Fast and Scalable Machine Learning in R and Python with H2O

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Introduction

- Statistician & Machine Learning Scientist at H2O.ai, in Mountain View, California, USA
- Ph.D. in Biostatistics with Designated Emphasis in Computational Science and Engineering from UC Berkeley (focus on Machine Learning)
- Worked as a data scientist at several startups
- Founder of Bay Area WiMLDS meetup

H2O.ai

Agenda

- Who/What is H2O?
- H2O Machine Learning Platform
- Sparking Water & Deep Water
- H2O in R & Python
- H2O Code Tutorial
- Microarray Code Demo

H2O.ai

H2O.ai, the Company

- Team: 85; Founded in 2012
- Headquarters: Mountain View, California, USA
- Stanford & Purdue Math & Systems Engineers

H2O, the Platform

- Open Source Software (Apache 2.0 Licensed)
- R, Python, Scala, Java and Web Interfaces
- Distributed Algorithms that Scale to Big Data

Scientific Advisory Council

Dr. Trevor Hastie

- John A. Overdeck Professor of Mathematics, Stanford University
- PhD in Statistics, Stanford University
- Co-author, *The Elements of Statistical Learning: Prediction, Inference and Data Mining*
- Co-author with John Chambers, *Statistical Models in S*
- Co-author, *Generalized Additive Models*

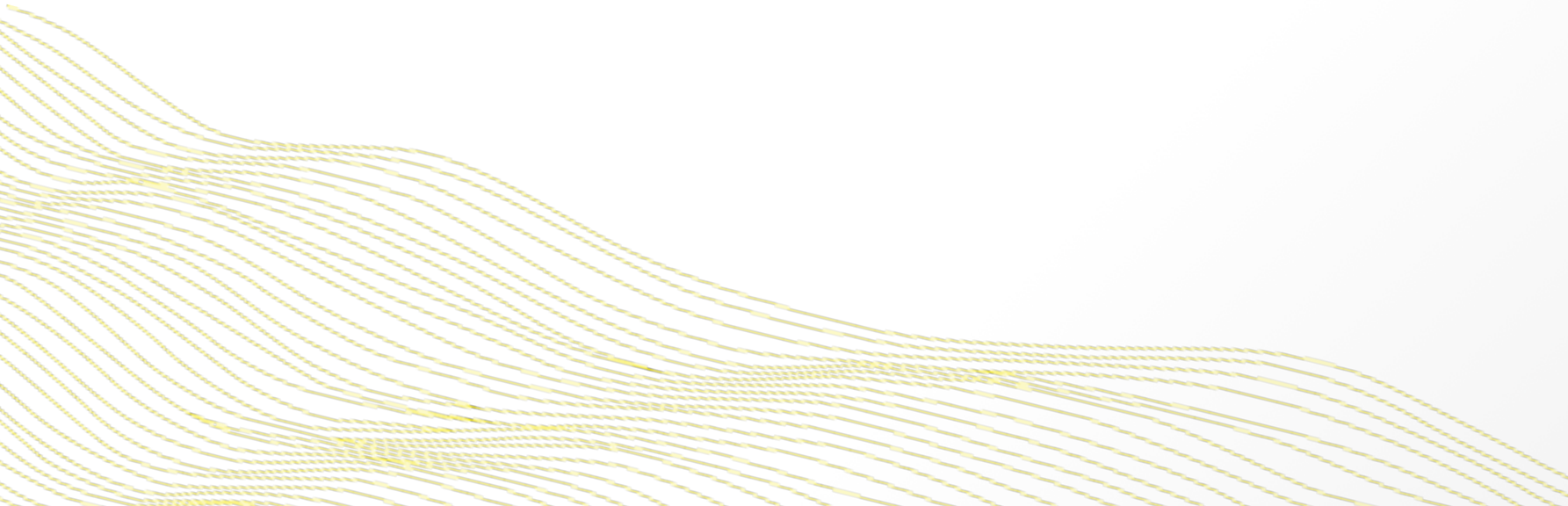
Dr. Robert Tibshirani

- Professor of Statistics and Health Research and Policy, Stanford University
- PhD in Statistics, Stanford University
- Co-author, *The Elements of Statistical Learning: Prediction, Inference and Data Mining*
- Author, *Regression Shrinkage and Selection via the Lasso*
- Co-author, *An Introduction to the Bootstrap*

Dr. Steven Boyd

- Professor of Electrical Engineering and Computer Science, Stanford University
- PhD in Electrical Engineering and Computer Science, UC Berkeley
- Co-author, *Distributed Optimization and Statistical Learning via the Alternating Direction Method of Multipliers*
- Co-author, *Linear Matrix Inequalities in System and Control Theory*
- Co-author, *Convex Optimization*

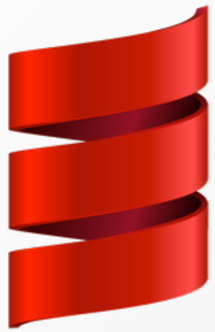
H2O Platform



H2O Platform Overview

- Distributed implementations of cutting edge ML algorithms.
- Core algorithms written in high performance Java.
- APIs available in R, Python, Scala, REST/JSON.
- Interactive Web GUI.



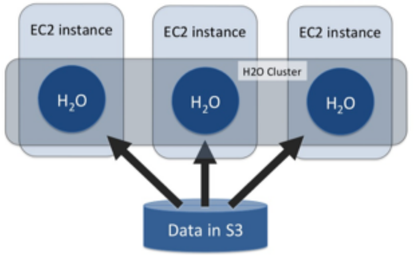




H2O Platform Overview

- Write code in high-level language like R (or use the web GUI) and output production-ready models in Java.
- To scale, just add nodes to your H2O cluster.
- Works with Hadoop, Spark and your laptop.

H2O Distributed Computing

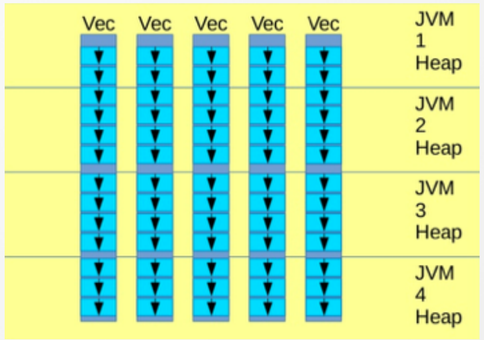
H2O Cluster



- Multi-node cluster with shared memory model.
- All computations in memory.
- Each node sees only some rows of the data.
- No limit on cluster size.

H2O Frame

- Distributed data frames (collection of vectors).
- Columns are distributed (across nodes) arrays.
- Works just like R's data.frame or Python Pandas DataFrame



Current Algorithm Overview

Statistical Analysis

- Linear Models (GLM)
- Naïve Bayes

Ensembles

- Random Forest
- Distributed Trees
- Gradient Boosting Machine
- R Package - Stacking / Super Learner

Deep Neural Networks

- Multi-layer Feed-Forward Neural Network
- Auto-encoder
- Anomaly Detection
- Deep Features

Clustering

- K-Means

Dimension Reduction

- Principal Component Analysis
- Generalized Low Rank Models

Solvers & Optimization

- Generalized ADMM Solver
- L-BFGS (Quasi Newton Method)
- Ordinary Least-Square Solver
- Stochastic Gradient Descent

Data Munging

- Scalable Data Frames
- Sort, Slice, Log Transform

Sparkling Water

H2O on Spark

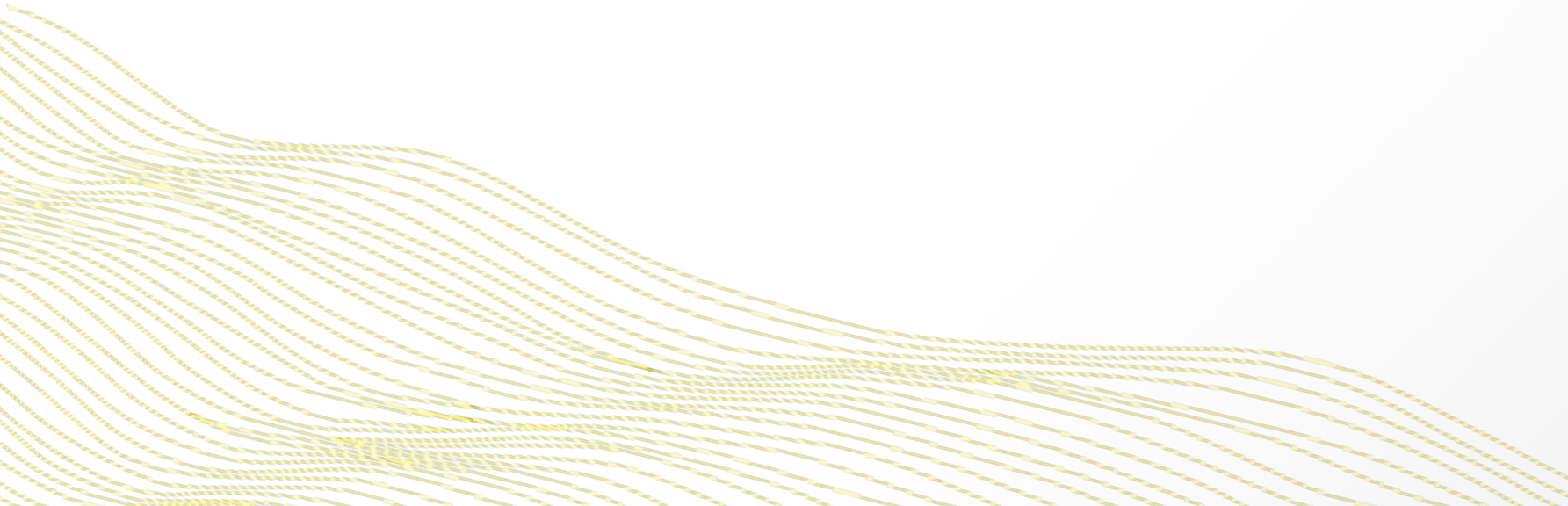
Sparkling Water

- Sparkling Water is transparent integration of H2O into the Spark ecosystem.
- H2O runs inside the Spark Executor JVM.

Features

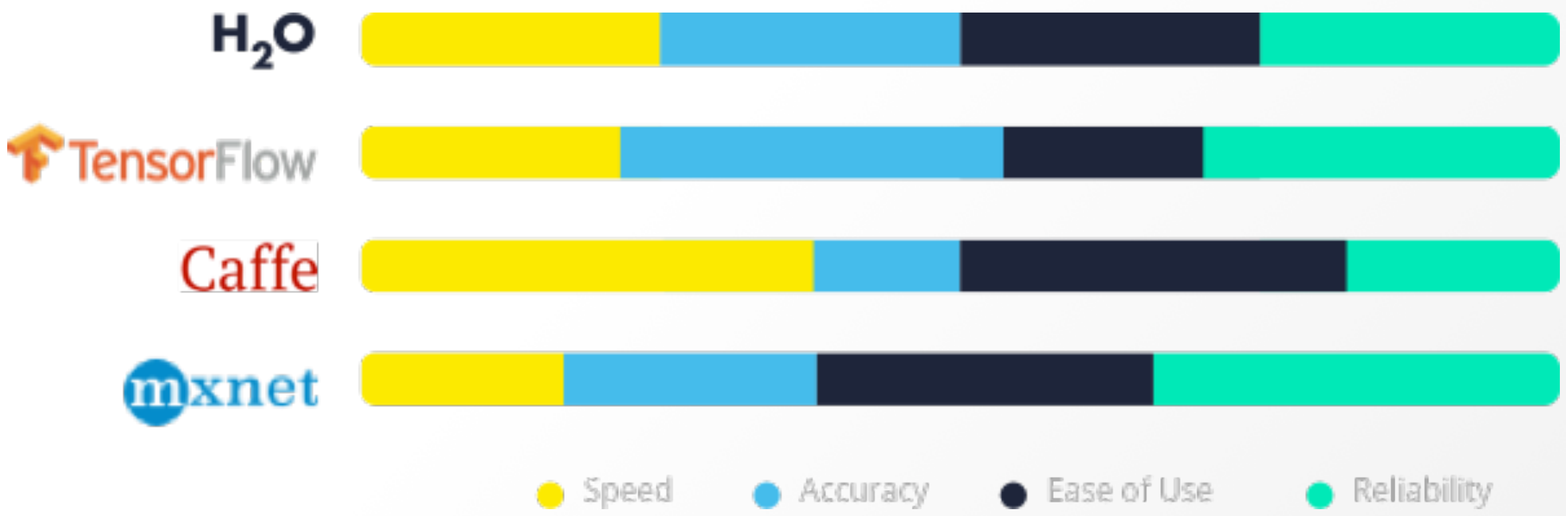
- Provides access to high performance, distributed machine learning algorithms to Spark workflows.
- Alternative to the default MLlib library in Spark.

Deep Water

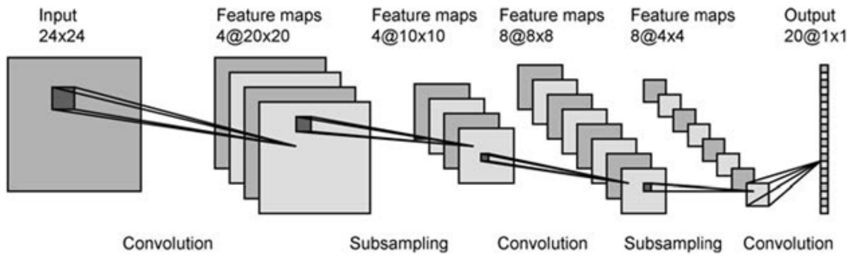


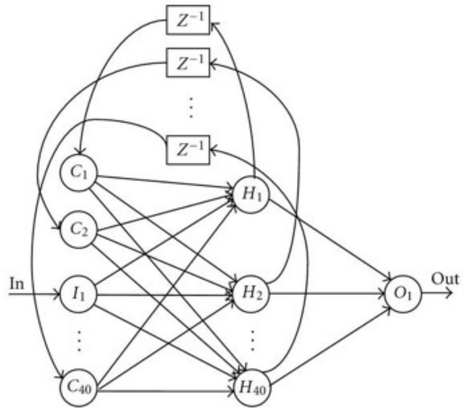
Deep Water

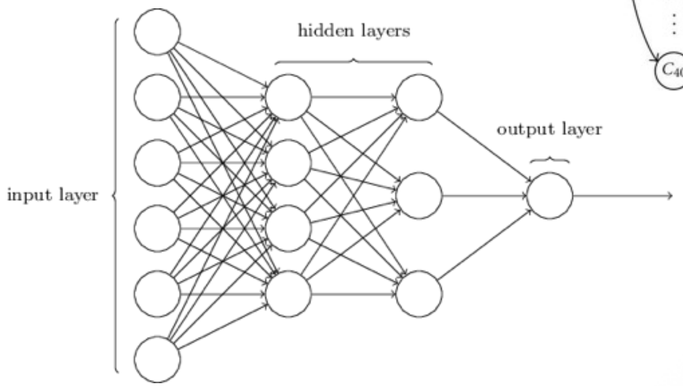
Project “Deep Water” is a unification of the top open source libraries for Deep Learning.



Deep Water Neural Architectures







- Convolutional Neural Networks (CNNs), which are popular for image data.
- Recurrent Neural Networks (RNNs), including Long-Short-Term-Memory (LSTMs) for sequence learning including text, audio and video.
- Multilayer Perceptrons (MLPs), fully connected multilayer artificial neural networks, useful for numeric data.

H2O in R and Python

h2o R Package

Installation

- Java 7 or later; R 3.1 and above; Linux, Mac, Windows
- The easiest way to install the h2o R package is CRAN.
- Latest version: http://www.h2o.ai/download/h2o/r

Design

All computations are performed in highly optimized Java code in the H2O cluster, initiated by REST calls from R.

H2O Startup & Load Data

Example

```
library(h2o)  # First install from CRAN
localH2O <- h2o.init()  # Initialize the H2O cluster

# Data directly into H2O cluster (avoids R)
train <- h2o.importFile(path = "train.csv")

# Data into H2O from R data.frame
train <- as.h2o(my_df)
```

H2O Supervised ML

Example

```
y <- "Class"
x <- setdiff(names(train), y)

fit <- h2o.gbm(x = x, y = y, training_frame = train)

pred <- h2o.predict(fit, test)
```

H2O Cartesian Grid Search

Example

```
hidden_opt <- list(c(200,200), c(100,300,100), c(500,500))
l1_opt <- c(1e-5,1e-7)
hyper_params <- list(hidden = hidden_opt, l1 = l1_opt)

grid <- h2o.grid(algorithm = "deeplearning",
                 hyper_params = hyper_params,
                 x = x, y = y,
                 training_frame = train,
                 validation_frame = valid)
```

H2O Random Grid Search

Example

```
search_criteria <- list(strategy = "RandomDiscrete",
                        max_runtime_secs = 600)

grid <- h2o.grid(algorithm = "deeplearning",
                 hyper_params = hyper_params,
                 search_criteria = search_criteria,
                 x = x, y = y,
                 training_frame = train,
                 validation_frame = valid)
```

Stacking via h2oEnsemble R package

Example

```
# Create a list of all the base models
models <- c(gbm_models, rf_models, dl_models, glm_models)

# Let's stack!
stack <- h2o.stack(models = models,
                   response_frame = train[,y],
                   metalearner = metalearner)
```

H2O Ensemble Resources

H2O Ensemble training guide:
http://tinyurl.com/learn-h2o-ensemble

H2O Ensemble homepage on Github:
http://tinyurl.com/github-h2o-ensemble

H2O Ensemble R Demos:
http://tinyurl.com/h2o-ensemble-demos

h2o Python Module

Installation

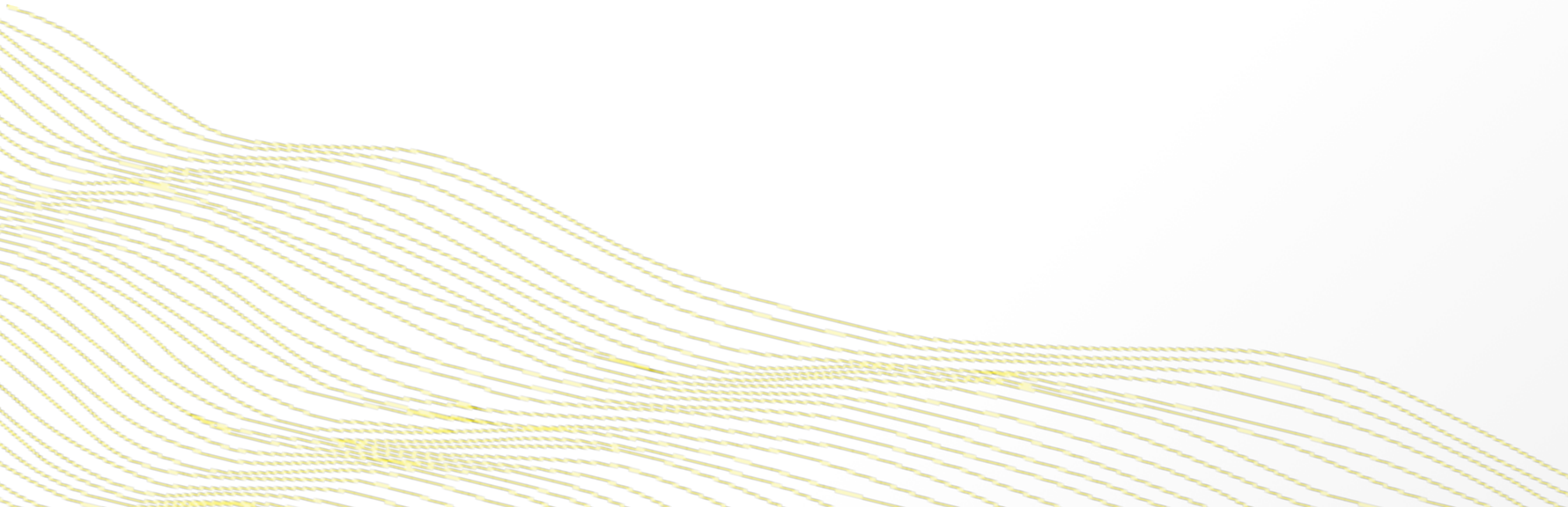
- Java 7 or later; Python 2.7, 3.5; Linux, Mac, Windows
- The easiest way to install the h2o Python module is PyPI.
- Latest version: http://www.h2o.ai/download/h2o/python

Design

All computations are performed in highly optimized Java code in the H2O cluster, initiated by REST calls from R.

Genomics Code Demo

http://tinyurl.com/h2o-rotterdam



H2O R & Python Tutorial

http://tinyurl.com/h2o-tutorial-rpy

Tutorial: Intro to H2O Algorithms

The "Intro to H2O" tutorial introduces five popular supervised machine learning algorithms in the context of a binary classification problem.

The training module demonstrates how to train models and evaluating model performance on a test set.

- Generalized Linear Model (GLM)
- Random Forest (RF)
- Gradient Boosting Machine (GBM)
- Deep Learning (DL)
- Naive Bayes (NB)

Tutorial: Grid Search for Model Selection

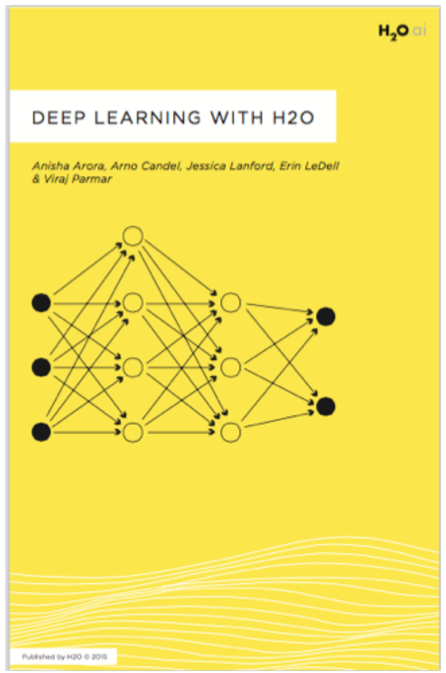
```
> print(gbm_gridperf)
H2O Grid Details
================

Grid ID: gbm_grid2
Used hyper parameters:
  -  sample_rate
  -  max_depth
  -  learn_rate
  -  col_sample_rate
Number of models: 72
Number of failed models: 0

Hyper-Parameter Search Summary: ordered by decreasing auc
  sample_rate max_depth learn_rate col_sample_rate          model_ids                auc
1           1         3       0.19                1 gbm_grid2_model_38 0.685166598389755
2         0.9         3       0.15                1 gbm_grid2_model_53 0.684956999713052
3         0.8         5       0.06                1 gbm_grid2_model_22 0.684843506375254
4         0.6         4       0.07                1  gbm_grid2_model_4 0.684327718715252
5        0.95         4       0.13                1 gbm_grid2_model_48 0.684042497773235
```

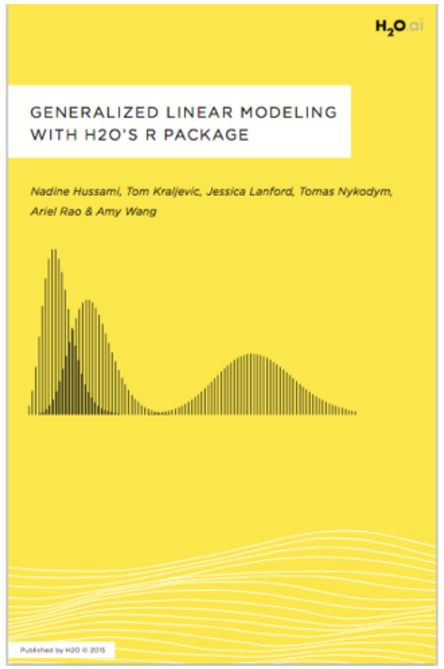
The second training module demonstrates how to find the best set of model parameters for each model using Grid Search.

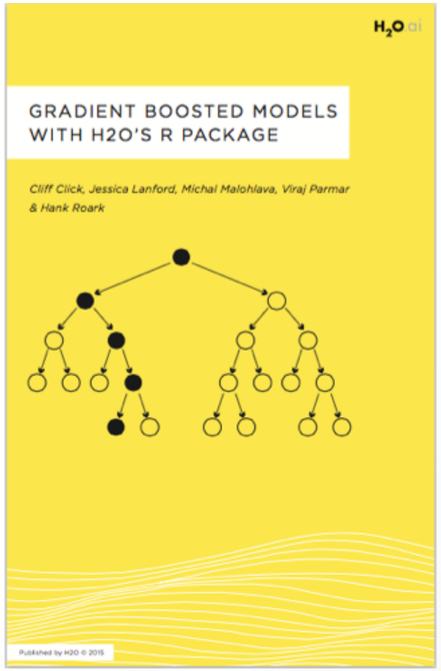
H2O Resources

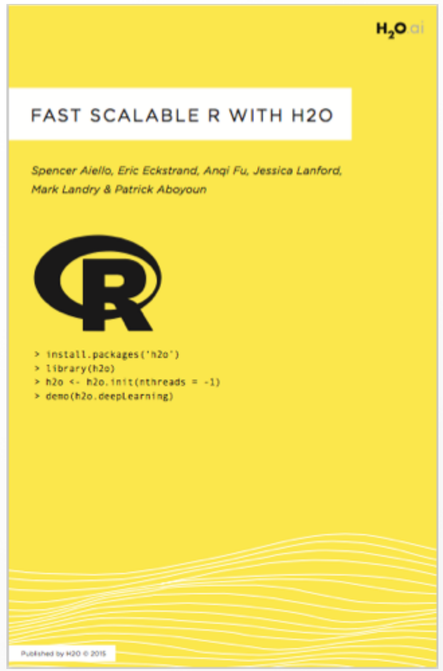
- H2O Online Training: http://learn.h2o.ai
- H2O Tutorials: https://github.com/h2oai/h2o-tutorials
- H2O Slidedecks: http://www.slideshare.net/0xdata
- H2O Video Presentations: https://www.youtube.com/user/0xdata
- H2O Community Events & Meetups: http://h2o.ai/events

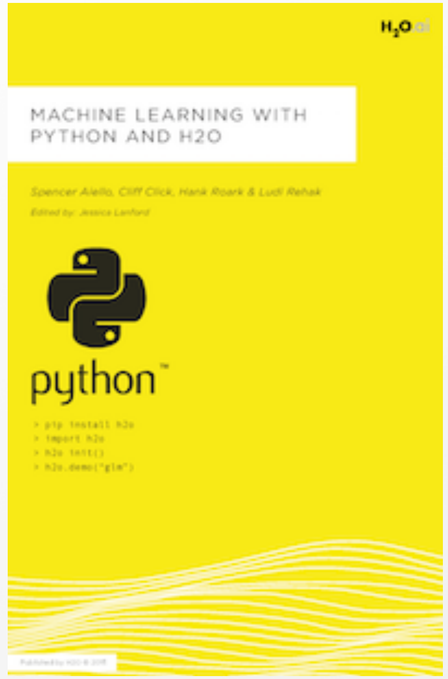
H2O Booklets











http://docs.h2o.ai/

Thank you!

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http://www.stat.berkeley.edu/~ledell