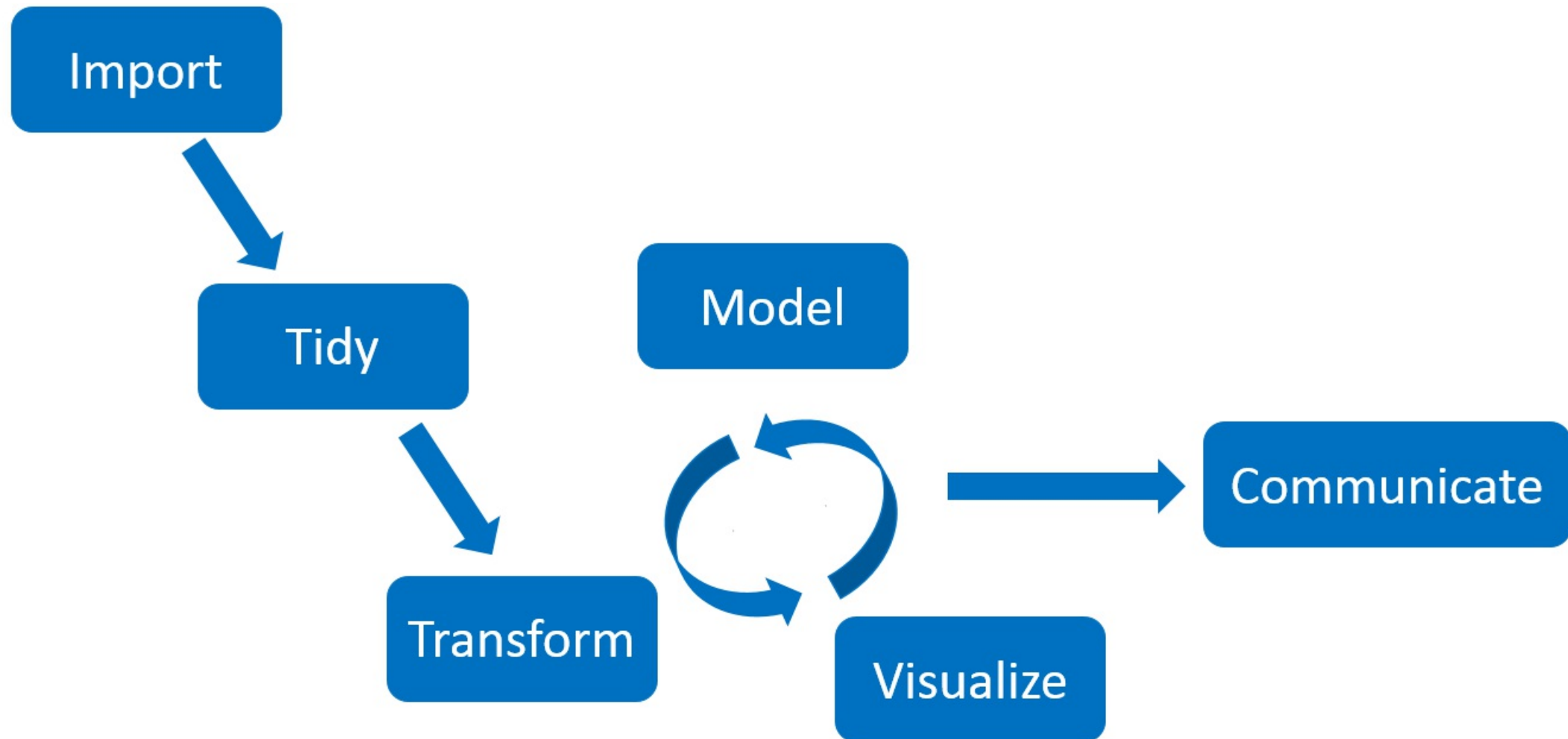


Reproducible workflows at scale with drake

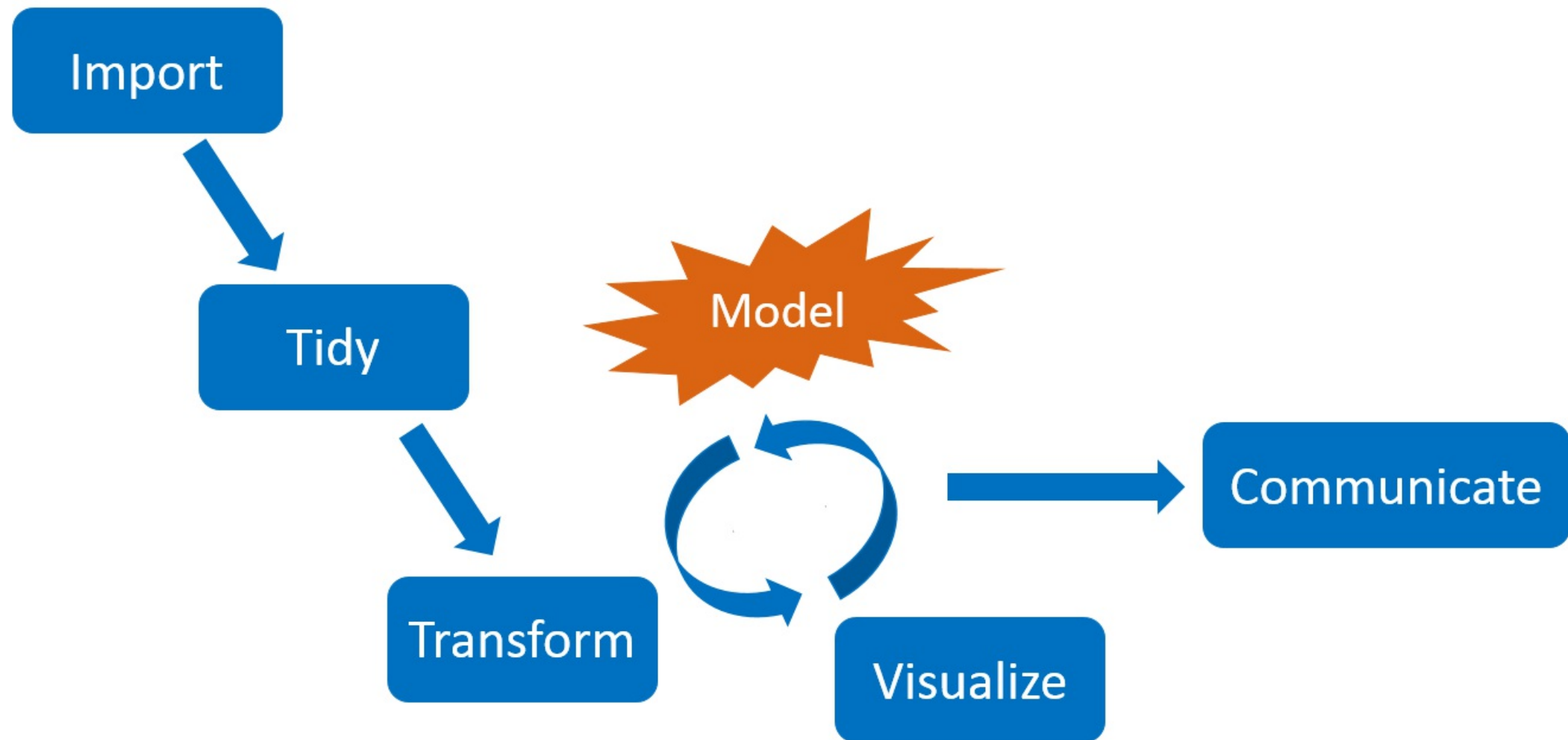


Will Landau

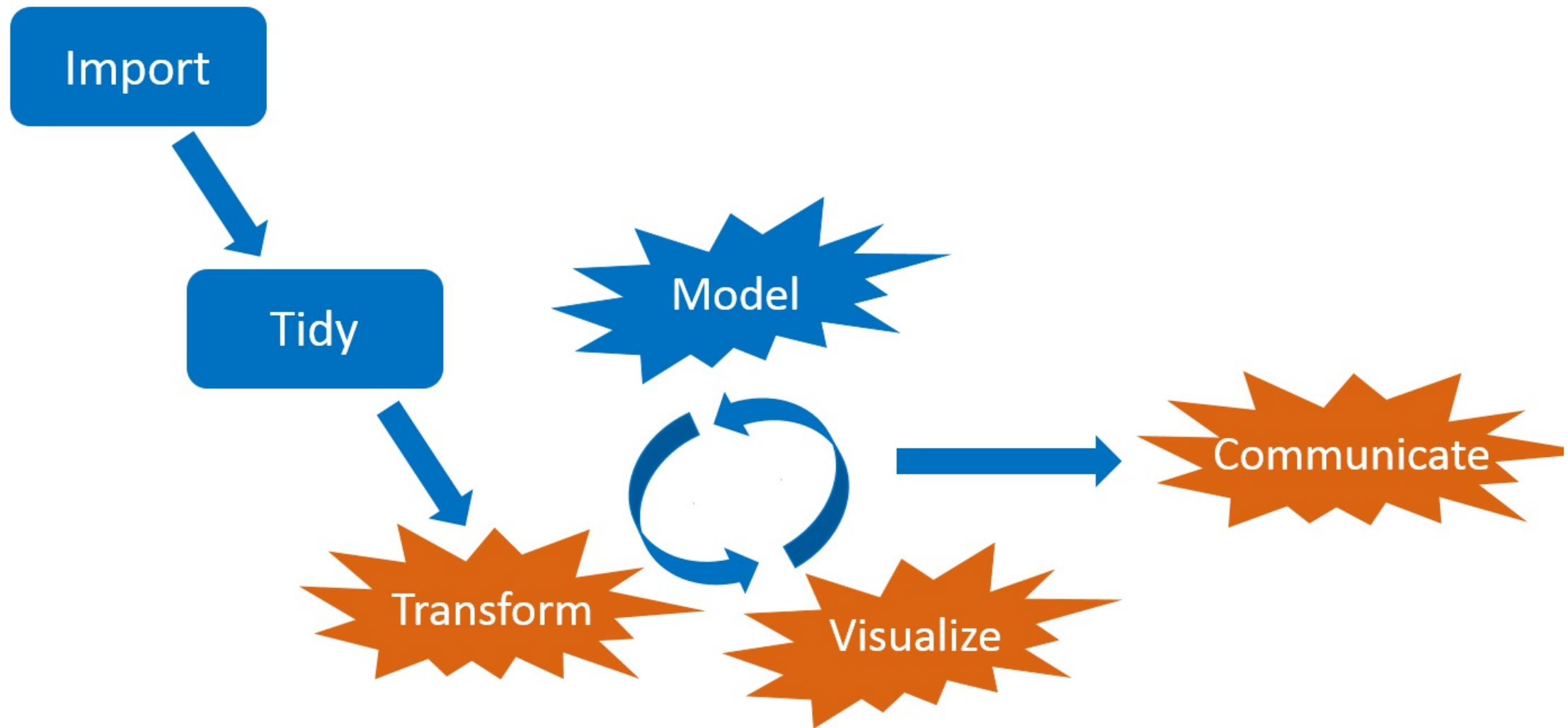
Workflows have interconnected steps.



When you change something...



...the downstream steps are no longer valid.



Do you rerun everything from scratch?

- Not if you deal with long runtimes!



<https://openclipart.org/detail/275842/sisyphus-overcoming-silhouette>

Do you pick and choose what to update?

- Messy.
- Prone to human error.
- Not reproducible.



<https://openclipart.org/detail/216179/messy-desk>

When do we face these issues?

- Long computation!
 - **Deep learning**
 - Classical machine learning.
 - Bayesian computation, e.g. Markov chain Monte Carlo.
 - Spatial data analysis.
 - Clinical trial modeling and simulation.
 - Subgroup identification.
 - Graph-based multiple comparison procedures.
 - Genomics pipelines.
 - PK/PD modeling (e.g. `mrgsolve`)
 - ...

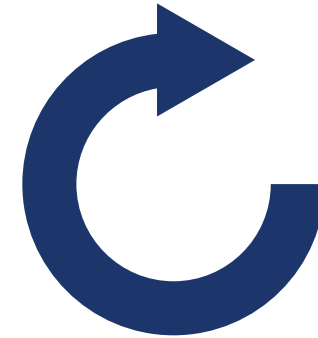
Solution: pipeline tools



Scale up the
work you need.



Skip the
work you don't.



See evidence of
reproducibility.

- Tons exist already: github.com/pditommaso/awesome-pipeline.
- Most are language-agnostic or designed for Python or the shell.

What makes drake different?



- Aggressively designed for R.
 - Think **functions**, not script files.
 - Think **variables**, not output files.
 - Think **data frames**, not Makefiles.
- Major improvements in late 2018 and early 2019:
 - A **domain-specific language** for workflows.
 - Increased speed and reduced memory usage.
 - **More reproducibility safeguards.**
 - **History and provenance.**
 - **Reproducible data recovery and renaming (experimental).**

Example: a deep learning workflow

- Goal: predict customers who cancel their subscriptions with a telecom company.
- Data: **IBM Watson Telco Customer Churn dataset**.
- Workflow principles generalize to other industries.



<https://openclipart.org/detail/90739/newplus>, <https://github.com/rstudio/keras>

File structure

```
make.R  
R/  
├─ packages.R  
├─ functions.R  
└─ plan.R  
data/  
└─ customer_churn.csv
```

packages.R

```
library(drake)  
library(keras)  
library(recipes)  
library(rsample)  
library(tidyverse)  
library(yardstick)
```

functions.R

```
prepare_recipe <- function(data) {  
  # ...  
}  
  
define_model <- function(rec, units1, units2, act1, act2, act3) {  
  # ...  
}  
  
train_model <- function(data, rec, units1, units2, act1, act2, act3) {  
  # ...  
}  
  
confusion_matrix <- function(data, rec, model) {  
  # ...  
}  
  
compare_models <- function(...) {  
  # ...  
}
```

plan.R

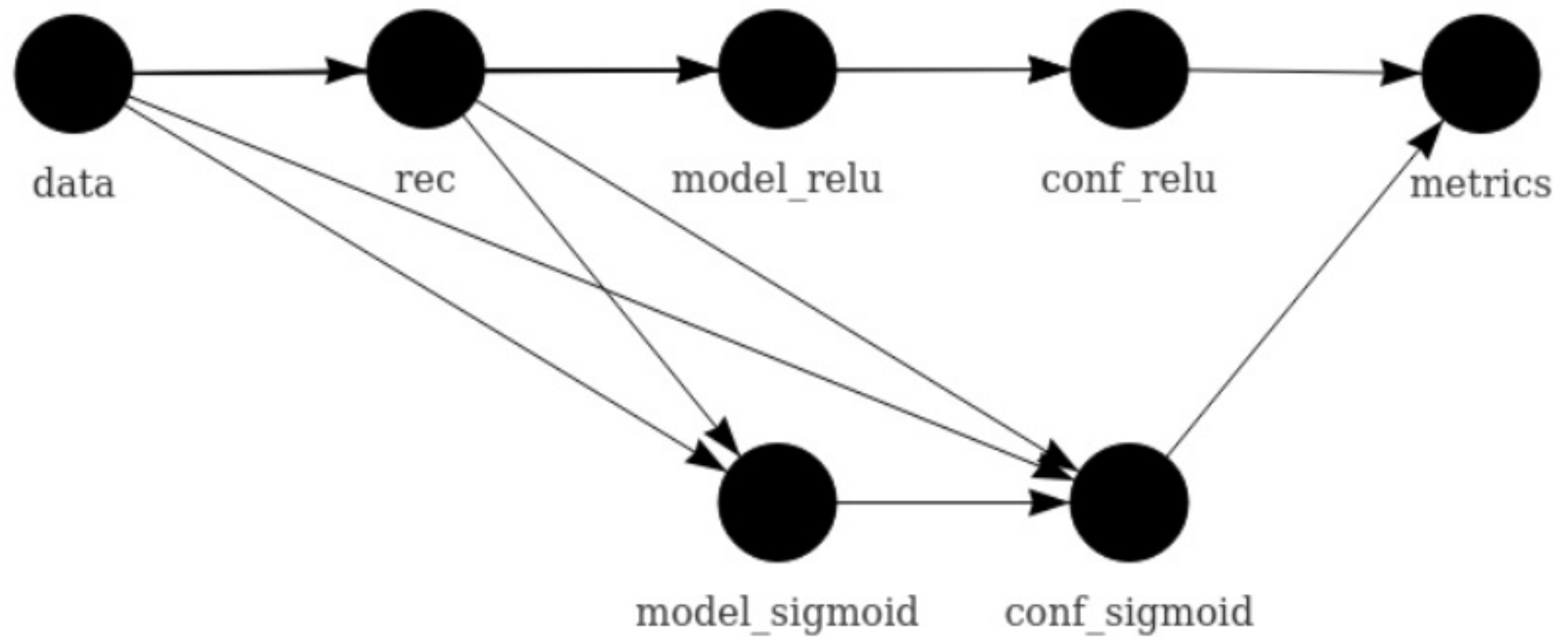
```
activations <- c("relu", "sigmoid")

plan <- drake_plan(
  data = read_csv(file_in("data/customer_churn.csv"), col_types = cols()) %>%
    initial_split(prop = 0.3),
  rec = prepare_recipe(data),
  model = target(
    train_model(data, rec, act1 = act),
    format = "keras",
    transform = map(act = !!activations)
  ),
  conf = target(
    confusion_matrix(data, rec, model),
    transform = map(model, .id = act)
  ),
  metrics = target(
    compare_models(conf),
    transform = combine(conf)
  )
)
```

Data frame of workflow steps

```
plan
## # A tibble: 7 x 3
##   target      command                                format
##   <chr>      <expr>                                <chr>
## 1 data      read_csv(file_in("data/customer_churn.csv"), col_type... <NA>
## 2 rec       prepare_recipe(data)                                ... <NA>
## 3 model_relu train_model(data, rec, act1 = "relu")                ... keras
## 4 model_sigm... train_model(data, rec, act1 = "sigmoid")              ... keras
## 5 conf_relu  confusion_matrix(data, rec, model_relu)                ... <NA>
## 6 conf_sigmo... confusion_matrix(data, rec, model_sigmoid)             ... <NA>
## 7 metrics   compare_models(conf_relu, conf_sigmoid)              ... <NA>
```

The workflow

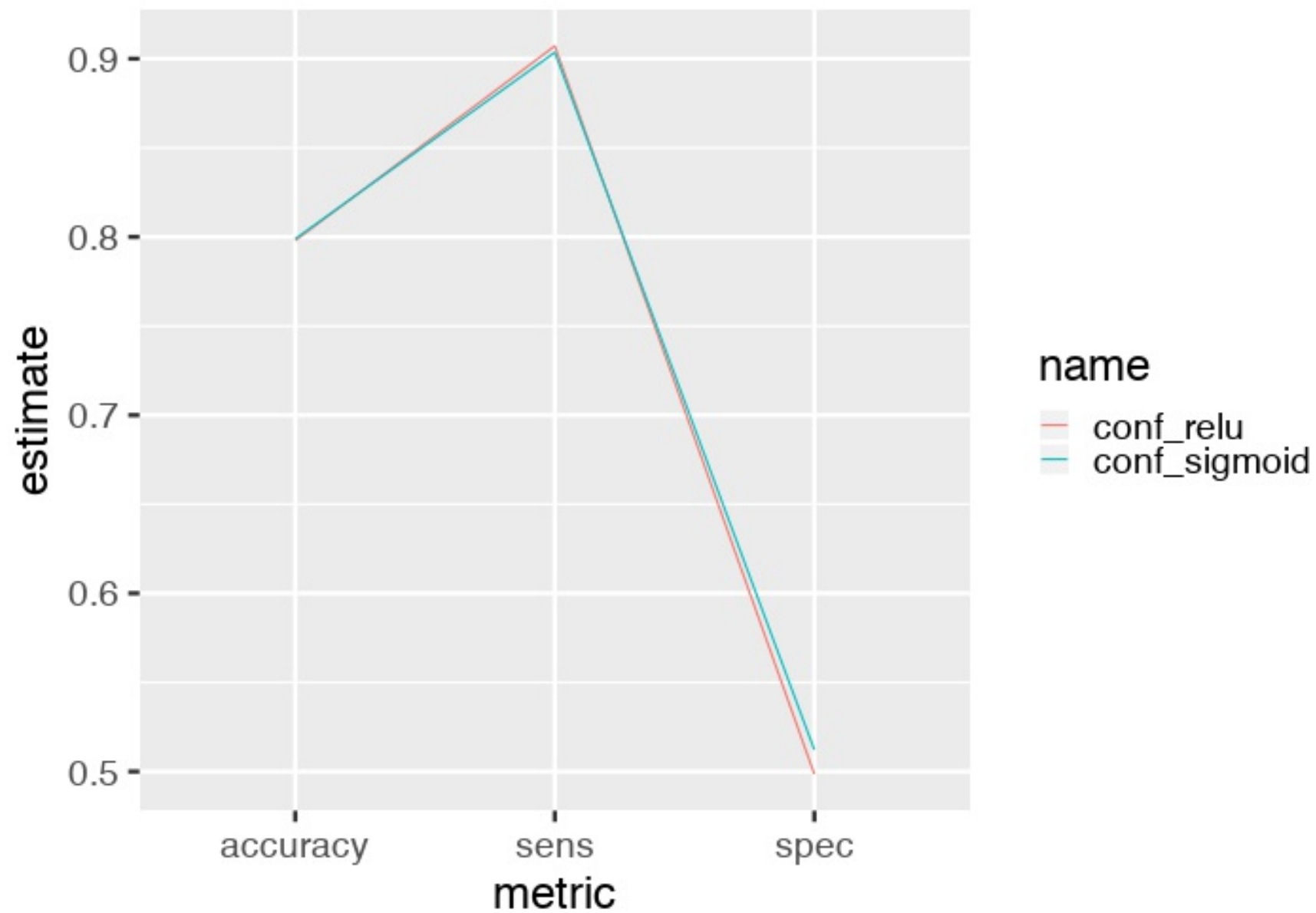


Run the project in make.R.

```
source("R/packages.R")  
source("R/functions.R")  
source("R/plan.R")  
  
make(plan)  
## target data  
## target rec  
## target model_relu  
## target model_sigmoid  
## target conf_relu  
## target conf_sigmoid  
## target metrics
```

Compare models.

```
readd(metrics) # See also loadd()
```

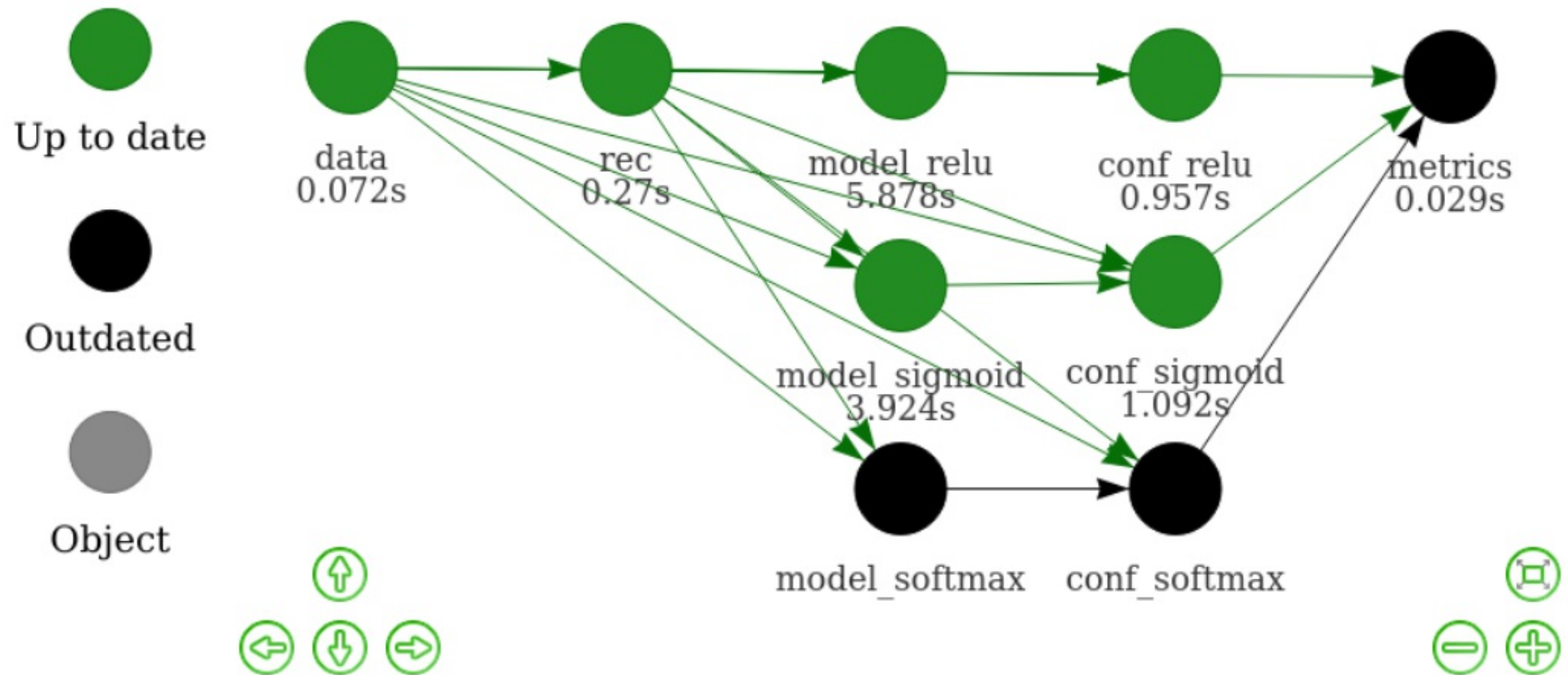


Try another activation function.

```
activations <- c("relu", "sigmoid", "softmax")

plan <- drake_plan(
  data = read_csv(file_in("data/customer_churn.csv"), col_types = cols()) %>%
    initial_split(prop = 0.3),
  rec = prepare_recipe(data),
  model = target(
    train_model(data, rec, act1 = act),
    format = "keras",
    transform = map(act = !!activations)
  ),
  conf = target(
    confusion_matrix(data, rec, model),
    transform = map(model, .id = act)
  ),
  metrics = target(
    compare_models(conf),
    transform = combine(conf)
  )
)
```

vis_drake_graph()



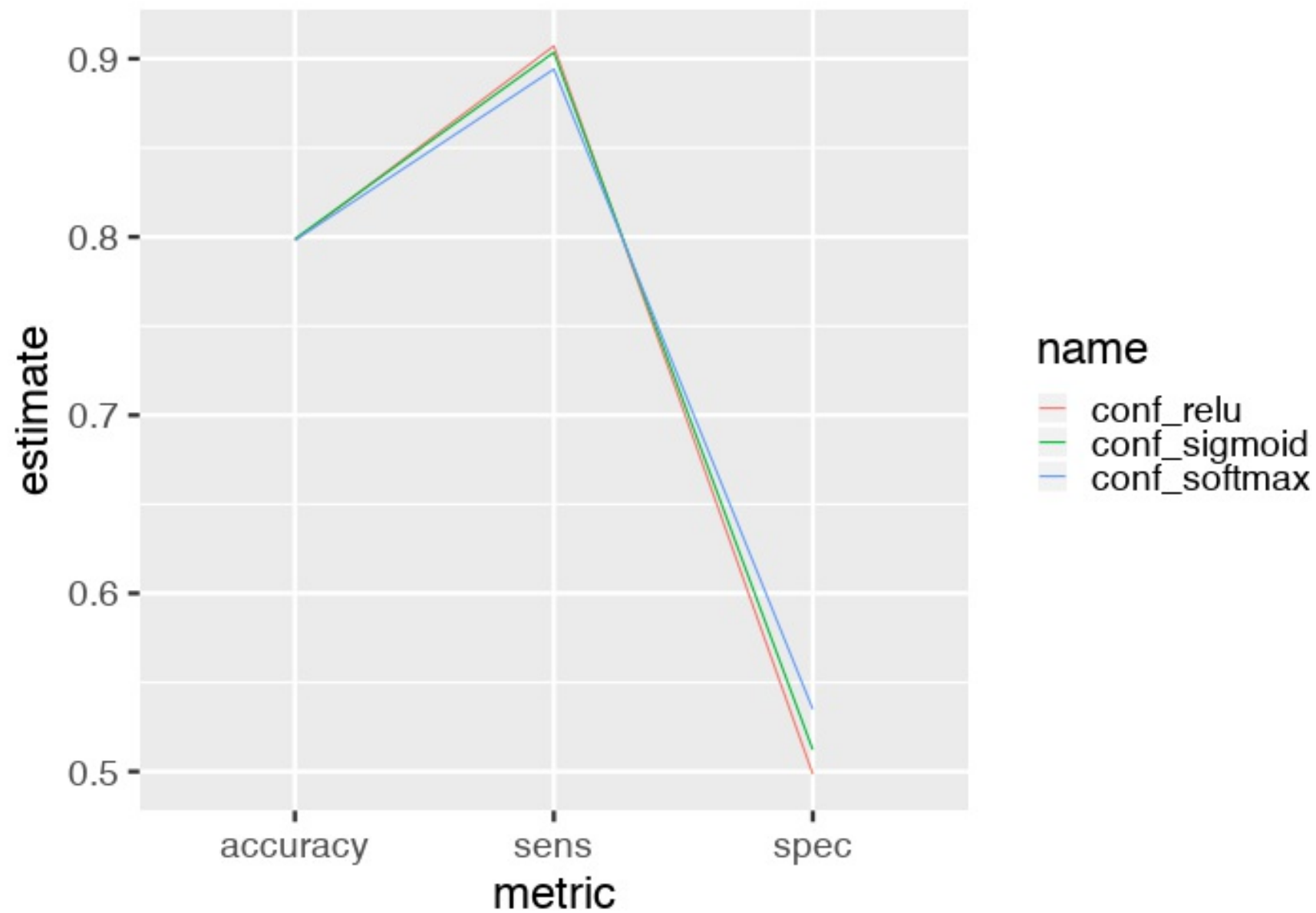
Refresh the results in make.R.

```
source("R/packages.R")  
source("R/functions.R")  
source("R/plan.R") # modified
```

```
make(plan)  
## target model_softmax  
## target conf_softmax  
## target metrics
```

Compare models.

```
readd(metrics)
```



Evidence of reproducibility

```
source("R/packages.R")
source("R/functions.R")
source("R/plan.R")

make(plan)
## All targets are already up to date.
```

- See also `outdated()`.

Specialized data formats

- Increased speed and reduced memory consumption

```
library(drake)
n <- 1e8 # Each target is 1.6 GB in memory.
plan <- drake_plan(
  data_fst = target(
    data.frame(x = runif(n), y = runif(n)),
    format = "fst"
  ),
  data_old = data.frame(x = runif(n), y = runif(n))
)
make(plan)
#> target data_fst
#> target data_old
build_times(type = "build")
#> # A tibble: 2 x 4
#>   target      elapsed      user      system
#>   <chr>    <Duration>    <Duration>    <Duration>
#> 1 data_fst 13.93s      37.562s      7.954s
#> 2 data_old 184s (~3.07 minutes) 177s (~2.95 minutes) 4.157s
```


History and provenance

```
drake_history()
## # A tibble: 10 x 10
##   target    current built exists hash  command      seed runtime  prop act
##   <chr>    <lgl>    <chr> <lgl> <chr> <chr>      <int>   <dbl> <dbl> <chr>
## 1 conf_r... TRUE    2019-... TRUE  880e... confusio... 4.05e8   0.224   NA    <NA>
## 2 conf_s... TRUE    2019-... TRUE  9211... confusio... 1.93e9   0.238   NA    <NA>
## 3 conf_s... TRUE    2019-... TRUE  793c... confusio... 1.80e9   0.228   NA    <NA>
## 4 data      TRUE    2019-... TRUE  1347... "read_cs... 1.29e9   0.0410  0.3    <NA>
## 5 metrics  FALSE    2019-... TRUE  3b36... compare_... 1.21e9   0.0290  NA     <NA>
## 6 metrics  TRUE     2019-... TRUE  fd9a... compare_... 1.21e9   0.0270  NA     <NA>
## 7 model_... TRUE     2019-... TRUE  d623... "train_m... 1.47e9   5.06    NA     rel
## 8 model_... TRUE     2019-... TRUE  5228... "train_m... 1.26e9   3.21    NA     sig
## 9 model_... TRUE     2019-... TRUE  283a... "train_m... 8.05e8   3.62    NA     sof
## 10 rec      TRUE     2019-... TRUE  1478... prepare_... 6.29e8   0.181   NA     <NA>
```

Reproducible data recovery

```
clean() # Oops!

start <- proc.time()
make(plan, recover = TRUE)
## recover data
## recover rec
## recover model_relu
## recover model_sigmoid
## recover model_softmax
## recover conf_relu
## recover conf_sigmoid
## recover conf_softmax
## recover metrics

proc.time() - start
##      user  system elapsed
##    0.088    0.036    0.232
```

- Details + how to rename a target: <https://ropenscilabs.github.io/drake-manual/walkthrough.html#automated-recovery-and-renaming>

High-performance computing

```
# template file with configuration
drake_hpc_template_file("slurm_clustermq.tmpl")

# Use SLURM resource manager with the template.
options(
  clustermq.scheduler = "slurm",
  clustermq.template = "slurm_clustermq.tmpl"
)

# make() is the basically the same.
make(plan, jobs = 2, parallelism = "clustermq")
```

High-performance computing

Resources

- Get **drake**:

```
install.packages("drake")
```

- Workshop materials:

```
remotes::install_github("wlandau/learndrake")
```

- Example code from these slides:

```
drake::drake_example("customer-churn")
```

Links

- Development repository: <https://github.com/ropensci/drake>
- Full user manual <https://ropenscilabs.github.io/drake-manual>
- Reference website: <https://ropensci.github.io/drake>
- Code examples: <https://github.com/wlandau/drake-examples>
- Discuss at rOpenSci.org: <https://discuss.ropensci.org>

rOpenSci use cases

- Use **drake**? Share your use case at <https://ropensci.org/usecases>.



Thanks



- Edgar Ruiz
- example code



- Matt Dancho
- blog post

Thanks



- Maëlle Salmon
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- Stefanie Butland

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- Michael Schubert
- Kendon Bell
- Miles McBain
- Patrick Schratz
- Alex Axthelm
- Jasper Clarkberg
- Tiernan Martin
- Ben Listyg
- TJ Mahr
- Ben Bond-Lamberty
- Tim Mastny
- Bill Denney
- Amanda Dobbyn
- Daniel Falster
- Rainer Krug
- Brianna McHorse
- Chan-Yub Park