Conquering confounds and covariates in machine learning and neuroscience

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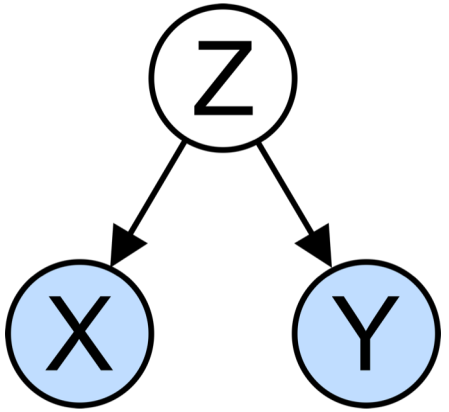
What are confounds?

- Causal definition^ from statistics: A confound* is a variable (z) that influences both the dependent variable (y) and independent variable (X), causing a *spurious* association between X and y
  - X and Y are confounded by z, if z causally influence both X and y
  - To estimate the effect of X on Y, we must suppress or remove the effects of z, that influence both X and y
- Neuroimaging example: X is often imaging features, y is patient diagnosis, and *z* are age + gender.



^ From Wikipedia *Also called a covariate, confounding factor, nuisance variable, lurking variable etc

Typical confounds/covariates

- Age
- Sex, Gender
- ICV, GMV, TBV
- Site, scanner
- Education, Intelligence
- Income, SES
- BMI, blood pressure, hypertension
- Lifestyle: exercise, smoking, alcohol
- Morphometrics
  - mean cortical thickness

And they are quite common in most of the studies and datasets now!

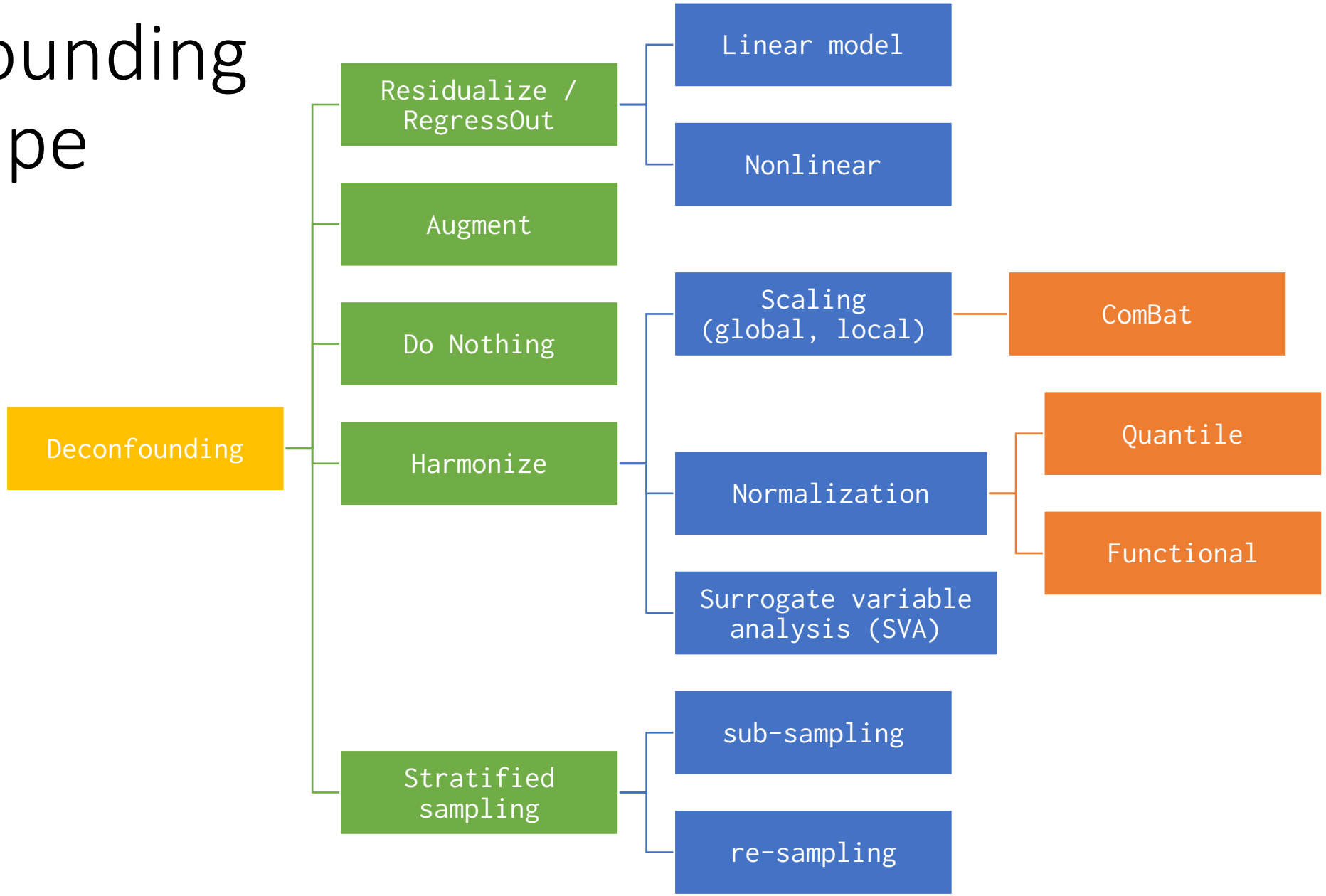
Open Challenges

- Common approach: *pick some potential confounding variables, regress them out, and pretend everything is fine!*
- BUT life and science aren't that simple!
  - there is no clear, accepted definition and method to establish whether a given variable is indeed a confound!
  - It is often assumed they are, but their level of confounding is not properly quantified
- when should we try to de-confound it?
  - how do we know we did it right?
- how do we properly assess their impact?
  - how are the confounds / deconfounding methods affecting a given analysis?

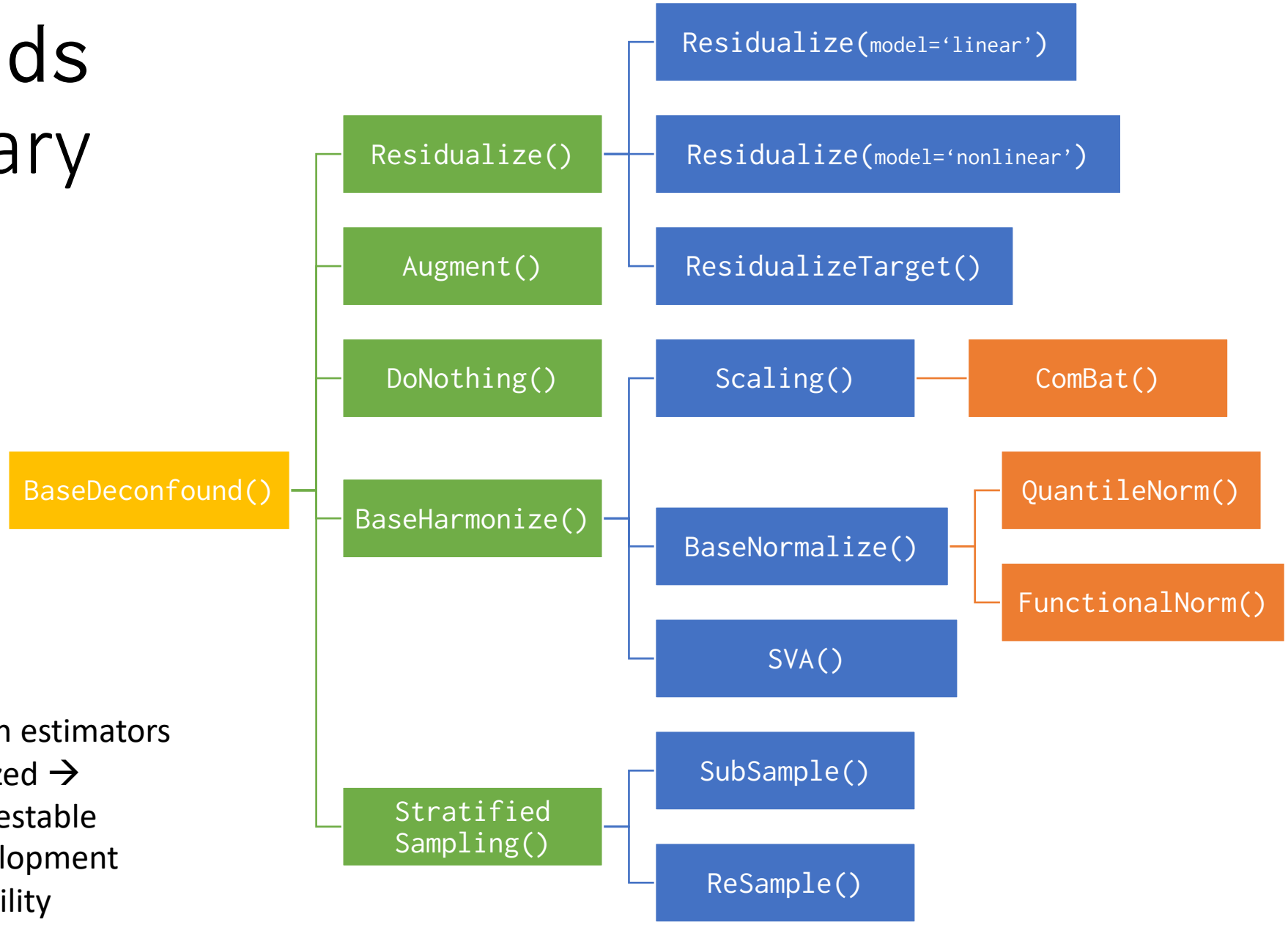
confounds library aims to help solve these challenges

- with an open-source high-quality well-tested library
- to visualize and establish the presence of confounds
  - e.g. quantifying confound-to-target relationships
- to offer solutions to handle them appropriately via correction or removal etc
- analyze the effect of the deconfounding methods in the processed data e.g.
  - ability to check if deconfounding methods worked at all
  - **or if they introduced new or unwanted biases etc**

Deconfounding Landscape



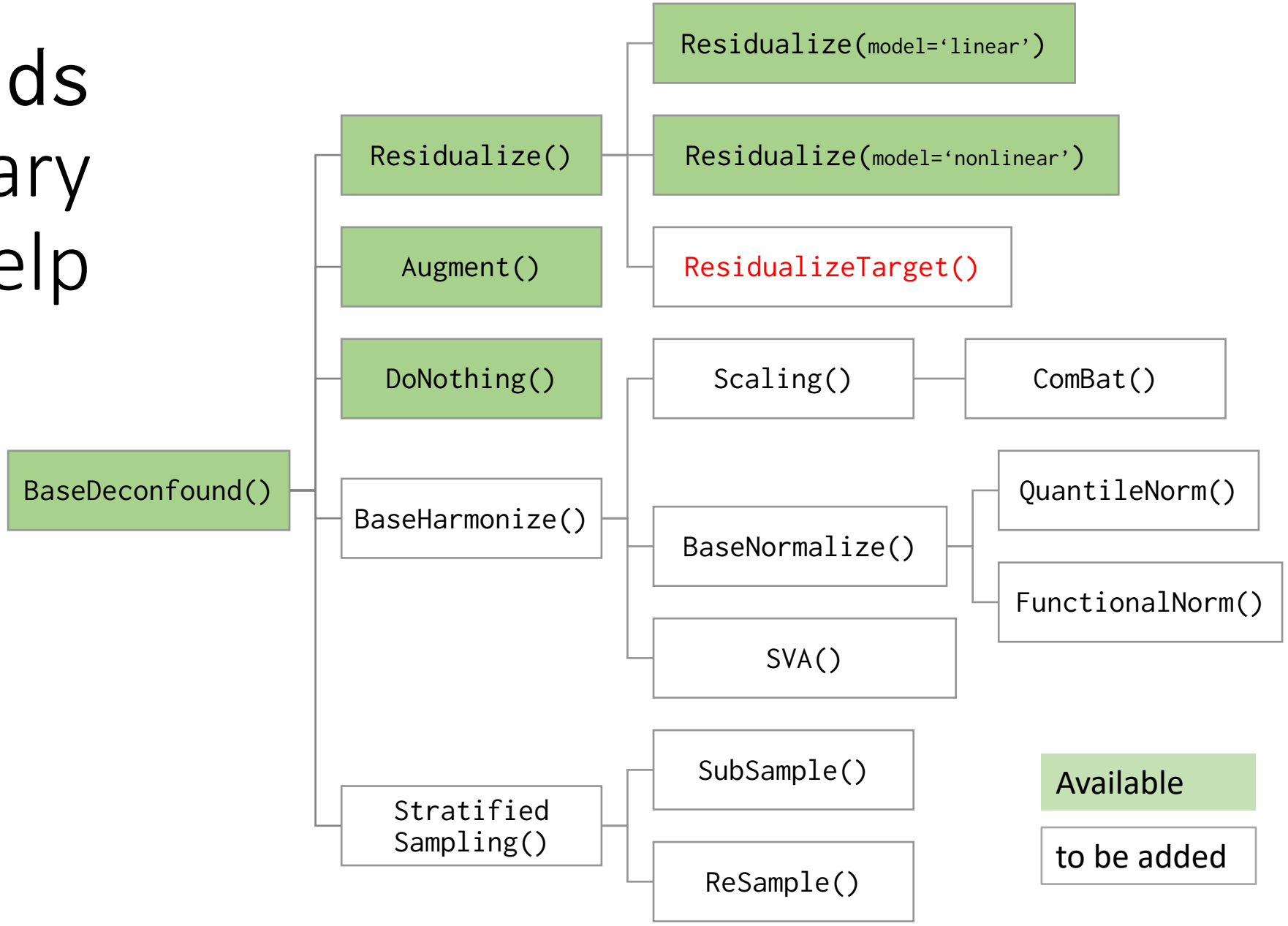
confounds library



Great features:

- act as scikit-learn estimators
- highly modularized → extensible and testable
- test-driven development
- focused on usability

confounds library needs help



Contribute to a great cause!

- `github.com/raamana/confounds`

- Focus of my OHBM'20 hackathon
  - Implement ComBat
    - from the ground up in Python
    - properly tested
      - individual components
      - as well as the whole
  - Related helpers and utils
    - viz tools
    - metrics etc