Large scale non-linear learning on a single CPU

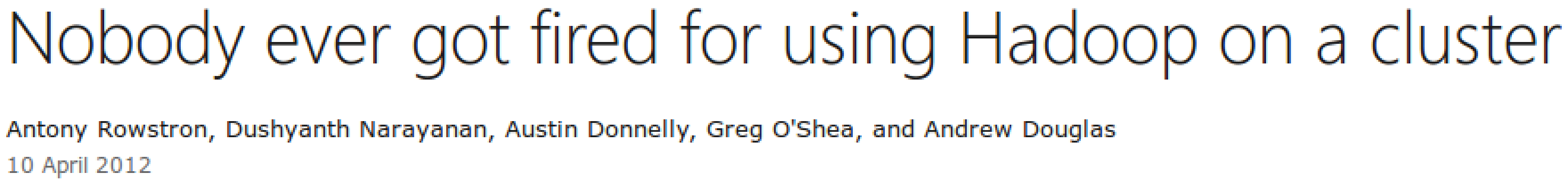
Andreas Mueller

Three regimes of data

- Fits in RAM
- Fits on a Hard Drive
- Doesn't fit on a single PC

Three regimes of data

- Fits in RAM (up to 256 GB?)
- Fits on a Hard Drive (up to 6TB?)
- Doesn't fit on a single PC



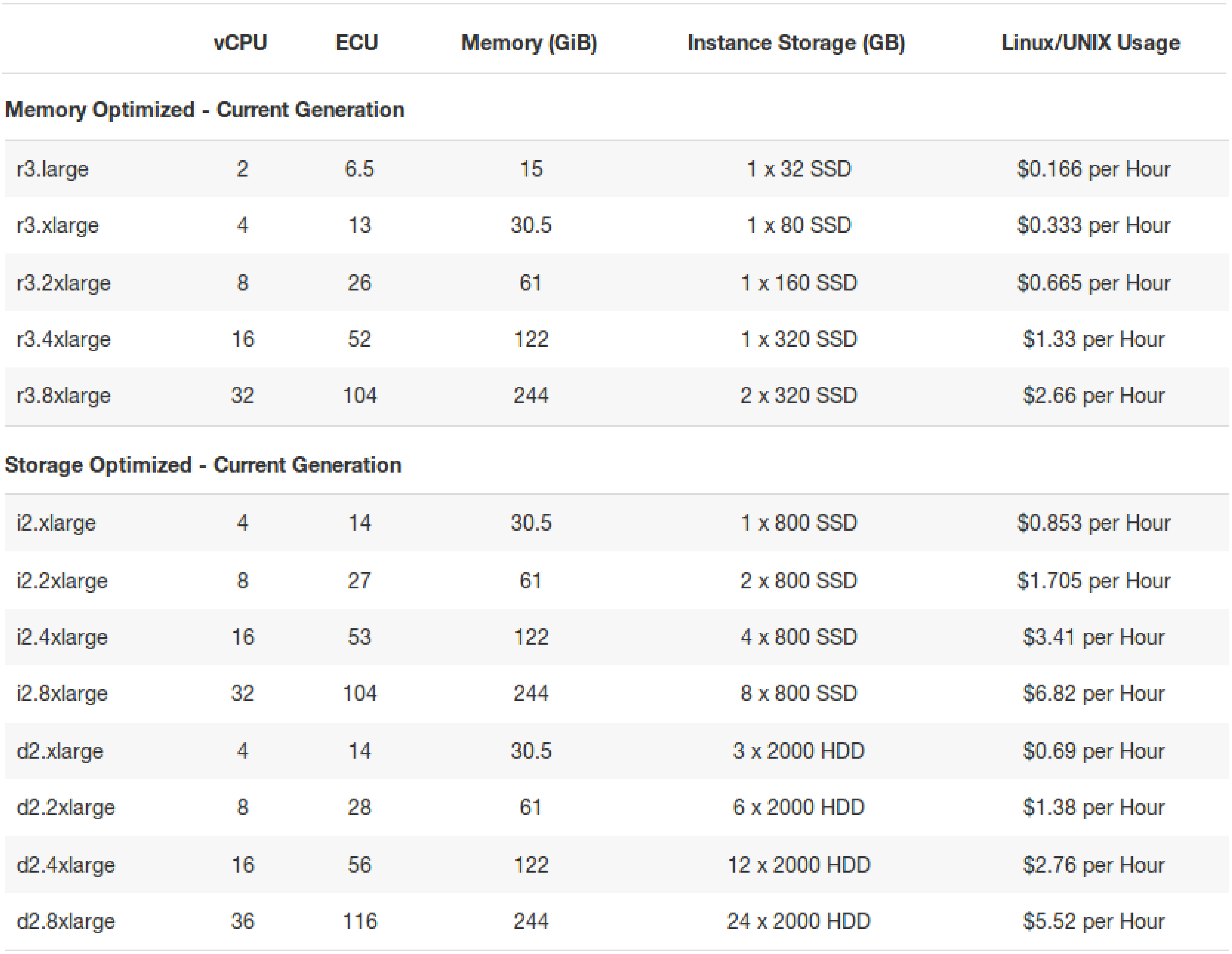
Nobody ever got fired for using Hadoop on a cluster

Antony Rowstron, Dushyanth Narayanan, Austin Donnelly, Greg O'Shea, and Andrew Douglas

10 April 2012

Why not do to out of core learning.

Your data is not that big!

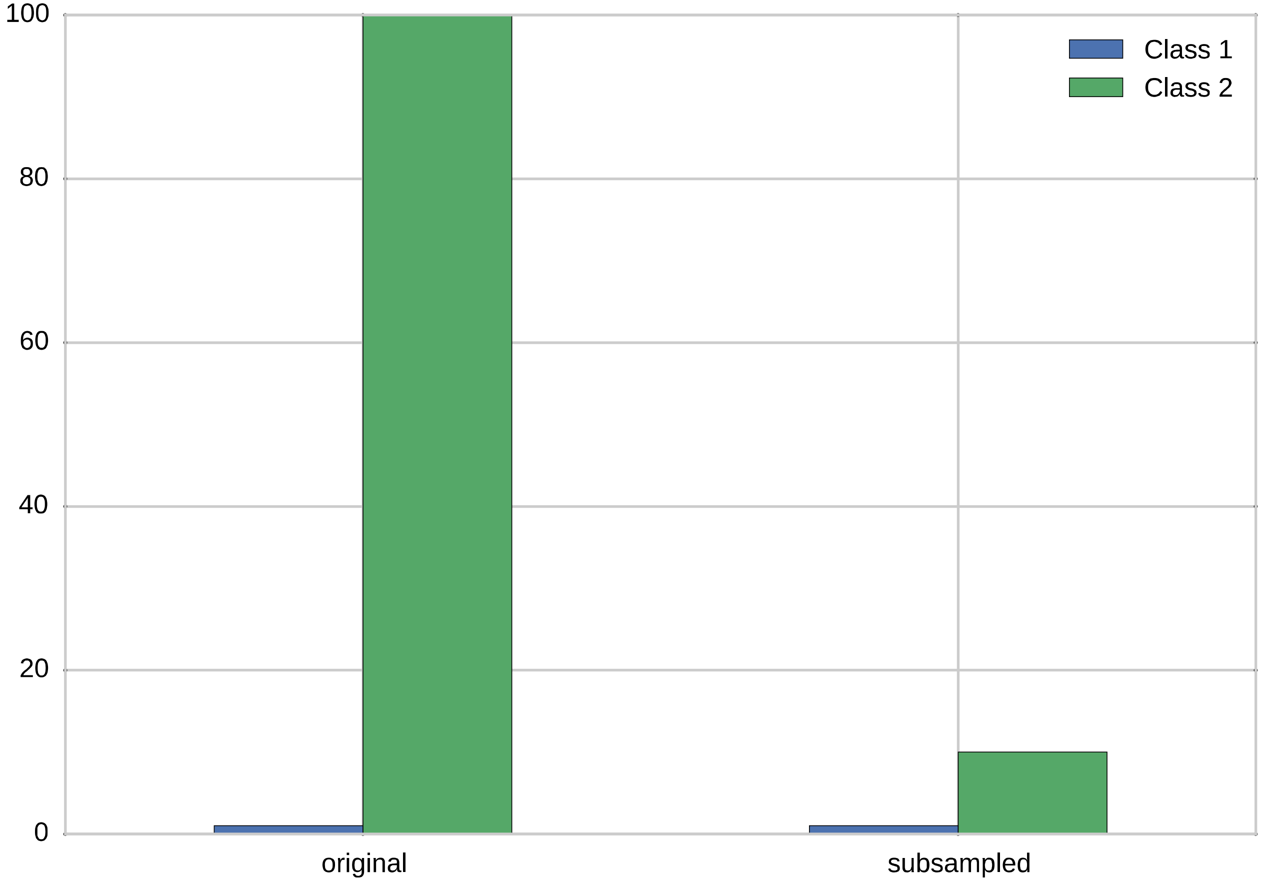


	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
Memory Optimized - Current Generation					
r3.large	2	6.5	15	1 x 32 SSD	$0.166 per Hour
r3.xlarge	4	13	30.5	1 x 80 SSD	$0.333 per Hour
r3.2xlarge	8	26	61	1 x 160 SSD	$0.665 per Hour
r3.4xlarge	16	52	122	1 x 320 SSD	$1.33 per Hour
r3.8xlarge	32	104	244	2 x 320 SSD	$2.66 per Hour
Storage Optimized - Current Generation					
i2.xlarge	4	14	30.5	1 x 800 SSD	$0.853 per Hour
i2.2xlarge	8	27	61	2 x 800 SSD	$1.705 per Hour
i2.4xlarge	16	53	122	4 x 800 SSD	$3.41 per Hour
i2.8xlarge	32	104	244	8 x 800 SSD	$6.82 per Hour
d2.xlarge	4	14	30.5	3 x 2000 HDD	$0.69 per Hour
d2.2xlarge	8	28	61	6 x 2000 HDD	$1.38 per Hour
d2.4xlarge	16	56	122	12 x 2000 HDD	$2.76 per Hour
d2.8xlarge	36	116	244	24 x 2000 HDD	$5.52 per Hour

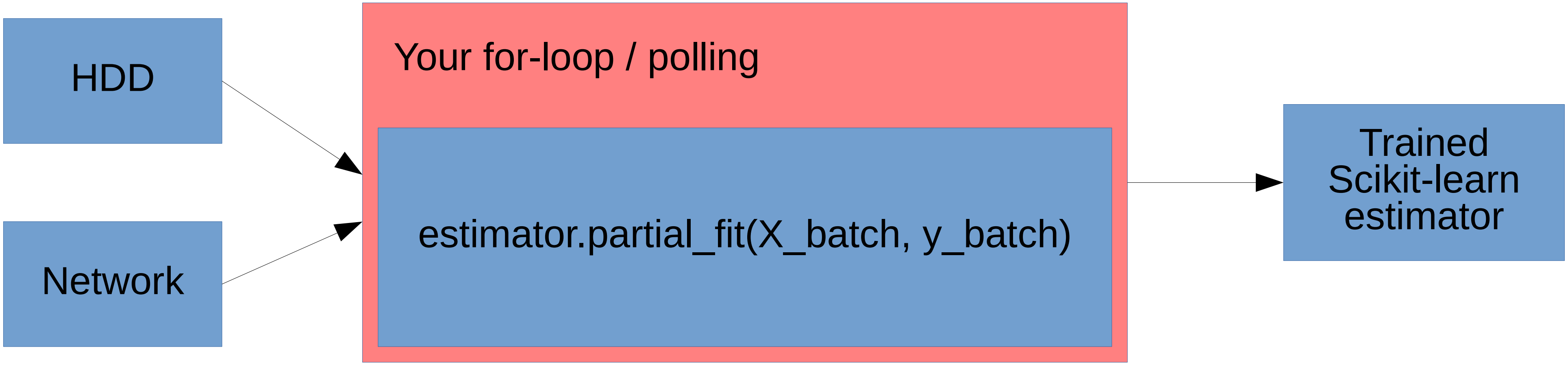
"512Gb ought to be enough for anybody."
- me

(for machine learning)

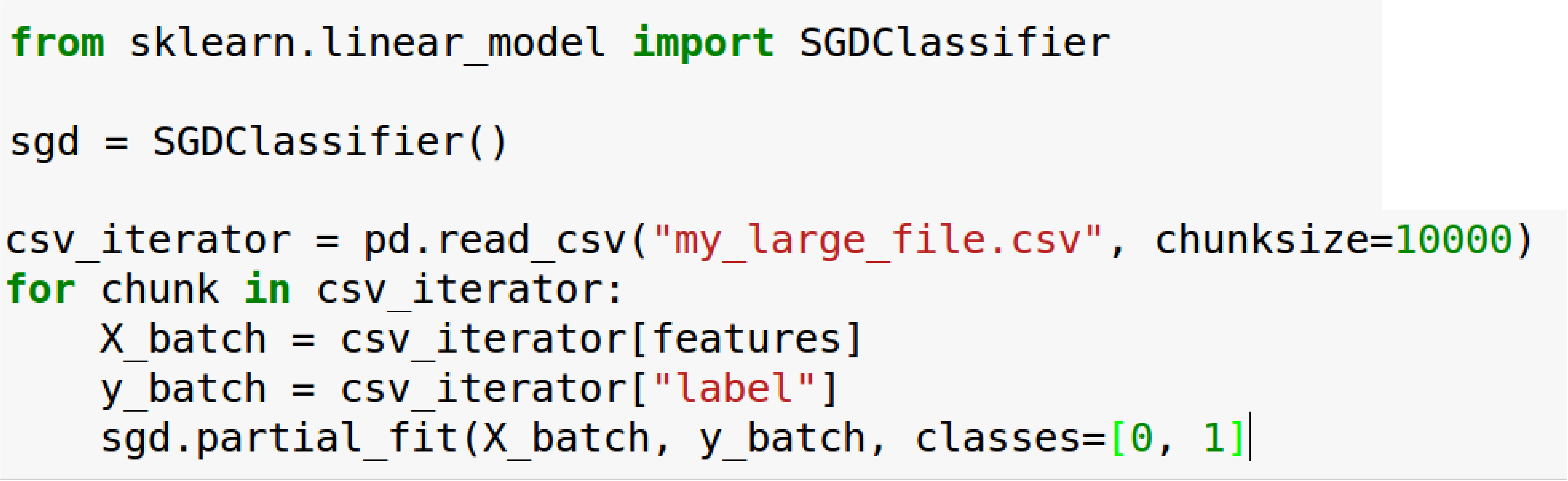
Subsample!



The scikit-learn way

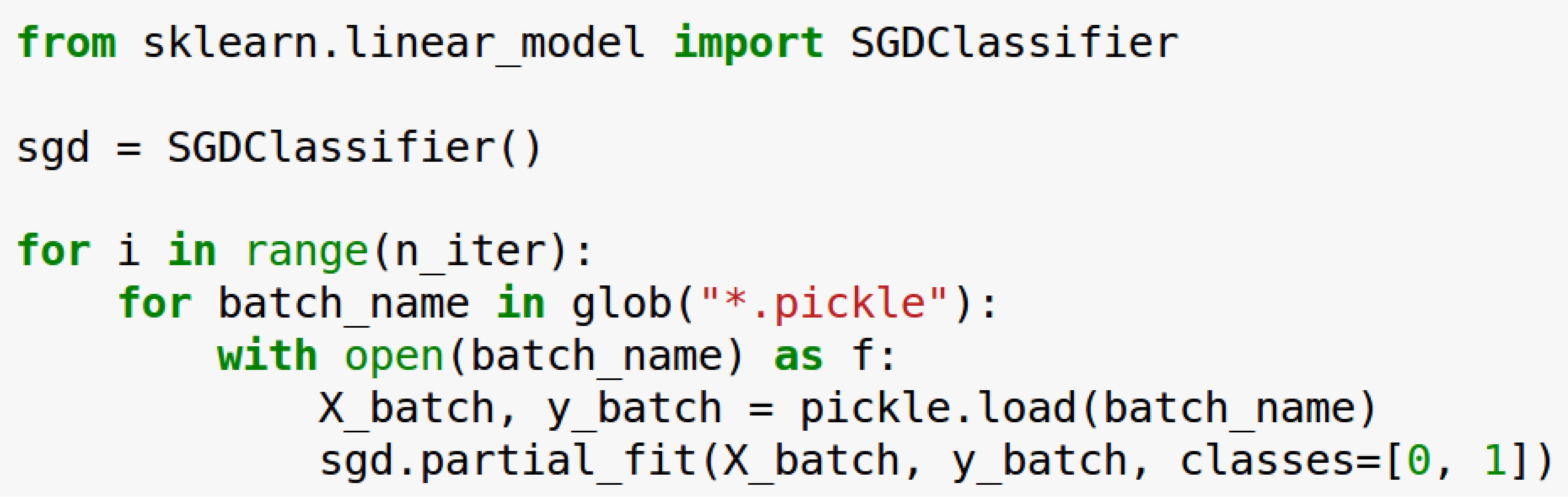

HDD
Network
Your for-loop / polling
estimator.partial_fit(X_batch, y_batch)
Trained Scikit-learn estimator

Linear Classification



```
from sklearn.linear_model import SGDClassifier

sgd = SGDClassifier()

csv_iterator = pd.read_csv("my_large_file.csv", chunksize=10000)
for chunk in csv_iterator:
    X_batch = csv_iterator[features]
    y_batch = csv_iterator["label"]
    sgd.partial_fit(X_batch, y_batch, classes=[0, 1]
```

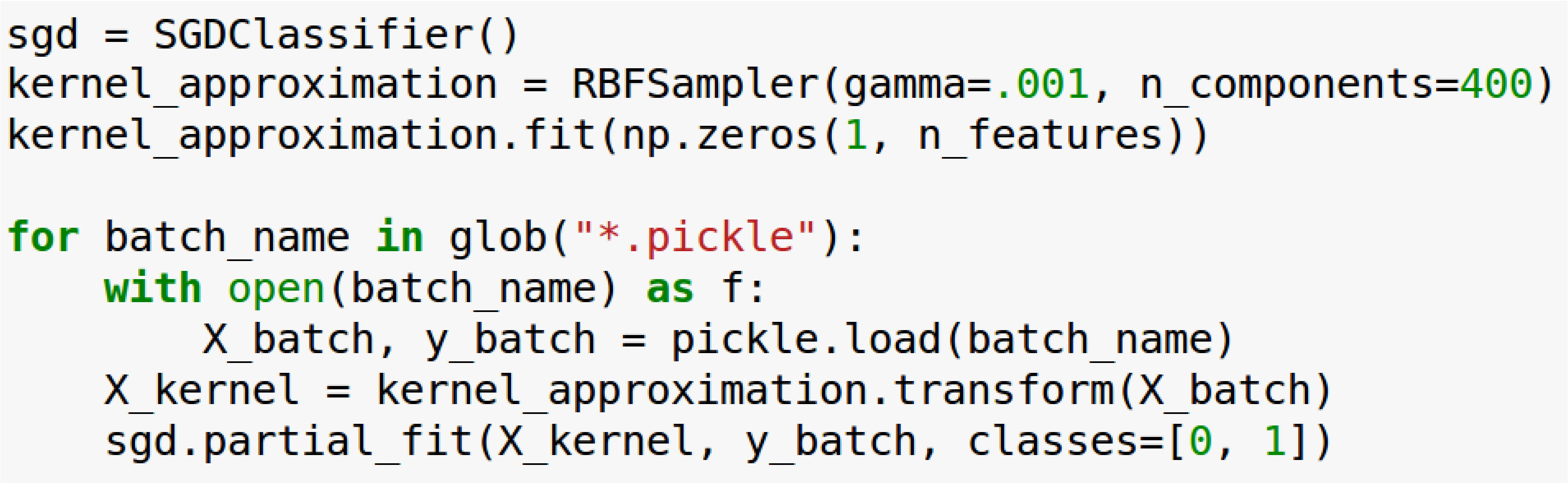
Linear Classification



```
from sklearn.linear_model import SGDClassifier

sgd = SGDClassifier()

for i in range(n_iter):
    for batch_name in glob("*.pickle"):
        with open(batch_name) as f:
            X_batch, y_batch = pickle.load(batch_name)
            sgd.partial_fit(X_batch, y_batch, classes=[0, 1])
```

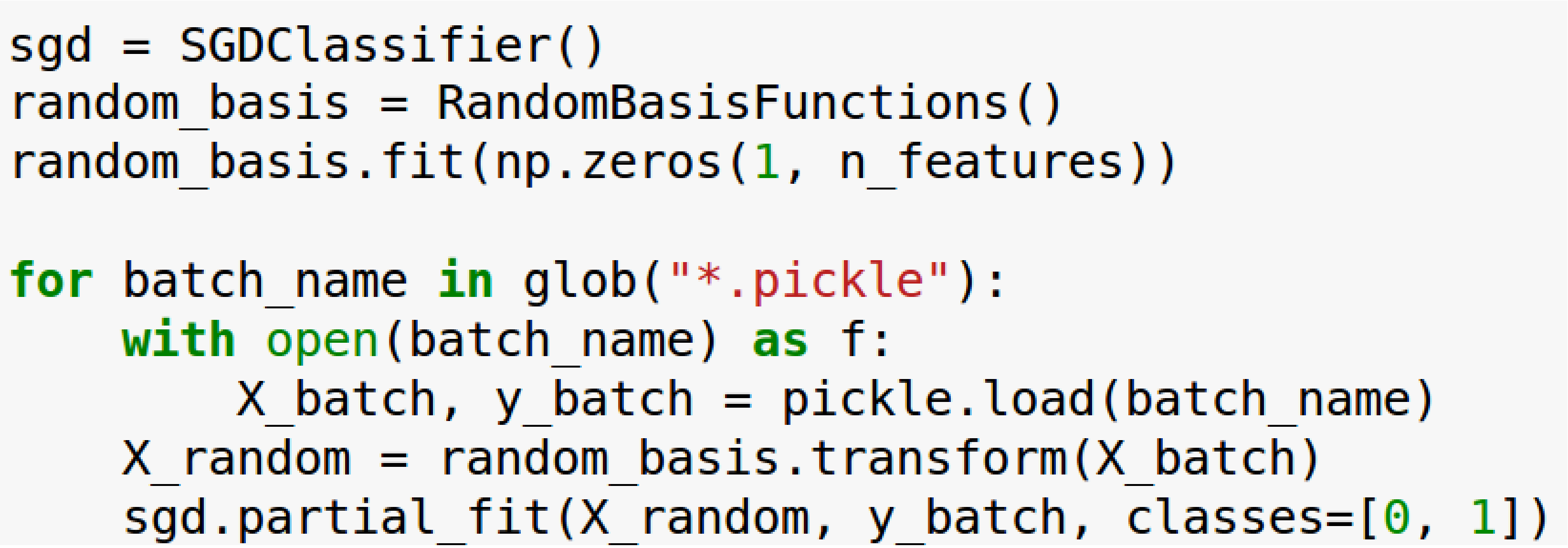
1st nonlinear option: Stateless Transformers

Kernel Approximation



```python
sgd = SGDClassifier()
kernel_approximation = RBFSampler(gamma=.001, n_components=400)
kernel_approximation.fit(np.zeros(1, n_features))

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
    X_kernel = kernel_approximation.transform(X_batch)
    sgd.partial_fit(X_kernel, y_batch, classes=[0, 1])
```

Random Neural Nets

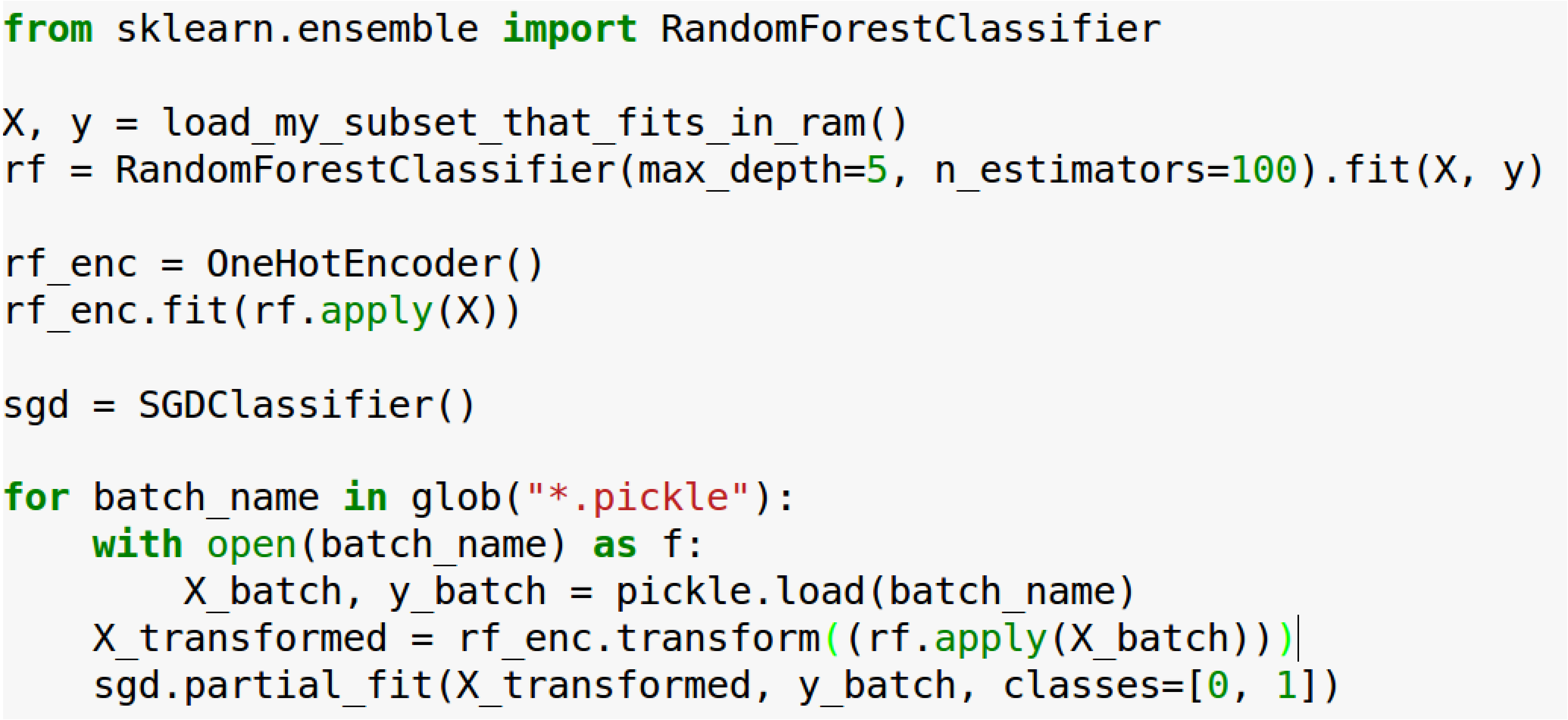


```
sgd = SGDClassifier()
random_basis = RandomBasisFunctions()
random_basis.fit(np.zeros(1, n_features))

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
    X_random = random_basis.transform(X_batch)
    sgd.partial_fit(X_random, y_batch, classes=[0, 1])
```

(not merged yet)

2nd nonlinear option: Learn Transformations on Subsets

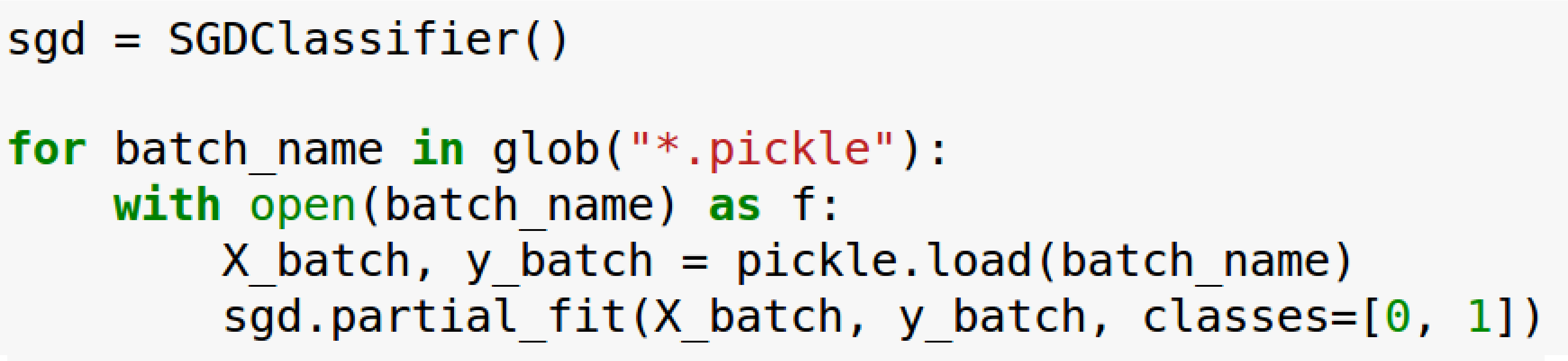
RandomForests



```python
from sklearn.ensemble import RandomForestClassifier

X, y = load_my_subset_that_fits_in_ram()
rf = RandomForestClassifier(max_depth=5, n_estimators=100).fit(X, y)

rf_enc = OneHotEncoder()
rf_enc.fit(rf.apply(X))

sgd = SGDClassifier()

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
    X_transformed = rf_enc.transform((rf.apply(X_batch)))
    sgd.partial_fit(X_transformed, y_batch, classes=[0, 1])
```

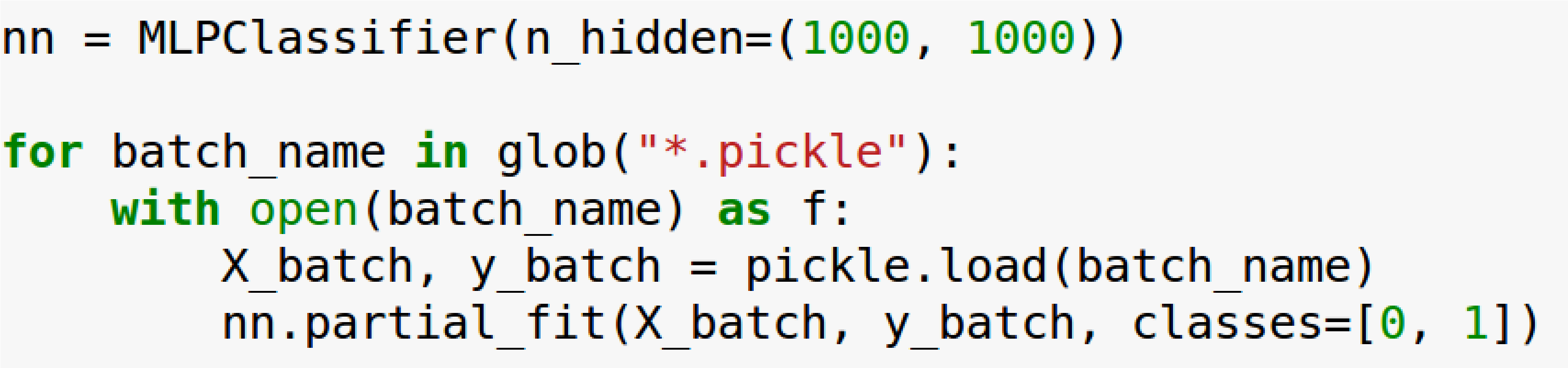
3rd nonlinear option: Online Nonlinear Classification

Neural Networks (MLPs)



```
sgd = SGDClassifier()

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
        sgd.partial_fit(X_batch, y_batch, classes=[0, 1])
```

Neural Networks (MLPs)



```
nn = MLPClassifier(n_hidden=(1000, 1000))

for batch_name in glob("*.pickle"):
    with open(batch_name) as f:
        X_batch, y_batch = pickle.load(batch_name)
        nn.partial_fit(X_batch, y_batch, classes=[0, 1])
```

Other algorithms

- Naive Bayes
- `MinibatchKMeans`
- `Birch`
- `IncrementalPCA`
- `MiniBatchDictionaryLearning`
- `Scalers`
- `...`

What Else is Out There?

- Vowpal Wabbit (VW)
- More deep learning
- Hogwild!