Reproducible Machine Learning

Why and how to accomplish reproducibility in ML pipelines

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```
~/Timothy Dobbins                                    base 🐍  12:06:34 PM
❯ whoami
timdobbins
~/Timothy Dobbins                                    base 🐍  12:06:39 PM
❯ tree -t
.
├── 2012 Belmont University
│   ├── Economics
│   └── Statistics
├── 2015 Perception Health
│   ├── Software Engineer Intern
│   └── Software Engineer Project lead
├── 2017 The General
│   ├── Data Scientist I
│   ├── Data Scientist II
│   └── Lead Data Scientist
├── 2020 Unum
│   ├── Move To Chattanooga
│   ├── Senior NLP Data Scientist
│   └── Principal Data Scientist
├── 2020 Gridsearch Consulting
│   └── Builder
└── 2022 Trilliant Health
    └── Principal Data Scientist

18 directories, 0 files
~/Timothy Dobbins                                    base 🐍  12:06:41 PM
❯
```

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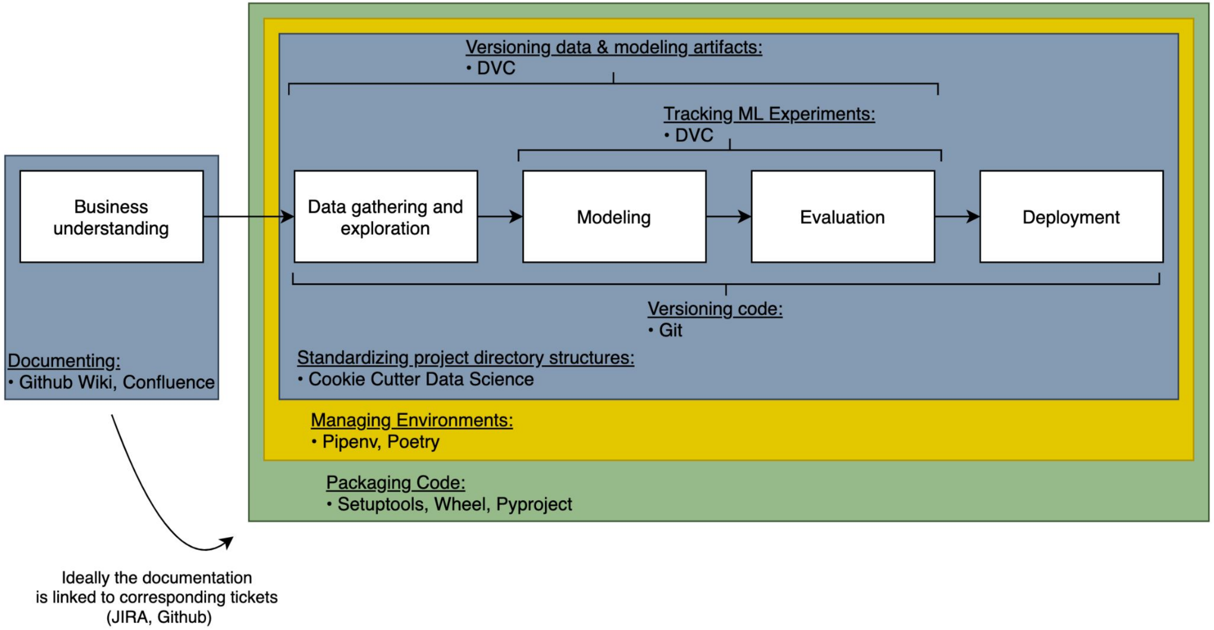
Who works with ML models that are in production?

Who works with reproducible ML models?

An ML reproducibility framework*

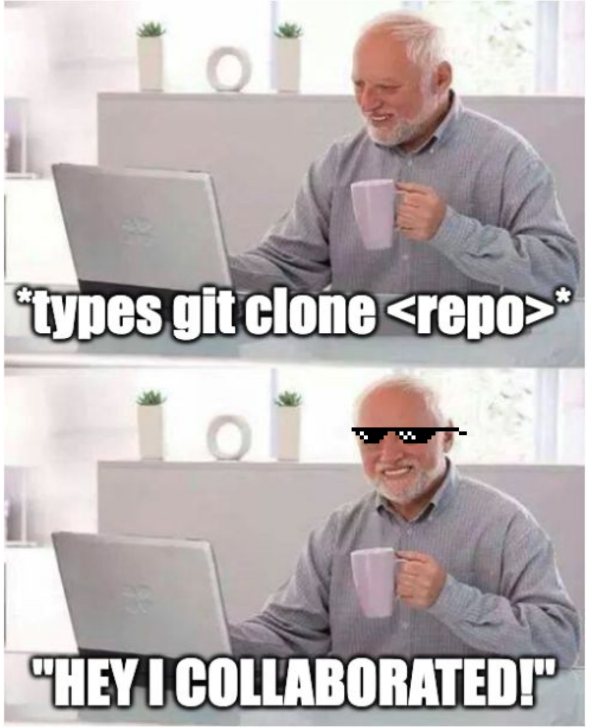


*Inspired by this framework.

Why reproducible machine learning?

Why reproducible machine learning?

- Collaborating

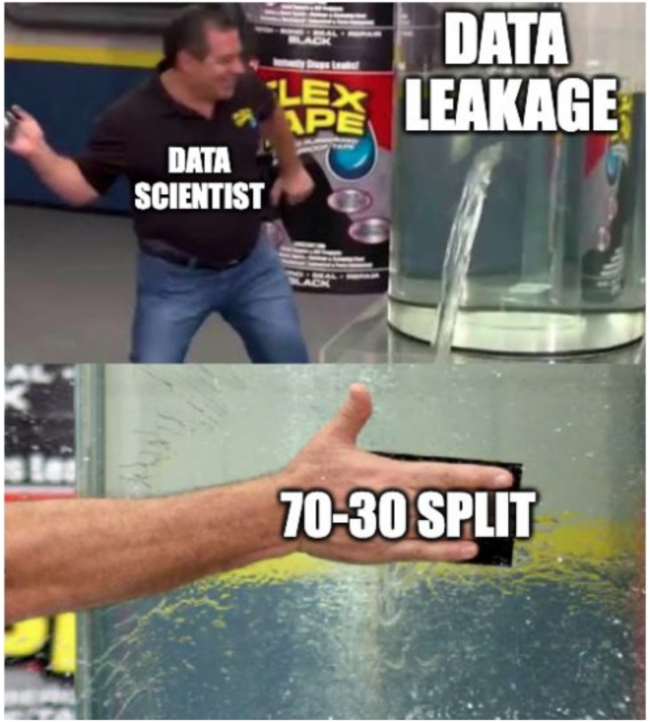


Why reproducible machine learning?

- Collaborating
- Debugging (remotely)

Why reproducible machine learning?

- Collaborating
- Debugging (remotely)
- Scientifically validating



Why reproducible machine learning?

- Collaborating
- Debugging (remotely)
- Scientifically validating
- Auditing

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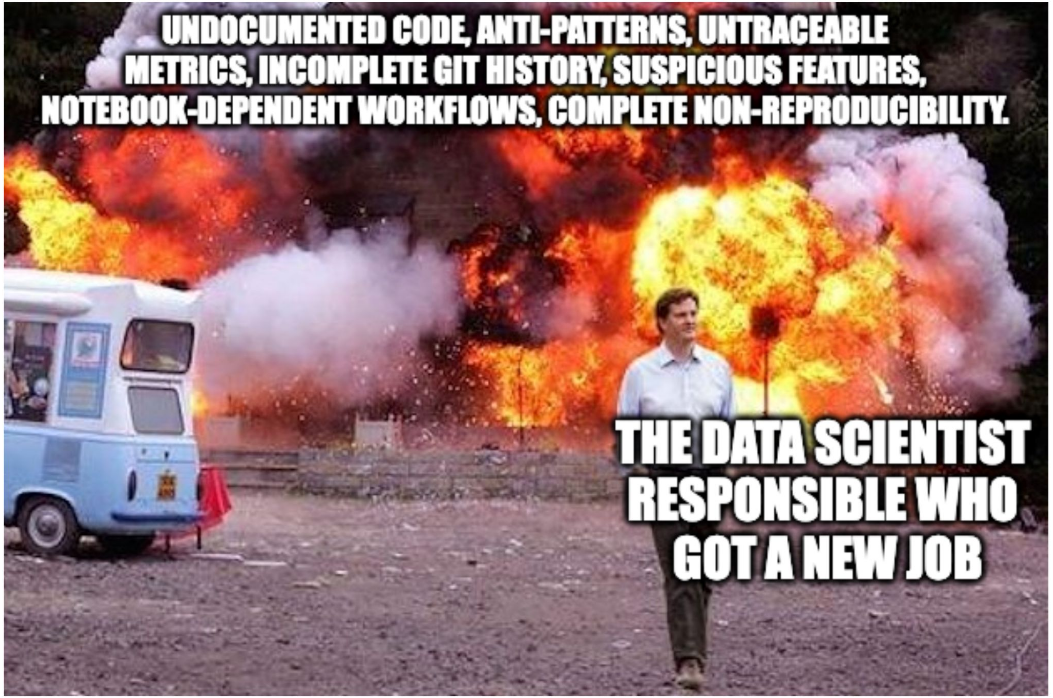
Why reproducible machine learning?

- Collaborating
- Debugging (remotely)
- Scientifically validating
- Auditing
- Legacy



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How to accomplish reproducibility?

Four components to account for

1. Environment

```
# common pipenv commands

pipenv install --dev        # install all deps in Pipfile

pipenv shell                # activate the env

pipenv run <command to run> # run without activating

pipenv sync --dev           # sync local env with Pipfile.lock
```

2. Code

```
# common git commands

git clone https://github.com/tmthyjames/ds-meetup-ml-repro.git

git checkout -b <branch>

git add .

git commit -m "commit message"

git push origin <branch>
```

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3. Data (data & model artifacts)

```
# common DVC commands

dvc remote add ...# link remote storage container to local code

dvc stage add ... # add stage for dvc to track

dvc dag           # view the pipeline's dag

dvc repro         # reproduce the entire pipeline

dvc push          # push all artifacts to remote storage
```

4. Results (performance metrics)

```
# common DVC commands
$ dvc metrics show
        eval.json:
                AUC: 0.66729
                error: 0.16982
                TP: 516
$ dvc metrics diff
Path        Metric    HEAD     workspace  Change
eval.json   ACU       0.65115  0.66729    0.01614
eval.json   error     0.1666   0.16982    0.00322
eval.json   TP        528      516        -12
```

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Let's walkthrough an example

Predicting a song’s genre given its lyrics

← Link to blog

← Link to code

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Setting up the environment

Setting up the environment

```
# getting started with our example
git clone https://github.com/tmthyjames/ds-meetup-ml-repro.git

# Install pipenv environment
pipenv install --dev

# Create IPython Kernel for the virtual environment
pipenv run ipython kernel install --user --name=reproml

pipenv run python setup.py develop # to get access to the CLI
entry point defined in setup.py
```

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Creating the **ETL** pipeline using **DVC**

```
# create the ETL pipeline
$ dvc stage add -n get-lyrics \
    -d reproml/etl/lyrics/_lyrics.py \
    -o data/raw/lyrics/ \
    reproml etl get-lyrics

$ dvc stage add -n prepro-lyrics \
    -d reproml/preprocess/_preprocess.py \
    -d data/raw/lyrics/ \
    -o data/processed/lyrics \
    reproml prepro process
```

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Creating the **modeling** pipeline using **DVC**

```
# creating the modeling pipeline
$ dvc stage add -n split-lyrics \
    -d reproml/preprocess/_preprocess.py \
    -d data/raw/lyrics/ \
    -o data/modeling/train_set.parquet \
    -o data/modeling/test_set.parquet \
    reproml prepro split

$ dvc stage add -n train-model \
    -d data/modeling/train_set.parquet \
    -d reproml/ml/_ml.py \
    -o model_artifacts/model.pkl \
    reproml ml train
```

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Creating the **validation** stage using **DVC**

```
# creating validationn stage

$ dvc stage add -n validate-model \
    -d model_artifacts/model.pkl \
    -d data/modeling/test_set.parquet \
    -m data/metrics/performance.json \
    reproml validate metrics
```

Now we can view our DAG

```
# viewing the DAG
$ dvc dag
  +------------+
  | get-lyrics |
  +------------+
         *
         *
         *
+---------------+
| prepro-lyrics |
+---------------+
         *
         *
         *
 +--------------+
 | split-lyrics |
 +--------------+
         *
         *
         *
  +-------------+
  | train-model |
  +-------------+
         *
         *
         *
+----------------+
| validate-model |
+----------------+
```

Now DVC knows how to track our pipeline

- DVC will track changes
- DVC will add all tracked files to a remote storage
- DVC knows how to handle branches

Let’s run the pipeline

```
$ dvc repro --force
Running stage 'get-lyrics':
> reproml etl get-lyrics

Running stage 'prepro-lyrics':
> reproml prepro process
Updating lock file 'dvc.lock'

Running stage 'split-lyrics':
> reproml prepro split
Updating lock file 'dvc.lock'

Running stage 'train-model':
> reproml ml train
Updating lock file 'dvc.lock'

Running stage 'validate-model':
> reproml validate metrics
Updating lock file 'dvc.lock'

To track the changes with git, run:

    git add dvc.lock

To enable auto staging, run:

    dvc config core.autostage true
Use `dvc push` to send your updates to remote storage.
```

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Here's our model training code

```
import joblib
import pandas as pd
from sklearn.feature_extraction.text import (
    CountVectorizer,
    TfidfVectorizer
)
from sklearn.naive_bayes import MultinomialNB
from sklearn.pipeline import Pipeline

from reproml.config import ml_conf as mc


def train(
    srcpath: str = (
        mc.root_path /
        mc.modeling_data_path /
        mc.train_set.filename
    ),
    dstpath: str = mc.root_path / mc.model_artifact_path,
    **kwargs
):

    train_df = pd.read_parquet(srcpath)

    # define our model
    text_clf = Pipeline(
        [
            ("vect", CountVectorizer()),
            ("clf", MultinomialNB(alpha=0.1))
        ]
    )

    # train our model on training data
    text_clf.fit(train_df["lyric"], train_df["ranker_genre"])

    joblib.dump(text_clf, dstpath)

    return text_clf
```

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We’re going to change our training code

```
################# Old Code ################
text_clf = Pipeline(                      #
    [                                     #
        ("vect", CountVectorizer()),      #
        ("clf", MultinomialNB(alpha=0.1)) #
    ]                                     #
)                                         #
###########################################
                    |
                    |
                    |
                    |
                    V
################# New Code ################
text_clf = Pipeline(                      #
    [                                     #
        ("vect", TfidfVectorizer()),      #
        ("clf", MultinomialNB(alpha=0.1)) #
    ]                                     #
)                                         #
###########################################
```

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And rerun dvc repro

```
$ dvc repro
Stage 'get-lyrics' didn't change, skipping    # notice these do not run again
Stage 'prepro-lyrics' didn't change, skipping # notice these do not run again
Stage 'split-lyrics' didn't change, skipping  # notice these do not run again
Running stage 'train-model':
> reproml ml train
Updating lock file 'dvc.lock'

Running stage 'validate-model':
> reproml validate metrics
Updating lock file 'dvc.lock'

To track the changes with git, run:

    git add dvc.lock

To enable auto staging, run:

    dvc config core.autostage true
Use `dvc push` to send your updates to remote storage.
```

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Now let's compare metrics

```
$ dvc metrics diff -- count-model tfidf-model

Path                             Metric     count-model    tfidf-model    Change
data/metrics/performance.json  f1         0.6016         0.59422        -0.00737
data/metrics/performance.json  fns        9753           9294           -459
data/metrics/performance.json  fps        9753           9294           -459
data/metrics/performance.json  precision  0.6177         0.64136        0.02366
data/metrics/performance.json  recall     0.60166        0.62041        0.01875
data/metrics/performance.json  tps        14731          15190          459
```

To close...

- 5 reasons to care about reproducibility in ML
  - Collaboration, Debugging, Validation, Auditing, Legacy
- 4 components to account for
  - Environment, Code, Data, Metrics

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Questions?

Code and slides on Github

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Let's connect!

Timothy Dobbins

DATA SCIENTIST

Helping visionaries bring data products to market

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