Code & Data Handling in Empirical Research Projects

Could We Do Better?

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HUB, TRR 266

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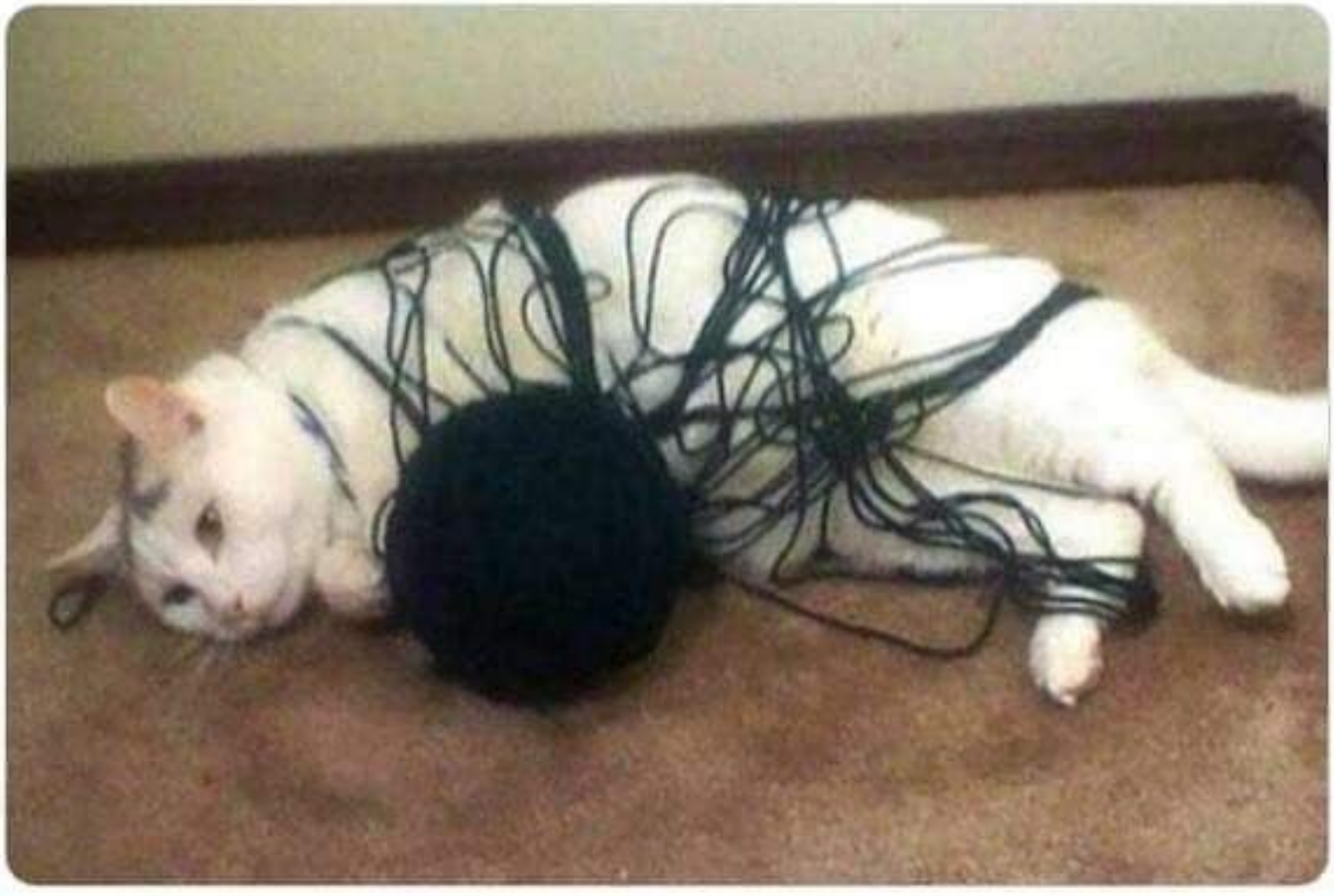
Mental juggling with research projects

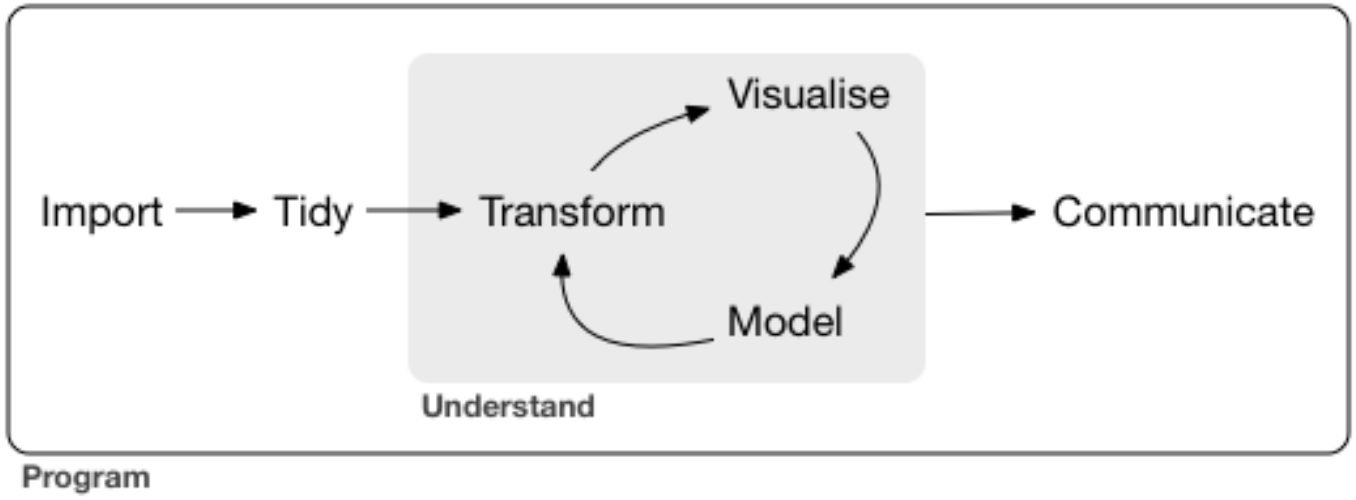
A while ago, every time I looked into old project folders, or project folders of others, it felt like...



Part 1: An integrated view on empirical research projects

Empirical researcher, data scientist or programmer?

Model of the tools needed in a typical data science project (Wickham and Grolemund 2017):



Empirical research projects

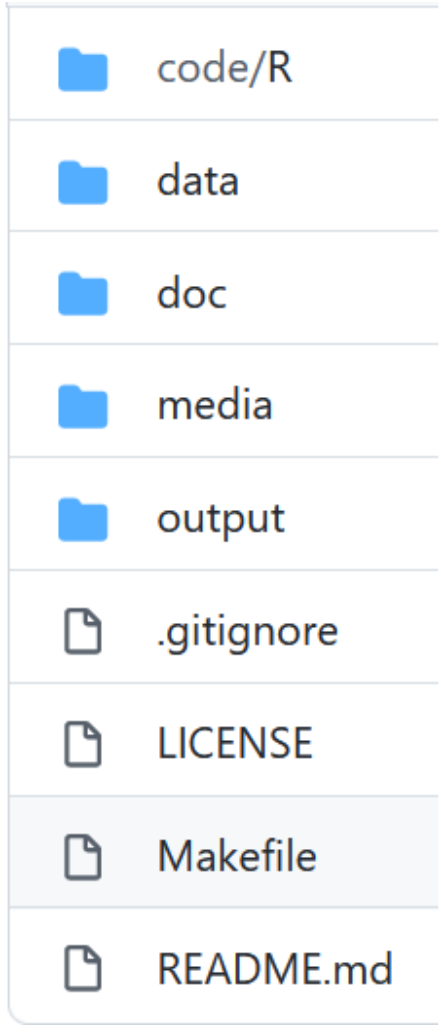
1. Retrieve/collect raw data
2. Import raw data
3. Tidy raw data
4. Transform (raw) data
5. Visualize transformed data [tables, figures, statistics]
6. Model [explore, describe, causally test for relationships between variables]
7. Generate research "products"
8. Communicate

Software developers as new best buddies?

Python File Structure Tree

```
Project_Name/
├── .git/
├── .vscode/
├── data/
├── debug/
├── docs/
├── etc/
├── include/
│   └── Project_Name/
│       └── public_functions.py
├── lib/
├── src/
│   ├── assets/
│   │   ├── fonts/
│   │   ├── images/
│   │   ├── sounds/
│   │   └── videos/
│   ├── utils/
│   ├── functions_code.py
│   ├── main.py
│   └── private_funtions.py
├── tests/
│   ├── alpha_version/
│   └── beta_version/
├── Python.gitignore
└── ReadMe.md
```

The TRR 266 template:



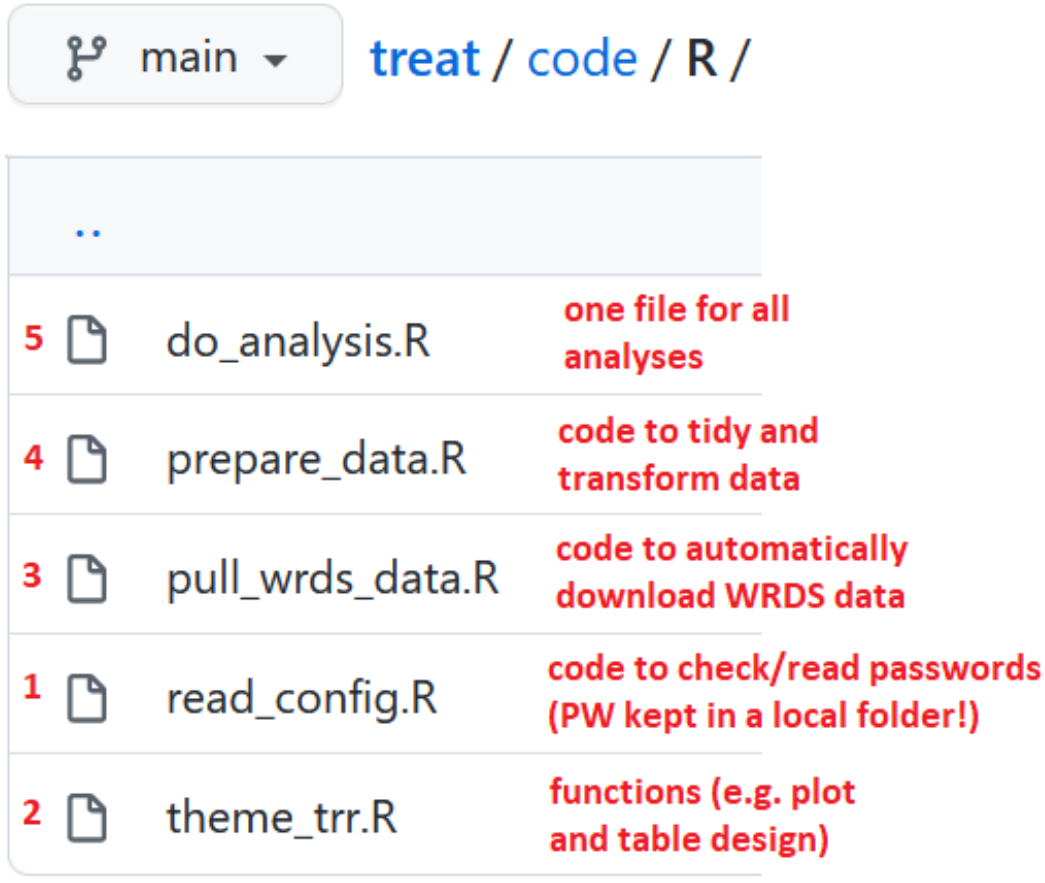
Part 2: Code & data

Code & data organization

- Product-oriented organization
  - Create software and data "products"
  - Products: functions, output
  - Publish your code and data, get a DOI?
  - License your stuff!
- Version control systems
  - Git and GitHub (free account for researchers)
  - Using clouds like Nextcloud (desktop application with local drive?)
  - Advantages of GitHub over clouds?

Code organization

An example from the TRR 266 template repository:

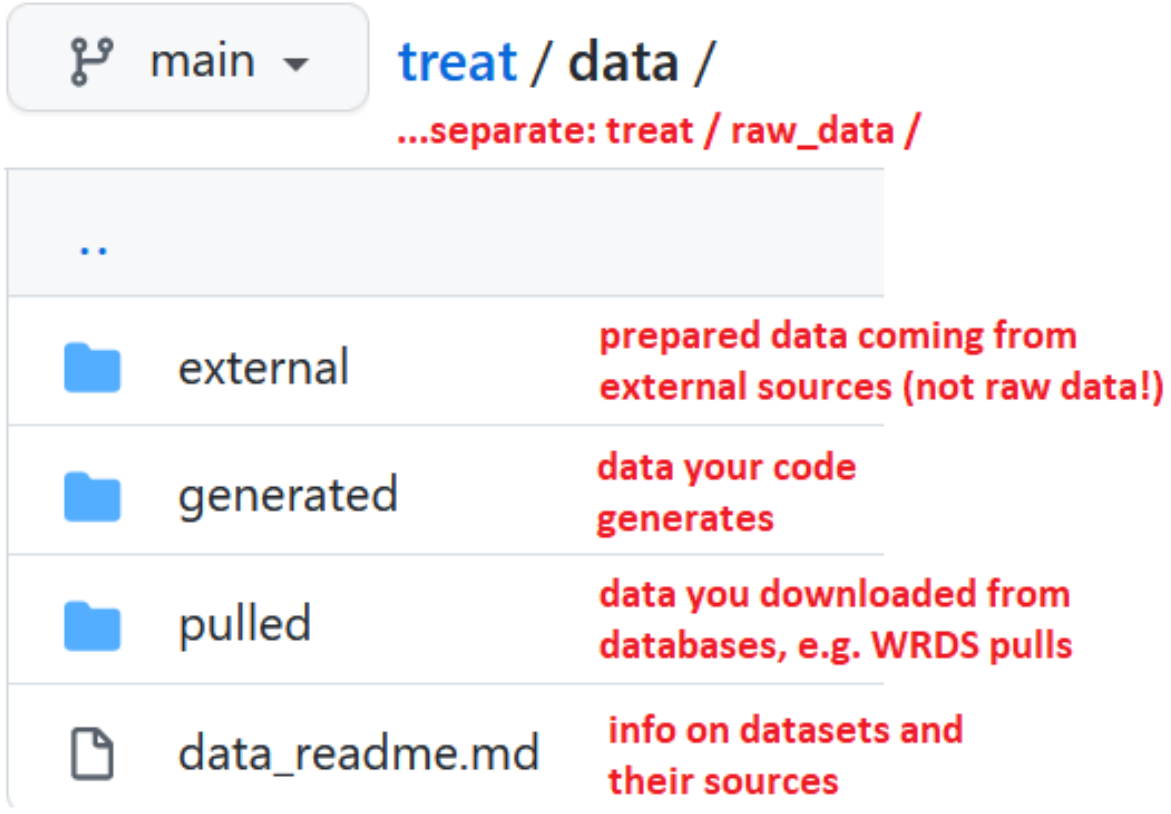


Code organization

- Consistent naming of code and variables!
  - you_could_use_snake_case
  - CamelCaseIsAnAlternative
- Code automation?
  - No need to run line-by-line, but script-by-script
  - Having a master file
  - Input/output pre-defined
  - Final product: Set of tables/figures, presentation or paper
- Functional vs object-oriented programming
  - Functional: A function takes a defined input to created a defined output
  - Repeated evaluation, efficient, re-using code
- Code testing: Writing tests that the code must pass

Data organization

An example from the TRR 266 template repository:



Data handling

- Consistent naming of data files!
  - 'raw_data_wrds_analyst_forecasts.csv'
  - 'dataset_final.csv'
- Automated data retrieval
  - Retrieve data using code
  - WRDS automated code for Stata, R, Python, SAS
- Product-orientation
  - Define data products upfront
  - Often several version ('_v08.csv', '_20220211.xlsx')
- Generate tidy data (next slide)

Tidy data

Have tidy data! (Wickham 2014) ...but what's tidy data?

1. Each variable forms a column.
2. Each observation forms a row.
3. Each type of observational unit forms a table.

Part 3: Looking at examples

Example 1: A project folder

.['Old versions']
.['Resources']
.['Raw data']
definition_of_variables.xlsx
data_snippet_A.xlsx
R_script_1_masterfile.R
R_script_2_load_and_class_variables.R
R_script_3_prepare_data.R
R_script_4_check_data_for_missing_values.R
R_script_5_check_data_for_missing_values_old_version.R
R_script_6_data_cleaning.R
R_script_7_running_analyses_A.R
R_script_8_running_analyses_B.R
R_script_9_additional_analyses.R
raw_data_af.xlsx
raw_data_step_1.xlsx
raw_data_step_2.xlsx
raw_data_step_3.xlsx
raw_data_step_4.xlsx
final_dataset.xlsx

Example 1: A project folder (ctd.)

.['Old versions']
.['Resources']
.['Raw data']
definition_of_variables.xlsx
data_snippet_A.xlsx
R_script_1_masterfile.R
R_script_2_load_and_....R
R_script_3_prepare_data.R
R_script_4_check_data....R
R_script_5_check_data_....R
R_script_6_data_cleaning.R
R_script_7_running_analyses_A.R
R_script_8_running_analyses_B.R
R_script_9_additional_analyses.R
raw_data_af.xlsx
raw_data_step_1.xlsx
raw_data_step_2.xlsx
raw_data_step_3.xlsx
raw_data_step_4.xlsx
final_dataset.xlsx

.[raw_data]
... raw_data.xlsx
... definition_of_variables.xlsx
.[data]
... main_dataset.xlsx
... definition_of_variables.xlsx
.[code]
... prepare_data.R
... do_analyses.R
.[output] <includes your 'products'>
... set_of_table_and_figures.docx
masterfile.R

(+ use if-else-clauses to check if a certain step was already carried out)

Example 2: A data folder

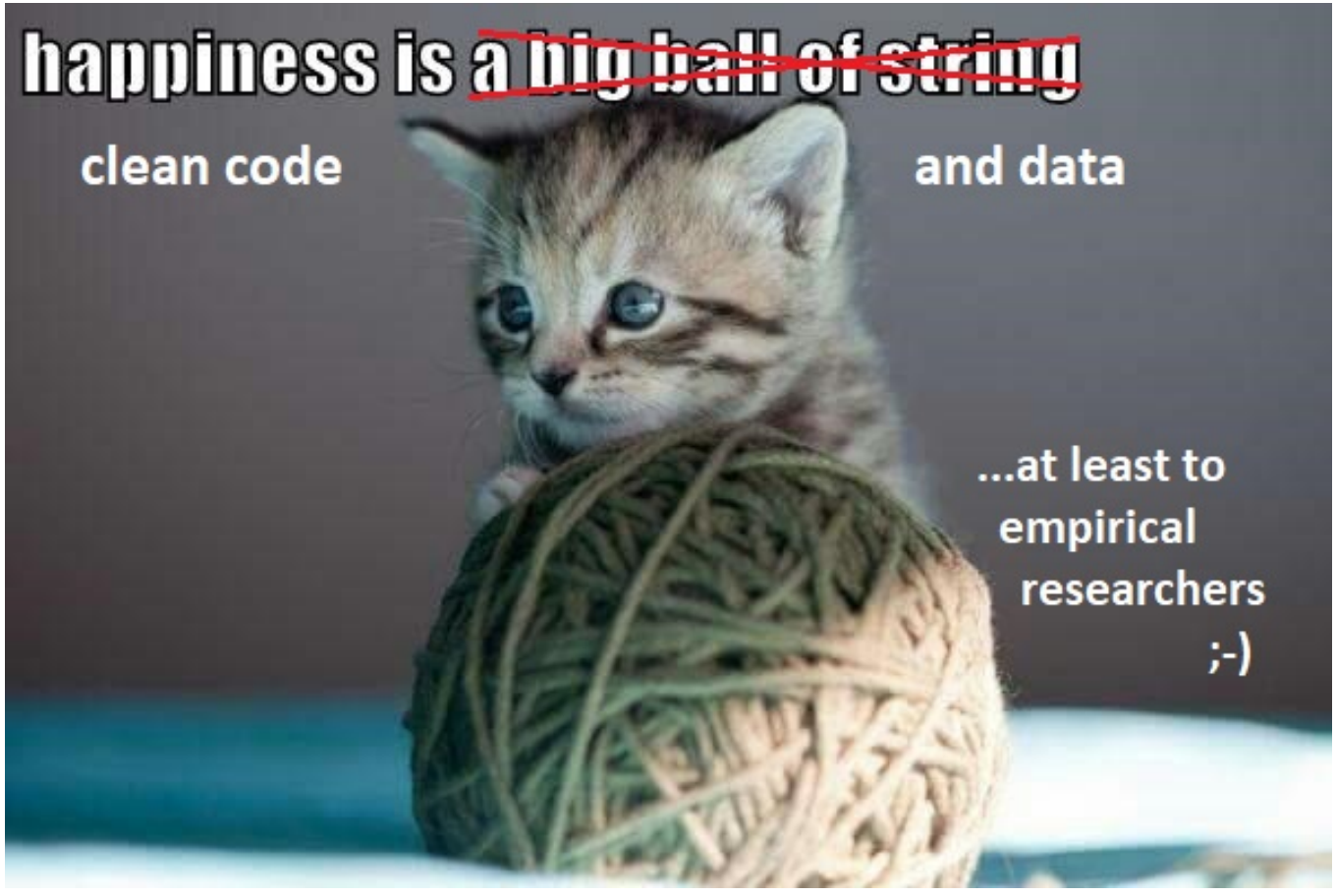
.['MainTestsData']
.['MainTestsData_v2']
data_A_yearly_v1.xlsx
data_A_yearly_v1.csv
data_B_yearly_v2.xlsx
data_B_yearly_v2.csv
data_C_yearly_final.xlsx
data_C_yearly_final.csv
data_C_yearly_final.txt
data_C_yearly_final2.txt
data_D_compustat_2005_20220210.txt
data_E_analysis_1.txt
data_E_analysis_1.xlsx
data_F_analysis_2.txt
data_F_analysis_2.xlsx

Example 2: A data folder (ctd.)

.['MainTestsData']
.['MainTestsData_v2']
data_A_yearly_v1.xlsx
data_A_yearly_v1.csv
data_B_yearly_v2.xlsx
data_B_yearly_v2.csv
data_C_yearly_final.xlsx
data_C_yearly_final.csv
data_C_yearly_final.txt
data_C_yearly_final2.txt
data_D_compustat_2005_20220210.txt
data_E_analysis_1.txt
data_E_analysis_1.xlsx
data_F_analysis_2.txt
data_F_analysis_2.xlsx

.[data]
... main_dataset.csv
... component_compustat.csv
... component_ibes.csv
... component_capitaliq.csv
... definition_of_variables.csv

Thanks for listening!



Resources

- The Python File Structure Tree was taken from AlexDCode (2020).
- The TRR 266 Template for Reproducible Empirical Accounting Research is available from TRR 266 (2021).
- Free data science resources: https://github.com/alastairrushworth/free-data-science
- Great book on data science using Python: VanderPlas (2016)
- Nice overview on Stata for data science: stata.com (n.d.)
- Read about tidy data here: Wickham (2014)
- Licensing of code and data: C02 Open Science office hours, Creative Commons (n.d.)
- Do's and don'ts from a survey of software developers (datree.io 2019)

Goals and characteristics of research templates

Reasons to follow a standard structure (AlexDCode 2020):

1. You avoid confusion
2. It is as simple as possible
3. You keep your code clean, neat, structured, and clutter free
4. The file structure system is modular
5. Each folder has an explanation
6. More documentation in the folder itself
7. Hierarchical tree file organization system
8. Standard for small to medium size projects
9. ...

References

AlexDCode. 2020. "Software Development Project Structure: A Template for Different Programming Languages." https://github.com/AlexDCode/Software-Development-Project-Structure.

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