Imputation

Imputing data

Need to specify

- Imputation method
- Variable(s) to impute
- Variables used as predictor

Simputation's goal

Easy to experiment, robust enough for production.

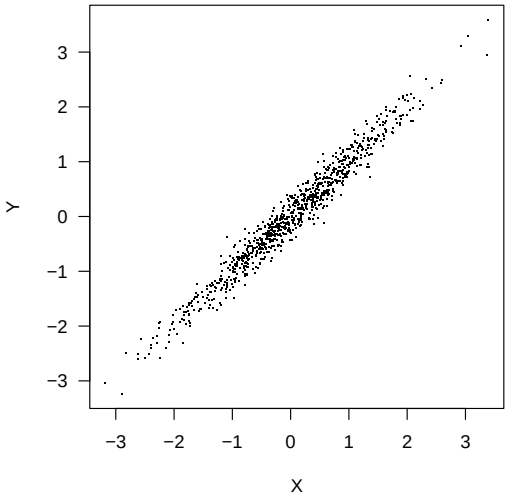
Simputation interface

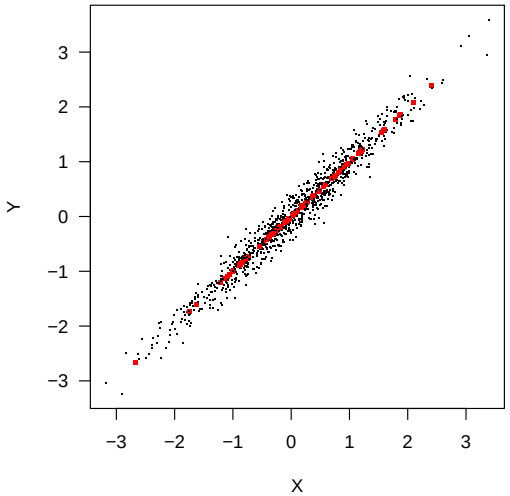
```
impute_<model>(data, imputed_variables ~ predictors, ...)
```

Imputing data with simputation

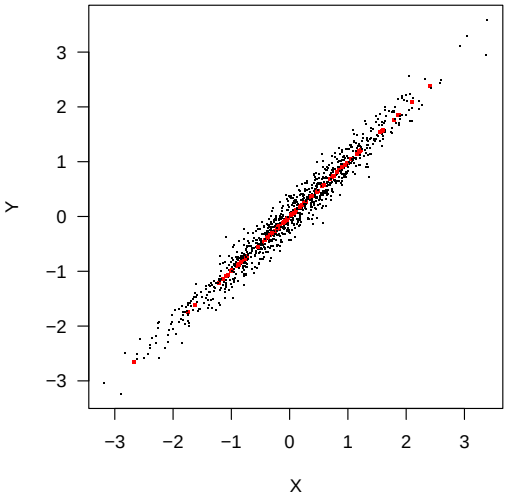
<model>	description
`proxy`	copy (transformation of) other variable(s)
`median`	(group-wise) median
`rlm`, `lm`, `en`	(robust) linear model, elasticnet regression
`cart`, `rf`	Classification And Regression Tree, RandomForest
`em`, `mf`	EM-alogithm (multivariate normal) `missForest`
`knn`	k nearest neighbours
`shd`, `rhd`	sequential, random, hot-deck
`pmm`	predictive mean matching
`impute_model`	use pre-trained model

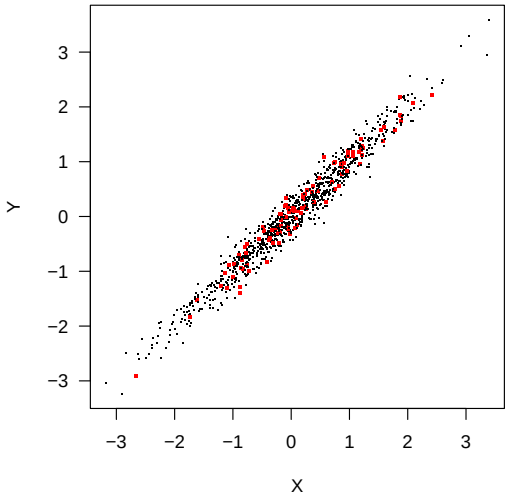
Imputation of the mean





Adding a random residual





Adding a random residual with simputation

Example

```
impute_rlm(companies, other.rev ~ turnover
         , add_residual = "normal")
```

Options

- "none"‘: (default)
- "normal"‘: from $N(0, \hat{\sigma})$
- "observed"‘: from observed residuals

Chaining methods

Example

```
companies %>%
  impute_lm(turnover ~ staff + profit) %>%
  impute_lm(turnover ~ staff)
```

More on missing data and (s)imputation

Missing data

Reasons

- nonresponse, data loss
- Value is observed but deemed wrong and erased

Solutions

- Measure/observe again
- Ignore
- Take into account when estimating
- **Impute**

Missing data mechanisms

Missing comletely at Random (MCAR)

Missingness is totally random.

Missing at Random (MAR)

Missingness probability can be modeled by other variables

Not Missing at Random (NMAR)

Missingness probability depends on missing value.

You can't tell the mechanism from the data

NMAR can look like MCAR

Given Y, X independent. Remove all $y \geq y^*$. Observer 'sees' no correlation between missingness and values of X: MAR.

NMAR can look like MAR

Given Y, X with $\text{Cov}(Y, X) > 0$. Remove all $y \geq y^*$. Observer 'sees' that higher X correlates with more missings in Y: MCAR.

Dealing with missing data mechanisms

Missing comletely at Random (MCAR)

Model-based imputation

Missing at Random (MAR)

Model-based imputation

Not Missing at Random (NMAR)

No real solution.

Imputation methodology

Model based

Estimate a value based on observed variables.

Donor-imputation

Copy a value from a record that you did observe.

The simputation package

Provide

- a *uniform interface*,
- with *consistent behaviour*,
- across *commonly used methodologies*

To facilitate

- experimentation
- configuration for production

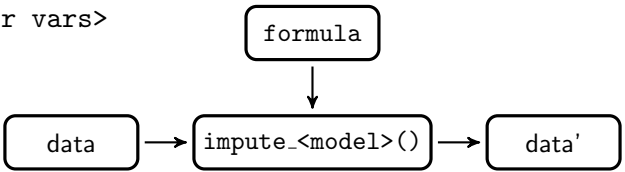
The simputation package

An imputation prodedure is specified by

1. The variable to impute
2. An imputation model
3. Predictor variables

The simputation interface

```
impute_<model>(data
  , <imputed vars> ~ <predictor vars>
  , [options])
```



Chaining methods


```
ret %>%
  impute_rlm(other.rev ~ turnover) %>%
  impute_rlm(other.rev ~ staff) %>% head(3)
```

```
##   staff turnover other.rev total.rev staff.costs total.costs profit vat
## 1    75       NA  64.88174      1130          NA       18915  20045  NA
## 2     9     1607  17.25247      1607         131        1544     63  NA
## 3    NA     6886 -33.00000      6919         324        6493    426  NA
```