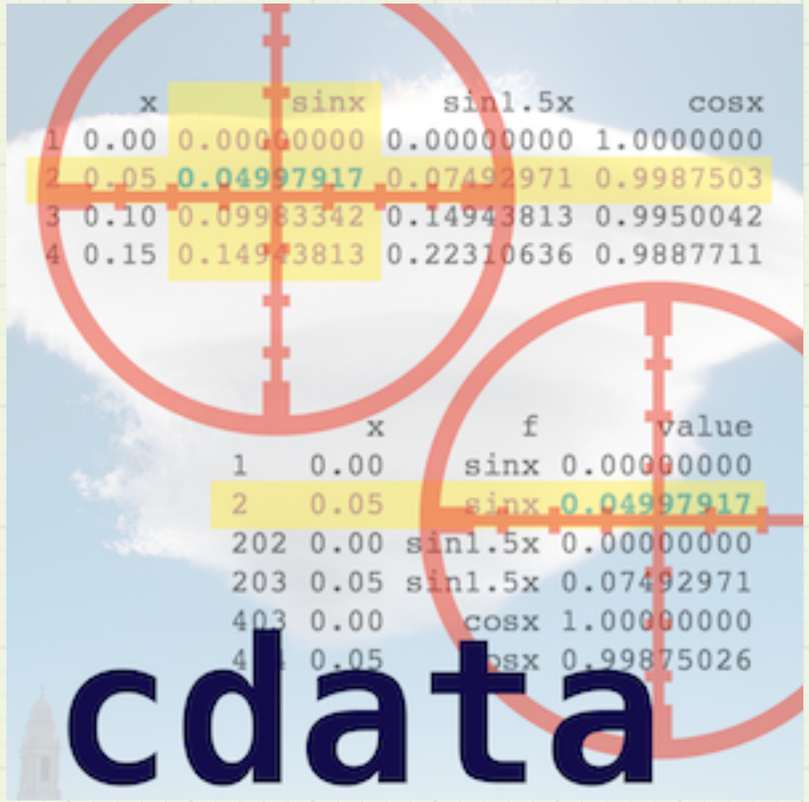
cdata

Fluid Data Transforms at Scale in R



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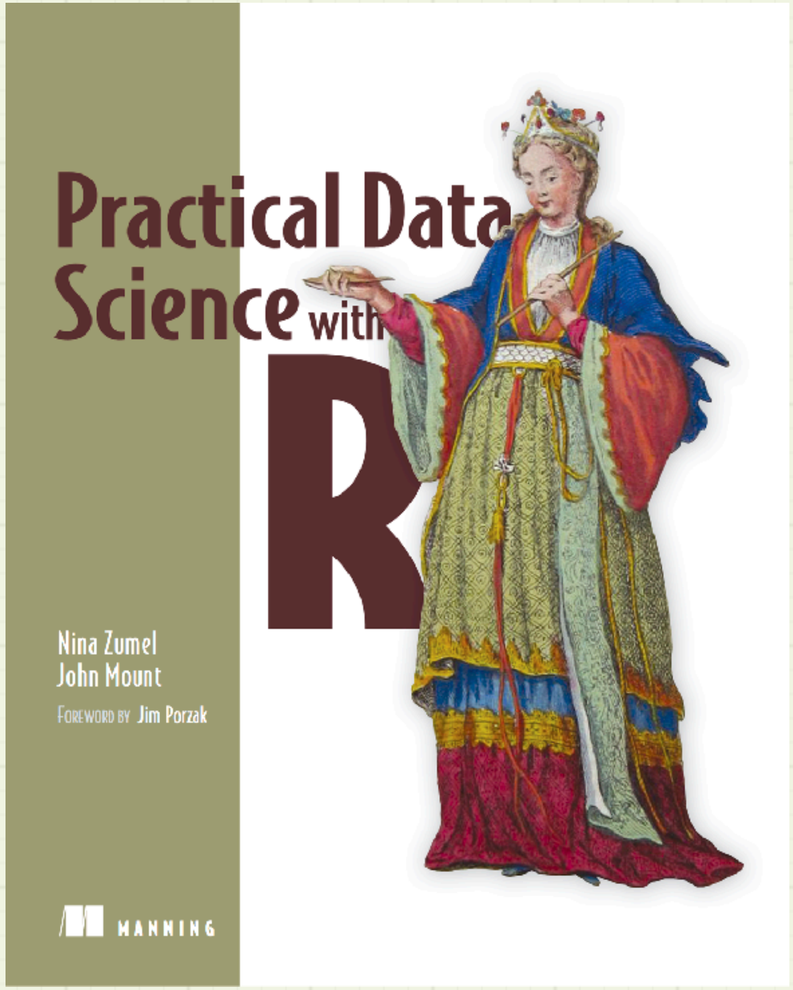
These slides:
https://github.com/WinVector/cdata/blob/master/extras/cdata.pdf

Win-Vector LLC

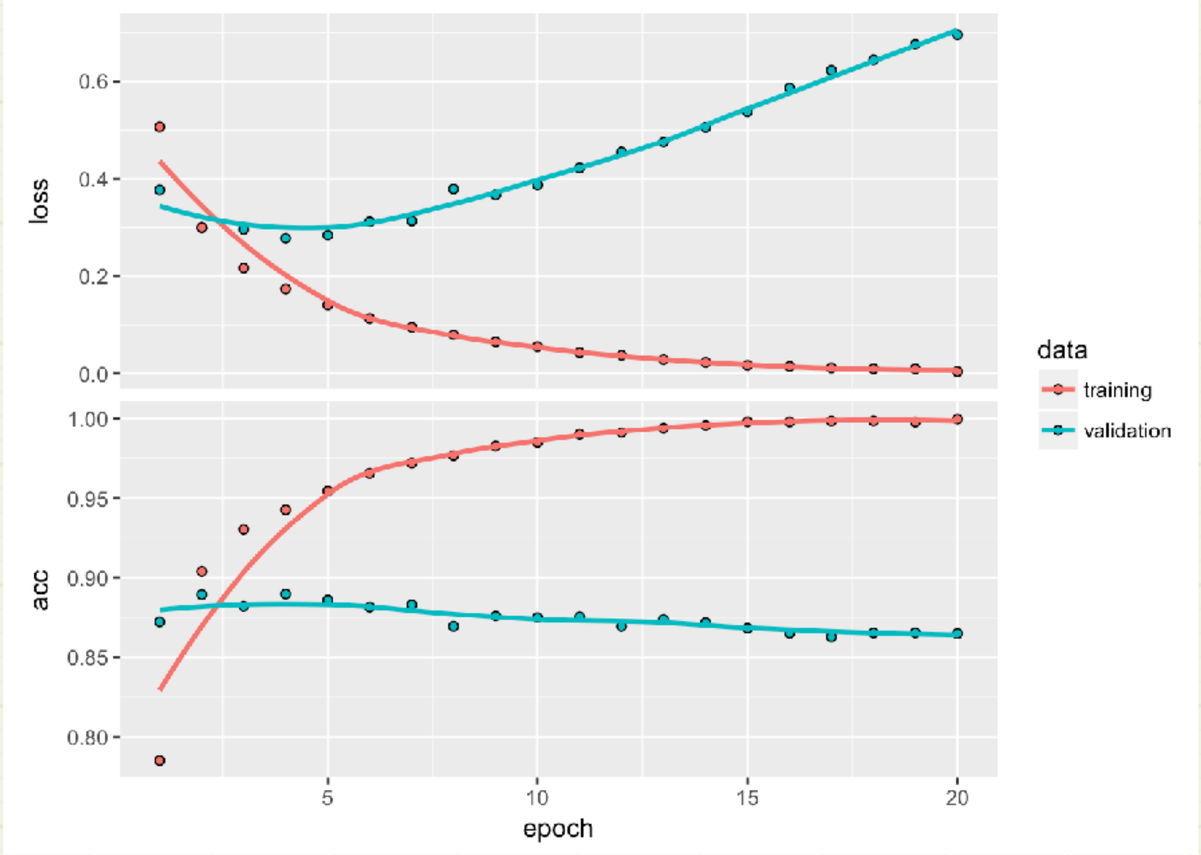
Who Am I?

- John Mount
- Principal Consultant at Win-Vector LLC (data science consulting and training).
- One of the authors of *Practical Data Science with R* (Manning 2014).
- Co-author of a number of R packages
    - **vtreat**: statistically sound advanced data preparation
    - **wrapr**: sweet code tools for R
    - **cdata**: fluid data transforms at scale
    - (in development) **rquery**: reliable big data operators (piped **SQL**).
    - and more
- Contributor to the Win-Vector Blog, read by data scientists worldwide
- Frequent speaker on algorithms, statistics, machine learning and data science topics

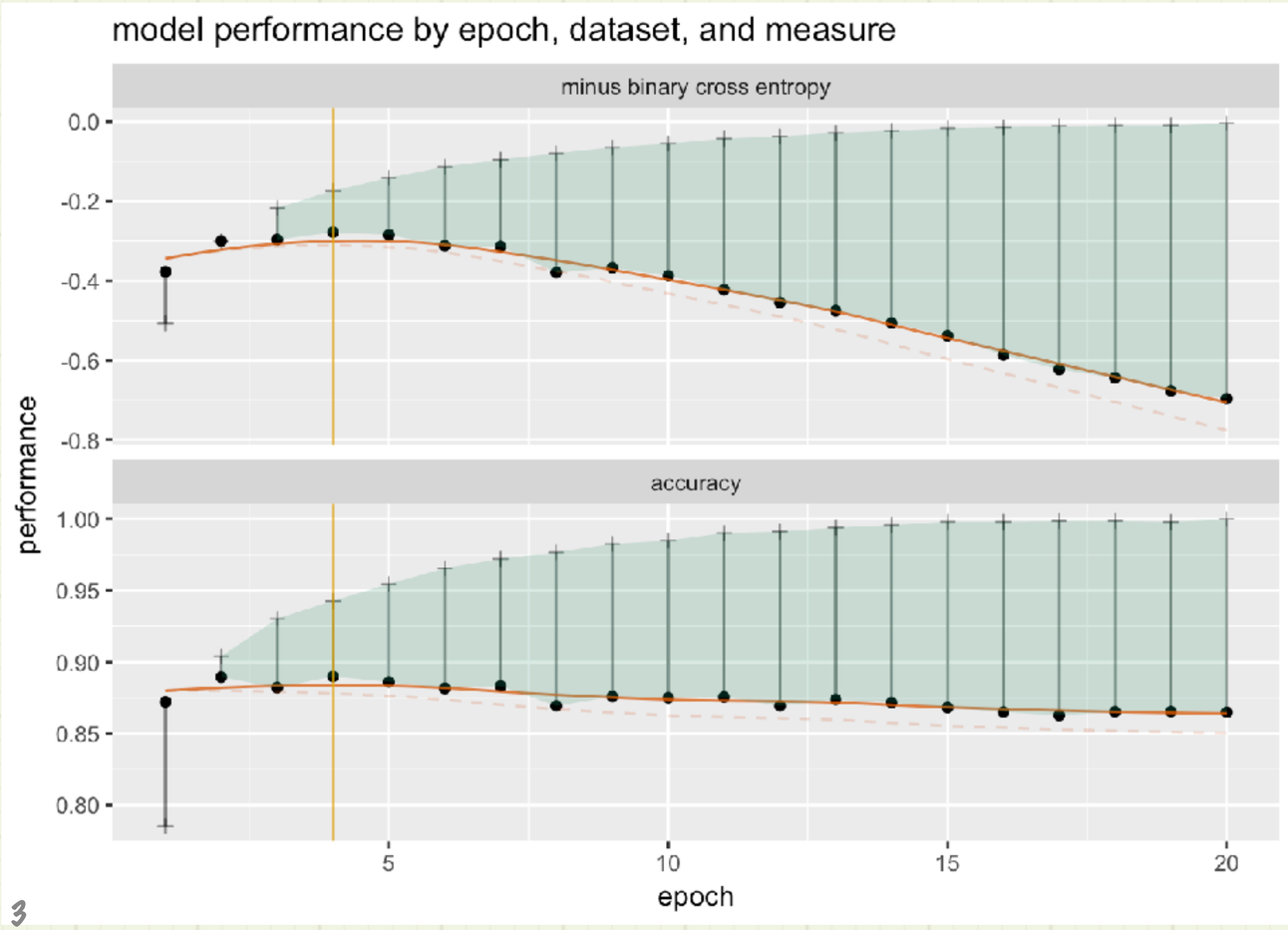


Our Example Problem

Replace this **Keras** deep learning fit trajectory plot

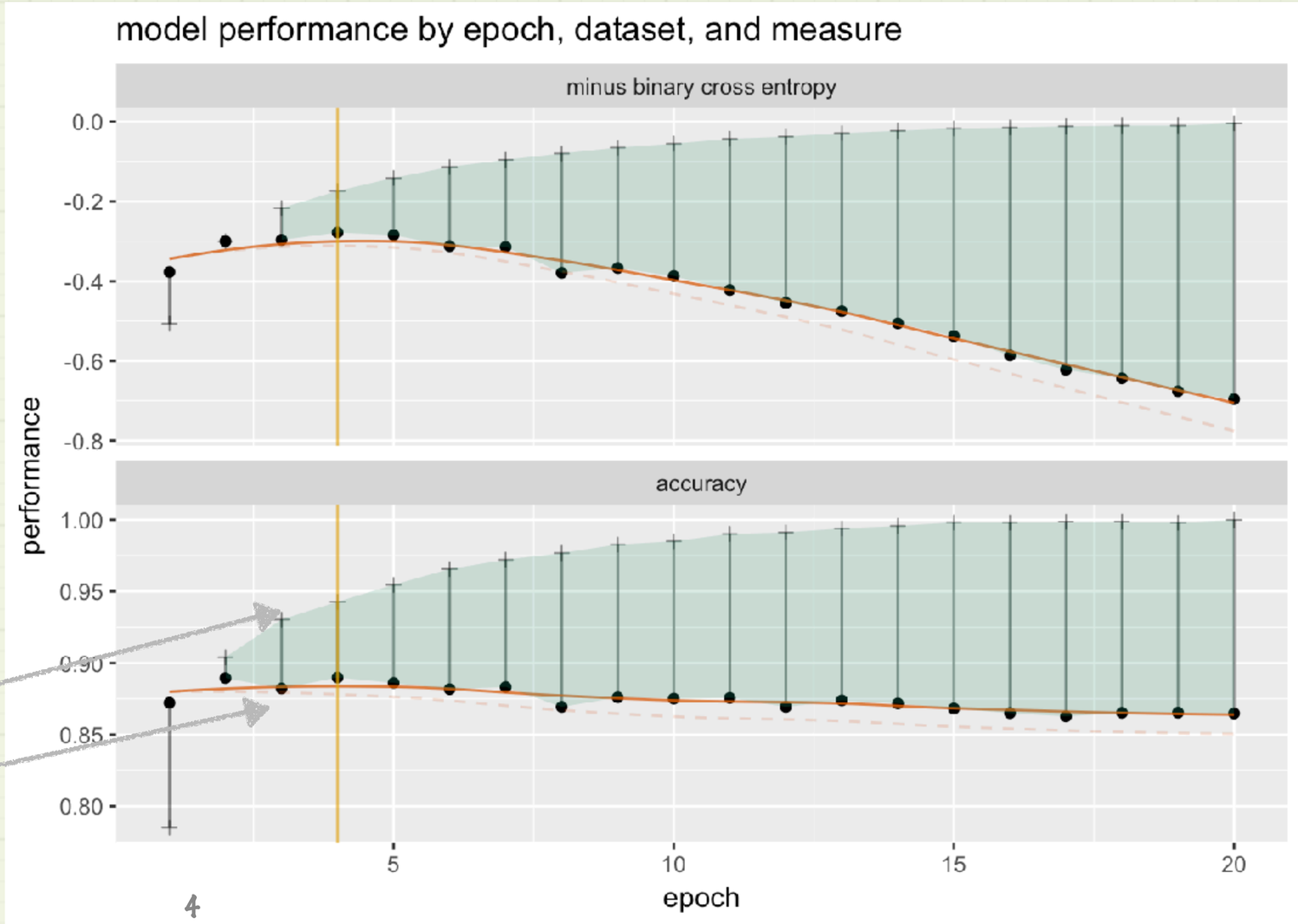


With this plot



Advantages of The New Presentation

- Up means better in all facets.
- Validation performance is rendered as the *only* horizontal curve.



Training performance

Test performance

The issue

- Plot history data looks like the table to the right.
  - **ggplot::geom_ribbon()** needs training and validation results in same row.
  - **ggplot::facet_wrap()** needs different measures in different rows.

val_loss	val_acc	loss	acc	epoch
-0.3769818	0.8722	-0.5067290	0.7852000	1
-0.2996994	0.8895	-0.3002033	0.9040000	2
-0.2963943	0.8822	-0.2165675	0.9303333	3
-0.2779052	0.8899	-0.1738829	0.9428000	4
-0.2842501	0.8861	-0.1410933	0.9545333	5
-0.3119754	0.8817	-0.1135626	0.9656000	6

We Need to re-Shape the Data

- Could do this with some combination of melt/cast, gather, cbind, rbind, and/or join.
- We are going to show a crystal clear "all in one step" tool for this: cdata (available on **CRAN**).
- This presentation will emphasize diagrammatic thinking and arguments.

The Concept

- Data has **coordinates**.
- Information is grouped in **records**.
- Exact realization in a given table is an inessential implementation detail.

This cell is "the epoch 2 training loss", independent of how the table is formatted.

val_loss	val_acc	loss	acc	epoch
-0.3769818	0.8722	-0.5067290	0.7852000	1
-0.2996994	0.8895	**-0.3002033**	0.9040000	2
-0.2963943	0.8822	-0.2165675	0.9303333	3
-0.2779052	0.8899	-0.1738829	0.9428000	4
-0.2842501	0.8861	-0.1410933	0.9545333	5
-0.3119754	0.8817	-0.1135626	0.9656000	6

This row is the record of all facts about epoch 4, independent of how the table is formatted.

Let's Look at One ~~Row~~ Record

Want to transform from this:

epoch	val_loss	val_acc	loss	acc
1	-0.3769818	0.8722	-0.506729	0.7852

To this:

epoch	measure	training	validation
1	minus binary cross entropy	-0.506729	-0.3769818
1	accuracy	0.785200	0.8722000

We ***Draw*** The Transform

List of Values (dual of RDF triple)

val_loss	val_acc	loss	acc
val_loss	val_acc	loss	acc

Row Record

epoch	val_loss	val_acc	loss	acc
1	-0.3769818	0.8722	-0.506729	0.7852

Control Table

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

Block Record

epoch	measure	training	validation
1	minus binary cross entropy	-0.506729	-0.3769818
1	accuracy	0.785200	0.8722000

The Transforms: rowrecs to blocks

controlTable: cT

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

epoch	val_loss	val_acc	loss	acc
1	-0.3769818	0.8722	-0.506729	0.7852

```
rowrecs_to_blocks(
  .,
  controlTable = cT,
  columnsToCopy = "epoch")
```

epoch	measure	training	validation
1	minus binary cross entropy	-0.506729	-0.3769818
1	accuracy	0.785200	0.8722000

The Transforms: blocks to rowrecs

controlTable: cT

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

epoch	val_loss	val_acc	loss	acc
1	-0.3769818	0.8722	-0.506729	0.7852

```
blocks_to_rowrecs(
    .,
    controlTable = cT,
    keyColumns = "epoch")
```

epoch	measure	training	validation
1	minus binary cross entropy	-0.506729	-0.3769818
1	accuracy	0.785200	0.8722000

Control Table *is* the Transform

Control table is a picture of what the control table transforms a single row into our from (depending on direction of operator).

controlTable: cT

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

val_loss	val_acc	loss	acc
val_loss	val_acc	loss	acc

```
rowrecs_to_blocks(
  .,
  controlTable = cT,
  columnsToCopy = NULL)
```

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

Control Table *is* the inverseTransform

Control table is a picture of a transform that takes itself to a single row.

controlTable: cT

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

val_loss	val_acc	loss	acc
val_loss	val_acc	loss	acc

```
blocks_to_rowrecs(
    .,
    controlTable = cT,
    keyColumns = NULL)
```

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

Anatomy of the Control Table

Column names (not a row)

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

Payload

First column behaves like row names *except* it also carries the extra column name “measure”.

Pivot/un-pivot or tidyr::gather()/ tidyr::spread() are exactly the cases where the control table payload is a single column.

Back to Our Task

val_loss	val_acc	loss	acc	epoch
-0.3769818	0.8722	-0.5067290	0.7852000	1
-0.2996994	0.8895	-0.3002033	0.9040000	2
-0.2963943	0.8822	-0.2165675	0.9303333	3
-0.2779052	0.8899	-0.1738829	0.9428000	4
-0.2842501	0.8861	-0.1410933	0.9545333	5
-0.3119754	0.8817	-0.1135626	0.9656000	6

...

controlTable: cT

measure	training	validation
minus binary cross entropy	loss	val_loss
accuracy	acc	val_acc

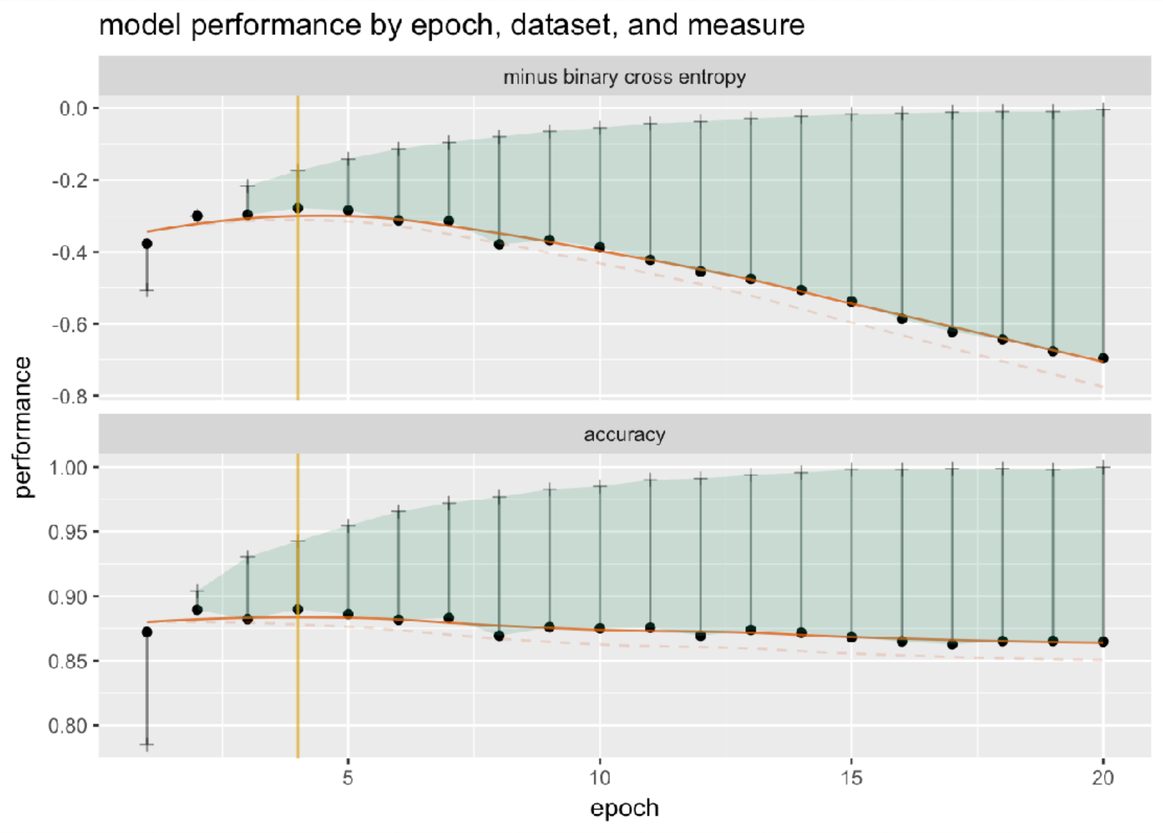
```
rowrecs_to_blocks(
   .,
   controlTable = cT,
   columnsToCopy = "epoch")
```

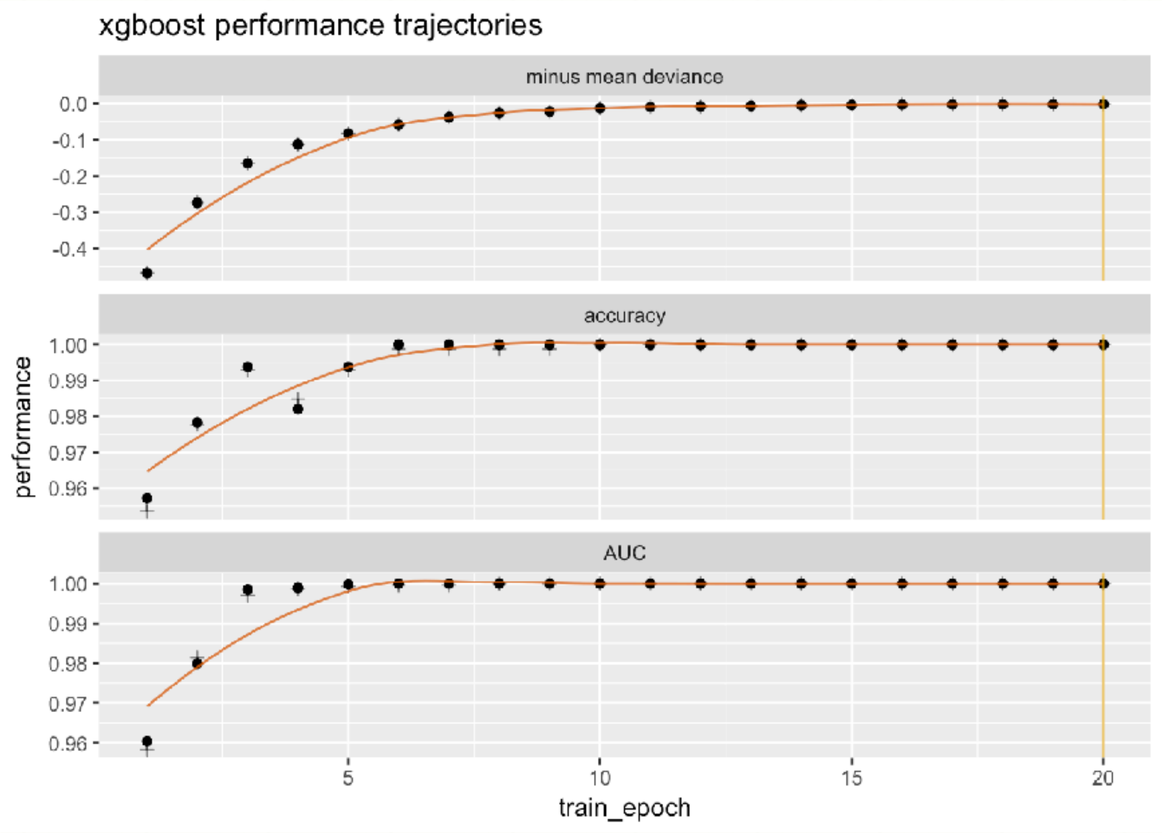
epoch	measure	training	validation
1	minus binary cross entropy	-0.5067290	-0.3769818
1	accuracy	0.7852000	0.8722000
2	minus binary cross entropy	-0.3002033	-0.2996994
2	accuracy	0.9040000	0.8895000
3	minus binary cross entropy	-0.2165675	-0.2963943
3	accuracy	0.9303333	0.8822000

...

To reverse transform, need to specify `keyColumns` (instead of `columnsToCopy`) which identify which sets of rows go together to form blocks.

And We are Ready to Plot





Keras example

xgboost example

```
WVPlots::plot_Keras_fit_trajectory(
  d,
  title = "model performance by epoch, dataset, and measure")
```

Why Use **cdata**?

- *Clear* teachable theory:
  - Abstract data coordinates and abstract records
  - `blocks_to_rowrecs()` (relational role: join)
  - `rowrecs_to_blocks()` (relational role: project)
  - Diagrammatic theory: **draw the transform diagram!**
- *Powerful* transforms:
  - pivot/un-pivot, `tidyr::spread()`/`tidry::gather()`, and one-hot-encode are all *easy* special cases.
  - Seamlessly move multiple values together.
  - Any block to block transform is at most `blocks_to_rowrecs()` followed by `rowrecs_to_blocks()`
- **cdata** is based on **SQL** and **DBI**
  - It can be *directly* applied to big data (via **Spark** or **PostgreSQL**).
  - Already have clients using this on **Spark** in production.

Thank you!

- Links:
  - The **R** package
    https://github.com/WinVector/cdata
  - Fluid data reshaping with **cdata**
    http://winvector.github.io/FluidData/FluidDataReshapingWithCdata.html
  - Coordinatized data theory:
    http://winvector.github.io/FluidData/RowsAndColumns.html
- More:
  - Ready to go **Keras** plot:
    http://winvector.github.io/FluidData/PlotExample/KerasPerfPlot.html
  - These slides:
    https://github.com/WinVector/cdata/blob/master/extras/cdata.pdf
  - All the code behind this talk (with more links):
    http://winvector.github.io/FluidData/PlotExample/PlotExample.html