Picture
2. Then work out what components you need

Develop components separately

One script for downloading the data, one script for analyzing

- Avoids waste of resources (e.g., unnecessary downloading multiple times)

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Start small, then scale up

- Take your plan (see above) and solve *one* problem at a time (e.g., parsing a review page; or getting the URLs of all review pages)

Develop components separately

One script for downloading the data, one script for analyzing

- Avoids waste of resources (e.g., unnecessary downloading multiple times)
- Makes it easier to re-use your code or apply it to other data

Start small, then scale up

- Take your plan (see above) and solve *one* problem at a time (e.g., parsing a review page; or getting the URLs of all review pages)
- (for instance, by using functions [next slides])

Develop components separately

If you copy-paste code, you are doing something wrong

- Write loops!

Develop components separately

If you copy-paste code, you are doing something wrong

- Write loops!
- If something takes more than a couple of lines, write a function!

Copy-paste approach
(ugly, error-prone, hard to scale up)

```
allreviews = []

response = requests.get('http://xxxxx')
tree = fromstring(response.text)
reviewelements = tree.xpath('//div[@class="review"]')
reviews = [e.text for e in reviewelements]
allreviews.extend(reviews)

response = requests.get('http://yyyyy')
tree = fromstring(response.text)
reviewelements = tree.xpath('//div[@class="review"]')
reviews = [e.text for e in reviewelements]
allreviews.extend(reviews)
```

Better: for-loop
(easier to read, less error-prone, easier to scale up (e.g., more URLs, read URLs from a file or existing list)))

```
allreviews = []

urls = ['http://xxxxx', 'http://yyyyy']

for url in urls:
    response = requests.get(url)
    tree = fromstring(response.text)
    reviewelements = tree.xpath('//div[@class="review"]')
    reviews = [e.text for e in reviewelements]
    allreviews.extend(reviews)
```

Even better: for-loop with functions
(main loop is easier to read, function can be re-used in multiple contexts)

```
def getreviews(url):
    response = requests.get(url)
    tree = fromstring(response.text)
    reviewelements = tree.xpath('//div[@class="review"]')
    return [e.text for e in reviewelements]


urls = ['http://xxxxx', 'http://yyyyy']

allreviews = []

for url in urls:
    allreviews.extend(getreviews(url))
```

Scaling up

If you continue working in this field, look into aspects like code style, re-usability, scalability

- Use functions and classes (Appendix D.3) to make code more readable and re-usable
- Avoid re-calculating values
- Think about how to minimize memory usage (e.g., Generators, Appendix D.2)
- Do not hard-code values, file names, etc., but take them as arguments

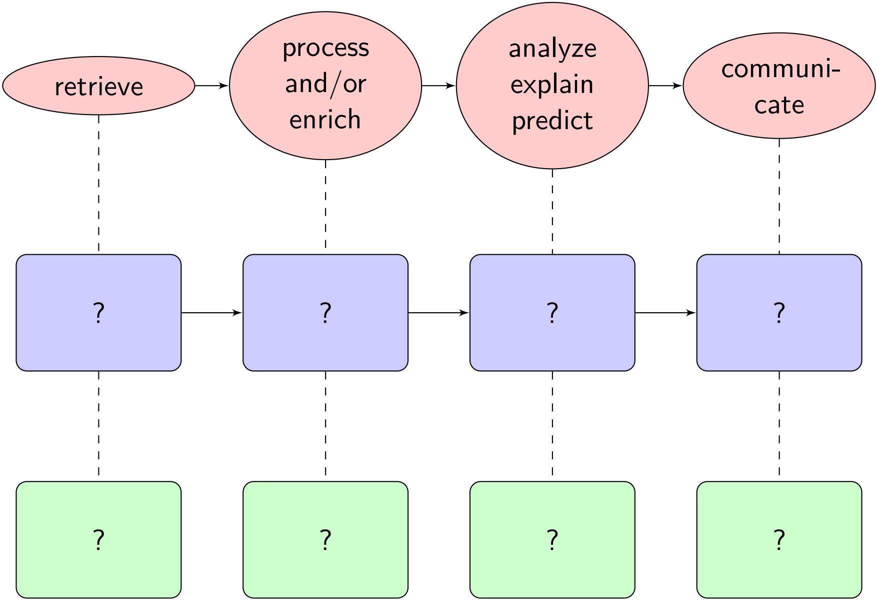
Make it robust

You cannot foresee every possible problem.
Most important: Make sure your program does not fail and loose all data just because something goes wrong at case 997/1000.

- Use `try/except` to explicitly tell the program how to handle errors
- Write data to files (or database) in between
- Use `assert len(x) == len(y)` for sanity checks

Looking forward

What other possibilities do exist for each step?


retrieve
process and/or enrich
analyze explain predict
communi- cate
?
?
?
?
?
?
?
?

Retrieve

Webscraping with Selenium

- If content is dynamically loaded (e.g., with JavaScript), our approach doesn't work (because we don't have a browser).
- Solution: Have Python literally open a browser and literally click on things
- $\Rightarrow$ Appendix E

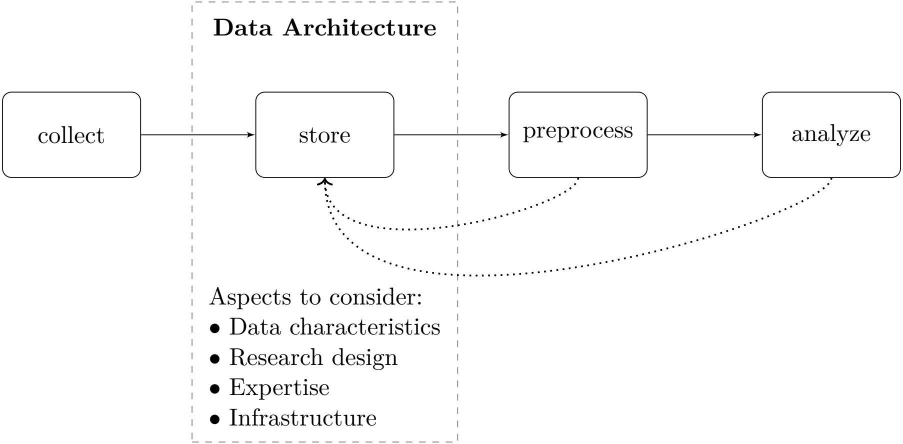
Retrieve

Use of databases

We did not discuss how to actually store the data

- We basically stored our data in files (often, one CSV or JSON file)
- But that's not very efficient if we have large datasets; especially if we want to select subsets later on
- SQL-databases to store tables (e.g., MySQL)
- NoSQL-databases to store less structured data (e.g., JSON with unknown keys) (e.g., MongoDB, ElasticSearch)
- ⇒ Günther, E., Trilling, D., & Van de Velde, R.N. (2018). But how do we store it? (Big) data architecture in the social-scientific research process. In: *Stuetzer, C.M., Welker, M., & Egger, M. (eds.): Computational Social Science in the Age of Big Data. Concepts, Methodologies, Tools, and Applications.* Cologne, Germany: Herbert von Halem.

Storing data



From retrieved data to enriched data

1. Retrieved →

```
<div>
<span id='author'
class='big'>
Author: John
Doe </span>
<span id='viewed'>
seen 42 times
</span>
</div>
```

2. Structured →

```
{
"author":
"Author: John Doe",
"viewed":
"seen 42 times"
}
```

3. Cleaned →

```
{
"author":
"john doe",
"viewed":
42,
}
```

4. Enriched

```
{
"author":
"john doe",
"author_gender":
"M",
"viewed":
42,
}
```

Process and/or enrich

Word embeddings

We did not really consider the *meaning* of words

- Word embeddings can be trained on large corpora (e.g., whole wikipedia or a couple of years of newspaper coverage)
- The trained model allows you to calculate with words (hence, word vectors): $king - man + woman = ?$
- You can find out whether documents are similar *even if they do not use the same words* (Word Mover Distance)
- $\Rightarrow$ word2vec (in gensim!), glove

Process and/or enrich

Advanced NLP

We did a lot of BOW (and some POS-tagging), but we can get more

- Named Entity Recognition (NER) to get names of people, organizations, . . .
- Dependency Parsing to find out exact relationships ⇒ nltk, Stanford, FROG. And now (that one is really cool): spacy

Process and/or enrich

Use images

- Supervised Machine learning does not care about what the features mean, so instead of texts we can also classify pictures
- Example: Teach the computer to decide whether an avatar on a social medium is an actual photograph of a person or a drawn image of something else (research Marthe)
- This principle can be applied to many fields and disciplines – for example, it is possible to teach a computer to indicate if a tumor is present or not on X-rays of people's brains

Process and/or enrich

Use images

- To learn more about this, the following websites useful information: `http://blog.yhat.com/posts/image-classification-in-Python.html` and `http://cs231n.github.io/python-numpy-tutorial/#numpy-arrays`
- Possibible workflow: Pixel color values as features $\Rightarrow$ PCA to reduce features $\Rightarrow$ train classifier
- Advanced stuff: Neural Networks

Analyze/explain/predict

More advanced modelling

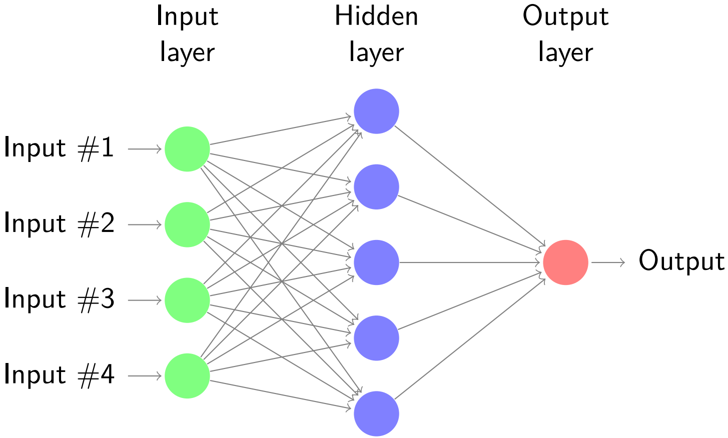
We only did some basic statistical tests

- There are more advanced regression techniques and dimension-reduction techniques tailored to data that are, e.g., large-scale, sparse, have a lot of features, ...
- $\Rightarrow$ scikit-learn, statsmodels

Neural Networks and Deep Learning

Neural Networks

- In “classical” machine learning, we predict an outcome directly based on the input features
- In neural networks, we can have “hidden layers” that we predict
- These layers are not necessarily interpretable
- “Neurons” that “fire” based on an “activation function”



⇒ If we had multiple hidden layers in a row, we'd call it a *deep* network.

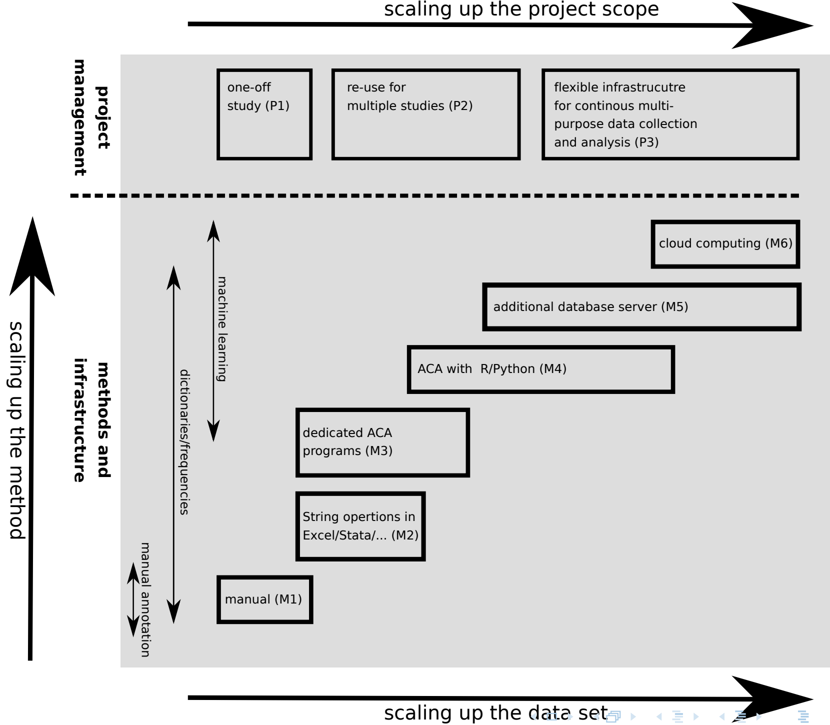
Why neural networks?

- learn hidden structures (e.g., embeddings (!))
- go beyond the idea that there is a direct relationship between occurrence of word X and label (or occurrence of pixel [R,G,B] and a label)
- images, machine translation — and more and more general NLP, sentiment analysis, etc.
- many Python frameworks available (e.g., Keras)

Example of a comparatively easy introduction:
`https://towardsdatascience.com/neural-network-embeddings-explained-4d028e6f0526`

An example for scaling up:
The INCA project

see also Trilling, D., & Jonkman, J.G.F. (2018). Scaling up content analysis. *Communication Methods and Measures*, doi:10.1080/19312458.2018.1447655



scaling up the project scope
project management
one-off study (P1)
re-use for multiple studies (P2)
flexible infrastrucutre for continous multi-purpose data collection and analysis (P3)
scaling up the method
methods and infrastructure
machine learning
dictionaries/frequencies
manual annotation
cloud computing (M6)
additional database server (M5)
ACA with R/Python (M4)
dedicated ACA programs (M3)
String opertions in Excel/Stata/... (M2)
manual (M1)
scaling up the data set

INCA

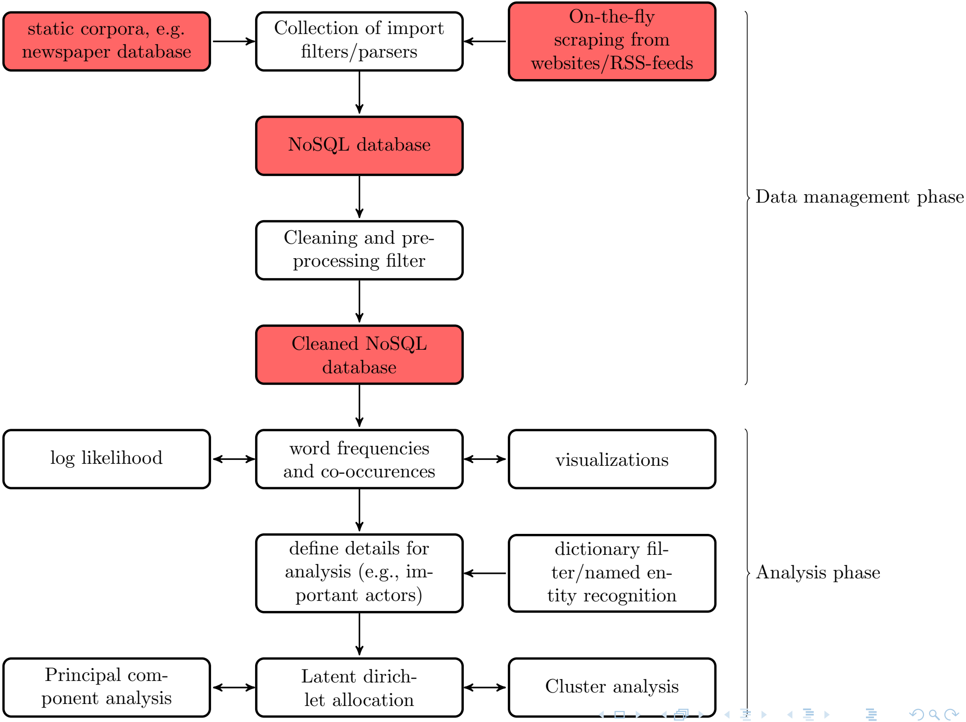
How do we move beyond one-off projects?

- Collect data in such a way that it can be used for multiple projects
- Database backend
- Re-usability of preprocessing and analysis code

INCA

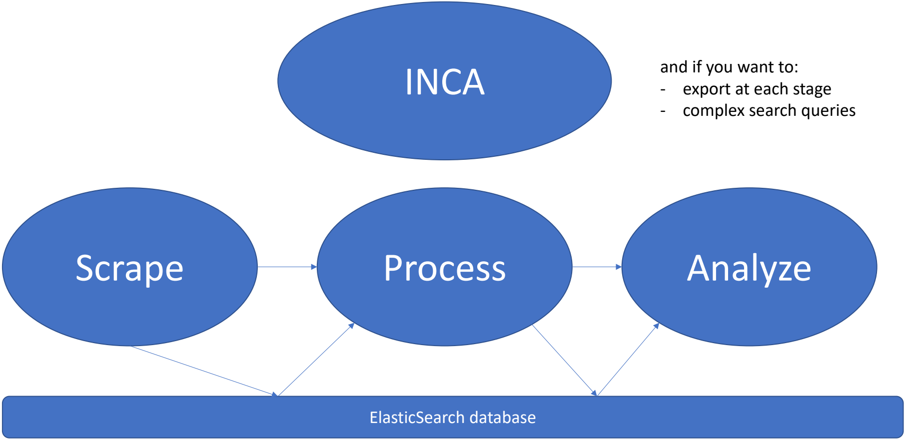
The idea

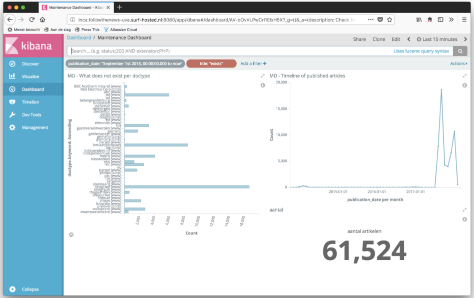
- Usable with minimal Python knowledge
- The "hard stuff" is already solved: writing a scraper often only involves replacing the XPATHs


static corpora, e.g. newspaper database
Collection of import filters/parsers
On-the-fly scraping from websites/RSS-feeds
NoSQL database
Cleaning and pre-processing filter
Cleaned NoSQL database
Data management phase
log likelihood
word frequencies and co-occurences
visualizations
define details for analysis (e.g., important actors)
dictionary filter/named entity recognition
Principal component analysis
Latent dirichlet allocation
Cluster analysis
Analysis phase

and if you want to:

- export at each stage
- complex search queries





analytics dashboard (KIBANA)

```
g = inca.analysis.timeline_analysis.timeline_generator()
g.analyse('moslim',"publication_date",granularity='year',from_time=‘2014’)
```

Direct access to all functionality via Python

	timestamp	moslim
0	2011-01-01T00:00:00.000Z	1631
1	2012-01-01T00:00:00.000Z	1351
2	2013-01-01T00:00:00.000Z	1221
3	2014-01-01T00:00:00.000Z	2333
4	2015-01-01T00:00:00.000Z	2892
5	2016-01-01T00:00:00.000Z	2253
6	2017-01-01T00:00:00.000Z	2680

We are looking for student assistants!

Different options:

- paid
- research participation/internship
- thesis

(or a combination)

Tasks involve contributing to the INCA codebase (e.g., writing/repairing scrapers) and data cleaning/processing. Requirements: Python, Linux. Additionally, you will need to learn git and ElasticSearch (but we'll help with that).

Next meeting

Friday

Final chance for questions regarding final project (if you don't have any, you don't need to come.)

Deadline final exam

Hand in via filesender.
One .zip or .tar.gz file with

- .py and/or .ipynb for code
- .pdf for text and figures
- .csv, .json, or .txt for data
- any additional file I need to understand or reproduce your work