Using Python with R

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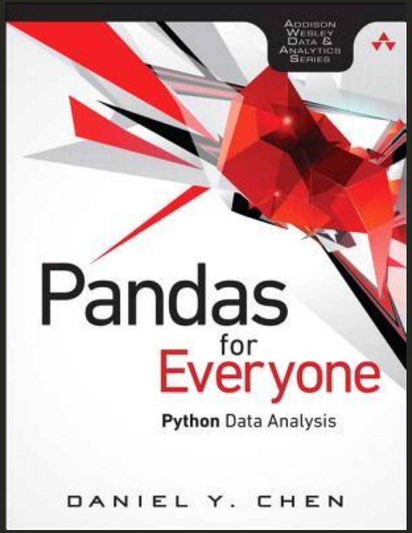
DCR Conference 2019

hi!

I'm Daniel

- PhD Student: Virginia Tech
    - Data Science education
    - Medical practitioners
- Inten at RStudio
    - `gradethis`
    - Code grader for `learnr` documents
- Author:



R and Python

The Tiobe Index Top 10

Following are the top 10 languages in the June 2019 Tiobe index:

1. Java
2. C
3. **Python**
4. C
5. Visual
6. C
7. JavaScript
8. PHP
9. SQL
10. Assembly

The Pypl Index Top 10

Following are the top 10 languages in the June 2018 Pypl index:

- **Python**
- Java
- JavaScript
- C
- PHP
- C
- **R**
- Objective
- Swift
- Matlab

Taken from: https://www.infoworld.com/article/3401536/python-popularity-reaches-an-all-time-high.html

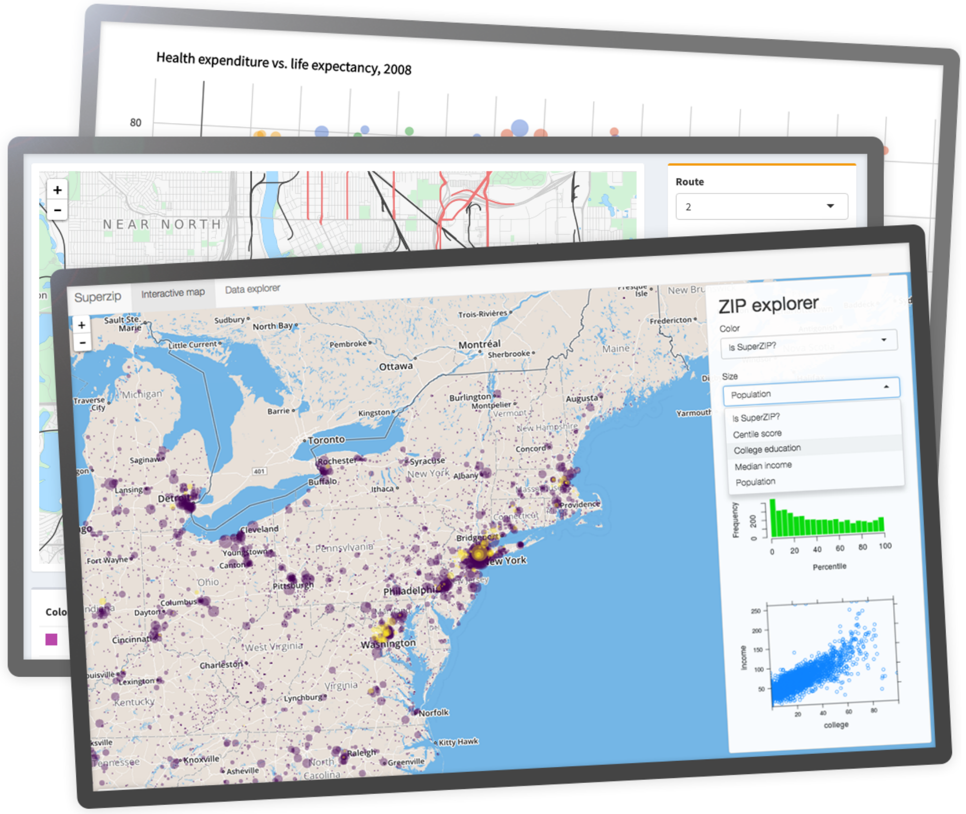
Python...

... a general-purpose programming language.

- May not be the best at everything (anything?)
    - but second best at everthing is pretty good.
- Python does environments better than R (waiting to test out `renv`)
- One thing that Python is objectively better at than R is *Web Development* and *Hardware*

What *I* like about R

Communication



More Examples

The rest of this document consists of a few test cases to make sure everything still works well in slightly more complicated scenarios. First we generate two plots in one figure environment with the chunk option `fig.show = 'hold'`:

```
p <- ggplot(mtcars2, aes(hp, mpg, color = am)) +
  geom_point()
p
p + geom_smooth()
```

Inspiration for talk

2019 Nonclinical Biostatistics Conference

- https://github.com/chendaniely/ncb-2019-python
- Jupyter notebook
    - RISE plugin (reveal.js)
    - Slow and clunky
    - Unable to see source (nicely) without Jupyter loaded
- RMarkdown + Reticulate = Slides! (hint hint: this talk ;D)

R and Python

R analysis - Load data

```r
library(here)
library(readr)

raw = readr::read_csv(here::here("./data/billboard.csv"))
head(raw)
```

```
## # A tibble: 6 x 83
##    year artist.inverted track time  genre date.entered date.peaked
##   <dbl> <chr>           <chr> <tim> <chr> <date>       <date>     
## 1  2000 Destiny's Child Inde… 03:38 Rock  2000-09-23   2000-11-18 
## 2  2000 Santana         Mari… 04:18 Rock  2000-02-12   2000-04-08 
## 3  2000 Savage Garden   I Kn… 04:07 Rock  1999-10-23   2000-01-29 
## 4  2000 Madonna         Music 03:45 Rock  2000-08-12   2000-09-16 
## 5  2000 Aguilera, Chri… Come… 03:38 Rock  2000-08-05   2000-10-14 
## 6  2000 Janet           Does… 04:17 Rock  2000-06-17   2000-08-26 
## # … with 76 more variables: x1st.week <dbl>, x2nd.week <dbl>,
## #   x3rd.week <dbl>, x4th.week <dbl>, x5th.week <dbl>, x6th.week <dbl>,
## #   x7th.week <dbl>, x8th.week <dbl>, x9th.week <dbl>, x10th.week <dbl>,
## #   x11th.week <dbl>, x12th.week <dbl>, x13th.week <dbl>,
## #   x14th.week <dbl>, x15th.week <dbl>, x16th.week <dbl>,
## #   x17th.week <dbl>, x18th.week <dbl>, x19th.week <dbl>,
## #   x20th.week <dbl>, x21st.week <dbl>, x22nd.week <dbl>,
## #   x23rd.week <dbl>, x24th.week <dbl>, x25th.week <dbl>,
## #   x26th.week <dbl>, x27th.week <dbl>, x28th.week <dbl>,
## #   x29th.week <dbl>, x30th.week <dbl>, x31st.week <dbl>,
```

R analysis - Filter data

```r
library(dplyr)

raw_filtered <- raw %>%
  dplyr::select(year, artist.inverted, track, time, date.entered,
                x1st.week:x73rd.week) %>%
  dplyr::rename(artist = artist.inverted)
raw_filtered
```

```
## # A tibble: 317 x 78
##     year artist track time  date.entered x1st.week x2nd.week x3rd.week
##    <dbl> <chr>  <chr> <tim> <date>           <dbl>     <dbl>     <dbl>
##  1  2000 Desti… Inde… 03:38 2000-09-23          78        63        49
##  2  2000 Santa… Mari… 04:18 2000-02-12          15         8         6
##  3  2000 Savag… I Kn… 04:07 1999-10-23          71        48        43
##  4  2000 Madon… Music 03:45 2000-08-12          41        23        18
##  5  2000 Aguil… Come… 03:38 2000-08-05          57        47        45
##  6  2000 Janet  Does… 04:17 2000-06-17          59        52        43
##  7  2000 Desti… Say … 04:31 1999-12-25          83        83        44
##  8  2000 Igles… Be W… 03:36 2000-04-01          63        45        34
##  9  2000 Sisqo  Inco… 03:52 2000-06-24          77        66        61
## 10  2000 Lones… Amaz… 04:25 1999-06-05          81        54        44
## # … with 307 more rows, and 70 more variables: x4th.week <dbl>,
## #   x5th.week <dbl>, x6th.week <dbl>, x7th.week <dbl>, x8th.week <dbl>,
## #   x9th.week <dbl>, x10th.week <dbl>, x11th.week <dbl>, x12th.week <dbl>,
## #   x13th.week <dbl>, x14th.week <dbl>, x15th.week <dbl>,
```

R analysis - Tidy data

```r
library(tidyr)

raw_tidy <- raw_filtered %>%
  tidyr::pivot_longer(cols = tidyselect::starts_with('x'),
                      names_to = "week",
                      values_to = "rank")
raw_tidy
```

```
## # A tibble: 23,141 x 7
##     year artist         track                 time  date.entered week       rank
##    <dbl> <chr>          <chr>                 <tim> <date>       <chr>     <dbl>
##  1  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x1st.we…     78
##  2  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x2nd.we…     63
##  3  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x3rd.we…     49
##  4  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x4th.we…     33
##  5  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x5th.we…     23
##  6  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x6th.we…     15
##  7  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x7th.we…      7
##  8  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x8th.we…      5
##  9  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x9th.we…      1
## 10  2000 Destiny's Ch… Independent Women… 03:38 2000-09-23   x10th.w…      1
## # … with 23,131 more rows
```

R analysis - Clean data

```r
library(purrr)
library(stringr)

billboard_clean <- raw_tidy %>%
  dplyr::mutate(
    week = purrr::map_int(
      week,
      #function(x){as.integer(stringr::str_extract(x, '\\d+'))}
      ~ as.integer(stringr::str_extract(., "\\d+"))
    )
  )
billboard_clean
```

```
## # A tibble: 23,141 x 7
##     year artist         track                time  date.entered  week  rank
##    <dbl> <chr>          <chr>                <tim> <date>       <int> <dbl>
##  1  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       1    78
##  2  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       2    63
##  3  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       3    49
##  4  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       4    33
##  5  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       5    23
##  6  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       6    15
##  7  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       7     7
##  8  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       8     5
##  9  2000 Destiny's Chi… Independent Women P… 03:38 2000-09-23       9     1
```

Python analysis

```python
import pandas as pd
import re

import janitor
from pyprojroot import here

raw_py = pd.read_csv(here('./data/billboard.csv'),
                     encoding = "ISO-8859-1")

billboard_clean_py = (
    raw_py
    .select_columns(['year', 'artist.inverted', 'track', 'time',
                     'date.entered', 'x*.week'])
    .rename_columns({"artist.inverted": "artist"})
    .melt(id_vars = ['year', 'artist', 'track', 'time',
                     'date.entered'],
          var_name = "week",
          value_name = "rank")
    .transform_column('week',
                      lambda x: int(re.findall(r'\d+', x)[0]))
)
```

Reticulate -- Python in R!

- Calling Python from R
- Translation between R and Python objects
- Python environments

Reticulate

```r
library(reticulate)
(conda_envs <- reticulate::conda_list())
```

```
##         name                            python
## 1 miniconda3 /home/dchen/miniconda3/bin/python
```

```r
# use my default conda environment
conda_envs$name[[1]]
```

```
## [1] "miniconda3"
```

```r
env <- conda_envs$name[[1]]
reticulate::use_condaenv(env)
```

```r
reticulate::py_config()
```

```
## python:         /home/dchen/miniconda3/bin/python
## libpython:      /home/dchen/miniconda3/lib/libpython3.7m.so
## pythonhome:     /home/dchen/miniconda3:/home/dchen/miniconda3
## version:        3.7.3 | packaged by conda-forge | (default, Jul  1 2019, 21:52:21)  [GCC 7.3.0]
## numpy:          /home/dchen/miniconda3/lib/python3.7/site-packages/numpy
## numpy_version:  1.17.3
```

A Python script

```python
import pandas as pd
import re

import janitor
from pyprojroot import here

raw_py = pd.read_csv(here('./data/billboard.csv'),
                     encoding = "ISO-8859-1")

billboard_clean_py = (
    raw_py
    .select_columns(['year', 'artist.inverted', 'track', 'time',
                     'date.entered', 'x*.week'])
    .rename_columns({"artist.inverted": "artist"})
    .melt(id_vars = ['year', 'artist', 'track', 'time',
                     'date.entered'],
          var_name = "week",
          value_name = "rank")
    .transform_column('week',
                      lambda x: int(re.findall(r'\d+', x)[0]))
)

mean_rank_by_week = (billboard_clean_py.groupby("week")["rank"]
                     .mean())
```

Python objects in R

```
reticulate::source_python(here::here("./scripts/01-02-python.py"))
```

```
head(mean_rank_by_week)
```

```
##        1        2        3        4        5        6
## 79.95899 71.17308 65.04560 59.76333 56.33904 52.36071
```

```
head(billboard_clean_py)
```

```
##   year              artist                                   track time
## 1 2000     Destiny's Child                 Independent Women Part I 3:38
## 2 2000             Santana                            Maria, Maria 4:18
## 3 2000       Savage Garden                      I Knew I Loved You 4:07
## 4 2000             Madonna                                   Music 3:45
## 5 2000 Aguilera, Christina Come On Over Baby (All I Want Is You) 3:38
## 6 2000               Janet                   Doesn't Really Matter 4:17
##   date.entered week rank
## 1   2000-09-23    1   78
## 2   2000-02-12    1   15
## 3   1999-10-23    1   71
## 4   2000-08-12    1   41
## 5   2000-08-05    1   57
## 6   2000-06-17    1   59
```

Type conversions table

R	Python	Examples
Single-element vector	Scalar	`1`, `1L`, `TRUE`, `"foo"`
Multi-element vector	List	`c(1.0, 2.0, 3.0)`, `c(1L, 2L, 3L)`
List of multiple types	Tuple	`list(1L, TRUE, "foo")`
Named list	Dict	`list(a = 1L, b = 2.0)`, `dict(x = x_data)`
Matrix/Array	NumPy ndarray	`matrix(c(1,2,3,4), nrow = 2, ncol = 2)`
Data Frame	Pandas DataFrame	`data.frame(x = c(1,2,3), y = c("a", "b", "c"))`
Function	Python function	`function(x) x + 1`
NULL, TRUE, FALSE	None, True, False	`NULL`, `TRUE`, `FALSE`

https://rstudio.github.io/reticulate/#type-conversions

Machine Learning

The data

No standard for how to transport data within a package...

```python
from sklearn.datasets import load_breast_cancer
cancer = load_breast_cancer()

print(type(cancer))
```

```
## <class 'sklearn.utils.Bunch'>
```

vs

```python
import seaborn as sns
tips = sns.load_dataset("tips")
print(type(tips))
```

```
## <class 'pandas.core.frame.DataFrame'>
```

The data

```
cancer.target[:10]
```

```
## array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0])
```

```
cancer.data[:10]
```

```
## array([[1.799e+01, 1.038e+01, 1.228e+02, 1.001e+03, 1.184e-01, 2.776e-01,
##         3.001e-01, 1.471e-01, 2.419e-01, 7.871e-02, 1.095e+00, 9.053e-01,
##         8.589e+00, 1.534e+02, 6.399e-03, 4.904e-02, 5.373e-02, 1.587e-02,
##         3.003e-02, 6.193e-03, 2.538e+01, 1.733e+01, 1.846e+02, 2.019e+03,
##         1.622e-01, 6.656e-01, 7.119e-01, 2.654e-01, 4.601e-01, 1.189e-01],
##        [2.057e+01, 1.777e+01, 1.329e+02, 1.326e+03, 8.474e-02, 7.864e-02,
##         8.690e-02, 7.017e-02, 1.812e-01, 5.667e-02, 5.435e-01, 7.339e-01,
##         3.398e+00, 7.408e+01, 5.225e-03, 1.308e-02, 1.860e-02, 1.340e-02,
##         1.389e-02, 3.532e-03, 2.499e+01, 2.341e+01, 1.588e+02, 1.956e+03,
##         1.238e-01, 1.866e-01, 2.416e-01, 1.860e-01, 2.750e-01, 8.902e-02],
##        [1.969e+01, 2.125e+01, 1.300e+02, 1.203e+03, 1.096e-01, 1.599e-01,
##         1.974e-01, 1.279e-01, 2.069e-01, 5.999e-02, 7.456e-01, 7.869e-01,
##         4.585e+00, 9.403e+01, 6.150e-03, 4.006e-02, 3.832e-02, 2.058e-02,
##         2.250e-02, 4.571e-03, 2.357e+01, 2.553e+01, 1.525e+02, 1.709e+03,
##         1.444e-01, 4.245e-01, 4.504e-01, 2.430e-01, 3.613e-01, 8.758e-02],
##        [1.142e+01, 2.038e+01, 7.758e+01, 3.861e+02, 1.425e-01, 2.839e-01,
##         2.414e-01, 1.052e-01, 2.597e-01, 9.744e-02, 4.956e-01, 1.156e+00,
##         3.445e+00, 2.723e+01, 9.110e-03, 7.458e-02, 5.661e-02, 1.867e-02,
```

Python -- Preprocess

```python
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import MinMaxScaler
from sklearn.svm import SVC

# split the data
X_train, X_test, y_train, y_test = train_test_split(
    cancer.data, cancer.target, random_state=0)

# compute minimum and maximum on the training data
scaler = MinMaxScaler().fit(X_train)

# rescale training data
X_train_scaled = scaler.transform(X_train)
```

Python -- Fit

```python
svm = SVC()
# learn an SVM on the scaled training data
svm.fit(X_train_scaled, y_train)
```

```
## SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
##     decision_function_shape='ovr', degree=3, gamma='auto_deprecated',
##     kernel='rbf', max_iter=-1, probability=False, random_state=None,
##     shrinking=True, tol=0.001, verbose=False)
```

Python -- Evaluate

```python
# scale test data and score the scaled data
X_test_scaled = scaler.transform(X_test)
svm.score(X_test_scaled, y_test)
```

```
## 0.951048951048951
```

Default scoring metric is accuracy

R -- Python setup

```r
library(reticulate)
# reticulate::use_condaenv("miniconda3")

(conda_envs <- reticulate::conda_list())
```

```
##         name                             python
## 1 miniconda3 /home/dchen/miniconda3/bin/python
```

```r
conda_envs$name[[1]]
```

```
## [1] "miniconda3"
```

```r
env <- conda_envs$name[[1]]
reticulate::use_condaenv(env)
```

R -- Get data

```r
sklearn_datasets = reticulate::import_from_path("sklearn.datasets")
cancer = sklearn_datasets$load_breast_cancer()

library(tibble)
cancer_df <- tibble::as_tibble(cancer$data)
names(cancer_df) <- cancer$feature_names
cancer_df$target <- cancer$target
cancer_df
```

```
## # A tibble: 569 x 31
##    `mean radius` `mean texture` `mean perimeter` `mean area`
##            <dbl>          <dbl>            <dbl>       <dbl>
##  1          18.0           10.4            123.        1001 
##  2          20.6           17.8            133.        1326 
##  3          19.7           21.2            130         1203 
##  4          11.4           20.4             77.6        386.
##  5          20.3           14.3            135.        1297 
##  6          12.4           15.7             82.6        477.
##  7          18.2           20.0            120.        1040 
##  8          13.7           20.8             90.2        578.
##  9          13             21.8             87.5        520.
## 10          12.5           24.0             84.0        476.
## # … with 559 more rows, and 27 more variables: `mean smoothness` <dbl>,
## #   `mean compactness` <dbl>, `mean concavity` <dbl>, `mean concave
## #   points` <dbl>, `mean symmetry` <dbl>, `mean fractal dimension` <dbl>,
```

R -- Preprocess

```r
library(rsample)
library(recipes)

cancer_split <- rsample::initial_split(cancer_df)
cancer_train <- rsample::training(cancer_split)
cancer_test <- rsample::testing(cancer_split)

res <- recipes::recipe(target ~ ., data = cancer_train) %>%
  recipes::step_scale(recipes::all_predictors()) %>%
  recipes::step_num2factor(recipes::all_outcomes())

res_preped <- res %>% recipes::prep()
res_baked <- res_preped %>% bake(new_data = cancer_train,
                                 composition = "tibble")
res_test <- res_preped %>% bake(new_data = cancer_test,
                                composition = "tibble")
```

R -- Fit

https://tidymodels.github.io/parsnip/articles/articles/Models.html

```r
library(parsnip)


svm <- parsnip::svm_rbf(mode = "classification", cost = 1) %>%
  parsnip::set_engine("kernlab") %>%
  parsnip::fit(target ~ ., data = res_baked)
```

R -- Evaluate

```r
library(yardstick)
predict(svm, res_test) %>%
  dplyr::bind_cols(res_test %>% dplyr::select(target)) %>%
  yardstick::accuracy(truth = target, estimate = .pred_class)
```

```
## # A tibble: 1 x 3
##   .metric  .estimator .estimate
##   <chr>    <chr>          <dbl>
## 1 accuracy binary         0.972
```

Communication

This presentation

- Written in RMarkdown exported as a xaringan slide deck
- All the R **and** Python code are live executed by changing the execution engine

~~~
```{r}
library(reticulate)
reticulate::use_condaenv("Anaconda3")
```

```{python}
from sklearn.datasets import load_breast_cancer
cancer = load_breast_cancer()
```
~~~

Sharing objects R < -- > Python

- In R chunks, you can access python objects with: `py$`
- In Python chunks, you can access R objects with: `r.`
  - Note the dot in `r.`

In Python chunk:

```
single_obs_py = X_test_scaled[:1, :] # first row of the test data
single_obs_py
```

```
## array([[0.30380046, 0.44854772, 0.30993021, 0.17527041, 0.62962963,
##         0.43668242, 0.33856607, 0.40616302, 0.53333333, 0.49052233,
##         0.10106826, 0.12555836, 0.11006926, 0.04942689, 0.17120785,
##         0.1958559 , 0.08717172, 0.25269937, 0.17111501, 0.10745132,
##         0.301672  , 0.47014925, 0.31321281, 0.16201337, 0.56943802,
##         0.34763416, 0.40782748, 0.70651051, 0.39818648, 0.36639118]])
```

In R chunk:

```
single_obs_r <-py$single_obs_py # get an R object
```

Python -- Prediction

```
svm.predict(single_obs_py) # using python variable
```

```
## array([0])
```

```
svm.predict(r.single_obs_r) # using R variable
```

```
## array([0])
```

R -- Prediction

```r
r_dat <- as.data.frame(single_obs_r)
names(r_dat) <- py$cancer$feature_names
predict(svm, r_dat)
```

```
## # A tibble: 1 x 1
##   .pred_class
##   <fct>
## 1 0
```

Shiny

https://scikit-learn.org/stable/modules/model_persistence.html

Save out the model

```python
from joblib import dump, load
from pyprojroot import here

dump(svm, here("output/python_model.joblib", warn=False))
```

```
## ['/home/dchen/git/hub/rstatsdc_2019-python-r/output/python_model.joblib']
```

Load the model

```python
python_model = load(here("output/python_model.joblib"))
```

Shiny

https://github.com/chendaniely/rstatsdc_2019-python-r/blob/master/shiny_example.Rmd

~~~
```{r}
inputPanel(
  sliderInput("bw_adjust", label = "Bandwidth adjustment:",
              min = 1, max = 20, value = 1, step = 1)
)

renderText({
  py$python_model$predict(py$X_test_scaled[1:input$bw_adjust, , drop=FALSE])
})
```
~~~

The -down ecosystem

All of this is using the `reticulate` R package

https://rstudio.github.io/reticulate/

- Bookdown
- Blogdown
  - Hugo academic already supports Jupyter notebooks
  - https://sourcethemes.com/academic/docs/jupyter

By the way...

- `knitpy`: https://github.com/jankatins/knitpy
- `jupyter books`: https://jupyterbook.org/intro.html

Creating a reticulated R package

The R keras package is an R wrapper around keras for Python

- https://keras.rstudio.com/

https://rstudio.github.io/reticulate/articles/package.html

Installing Python...

I recommend looking at the Software-Carpentry setup instructions:

https://swcarpentry.github.io/python-novice-inflammation/setup/index.html

Most people in data science use Anaconda to install Python

- https://www.anaconda.com/distribution/

People who mainly use python for Web development don't use Anaconda

About conda..

What they forgot to teach you about R: https://rstats.wtf/

There's a section about using conda with R: https://rstats.wtf/set-up-an-r-dev-environment.html#what-about-conda

tl;dr - don't mix `conda install` with `install.packages()`

Apache arrow

If you heard me speak before...

- DCR 2018: Structuring Your Data Science Projects
  - https://youtu.be/UQHz38s3DyA
- NYR 2019: Building Reproducible and Replicable Projects
  - https://youtu.be/t-vY9FeIIMk

Save out data objects to share between Python and R scripts

- Python: https://arrow.apache.org/docs/python/
- R: https://arrow.apache.org/docs/r/

Thanks!

@chendaniely

Slides: https://github.com/chendaniely/rstatsdc_2019-python-r