Introduction to Gradient Boosting

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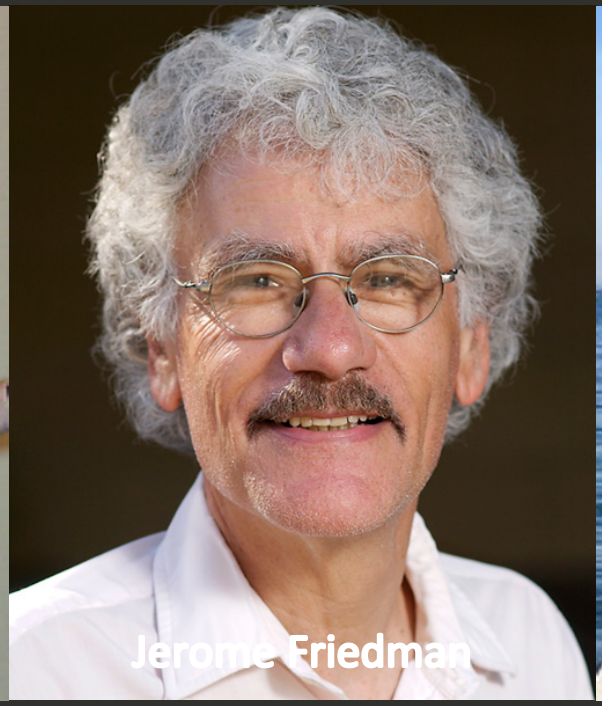
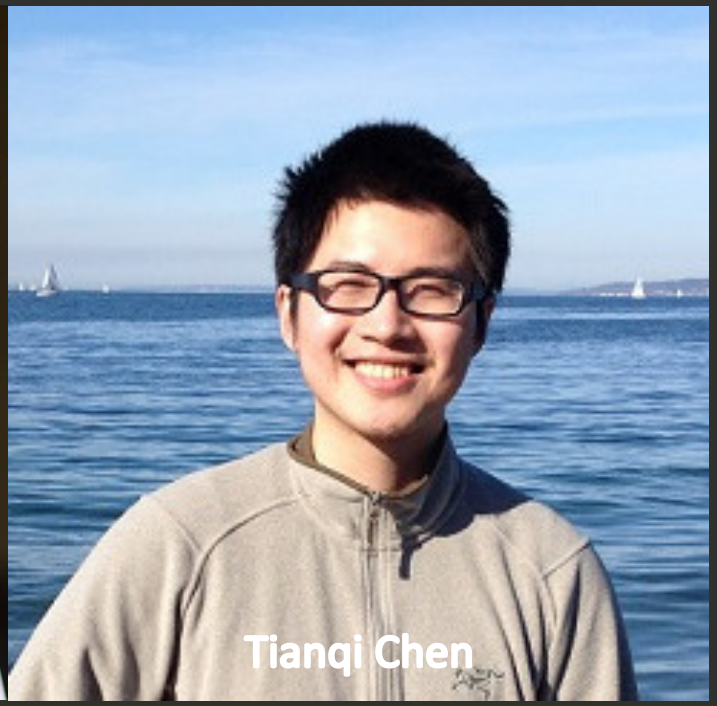
Proactive Technical Services, MongoDB

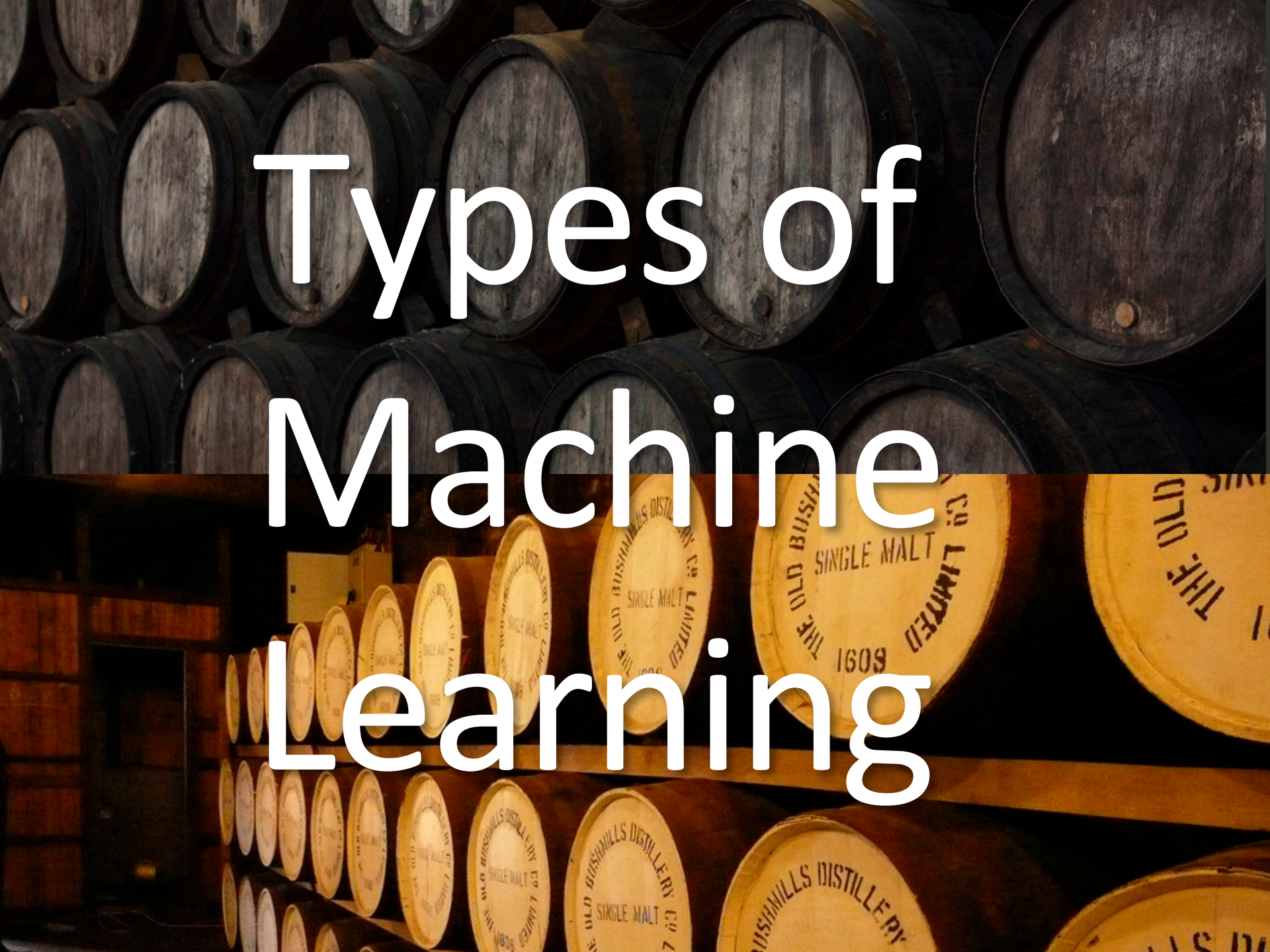
Github repo for this talk:
http://github.com/braz/pycon2016_talk/

From Theory to Python Libraries

What this talk will cover






Types of
Machine
Learning

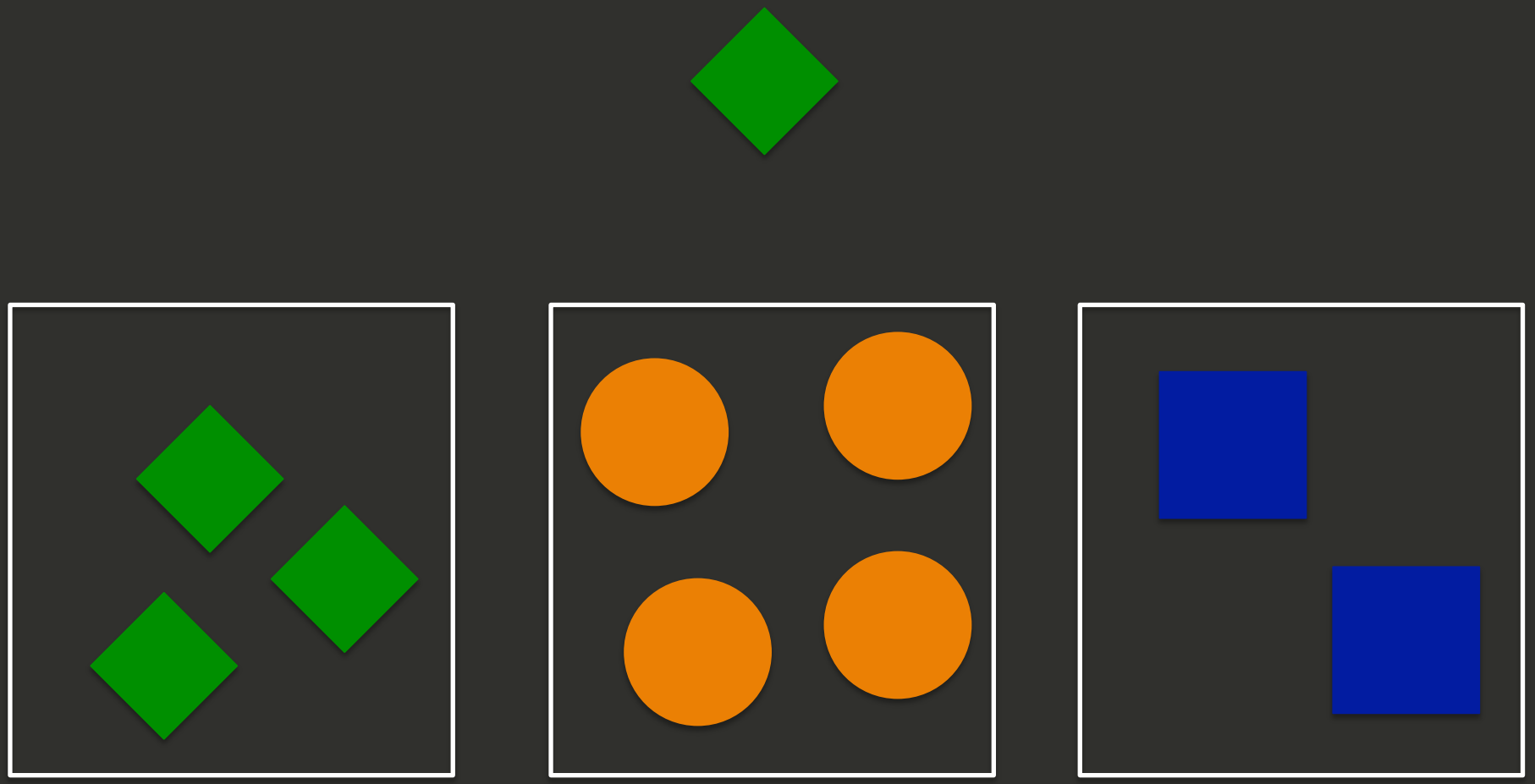
Iris Dataset

150 observations of 4 variable (sepal l/w and petal l/w)

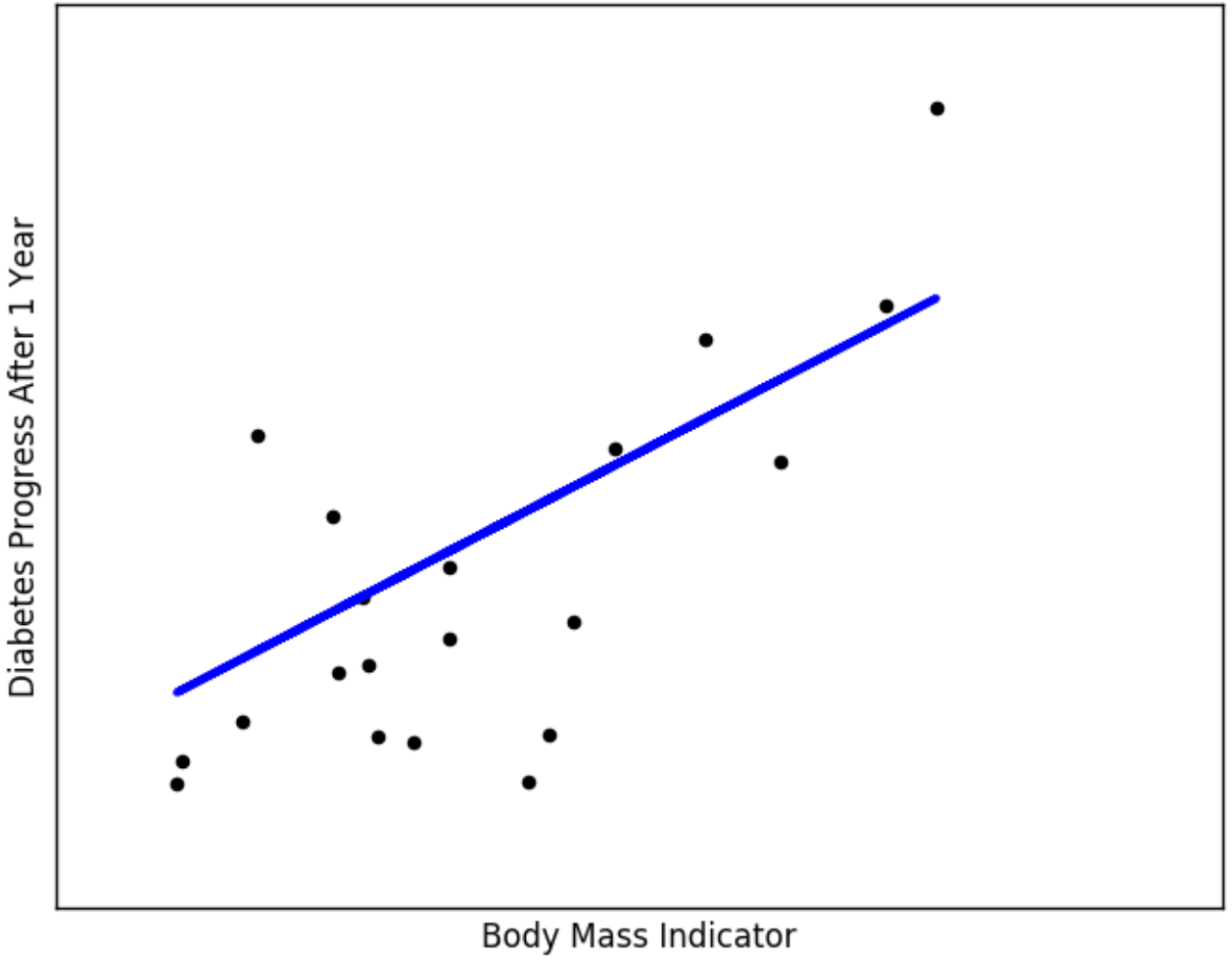
Supervised Techniques

- ***Classification***
- Ranking
- **Regression**

Classification



Regression



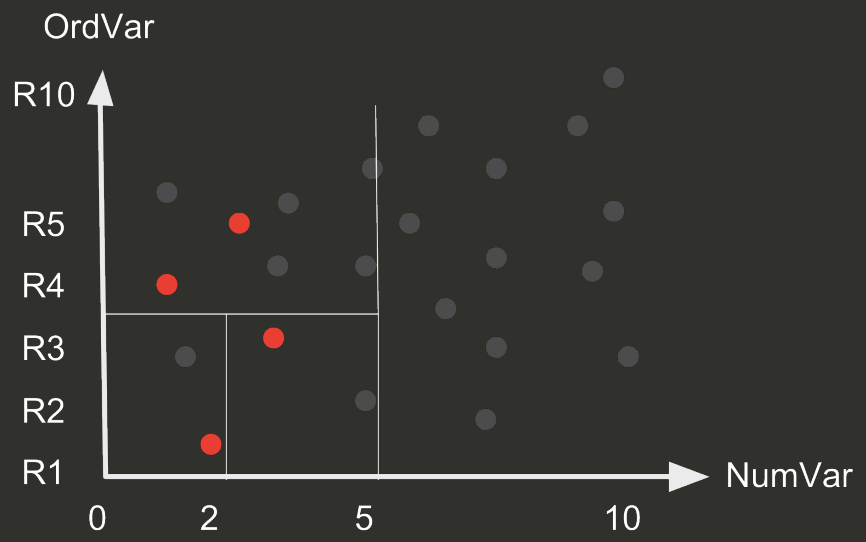
Context or a bit of history

Decision Trees

1

NumVar	OrdVar	CatVar
1	R2	Good
1.5	R4	Bad
2	R1	Bad
2.5	R5	Good
3	R3	Good
3.5	R3	Bad
⋮	⋮	⋮

3



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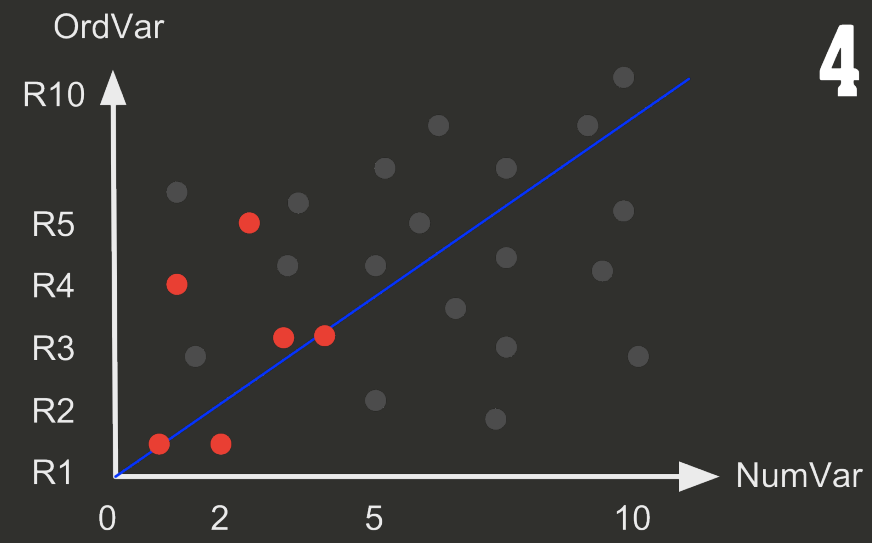

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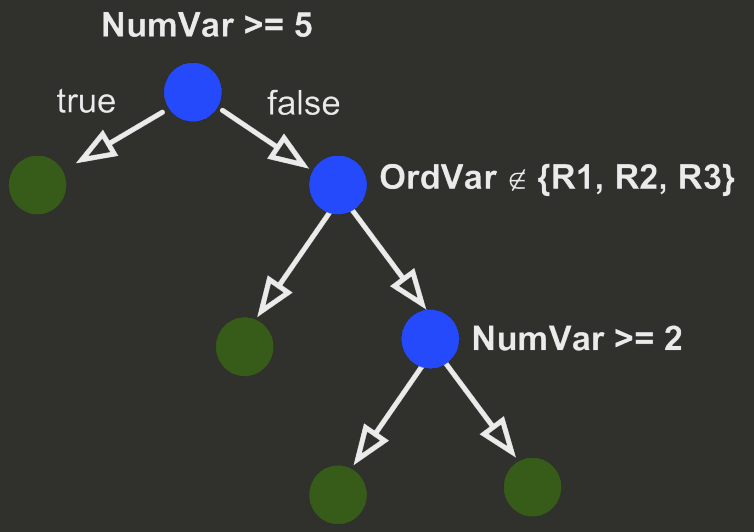
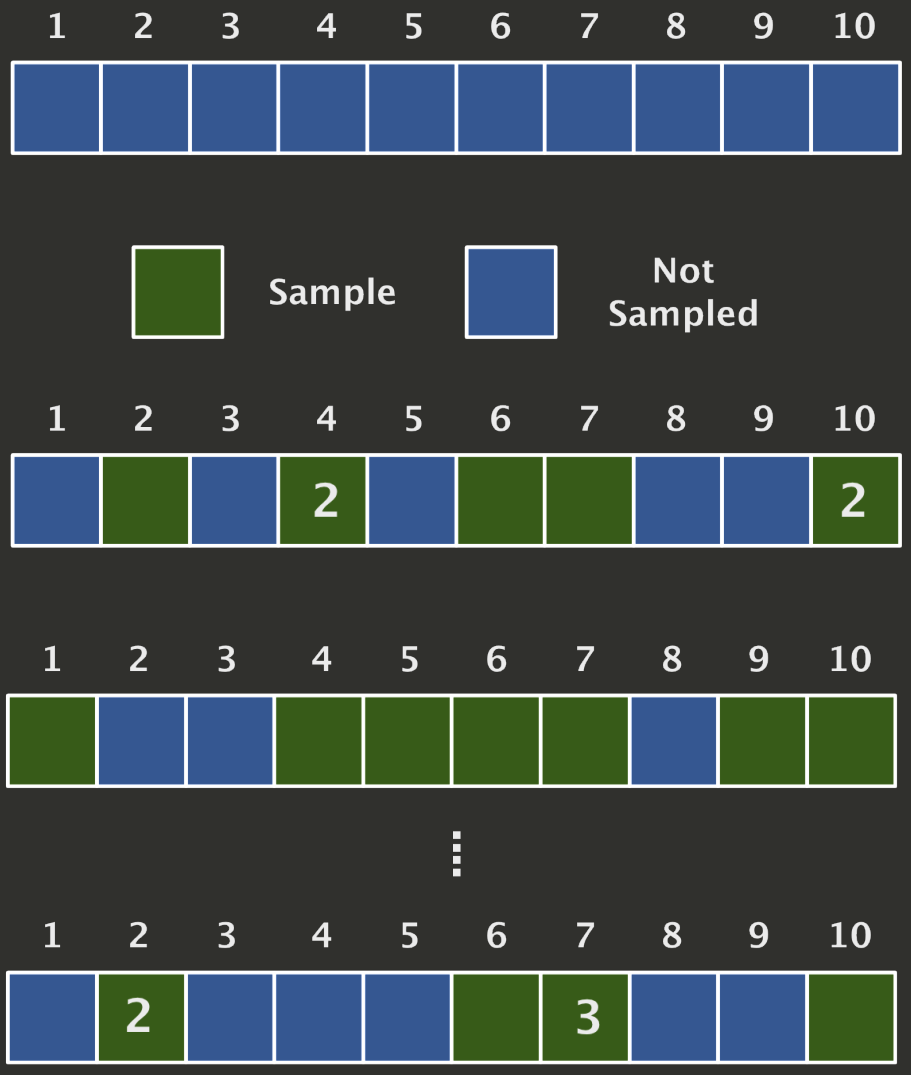


Refining / Improving

- Bagging
- Boosting
- Random Forests

Bagging



Samples the original training set uniformly with replacement to generate new bootstrapped training sets. This reduces variance and helps to avoid overfitting.

Training set 1 – Bootstrap samples 7

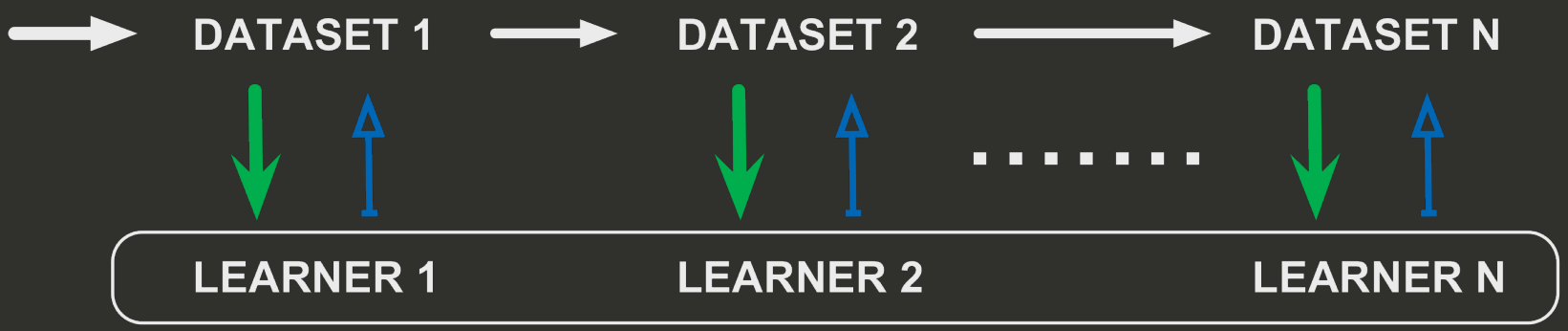
Training set 2 – Bootstrap samples 7

Training set N – Bootstrap samples 7

Boosting

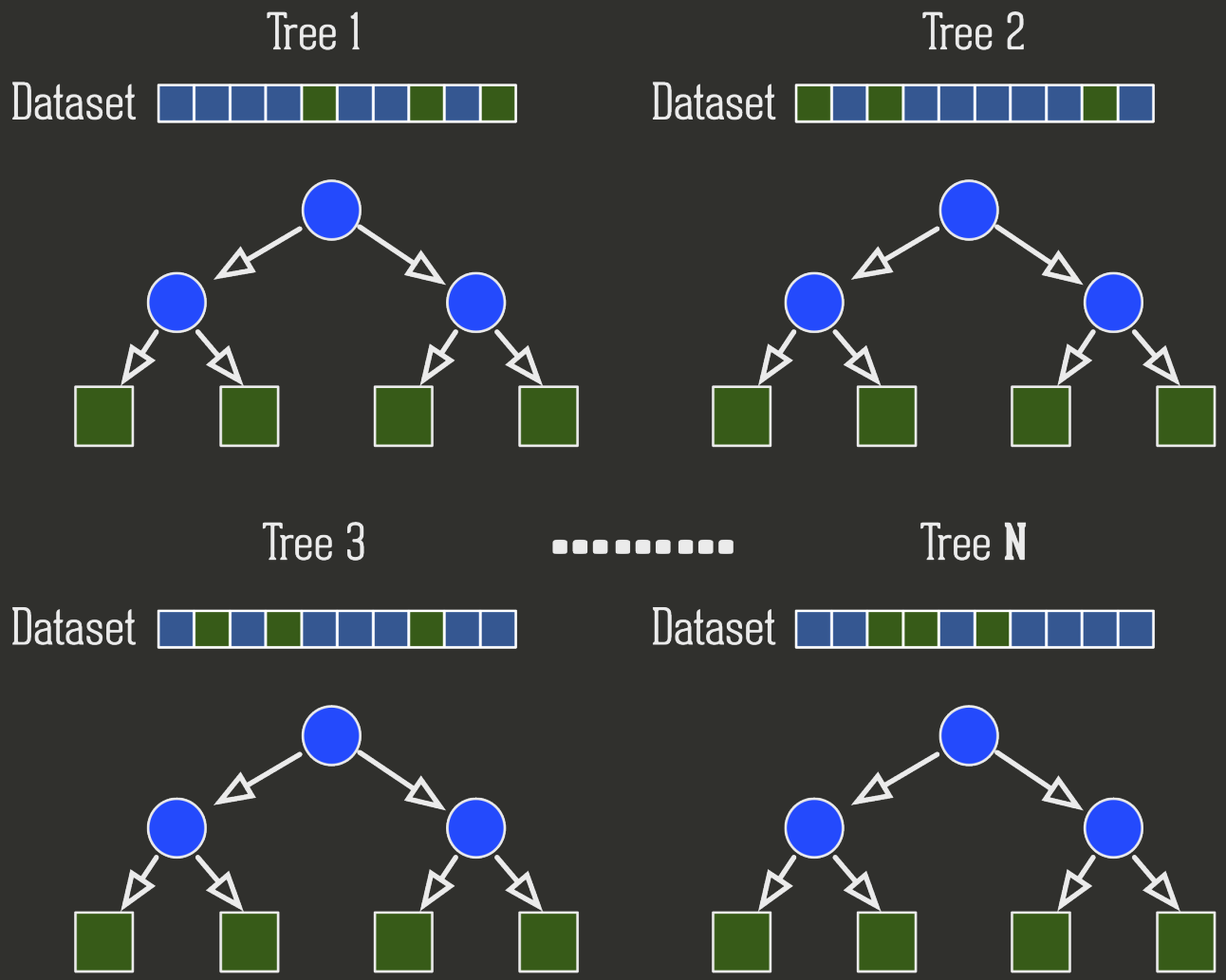
Adds weak learners, so new learners pick up the slack. Incrementally increase the accuracy of model as weak learners focus more on misclassified examples from the previous weak learners.

NumVar	OrdVar	CatVar
1	R2	Good
1.5	R4	Bad
2	R1	Bad
2.5	R5	Good
3	R3	Good
3.5	R3	Bad
⋮	⋮	⋮



Weighted combination

Random Forests



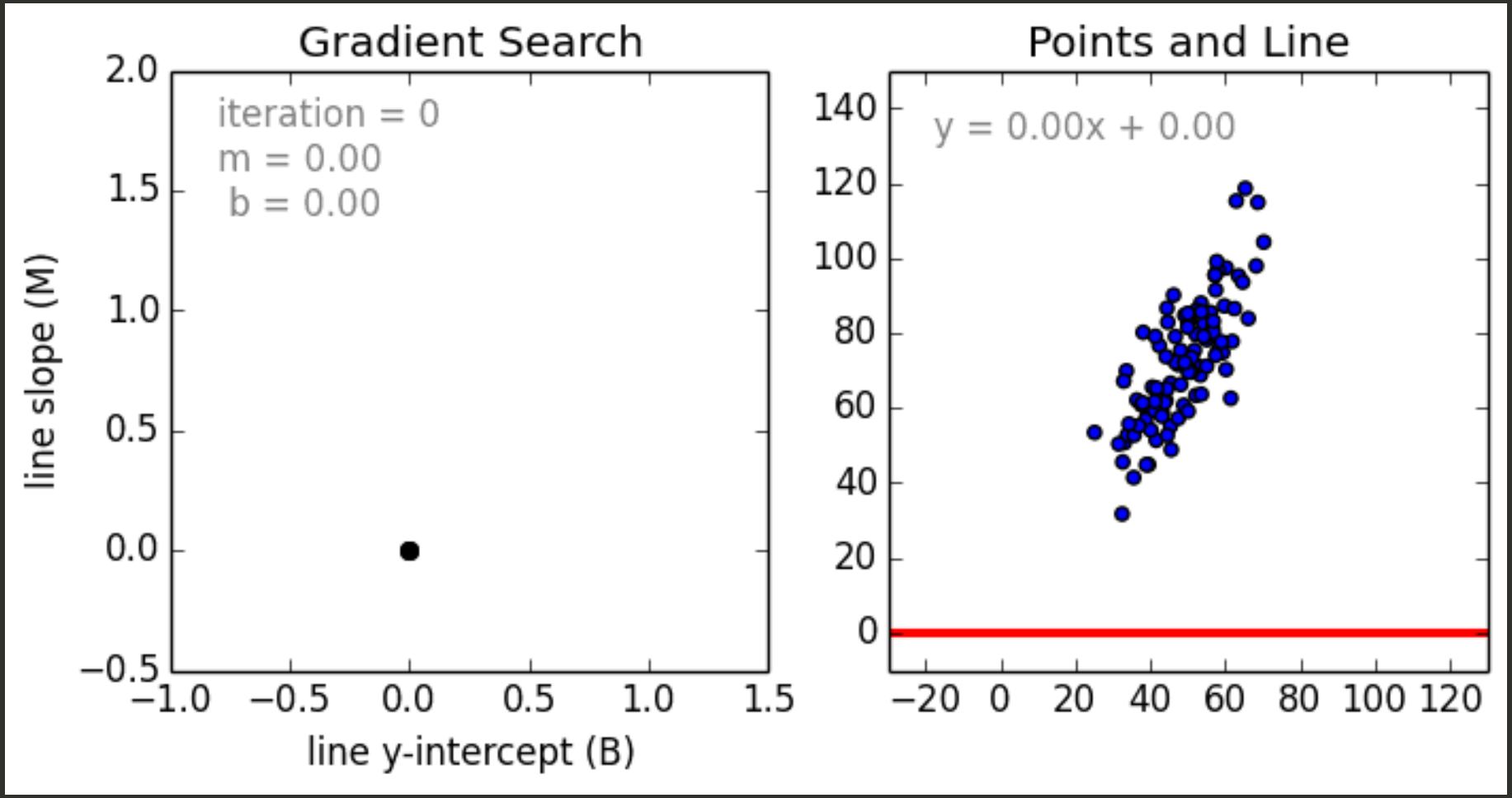
Traverse each tree and at each node in a tree:

i. Select **m** random predictor variables from available set
ii. Use the variable with best split [use objective function]
iii. Move to next node in tree

Gradient Boosting

Gradient Descent + Boosting

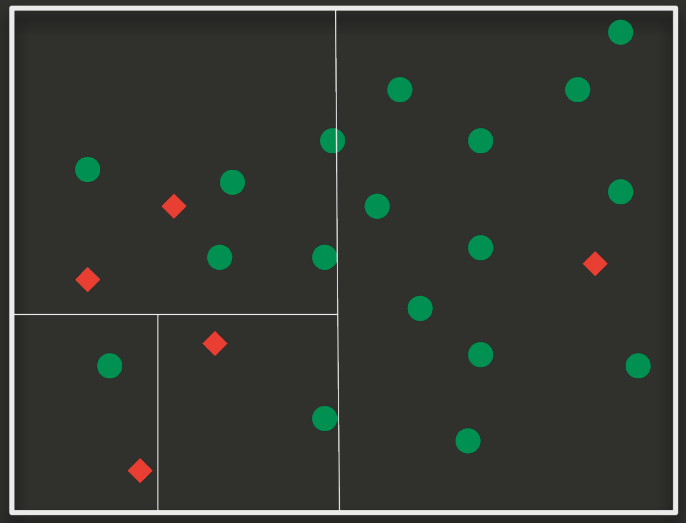
Gradient Descent



https://github.com/mattnedrich/GradientDescentExample

Gradient Boosting

1



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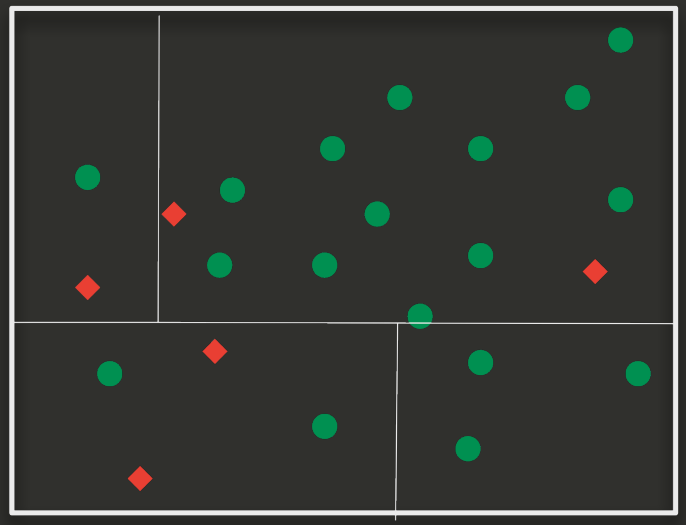

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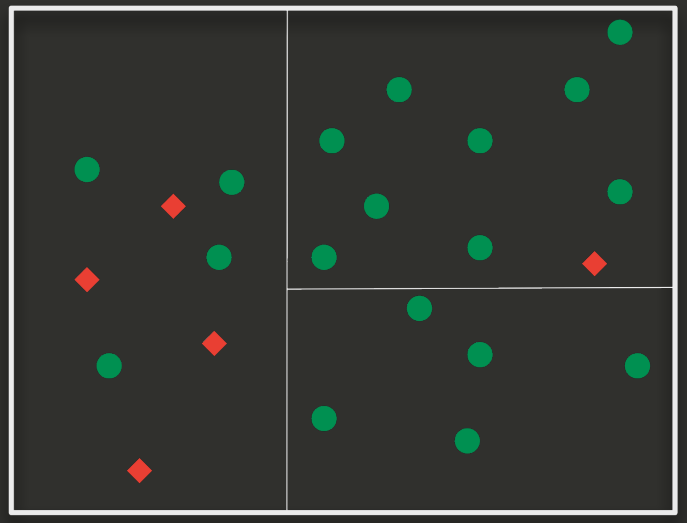

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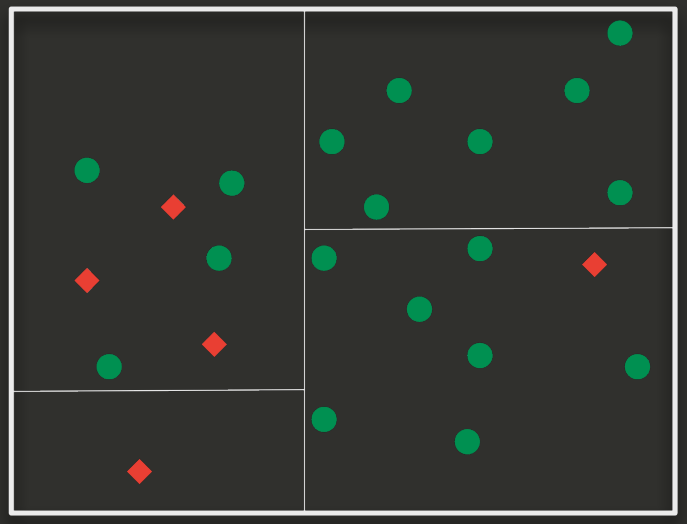


Tunables

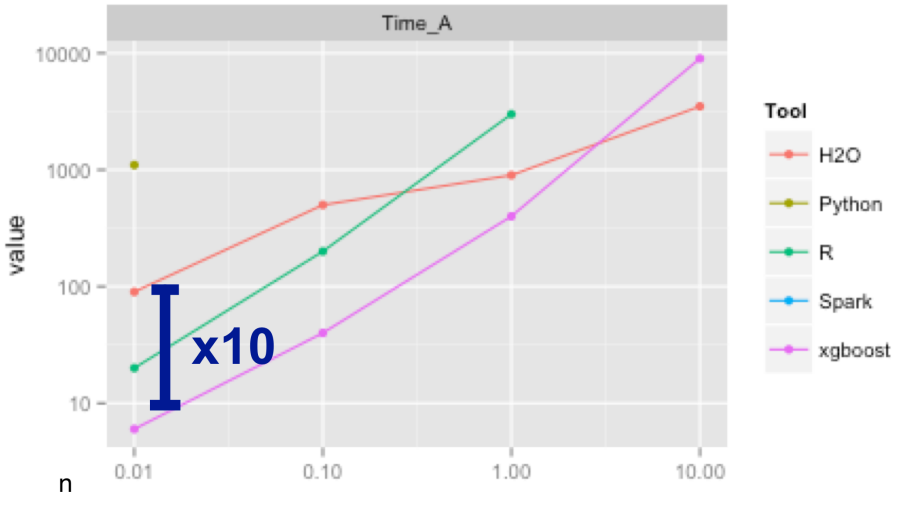
- **Number of trees** and **the learning rate**
- *Across all trees*
  - subsampling rows
  - different loss function
- *Per tree*
  - maximum tree depth
  - minimum samples to split a node
  - minimum samples in a leaf node
  - subsampling features

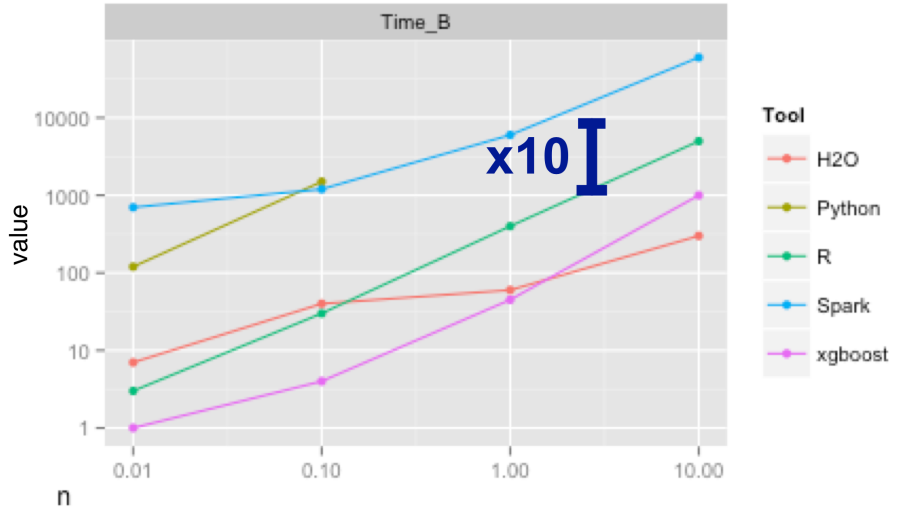
scikit learn

H2O.ai

dmlc XGBoost

Which to choose ?





https://github.com/szilard/benchm-ml

7.5 hrs / 79.8 AUC H20
14 hrs / 81.1 AUC xgboost

Caveat for xgboost

Models by representing all problems as a regression predictive modeling problem and only takes numerical values as input.

```
import urllib.request
import pandas
import xgboost
from sklearn import cross_validation
from sklearn.metrics import accuracy_score
from sklearn.preprocessing import LabelEncoder

# URL for the Iris dataset (UCI Machine Learning Repository)
url = "http://archive.ics.uci.edu/ml/machine-learning-databases/iris/
iris.data"

# download the file
raw_data = urllib.request.urlopen(url)

# load the CSV file as a numpy matrix
data = pandas.read_csv(raw_data, header=None)
dataset = data.values

# split data into X and y
X = dataset[:,0:4]
Y = dataset[:,4]

# encode string class values as integers
label_encoder = LabelEncoder()
label_encoder = label_encoder.fit(Y)
label_encoded_y = label_encoder.transform(Y)

seed = 7
test_size = 0.33
X_train, X_test, y_train, y_test = cross_validation.train_test_split(X,
label_encoded_y, test_size=test_size, random_state=seed)

# fit model
model = xgboost.XGBClassifier()
model.fit(X_train, y_train)

# make predictions for test data
y_pred = model.predict(X_test)
predictions = [round(value) for value in y_pred]

# evaluate predictions
accuracy = accuracy_score(y_test, predictions)
print("Accuracy: %.2f%%" % (accuracy * 100.0))
```

1 Libraries

2 Data Processing

3 Modelling & Prediction

A better example

```
import numpy as np
import urllib.request
import xgboost
from sklearn import cross_validation
from sklearn.metrics import accuracy_score

# URL for the Pima Indians Diabetes dataset = "http://
archive.ics.uci.edu/ml/machine-learning-databases/pima-
indians-diabetes/pima-indians-diabetes.data"

# download the file
raw_data = urllib.request.urlopen(url)
```

A better example

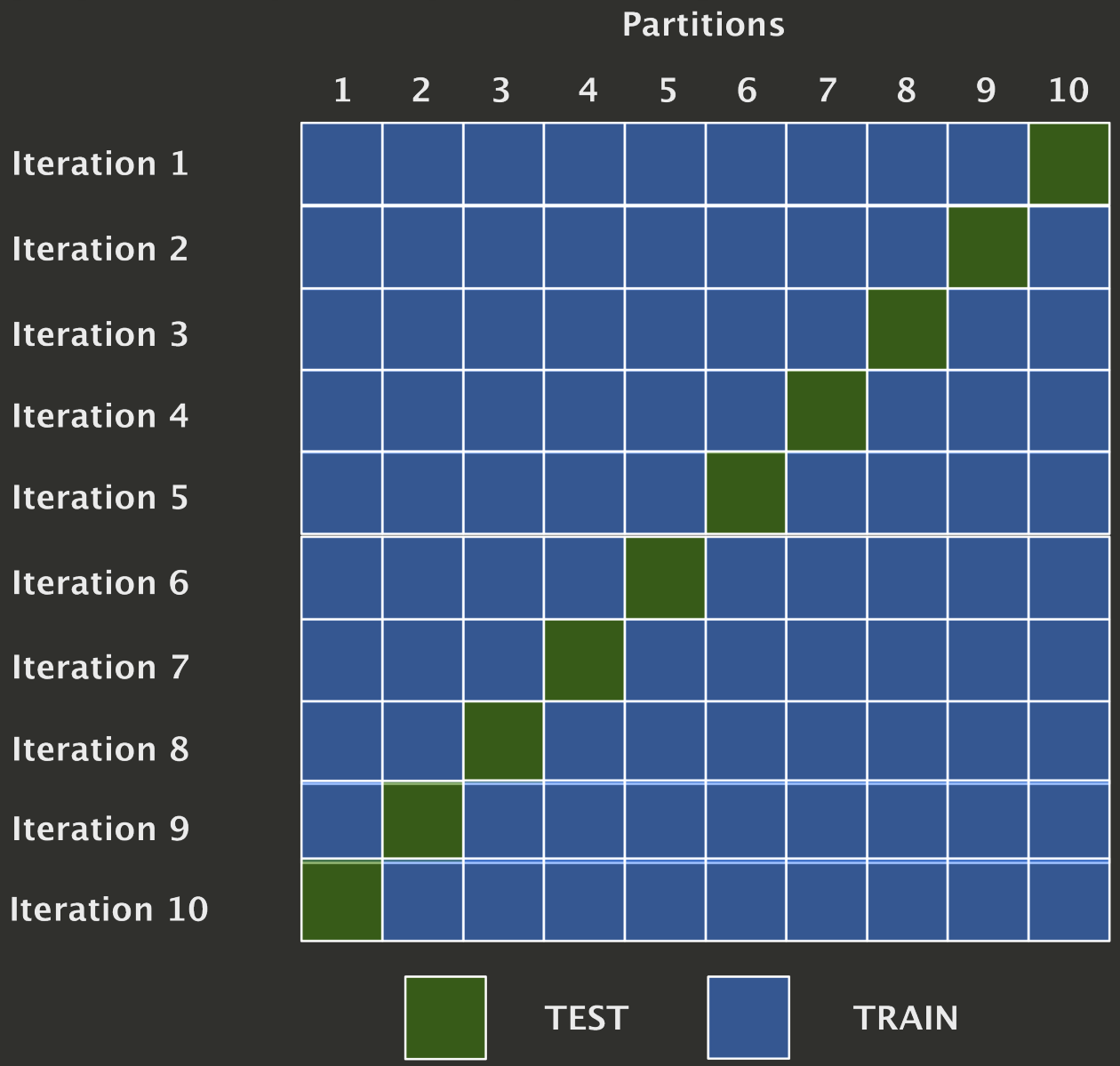
```
# load the CSV file as a numpy matrix
dataset = np.loadtxt(raw_data, delimiter=",")
print(dataset.shape)

X = dataset[:,0:8]
Y = dataset[:,8]

# split data into train and test sets
seed = 7
test_size = 0.33
X_train, X_test, y_train, y_test =
cross_validation.train_test_split(X, Y, test_size=test_size,
random_state=seed)
```

A better example

```
model = xgboost.XGBClassifier()
model.fit(X_train, y_train)

# make predictions for test data
y_pred = model.predict(X_test)
predictions = [round(value) for value in y_pred]

# evaluate predictions
accuracy = accuracy_score(y_test, predictions)
print("Accuracy: %.2f%%" % (accuracy * 100.0))
```

Accuracy: 77.95%

Cross-validation



Cross-validation

```
import numpy as np
from sklearn.model_selection import KFold

X = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

kf = KFold(n_splits=10)
for train, test in kf.split(X):
    print("%s %s" % (train, test))
```

Cross-validation

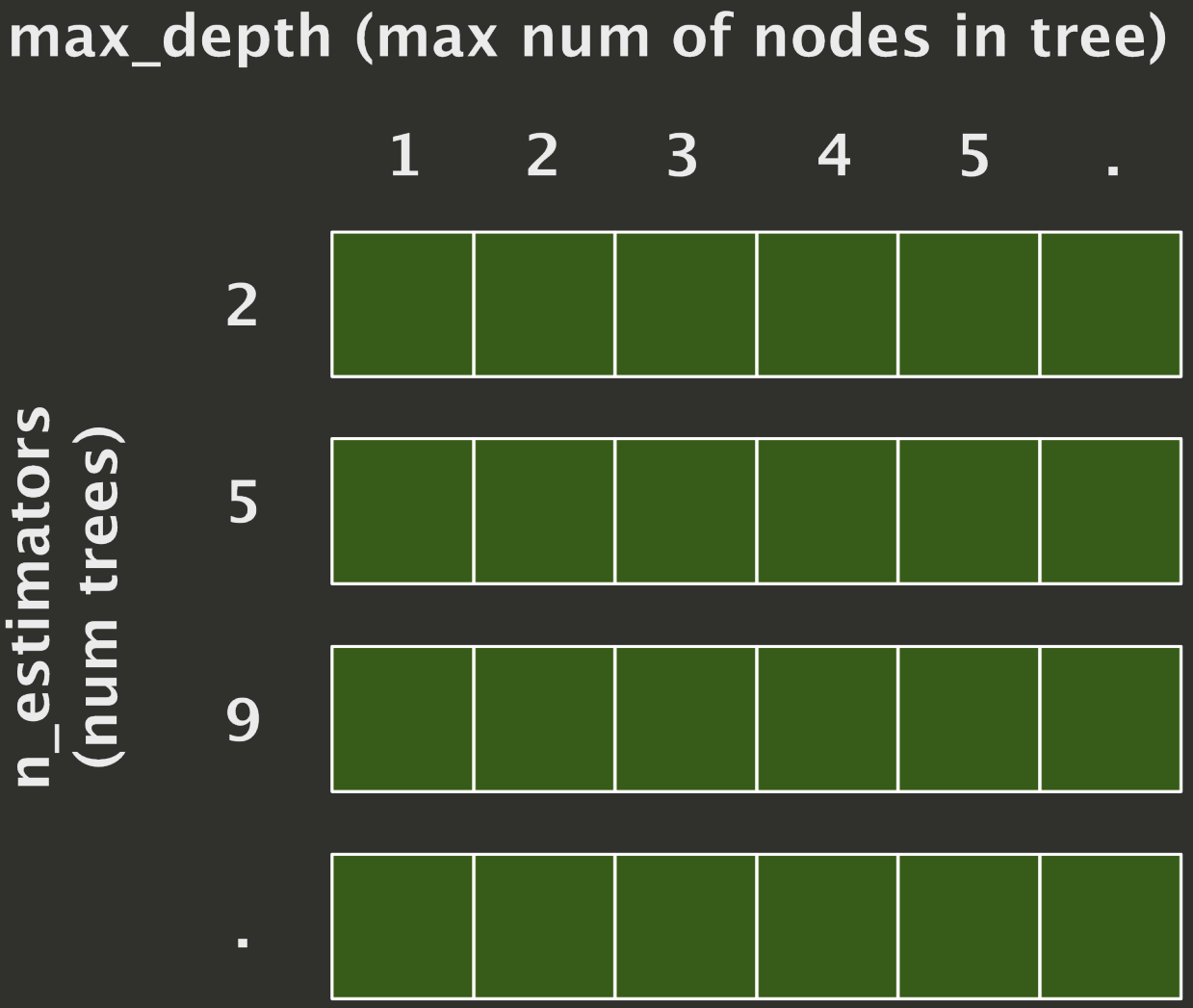
[2 3 4 5 6 7 8 9 10]	[0 1]
[0 1 3 4 5 6 7 8 9 10]	[2]
[0 1 2 4 5 6 7 8 9 10]	[3]
[0 1 2 3 5 6 7 8 9 10]	[4]
[0 1 2 3 4 6 7 8 9 10]	[5]
[0 1 2 3 4 5 7 8 9 10]	[6]
[0 1 2 3 4 5 6 8 9 10]	[7]
[0 1 2 3 4 5 6 7 9 10]	[8]
[0 1 2 3 4 5 6 7 8 10]	[9]
[0 1 2 3 4 5 6 7 8 9]	[10]

Scikit Only

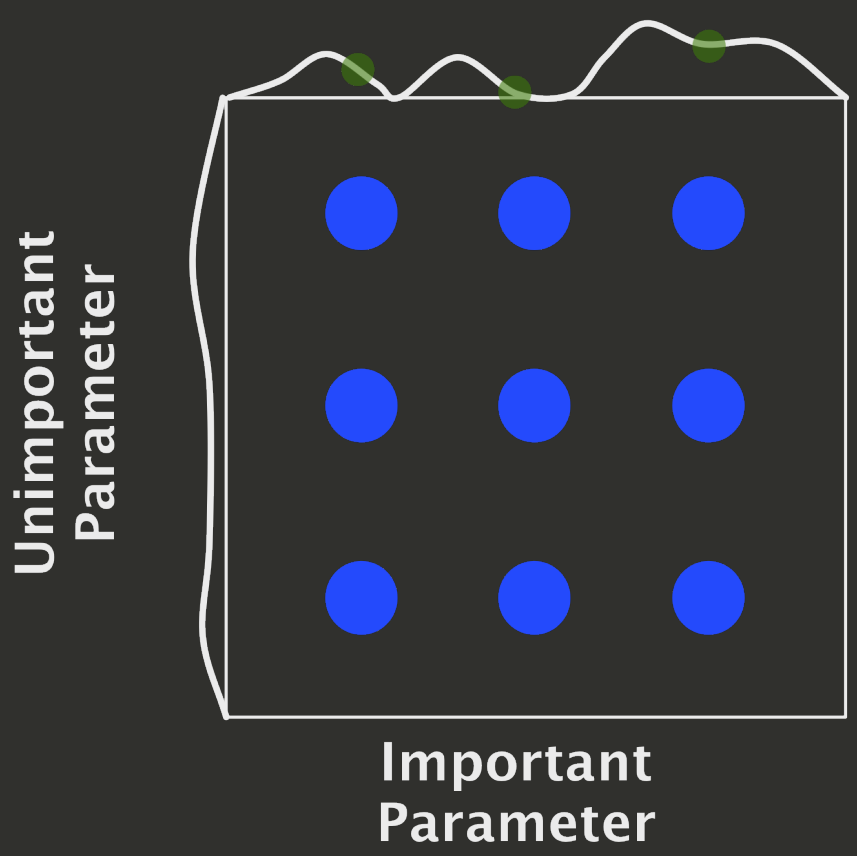
```
from sklearn.ensemble import GradientBoostingClassifier #For Classification
from sklearn.ensemble import GradientBoostingRegressor #For Regression

clf = GradientBoostingClassifier(n_estimators=100, learning_rate=1.0, max_depth=1)

clf.fit(X_train, y_train)
```

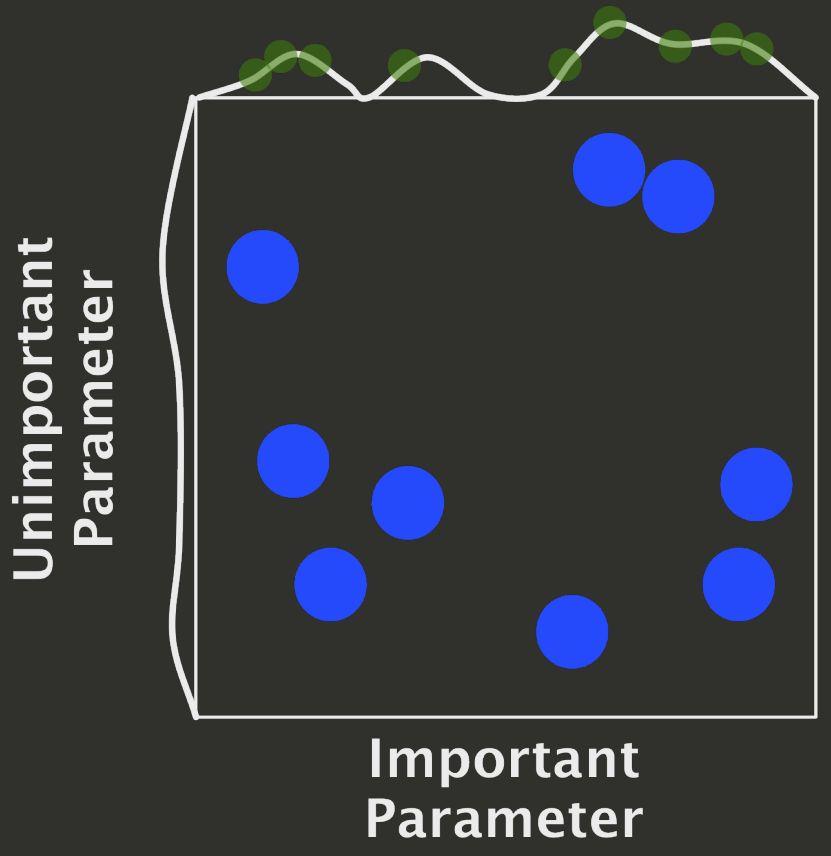
Getting the best results

Which Parameters



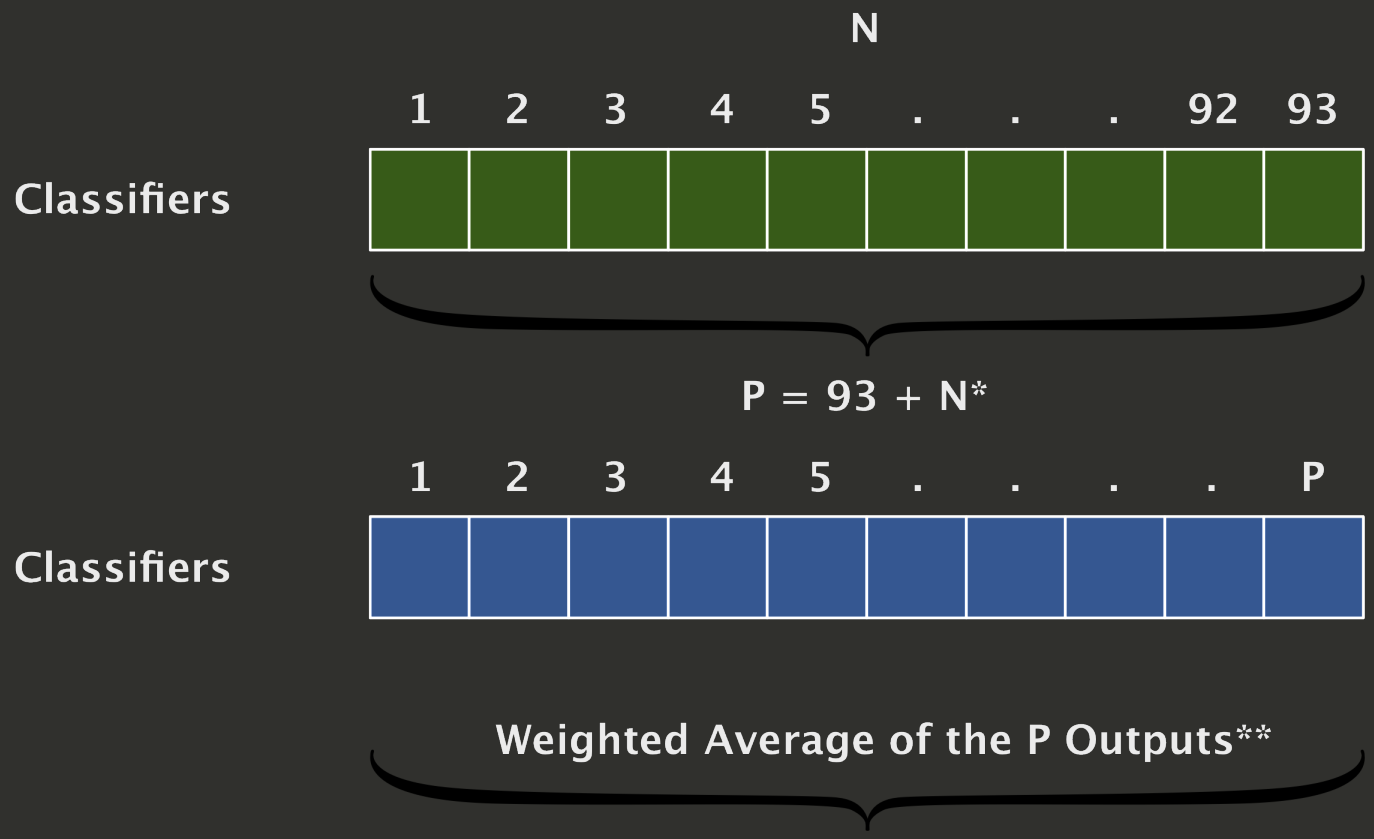
Kinds of Parameter Search





http://blog.kaggle.com/2015/07/16/scikit-learn-video-8-efficiently-searching-for-optimal-tuning-parameters/

Stacking, Blending, & Averaging



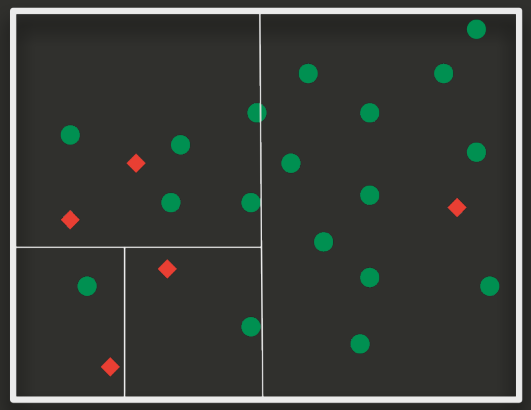
Christophe Bourguignon

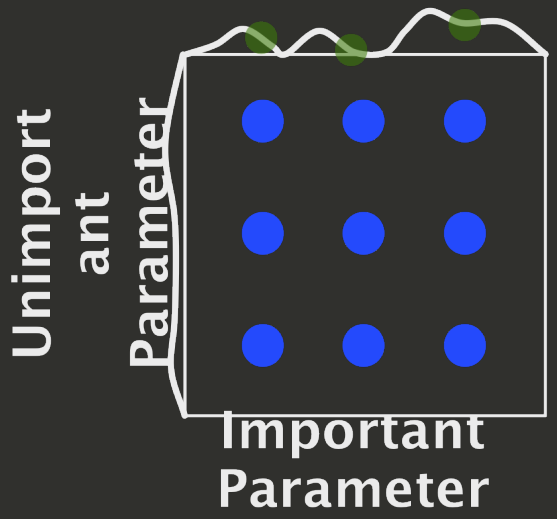
* Added N features using logit (log odds) of prediction rather than the prediction istelf

**Harmonic mean (for average)

https://medium.com/@chris_bour/6-tricks-i-learned-from-the-otto-kaggle-challenge-a9299378cd61#.3ziqa2hhz

Recap





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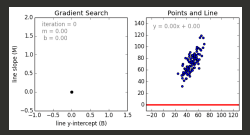

Matt Nedrich
https://github.com/mattnedrich/GradientDescentExample

Various
https://en.wikipedia.org/wiki/Iris_flower_data_set

Chia Ying Yang
https://www.flickr.com/photos/enixii/17074838535/

Link to Slides & Code

http://github.com/braz/pycon2016_talk/