Simplifier le déploiement de modèles de machine learning avec ONNX

Xavier Dupré

Senior Data Scientist at Microsoft

Professor at ENSAE

Open Source

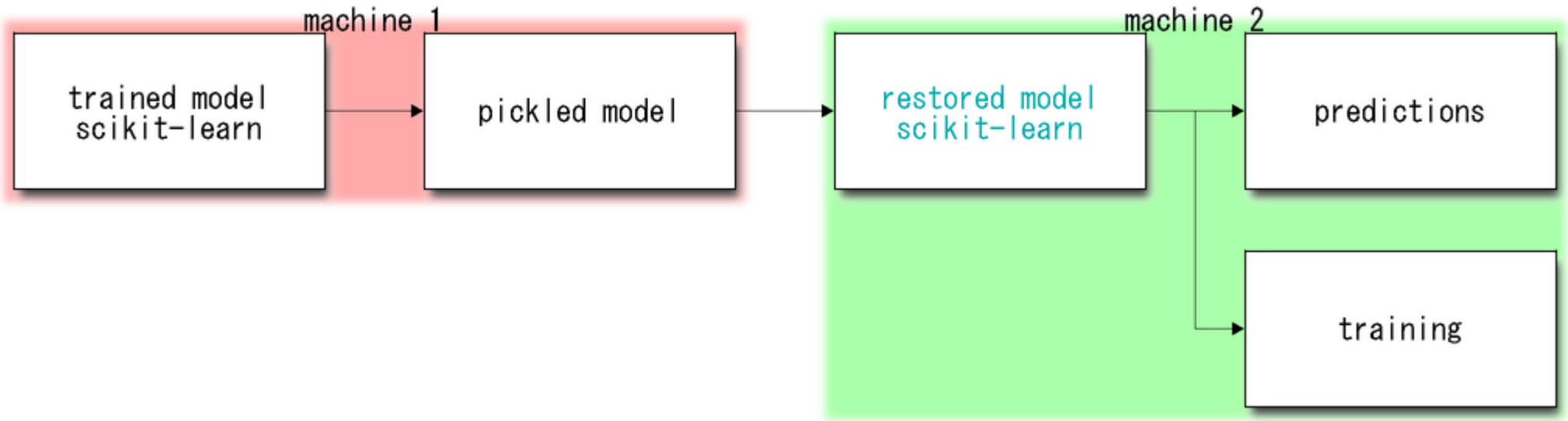
Tout est **open source** (**MIT** license) et sur **github**.

Plan

- Prédictions en production
- ONNX spécifications
- Conversion to ONNX
- Runtime / Benchmark
- Customisation
- La suite…

Prédictions en production

Sauver un modèle avec pickle

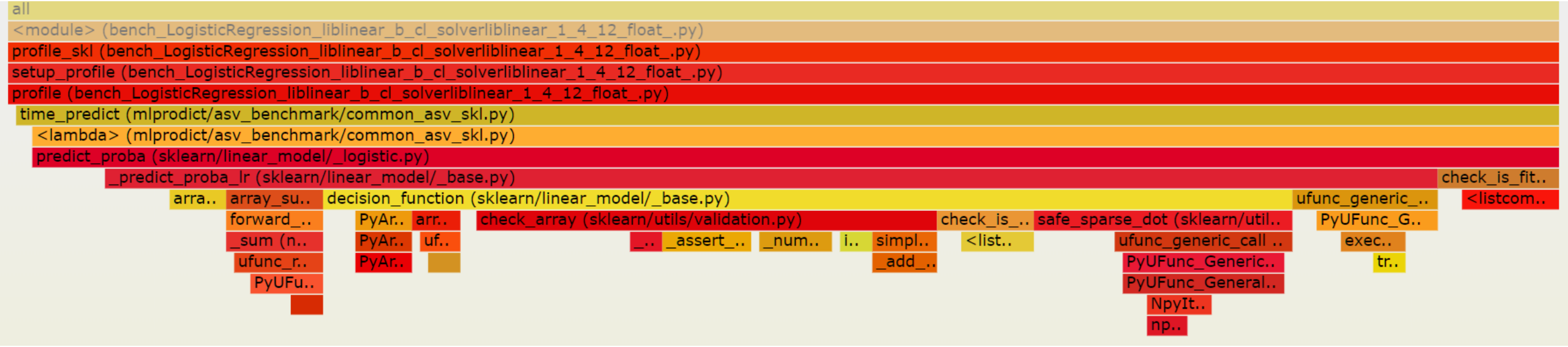


Issues:

- pickle est instable (version de python…)
- Pas mal de monde utilise docker + kubernetes
- Les prédictions ne sont pas rapides (scikit-learn est optimisé pour des « batch predictions » ou prédictions par lot.

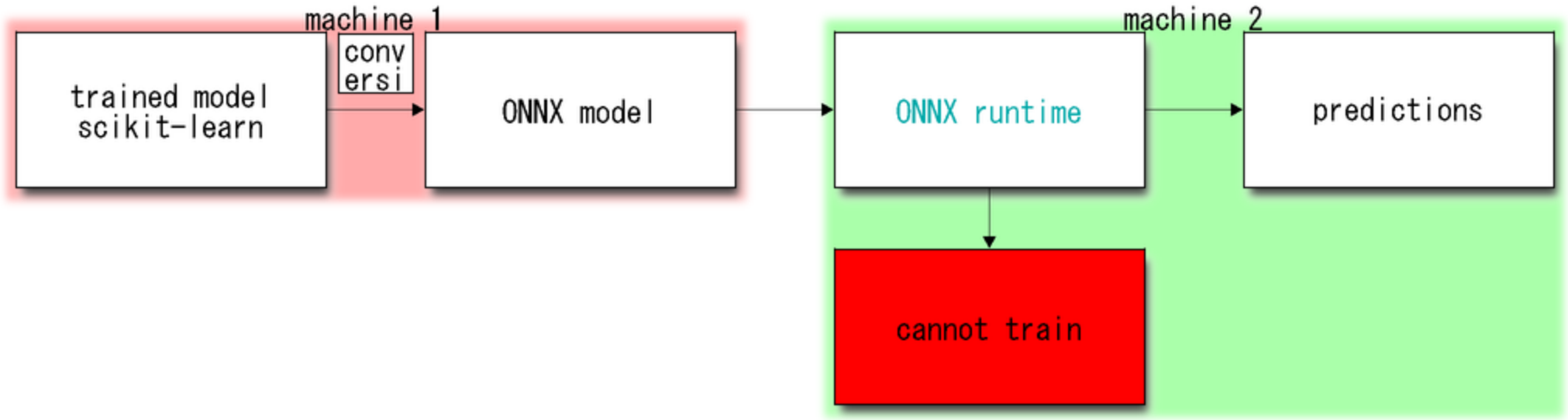
Exemple avec une régression logistique

clr.predict_proba(X)



Astuce:
sklearn.config_context(assume_finite=True/False)

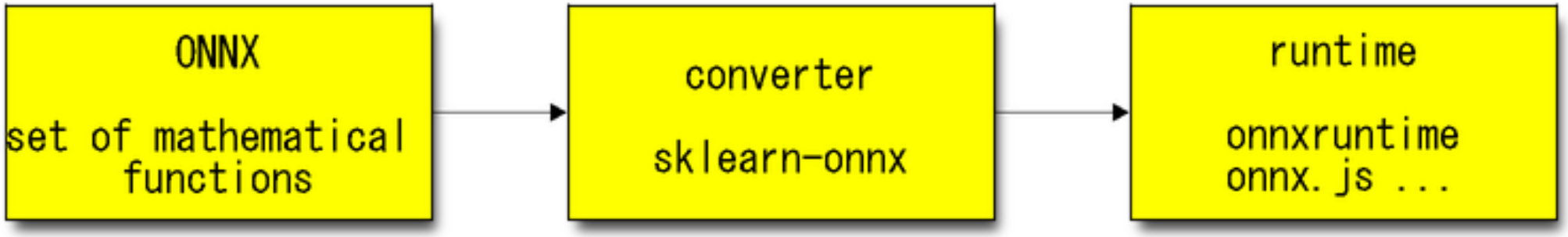
Déploiement avec ONNX…



ONNX est…

- Un format de sérialisation basé sur protobuf
- Une façon de décrire toute fonction de prédiction d'un modèle de machine learning

3 composants pour ONNX



ONNX

- ONNX = **ensemble d'opérations** mathématiques assemblées dans un **graphe**
- C'est versionné et **stable**: conserve la compatibilité.
- C'est optiimisé pour le deep learning, implémenté avec des **single float**

Simple fonction avec ONNX

f(X)=…

```
In [11]: beta = np.random.randn(4, 3)
         M = (X @ beta)
         expM = np.exp(M)
         pred = expM / (expM + 1)
         pred[:5]
```

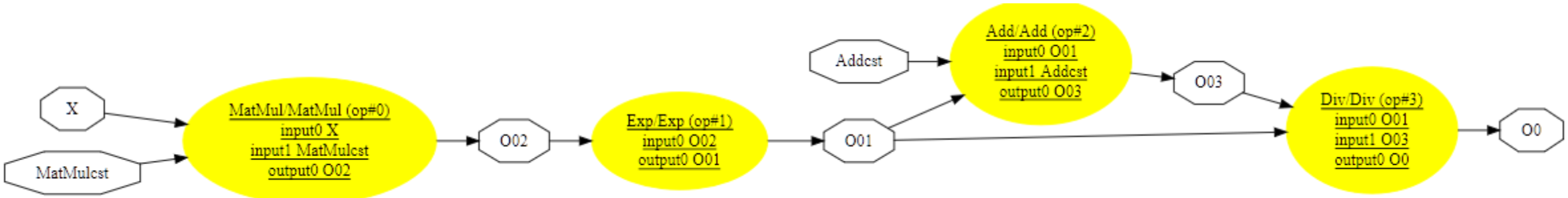
```
Out[11]: array([[0.0022439 , 0.60292776, 0.11036919],
                [0.00474268, 0.46085765, 0.15304197],
                [0.00367439, 0.5859233 , 0.13088156],
                [0.00469139, 0.54574802, 0.15141273],
                [0.00201307, 0.65597864, 0.10384264]])
```

```
:  X32 = X.astype(np.float32)
   beta32 = beta.astype(np.float32)
```

```
onnxExpM = OnnxExp(OnnxMatMul('X', beta32))

cst = np.ones((1, 3), dtype=np.float32)
onnxExpM1 = OnnxAdd(onnxExpM, cst)        # use of broadcasting

onnxPred = OnnxDiv(onnxExpM, onnxExpM1)
```



Sérialisation, métadonnées

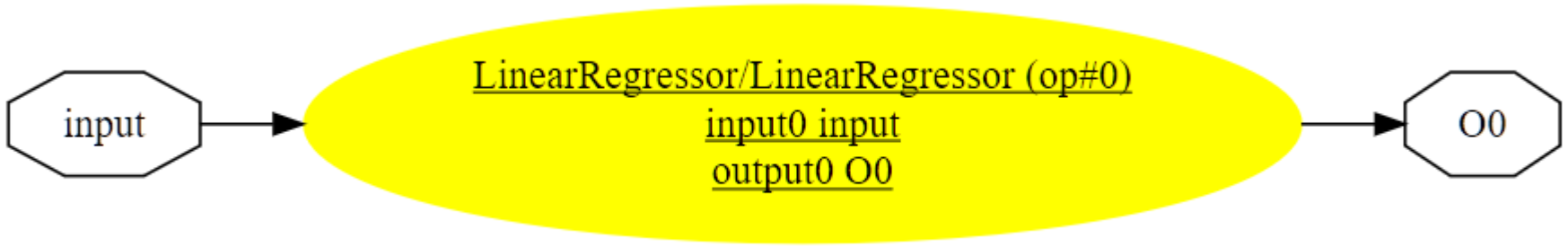
```
In [92]: with open("model-1.onnx", "wb") as f:
             f.write(model_onnx.SerializeToString())
```

```
In [94]: import onnx
         model2 = onnx.load("model-1.onnx")
```

```
ir_version: 5
producer_name: "skl2onnx"
producer_version: "1.4.9999"
domain: "ai.onnx"
model_version: 0
graph {
  node {
    input: "X"
    input: "MatMulcst"
    output: "O02"
    name: "MatMul"
    op_type: "MatMul"
    domain: ""
  }
  node {
...
```

Modèle de machine learning

```
lin_reg = OnnxLinearRegressor('input',
                              coefficients=beta, targets=2)
```



Conversion vers ONNX

Keras	https://github.com/onnx/keras-onnx	
LibSVM	https://github.com/onnx/onnxmltools	
LightGBM	https://github.com/onnx/onnxmltools	
MATLAB	https://www.mathworks.com/matlabcentral/fileexchange/67296-deep-learning-toolbox-converter-for-onnx-model-format	
Menoh	https://github.com/pfnet-research/menoh/releases	
ML.NET	https://www.nuget.org/packages/Microsoft.ML/	
MXNet (Apache)	http://mxnet.incubator.apache.org/api/python/contrib/onnx.html	
NCNN		
NNL (Sony)	https://nnabla.readthedocs.io/en/latest/python/file_format_converter/file_format_converter.html	http
PaddlePaddle	https://github.com/PaddlePaddle/paddle-onnx	
PyTorch	https://pytorch.org/docs/master/onnx.html	
SAS	https://github.com/sassoftware/python-dlpy	
Scikit-Learn	https://github.com/onnx/sklearn-onnx	

- Chaque libraire a sa librairie de conversion vers ONNX
- **sklearn-onnx** pour **scikit-learn**

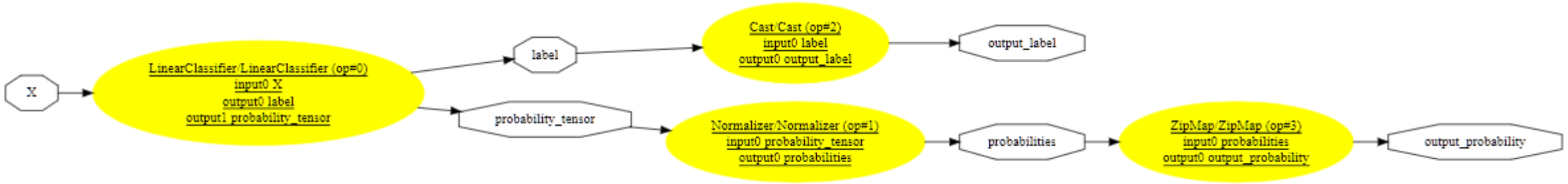
Régression Logistique vers ONNX

In [19]:
```
clr = LogisticRegression(multi_class="auto", solver="liblinear").fit(X, y)
clr
```

Out[19]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=None, solver='liblinear', tol=0.0001, verbose=0,
                   warm_start=False)
```

In [20]:
```
from skl2onnx import to_onnx

model_onnx = to_onnx(clr, X.astype(np.float32))
```

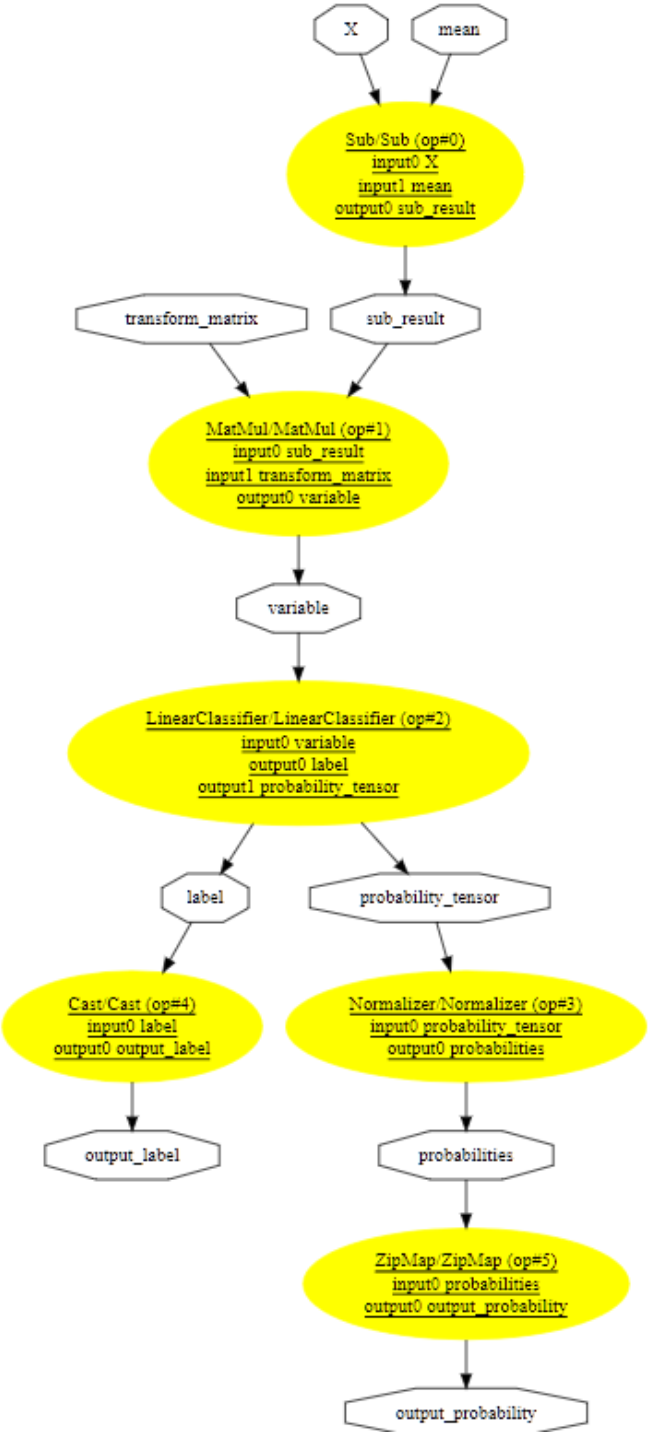


Pipeline vers ONNX

```
pipe = Pipeline([('pca', PCA(n_components=2)),
                 ('lr', LogisticRegression(multi_class="auto"))])
pipe.fit(X, y)
```

```
Pipeline(memory=None,
         steps=[('pca',
                 PCA(copy=True, iterated_power='auto', n_components=2,
                     random_state=None, svd_solver='auto', tol=0.0,
                     whiten=False))
```

```
In [22]: model_onnx = to_onnx(pipe, X.astype(np.float32))
```



Runtime

- Prédire partout (CPU, GPU, ARM, js, …)
- Plus de dépendances sur la librairie d'apprentissage
- Un runtime implémente un sous-ensemble de fonctions mathématiques définies par ONNX

onnxruntime (de Microsoft)

- Runtime écrit in C++
- Disponible sur CPU, GPU, ARM
- API pour plusieurs langages C, C++, C#, Python
- Utilise openmp, mkldnn, tensorrt, tvm, ngraph…

```
In [23]: from onnxruntime import InferenceSession

         sess = InferenceSession(model_onnx.SerializeToString())

         label, proba = sess.run(None, {'X': X32})
         label[:3]
Out[23]: array([0, 0, 0], dtype=int64)
```

OS	Windows	Linux	Mac		
Language	Python (3.5-3.7)	C++	C#	C	Java
Architecture	X64	X86	ARM64	ARM32	
Hardware Acceleration	Default CPU	CUDA	TensorRT	DirectML	MKL-DNN
	MKL-ML	nGraph	NUPHAR	OpenVINO	
Installation Instructions	pip install onnxruntime				

Benchmark: prédiction one-off avec LR

In [75]:
```
clr = LogisticRegression(multi_class="auto", solver="liblinear").fit(X, y)
```

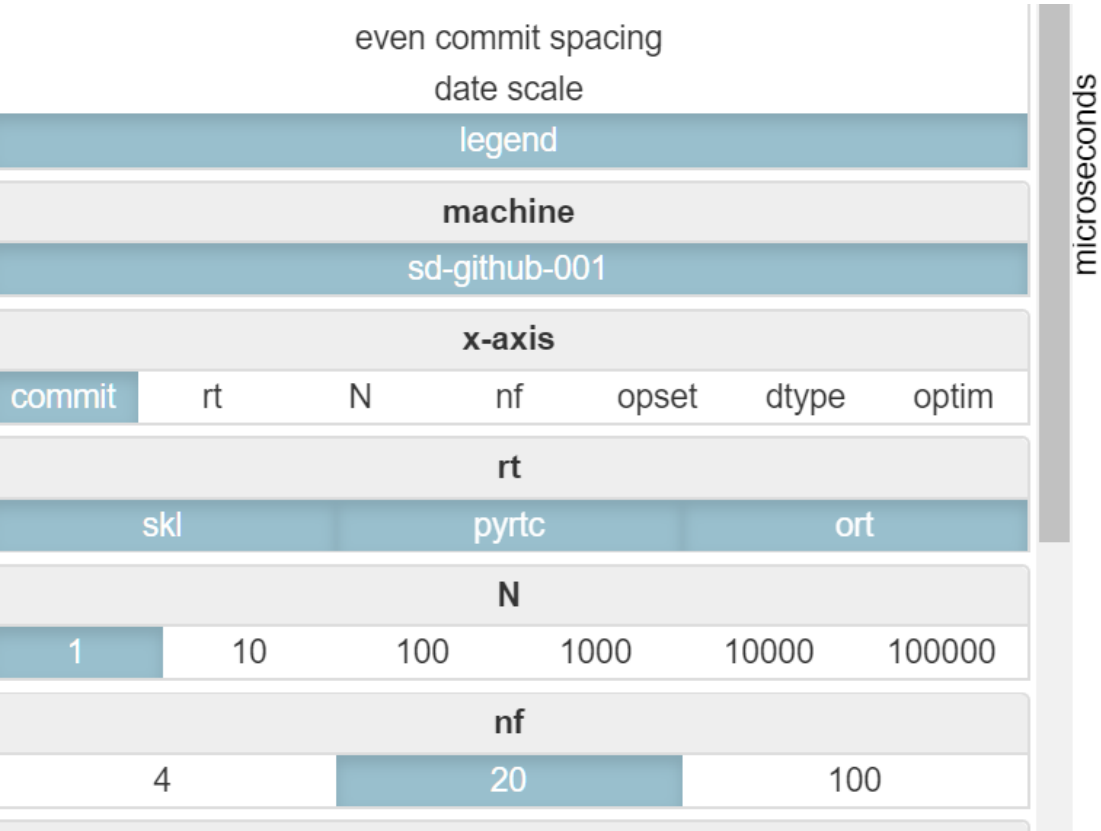
In [76]:
```
%timeit clr.predict_proba(X[:1])
```

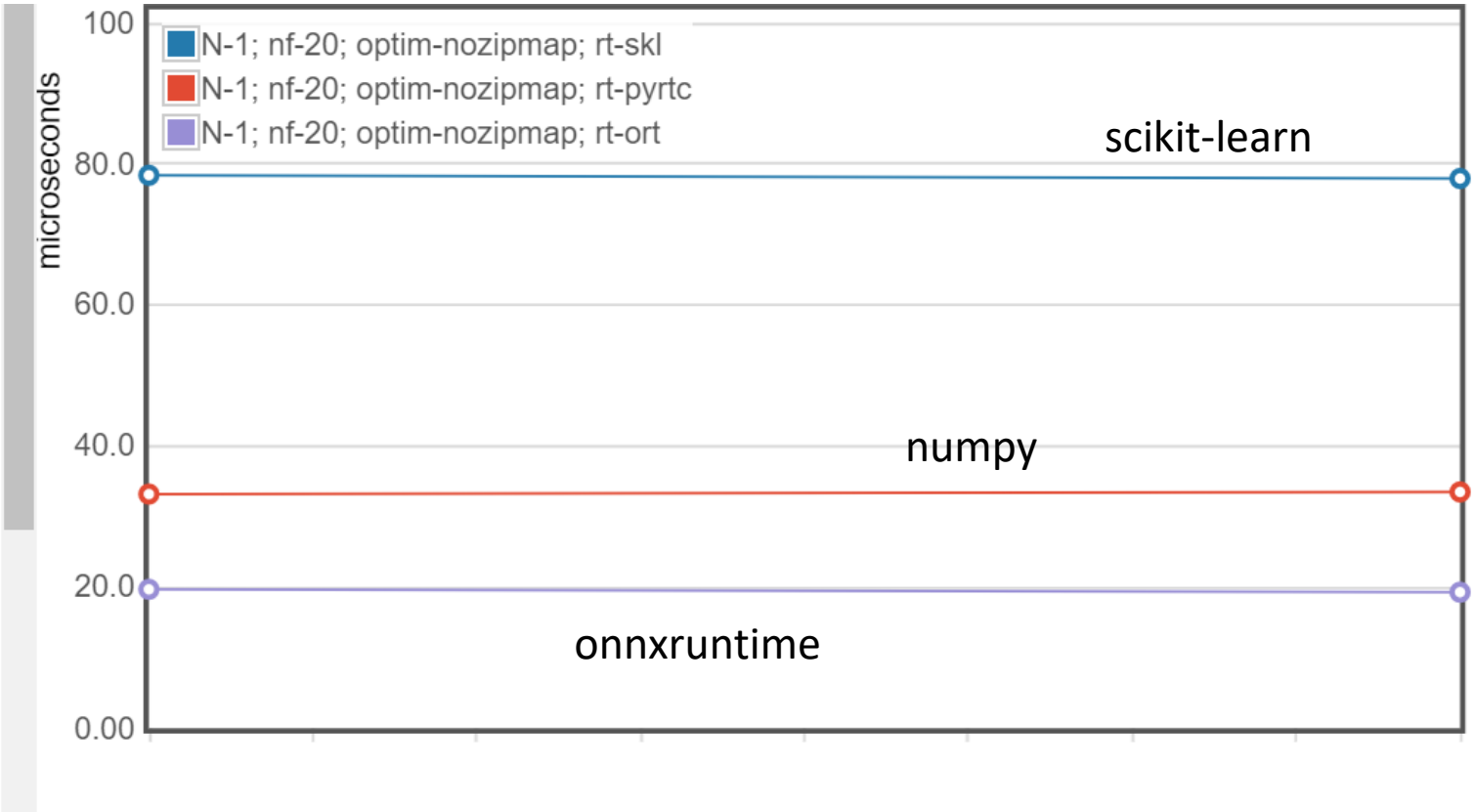
```
59.7 µs ± 4.22 µs per loop (mean ± std. dev. of 7 runs, 10000 loops each)
```

In [77]:
```
sess = InferenceSession(model_onnx.SerializeToString())
X32 = X.astype(np.float32)
%timeit sess.run(None, {'X': X32[:1]})
```

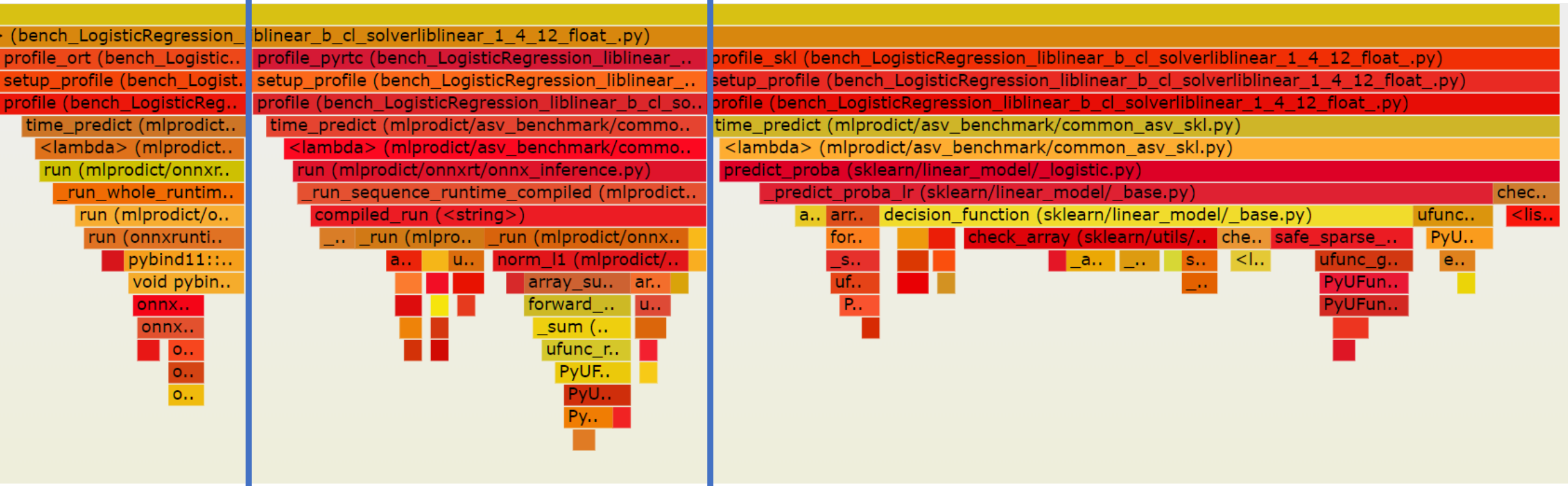
```
17.5 µs ± 521 ns per loop (mean ± std. dev. of 7 runs, 100000 loops each)
```

Benchmark: prédiction one-off avec LR





Benchmark: prédiction one-off avec LR



onnxruntime

numpy

scikit-learn

Benchmark: prédiction one-off avec RF

In [78]:
```
clr = RandomForestClassifier(n_estimators=10).fit(X, y)
```

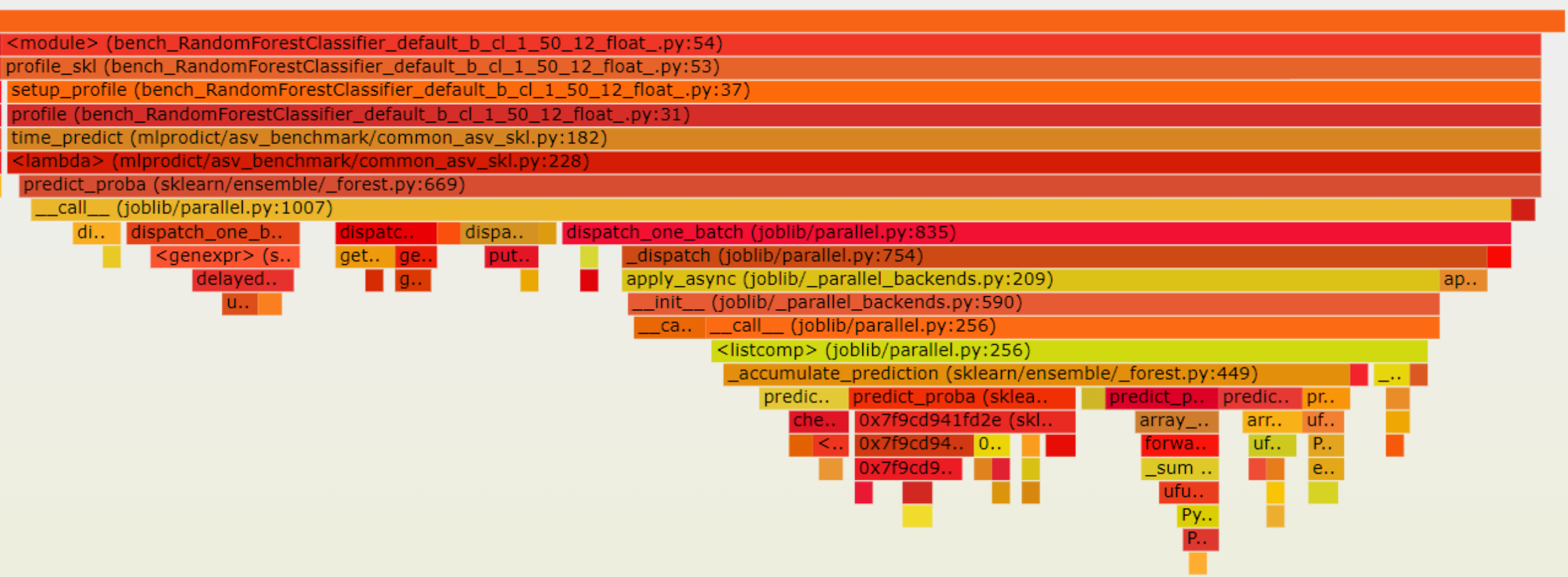
In [79]:
```
%timeit clr.predict_proba(X[:1])
```

```
770 µs ± 85.3 µs per loop (mean ± std. dev. of 7 runs, 1000 loops each)
```

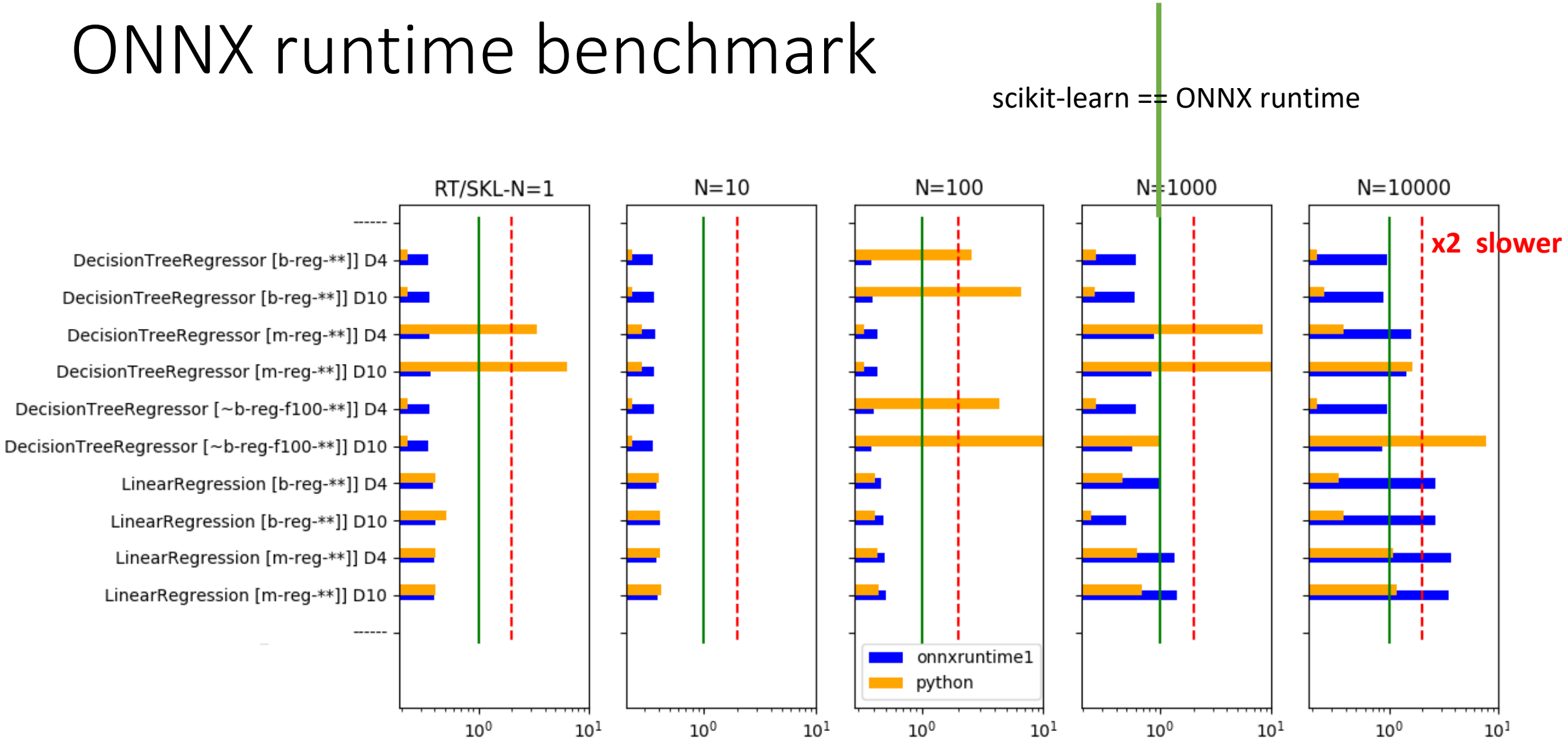
In [80]:
```
sess = InferenceSession(model_onnx.SerializeToString())
X32 = X.astype(np.float32)
%timeit sess.run(None, {'X': X32[:1]})
```

```
18.4 µs ± 2.79 µs per loop (mean ± std. dev. of 7 runs, 100000 loops each)
```

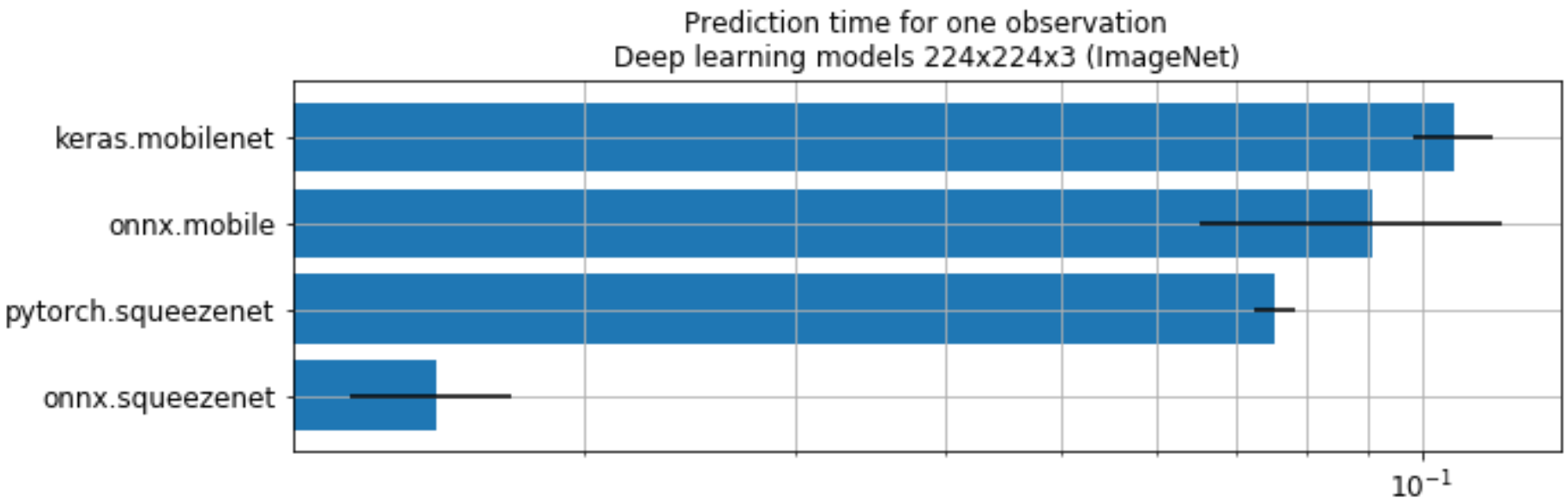
Benchmark: prédiction one-off avec RF



ONNX runtime benchmark



Benchmark: deep learning (CPU)



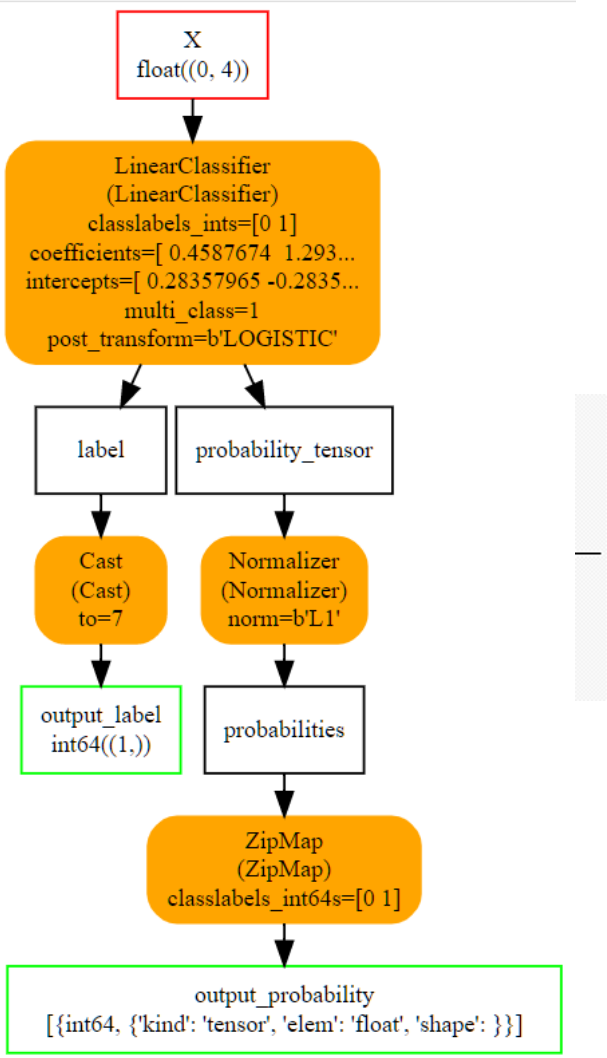
Customisation

Options…

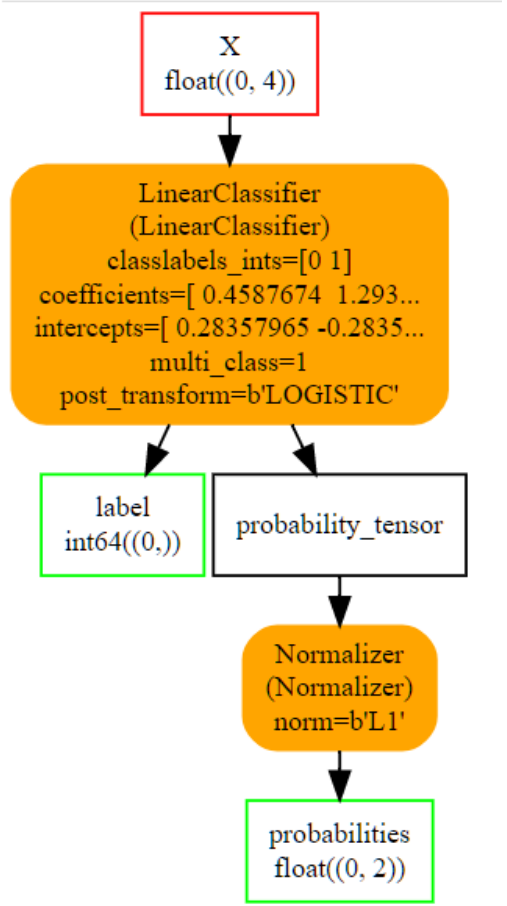
Que faire avec son propre modèle de machine learning ?

Transfer Learning

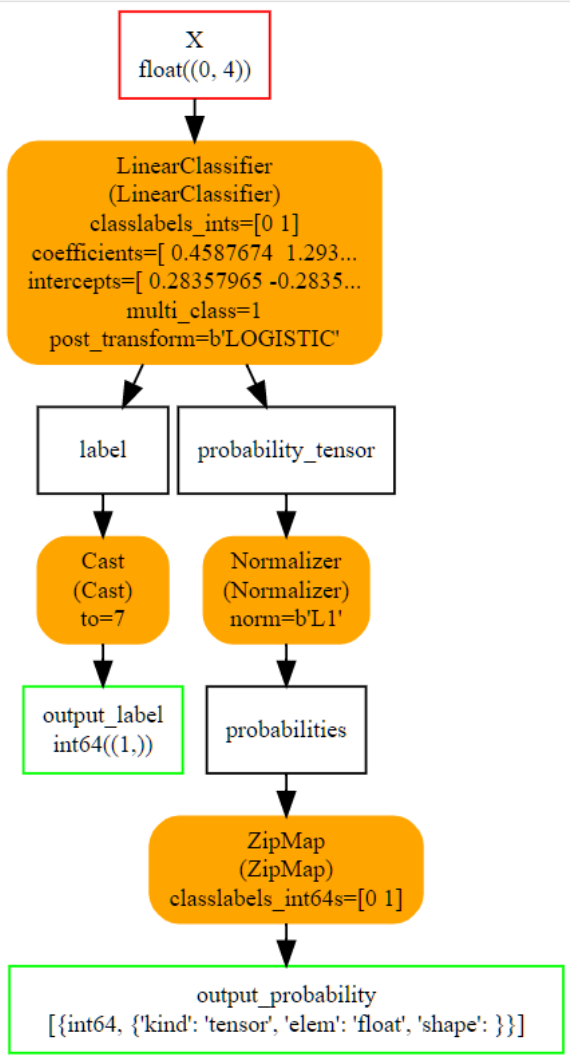
Changer le type de résultat



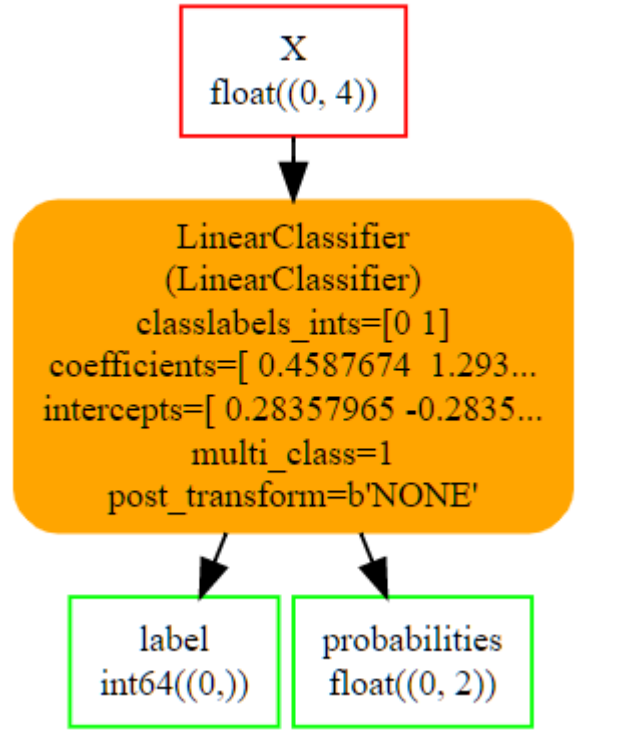

```
clr = LogisticRegression(max_iter=500)
clr.fit(X_train, y_train)
onx2 = convert_sklearn(
    clr, initial_types=initial_type,
    options={id(clr): {'zipmap': False}})
```



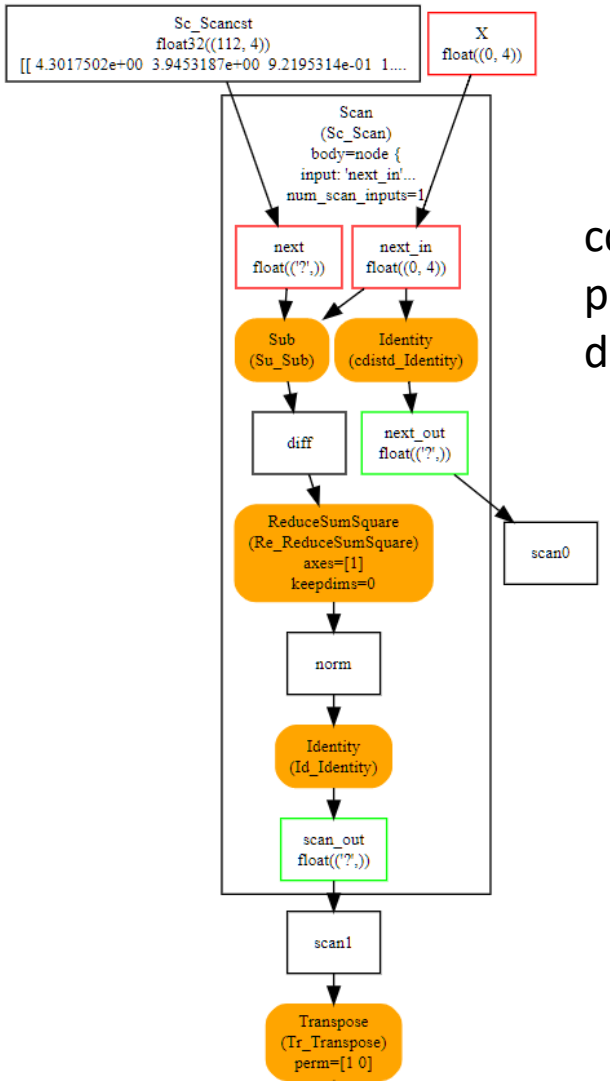
Pas de probabilités mais score bruts



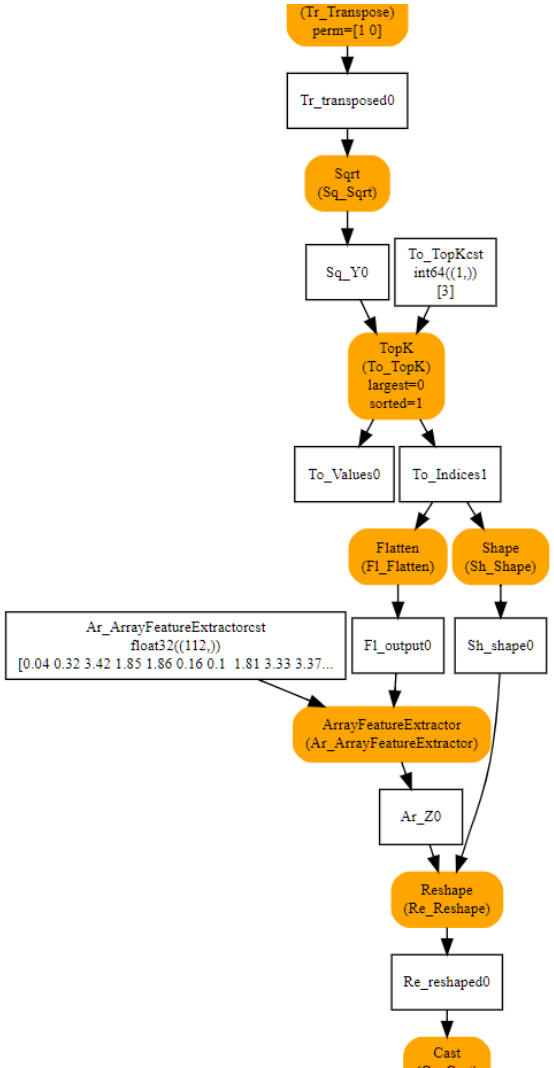

```
clr = LogisticRegression(max_iter=500)
clr.fit(X_train, y_train)
onx2 = convert_sklearn(
    clr, initial_types=initial_type,
    options={id(clr): {'raw_scores': True,
                       'zipmap': False}})
```

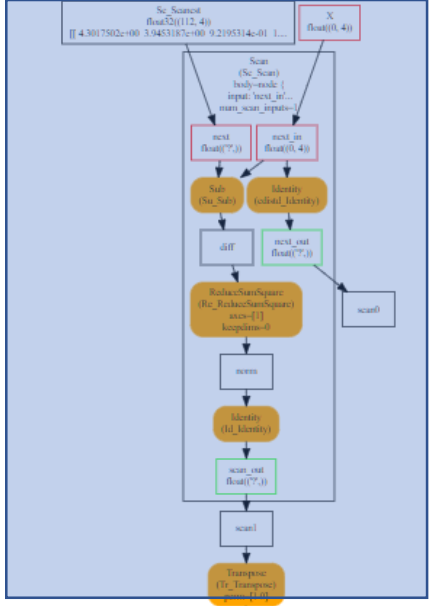


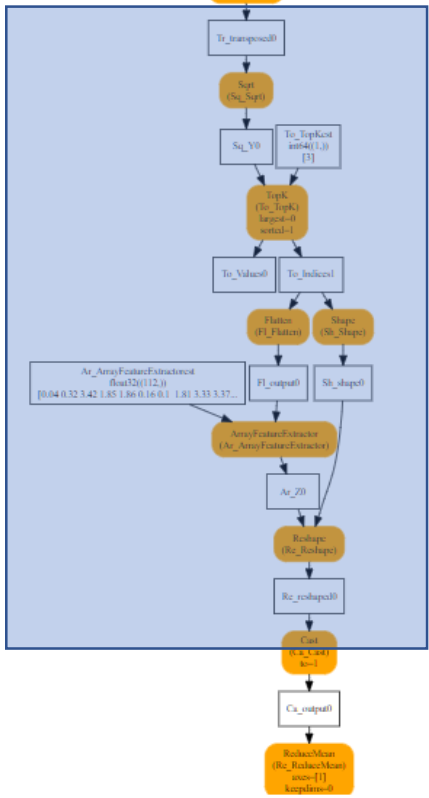
Opérateur et performance : kNN



cdist : pairwise distance



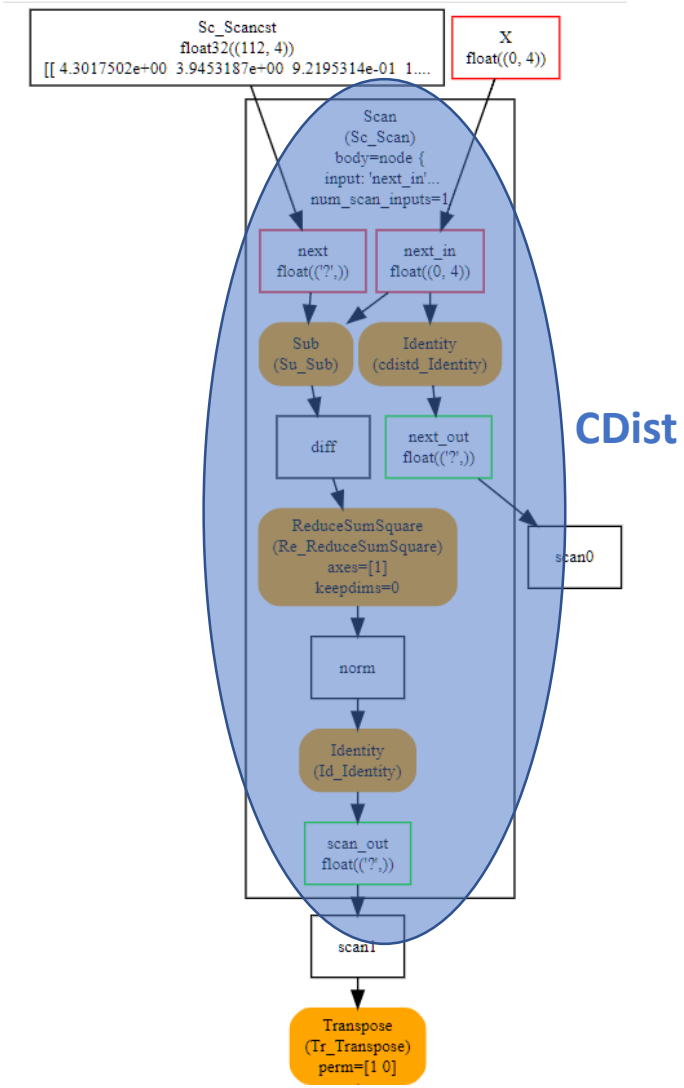




Options spécifiques

Création d'un opérateur spécifique CDist

- Améliorer le temps d'exécution
- Nul besoin de l'ajouter à ONNX pour tester
- Création d'une option pour passer à un nouvel opérateur Cdist
- Implémentation d'un runtime dédié à ce nouvel opérateur



Convertisseurs pour un nouveau modèle

- Implémenter son propre modèle

- Inférer la dimension des sorties
- Implémenter un convertisseur
- Enregistrer le convertisseur

- Convertir de la même façon que n'importe quel modèle

```
class PredictableTSNE(BaseEstimator, TransformerMixin):
```

```
def predictable_tsne_shape_calculator(operator):
```

```
def predictable_tsne_converter(scope, operator, container):
    ....
```

```
update_registered_converter(PredictableTSNE, 'CustomPredictableTSNE',
                            predictable_tsne_shape_calculator,
                            predictable_tsne_converter)
```

```
model_onnx = convert_sklearn(
    ptsne_knn, 'predictable_tsne',
    [('input', FloatTensorType([None, X_test.shape[1]]))])
```

Transfer Learning

[12]:
```
from mlprodict.sklapi import OnnxTransformer

with open('mobilenetv2-1.0.onnx', 'rb') as f:
    content = f.read()

tr = OnnxTransformer(content, runtime='onnxruntime1')
tr.fit(None)
tr.transform(image_data)
```

La suite…

Aujourd'hui

- Conversion de code python en opérateurs python

Next

- Meilleure performance
- Meilleure documentation
- Meilleure couverture

OnnxSklearnAdaBoostClassifier	OnnxSklearnLabelEncoder	OnnxSklearnRandomForestCl
OnnxSklearnAdaBoostRegressor	OnnxSklearnLasso	OnnxSklearnRandomForestRe
OnnxSklearnBernoulliNB	OnnxSklearnLassoLars	OnnxSklearnRidge
OnnxSklearnBinarizer	OnnxSklearnLinearRegression	OnnxSklearnRobustScaler
OnnxSklearnCalibratedClassifierCV	OnnxSklearnLinearSVC	OnnxSklearnSGDClassifier

Merci.

Questions: xadupre@microsoft.com