Structuring Machine Learning Projects

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Agenda

- Machine learning: The life-cycle
- Why care about the structure?
- A **structured** approach to **structuring**
  - A polished directory structure
  - Workspace setup
  - Building mental models of the project’s flow
  - Experimentation
  - ....
- Taking the next steps
- Guiding lights

Life-cycle of a machine learning project

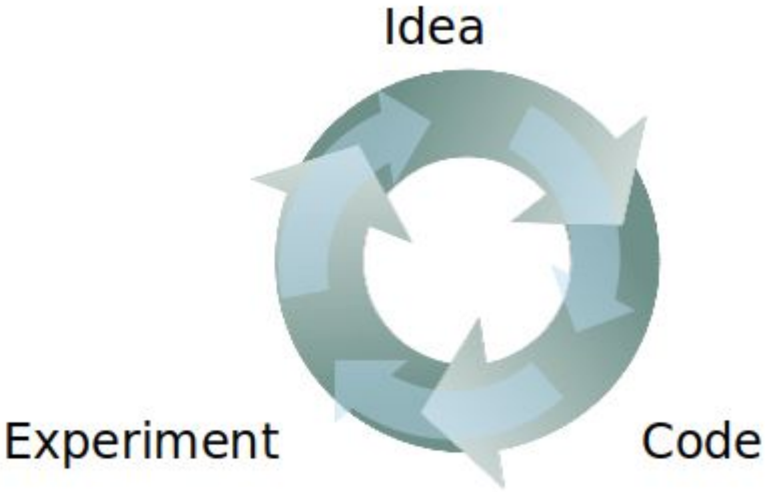
- Problem understanding
- Data collection, wrangling and so on
- Understanding of the data
- Beginning the modeling process
- Evaluate, tune, repeat
- Model deployment, monitoring and so on...

Note that the above steps are very summarized

Structuring machine learning projects: The need

Applied machine (and deep) learning is iterative

- Lots of experimentations make it hard to keep track
- Hyperparameter tuning
- Dataset reconstructions
- KPI: Time-Cost tradeoff



Source

Reproducibility crisis

- **Stochasticity** in machine learning models (neural nets specifically)
- Code breakdown due to dependency mismatches
- Difference in machine configurations

Versioning data and codebase

- Training data might change over time (less frequent)

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Versioning data and codebase

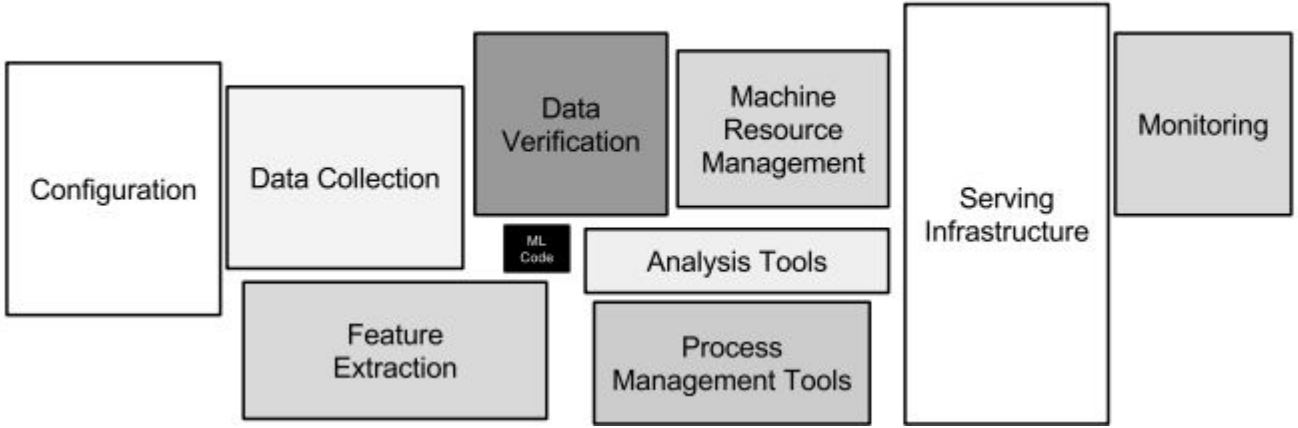
- Training data might change over time (less frequent)
- Changes in project’s codebase are far more frequent

Regularity in checkpointing

Decrease in validation loss was steady during the training, but what if that model is lost?

A directory structure

- A full-fledged ML project is **not just about models**



Source

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A high-interest technical debt

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- Not everyone in the team understands everything
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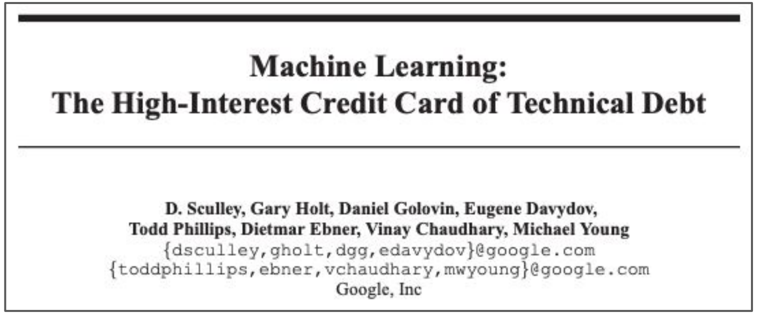


Machine Learning:
The High-Interest Credit Card of Technical Debt

D. Sculley, Gary Holt, Daniel Golovin, Eugene Davydov,
Todd Phillips, Dietmar Ebner, Vinay Chaudhary, Michael Young
{dsculley,gholt,dgg,edavydov}@google.com
{toddphillips,ebner,vchaudhary,mwyoung}@google.com
Google, Inc

Quick summary

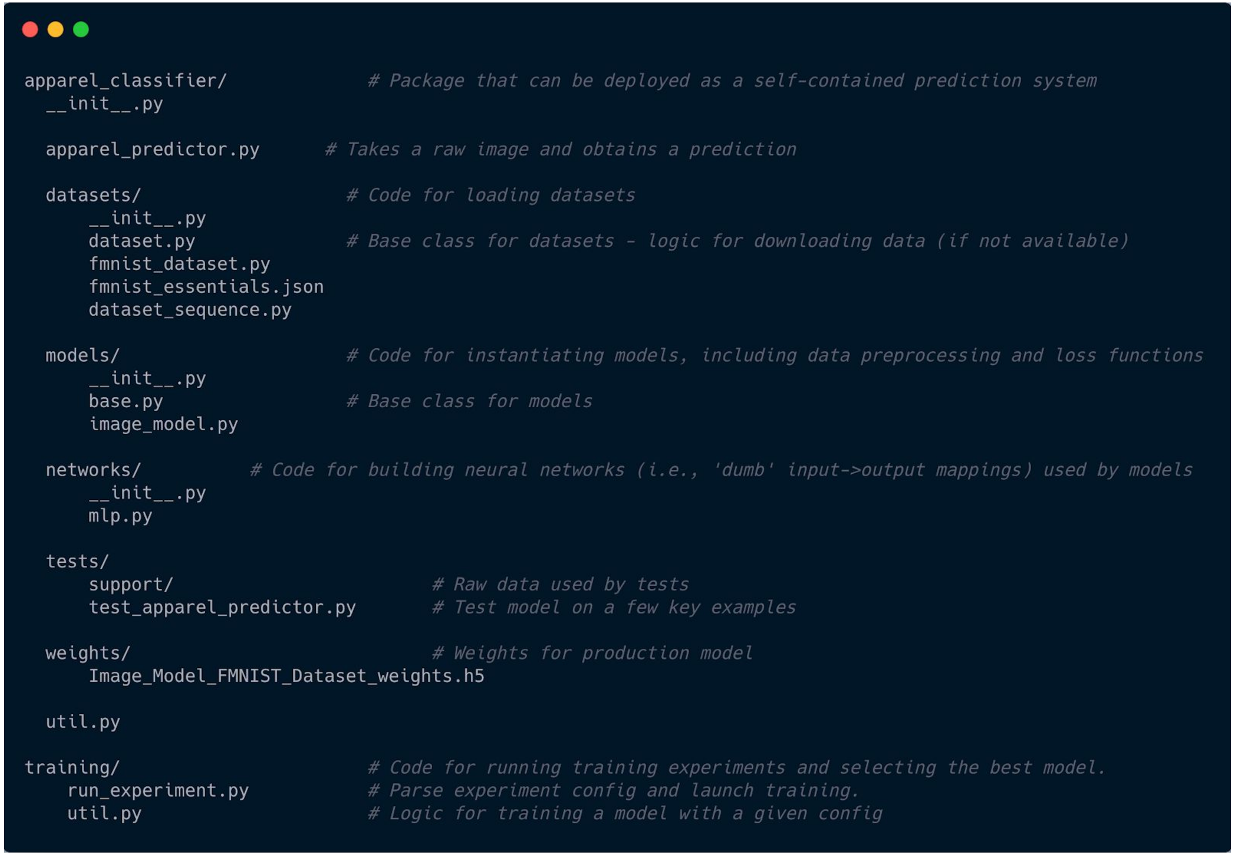
- Applied machine learning is an iterative process
- Reproducibility crisis
- Versioning data and codebase
- Regularity in checkpointing
- Directory structures
- Technical debt

Structuring Machine Learning projects: A definitive approach

Starting with a polished directory structure

- Data (along with scripts to *download it* and *preprocess it*)
- Experimentations
- Web backend
- Utility scripts
- Model building and model training scripts

A reference directory structure



```
apparel_classifier/             # Package that can be deployed as a self-contained prediction system
  __init__.py

  apparel_predictor.py      # Takes a raw image and obtains a prediction

  datasets/                   # Code for loading datasets
      __init__.py
      dataset.py              # Base class for datasets - logic for downloading data (if not available)
      fmnist_dataset.py
      fmnist_essentials.json
      dataset_sequence.py

  models/                     # Code for instantiating models, including data preprocessing and loss functions
      __init__.py
      base.py                 # Base class for models
      image_model.py

  networks/          # Code for building neural networks (i.e., 'dumb' input->output mappings) used by models
      __init__.py
      mlp.py

  tests/
      support/                        # Raw data used by tests
      test_apparel_predictor.py       # Test model on a few key examples

  weights/                            # Weights for production model
      Image_Model_FMNIST_Dataset_weights.h5

  util.py

training/                       # Code for running training experiments and selecting the best model.
    run_experiment.py           # Parse experiment config and launch training.
    util.py                     # Logic for training a model with a given config
```

Workspace setup

- Use of environment management tools - **pipenv**, **virtualenv** etc
- Incorporating containers - **Docker**, **Kubernetes** etc
- Use of unified machine learning platforms like FloydHub

Keeping track of the experiments

Machine learning experiments have a lot of components:

- Loss/Accuracy metrics
- Model parameters
- CPU, GPU and disk usage

And so on ...

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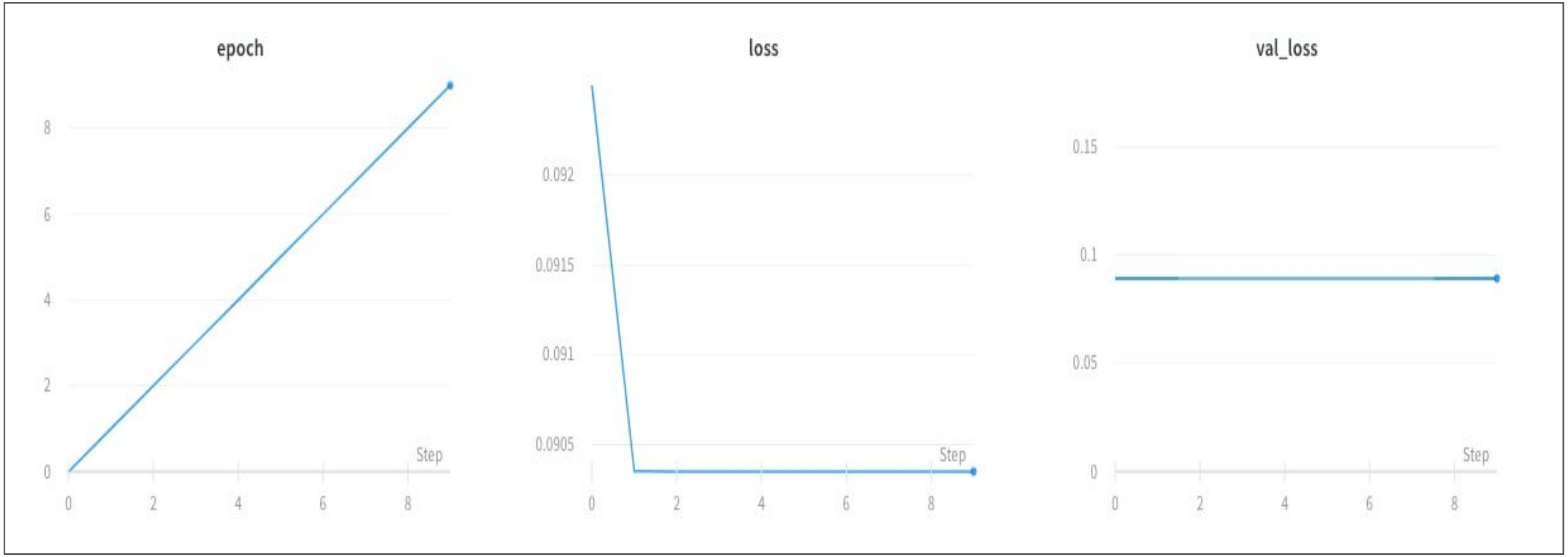
Use **Weights and Biases** to automatically keep track of these for you on the **cloud**!


epoch
8
6
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2
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Step
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2
4
6
8
loss
0.092
0.0915
0.091
0.0905
Step
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val_loss
0.15
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4
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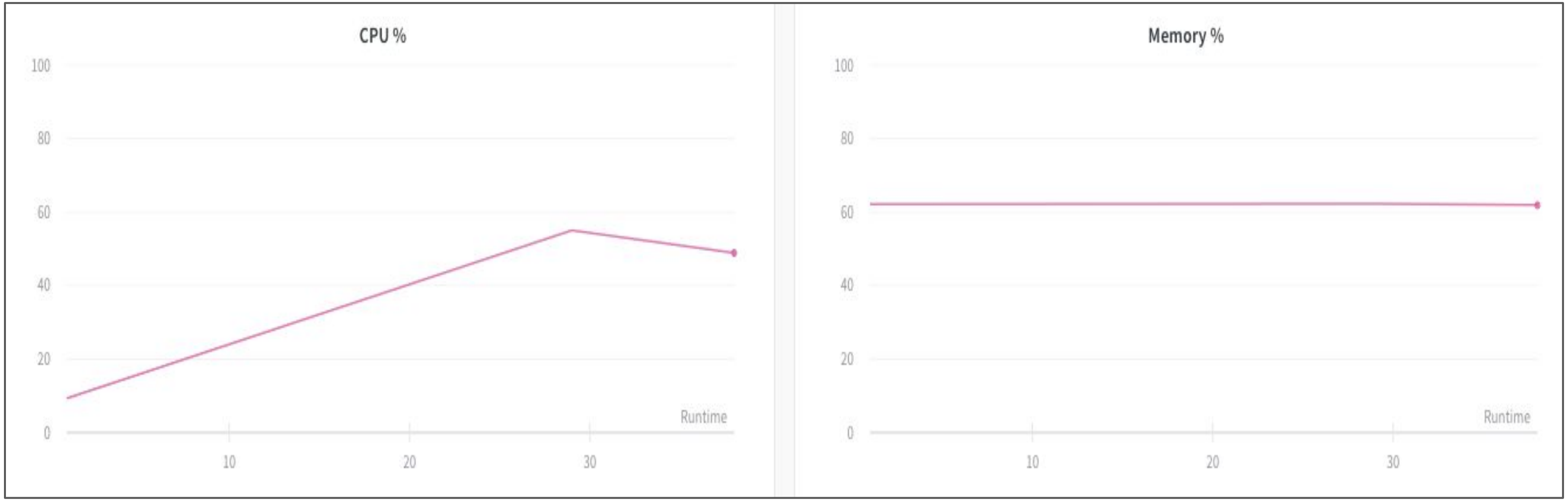
8


CPU %
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30
Memory %
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Runtime
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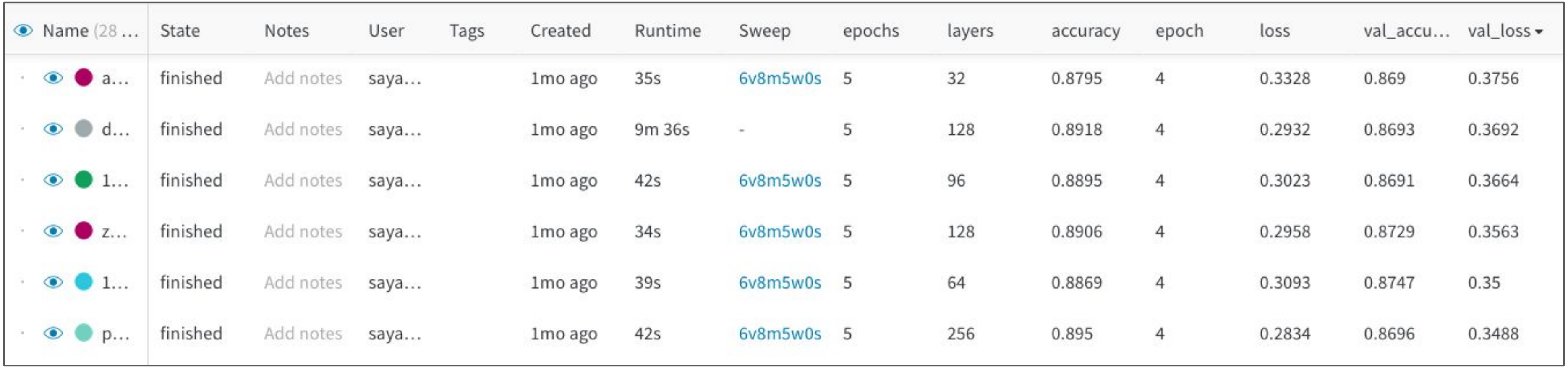
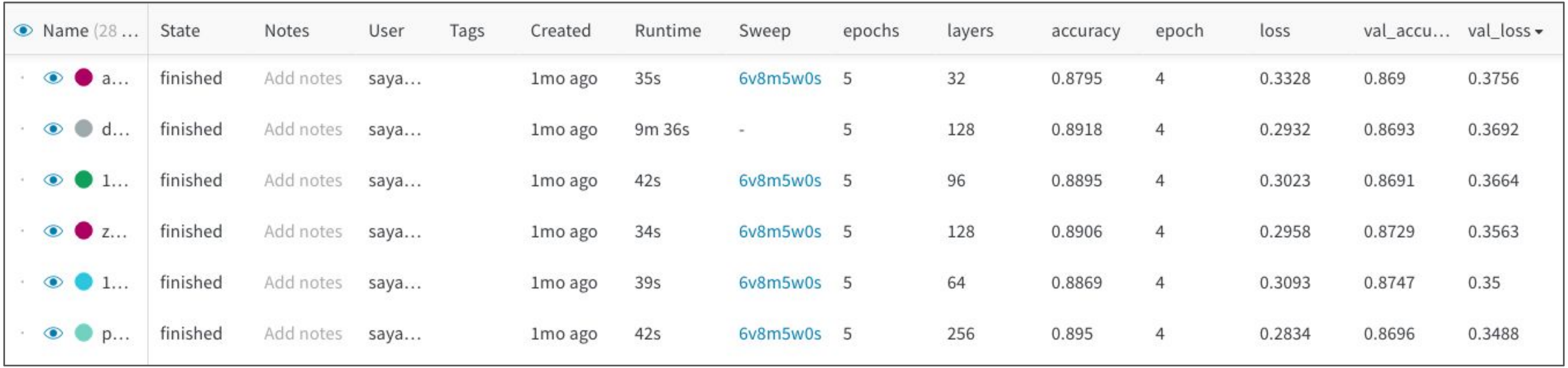


Name (28 …	State	Notes	User	Tags	Created	Runtime	Sweep	epochs	layers	accuracy	epoch	loss	val_accu…	val_loss ▾
● a…	finished	Add notes	saya…		1mo ago	35s	6v8m5w0s	5	32	0.8795	4	0.3328	0.869	0.3756
● d…	finished	Add notes	saya…		1mo ago	9m 36s	-	5	128	0.8918	4	0.2932	0.8693	0.3692
● 1…	finished	Add notes	saya…		1mo ago	42s	6v8m5w0s	5	96	0.8895	4	0.3023	0.8691	0.3664
● z…	finished	Add notes	saya…		1mo ago	34s	6v8m5w0s	5	128	0.8906	4	0.2958	0.8729	0.3563
● 1…	finished	Add notes	saya…		1mo ago	39s	6v8m5w0s	5	64	0.8869	4	0.3093	0.8747	0.35
● p…	finished	Add notes	saya…		1mo ago	42s	6v8m5w0s	5	256	0.895	4	0.2834	0.8696	0.3488



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Try it out here:
http://bit.ly/w_and_b

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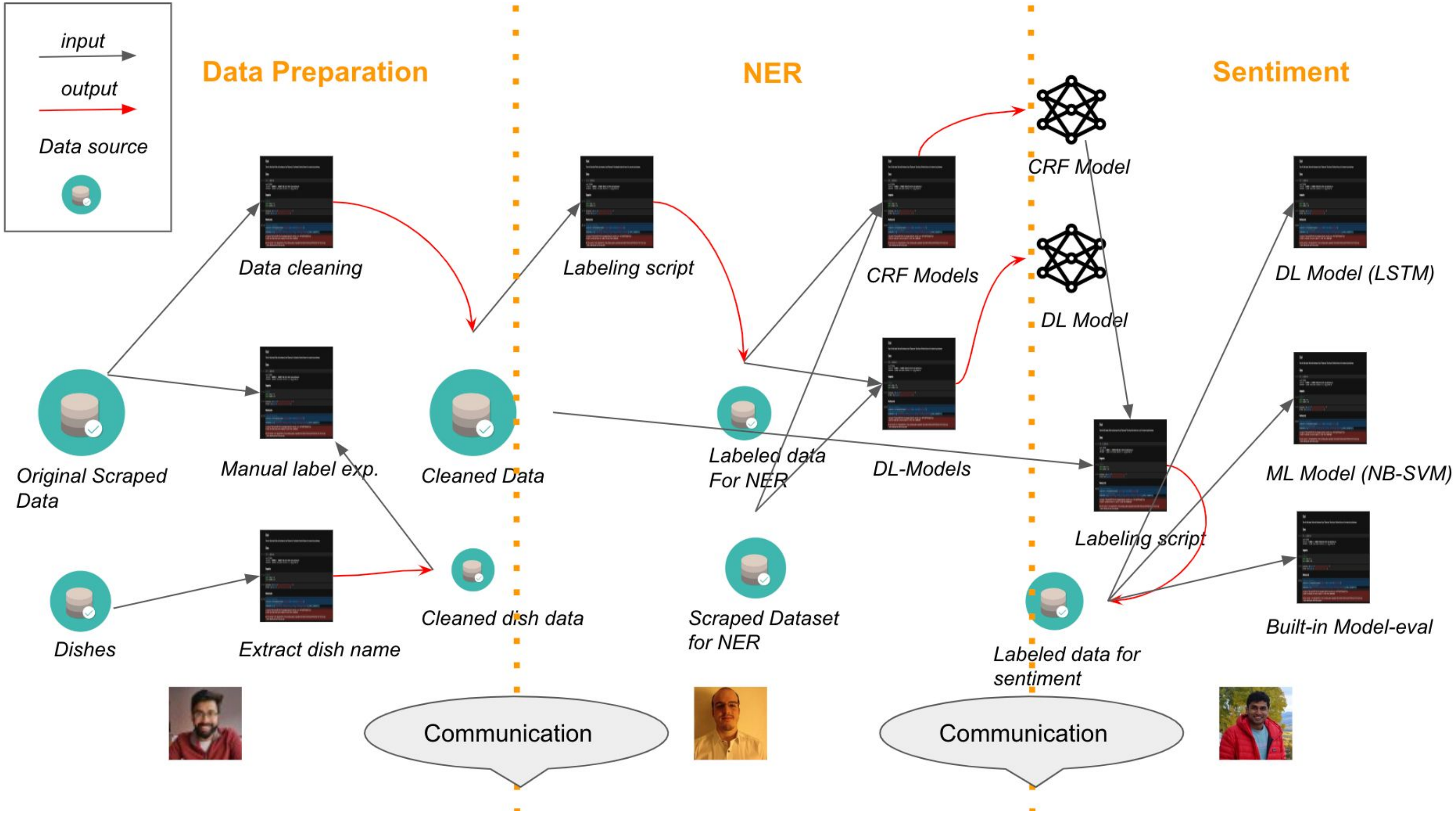
Hence a mental model to keep track of these lego blocks always helps!

A specimen of a mental model



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Version controlling data and codebase *separately*

Here are some situations:

- Need to replace the older images with newer ones
- Need to add new images to an already existing training set
- Decision to incorporate active learning to select interesting test data points to manually label them and add to the existing training set

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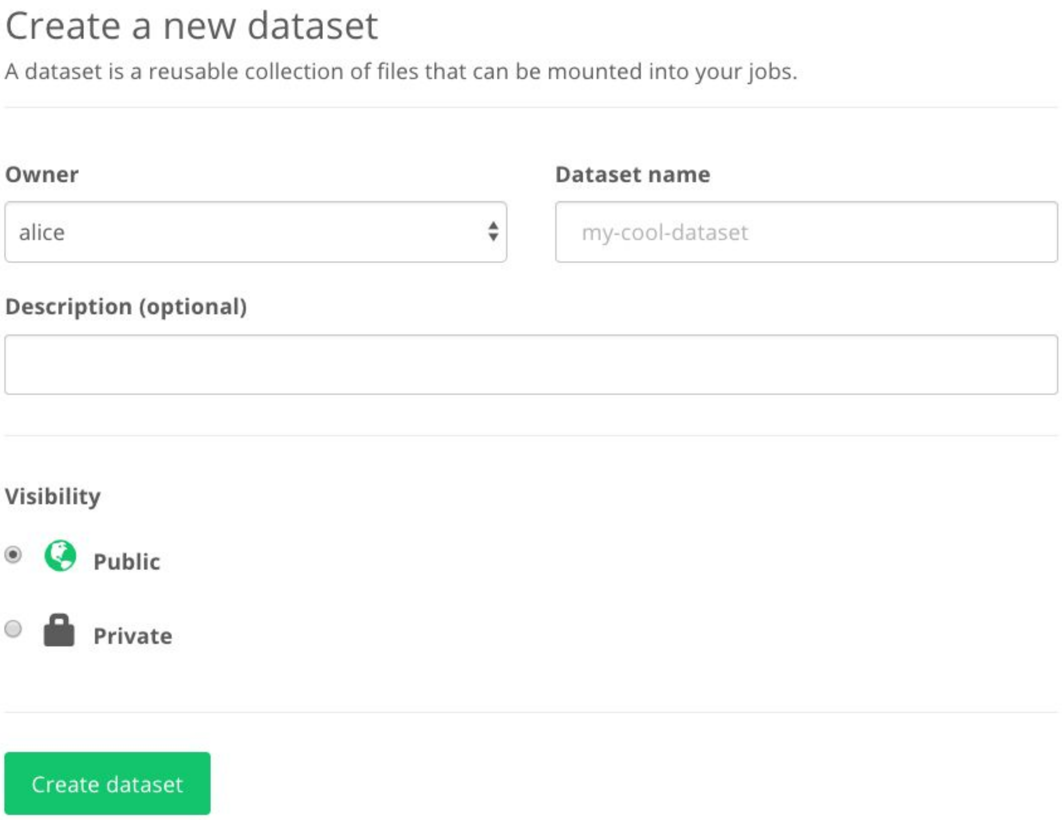
Version control of codebase remains traditional!

FloydHub datasets



Create a new dataset

A dataset is a reusable collection of files that can be mounted into your jobs.

Owner

alice

Dataset name

my-cool-dataset

Description (optional)

Visibility

● **Public**

○ **Private**

FloydHub datasets are a good way to version control your data!

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Quick summary

- Maintaining a healthy directory structure
- Setting up the workspace
- Keeping track of your experiments
- Building a mental model of the project flow
- Version control of data and codebase

What did we *not* cover?

- Test cases for machine learning projects
- Model deployment

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- Test cases for machine learning projects
- Model deployment

Maybe next time :)

Slides available here:
http://bit.ly/izmir-sayak

References

- How to plan and execute your ML and DL projects
- Troubleshooting Deep Neural Networks
- Production Machine Learning Systems

See you next time

Find me here:
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Thank you very much :)

Experts

pyimagesearch