
# INSTALLING AND RUNNING SPARK



Jesús Maillo (jesusmh@decsai.ugr.es)

# First of all



- **Virtual Machine with all that you would need**

**VMWare Player:**

https://my.vmware.com/en/web/vmware/free#desktop_end_user_computing/vmware_workstation_player/14_0

**User: spark | Pass: spark | RootPass: spark**

https://mega.nz/#!DdRnhAYJ!7PeO-U28OAadLb8KFYBsa0CDSSX74t9c6QdqWmEdA2A

# Outline



- **Downloading and Installing Spark**
- Datasets: SUSY
- Datasets: ECBDL_14
- MLlib: Machine Learning on Spark
  - Statistical
  - Spark-packages
  - kNN-IS

# Downloading and Installing



## Scala

- wget http://scala-lang.org/files/archive/scala-2.11.6.tgz
- tar xzf scala-2.11.6.tgz -C /usr/local
- cd /usr/local/
- ln -s scala-2.11.6 scala
- vi /etc/profile.d/scala.sh


```
export SCALA_HOME=/usr/local/scala
export PATH=${SCALA_HOME}/bin:${PATH}
```

# Downloading and Installing



## Maven

- wget http://mirror.cc.columbia.edu/pub/software/apache/maven/maven-3/3.0.5/binaries/apache-maven-3.0.5-bin.tar.gz
- tar xzf apache-maven-3.0.5-bin.tar.gz -C /opt
- mv /opt/apache-maven-3.0.5/ /opt/maven
- vi /etc/profile.d/maven.sh

```
export M2_HOME=/opt/maven
export PATH=${M2_HOME}/bin:${PATH}
```

# Downloading and Installing



## Spark

- wget http://ftp.cixug.es/apache/spark/spark-2.2.0/spark-2.2.0-bin-hadoop2.7.tgz
- tar xzf spark-2.2.0-bin-hadoop2.7.tgz -C /opt/
- vi /etc/profile.d/spark.sh

```
export SPARK_HOME=/opt/spark-2.2.0-bin-hadoop2.7
export PATH=${SPARK_HOME}/bin:${PATH}
```

# Downloading and Installing



## Scala IDE

- wget http://downloads.typesafe.com/scalaide-pack/4.7.0-vfinal-oxygen-212-20170929/scala-SDK-4.7.0-vfinal-2.12-linux.gtk.x86_64.tar.gz
- tar -xvzf scala-SDK-4.7.0-vfinal-2.12-linux.gtk.x86_64 -C /opt
- chmod -R +r /opt/eclipse/
- vi /usr/bin/eclipse

```
#!/bin/sh
export ECLIPSE_HOME="/opt/eclipse"
$ECLIPSE_HOME/eclipse $*
```

- chmod 755 /usr/bin/eclipse

# Downloading and Installing



## Scala IDE

- vi /usr/share/applications/eclipse.desktop

```
[Desktop Entry]
Encoding=UTF-8
Name=Eclipse
Comment=Eclipse Mars.1 4.5.1
Exec=eclipse
Icon=/opt/eclipse/icon.xpm
Terminal=false
Type=Application
Categories=GNOME;Application;Development;
StartupNotify=true
```

# Downloading and Installing Spark



## Update Path

- source /etc/profile.d/*.sh
- Log Out & Log In
- Restart

# Outline



- Downloading and Installing Spark
- **Datasets: SUSY**
- Datasets: ECBDL_14
- MLlib: Machine Learning on Spark
  - Statistical
  - Spark-packages
  - kNN-IS

# Dataset: SUSY



## SUSY

- Subset of 10,000 instances in the VM. (5M original)
- Number of instances: 10.000 + 10.000 (18 features)
  training test
- Classification problem
- Real features

UCI Machine Learning Repository

Machine Learning Repository. SUSY Data Set
https://archive.ics.uci.edu/ml/datasets/SUSY

# Dataset: SUSY



## SUSY: Path

- Local (Virtual Machine):
  - Training: /home/spark/datasets/susy-10k-tra.data
  - Test: /home/ spark /datasets/susy-10k-tst.data
  - Header: /home/ spark /datasets/susy.header

# Outline



- Downloading and Installing Spark
- Datasets: SUSY
- **Datasets: ECBDL_14**
- MLlib: Machine Learning on Spark
  - Statistical
  - Spark-packages
  - kNN-IS

# Dataset: ECBDL_14



## ECBDL_14

- Number of instances: 499,449 + 500,353 (631 features)

  training test

- Imbalance Ratio (IR): 70 % + 30 %

  label: “0.0” “1.0”

Arnaldo, K. Veeramachaneni, U. O’Reilly and J. Bacardit. *ECBDL14 dataset: Protein structure prediction and contact map for the ECBDL2014 big data competition*, 2014, Link

# Dataset: ECBDL_14



## ECBDL_14: Path

- Cluster (HDFS):
  - Training: /user/spark/datasets/ECBDL14_mbd/ecbdl14tra.data
  - Test: /user/spark/datasets/ECBDL14_mbd/ecbdl14tst.data
  - Header: /user/spark/datasets/ECBDL14_mbd/ecbdl4.header

# Outline



- Downloading and Installing Spark
- Datasets: SUSY
- Datasets: ECBDL_14
- **MLlib: Machine Learning on Spark**
  - Statistical
  - Spark-packages
  - kNN-IS

# Mllib: Running



## Virtual Machine examples

### Interactive Shell Scala (Virtual Machine):

- /opt/spark-2.2.0-bin-hadoop2.7/bin/spark-shell

### Spark Submit (Virtual Machine):

- /opt/spark-2.2.0-bin-hadoop2.7/bin/spark-submit

### Interactive Shell R (Virtual Machine):

- /opt/spark-2.2.0-bin-hadoop2.7/bin/sparkR

# Mllib: Running



## Cluster examples

### Interactive Shell Scala (Virtual Machine):

- /opt/spark-2.2.0/bin/spark-shell

### Spark Submit (Virtual Machine):

- /opt/spark-2.2.0/bin/spark-submit

### Interactive Shell R (Virtual Machine):

- /opt/spark-2.2.0/bin/sparkR

# Outline



- Downloading and Installing Spark
- Datasets: SUSY
- Datasets: ECBDL_14
- MLlib: Machine Learning on Spark
  - **Statistical**
  - Spark-packages
  - kNN-IS

# Mllib with Scala: Statistical



## Basic Statistics

- Summary statistics
- Correlations
- Stratified sampling
- Hypothesis testing
  - Streaming Significance Testing
- Random data generation

https://github.com/JMailloH/BasicStatisticsSpark

https://spark.apache.org/docs/2.2.0/mllib-statistics.html#summary-statistics

# Statistical: import



```
import org.apache.spark.SparkContext
import org.apache.spark.SparkConf
import org.apache.spark.mllib.linalg._
import org.apache.spark.mllib.regression.LabeledPoint
import org.apache.spark.mllib.stat.{ MultivariateStatisticalSummary, Statistics }
import scala.collection.mutable.ListBuffer
```

# Statistical: Read



```
val train = sc.textFile(pathTrain).map { line =>
            val array = line.split(“,”)
            var arrayDouble = array.map(f => f.toDouble)
            val featureVector = Vectors.dense(arrayDouble.init)
            val label = arrayDouble.last
            LabeledPoint(label, featureVector)
}.persist
val test = sc.textFile(pathTest).map { line =>
            val array = line.split(“,”)
            var arrayDouble = array.map(f => f.toDouble)
            val featureVector = Vectors.dense(arrayDouble.init)
            val label = arrayDouble.last
            LabeledPoint(label, featureVector)
}.persist
```

# Statistical: StatisticalSummary



ES UN RDD

CREA UN MAP PARA QUEDARSE SOLO CON LAS CARACTERISRICAS. EL _ HACE REFERENCIA A TODOS LOS DATOS DE LA ESTRUCTURA.

```
val observationsTrain = train.map(_.features)
val observationsTest = test.map(_.features)

val summaryTrain: MultivariateStatisticalSummary = Statistics.colStats(observationsTrain)
val summaryTest: MultivariateStatisticalSummary = Statistics.colStats(observationsTest)
```

**summaryTrain.max is a dense vector containing the max value for each column**

# Statistical: StatisticalSummary



```
val observationsTrain = train.map(_.features)
val observationsTest = test.map(_.features)

val summaryTrain: MultivariateStatisticalSummary = Statistics.colStats(observationsTrain)
val summaryTest: MultivariateStatisticalSummary = Statistics.colStats(observationsTest)
```

**summaryTrain.max is a dense vector containing the max value for each column**

# Statistical: Result and write



LIST BUFFER ÚTIL PARA LA SALIDA

```
var outputString = new ListBuffer[String]
outputString += "******TRAIN******\n\n"
outputString += "@Max (0) --> " + summaryTrain.max(0) + "\n"
outputString += "@Min (0) --> " + summaryTrain.min(0) + "\n"
outputString += "@Mean (0) --> " + summaryTrain.mean(0) + "\n"
outputString += "@Variance (0) --> " + summaryTrain.variance(0) + "\n"
outputString += "@NumNonZeros (0) --> " + summaryTrain.numNonzeros(0) + "\n"

outputString += "\n\n******TEST******\n\n"
outputString += "@Max (0) --> " + summaryTest.max(0) + "\n"
outputString += "@Min (0) --> " + summaryTest.min(0) + "\n"
outputString += "@Mean (0) --> " + summaryTest.mean(0) + "\n"
outputString += "@Variance (0) --> " + summaryTest.variance(0) + "\n"
outputString += "@NumNonZeros (0) --> " + summaryTest.numNonzeros(0) + "\n"
```

# Statistical: StatisticalSummary



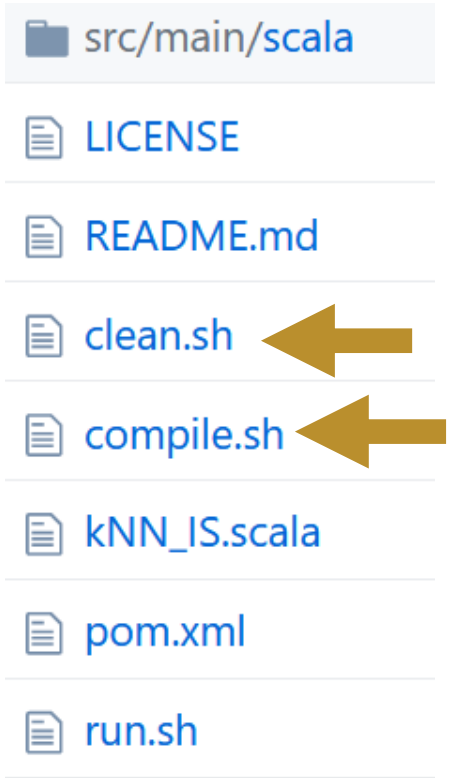
```
val predictionsTxt = sc.parallelize(outputString, 1)

predictionsTxt.saveAsTextFile(pathOutput)
```

Number of partition = 1 to obtain only 1 part

SaveAsTextFile for readable stile

# Statistical: compile.sh & clean.sh






**Build the .jar file**

mvn package -Dmaven.test.skip=true

**Remove old compilation**

mvn clean

**Run the example with**

./clean.sh ; ./compile.sh ; ./run.sh

# Statistical: run.sh



- src/main/scala
- LICENSE
- README.md
- clean.sh
- compile.sh
- kNN_IS.scala
- pom.xml
- run.sh

**Submit an application**

```
/opt/spark-2.2.0-bin-hadoop2.7/bin/spark-submit
--master local[*]
--class org.apache.spark.run.runBasicStatistics
./target/BasicStatistics-1.0.jar
/home/spark/datasets/susy-10k-tra.data
/home/spark/datasets/susy-10k-tst.data
./outputBasicStatistics
```

# Outline

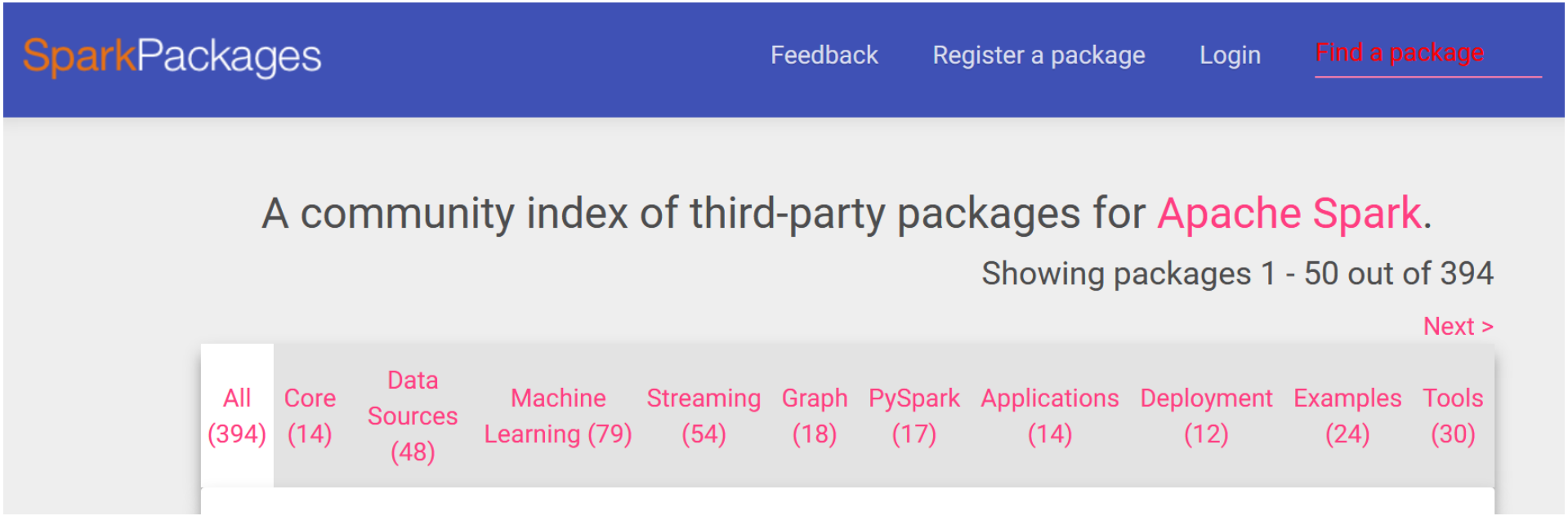


- Downloading and Installing Spark
- Datasets: SUSY
- Datasets: ECBDL_14
- MLlib: Machine Learning on Spark
  - Statistical
  - **Spark-packages**
  - kNN-IS

# Spark-packages



https://spark-packages.org/




- Large number of "utils" implementations
- Machine learning algorithms
- Many other third parties algorithm for spark

# Spark-packages



https://spark-packages.org/package/h2oai/sparkling-water

## sparkling-water (homepage)

Sparkling Water provides H2O algorithms inside Spark cluster

@h2oai / ★★★★★ (👤2)

Sparkling Water connects worlds of H2O and Spark. It enables launching H2O on top of Spark and using H2O capabilities including various ML algorithms, graphical user interface, or R integration.

# Spark-packages



https://spark-packages.org/package/h2oai/sparkling-water

## sparkling-water (homepage)

Sparkling Water provides H2O algorithms inside Spark cluster

@h2oai / ★★★★★ (👤2)

Sparkling Water connects worlds of H2O and Spark. It enables launching H2O on top of Spark and using H2O capabilities including various ML algorithms, graphical user interface, or R integration.



**Michal Malohlava** • 3 years ago

More about Sparkling Water is available at h2o blog: http://h2o.ai/blog

Example code is part of GitHub repository: https://github.com/h2oai/sp...

^ | v • Reply • Share ›

# Spark-packages



https://spark-packages.org/package/lensacom/sparkit-learn

## sparkit-learn (homepage)

PySpark + Scikit-learn = Sparkit-learn

@lensacom / ★★★★★ (👤2)

Sparkit-learn aims to provide scikit-learn functionality and API on PySpark. The main goal of the library is to create an API that stays close to sklearn's.

The driving principle was to "Think locally, execute distributively." To accomodate this concept, the basic data block is always an array or a (sparse) matrix and the operations are executed on block level.

# Spark-packages



https://spark-packages.org/package/lensacom/sparkit-learn

## sparkit-learn (homepage)

PySpark + Scikit-learn = Sparkit-learn

@lensacom / ★★★★★ (👤2)

Sparkit-learn aims to provide scikit-learn functionality and API on PySpark. The main goal of the library is to create an API that stays close to sklearn's.

The driving principle was to "Think locally, execute distributively." To accomodate this concept, the basic data block is always an array or a (sparse) matrix and the operations are executed on block level.

## How to

This package doesn't have any releases published in the Spark Packages repo, or with maven coordinates supplied. You may have to build this package from source, or it may simply be a script. To use this Spark Package, please follow the instructions in the README.

# Spark-packages



https://spark-packages.org/package/Azure/mmlspark

## mmlspark (homepage)

Microsoft Machine Learning for Apache Spark

@Azure / ☆☆☆☆☆ (3)

MMLSpark provides a number of deep learning and data science tools for Apache Spark, including seamless integration of Spark Machine Learning pipelines with Microsoft Cognitive Toolkit (CNTK) and OpenCV, enabling you to quickly create powerful, highly-scalable predictive and analytical models for large image and text datasets.

## Tags

3 ml | 3 machine learning | 3 Microsoft | 3 Azure | 3 pyspark | 3 cntk | 3 Microsoft Machine Learning | 2 tools

## How to [+]

Include this package in your Spark Applications using:

spark-shell, pyspark, or spark-submit

```
> $SPARK_HOME/bin/spark-shell --packages Azure:mmlspark:0.11
```

$SPARK_HOME/bin/spark-shell –packages Azure:mmlspark:0.11

# Outline



- Downloading and Installing Spark
- Datasets: SUSY
- Datasets: ECBDL_14
- MLlib: Machine Learning on Spark
  - Statistical
  - Spark-packages
  - **kNN-IS**

# Mllib: Spark-packages



https://spark-packages.org/package/JMailloH/kNN_IS

## kNN_IS (homepage)

SparkPackages

kNN-IS: An Iterative Spark-based design of the k-Nearest Neighbors classifier for big data.

@JMailloH / ★★★★★ (👤4)

This is an open-source Spark package about an exact k-nearest neighbors classification based on Apache Spark. We take advantage of its in-memory operations to simultaneously classify big amounts of unseen cases against a big training dataset. The map phase computes the k-nearest neighbors in different splits of the training data. Afterwards, multiple reducers process the definitive neighbors from the list obtained in the map phase. The key point of this proposal lies on the management of the test set, maintaining it in memory when it is possible. Otherwise, this is split into a minimum number of pieces, applying a MapReduce per chunk, using the caching skills of Spark to reuse the previously partitioned training set.

**>$: /opt/spark-2.2.0-bin-hadoop2.7/bin/spark-shell --packages JMailloH:kNN_IS:3.0**

# Mllib: Script with kNN-IS



https://spark-packages.org/package/JMailloH/kNN_IS

- src/main/scala
- LICENSE
- README.md
- clean.sh
- compile.sh
- kNN_IS.scala
- pom.xml
- run.sh


# kNN-IS: import



```
import org.apache.spark.SparkContext
import org.apache.spark.SparkConf
import org.apache.spark.rdd._
import org.apache.spark.mllib.linalg.Vectors
import org.apache.spark.mllib.regression.LabeledPoint
import org.apache.spark.mllib.evaluation.MulticlassMetrics
import org.apache.spark.mllib.evaluation.BinaryClassificationMetrics
import org.apache.spark.mllib.classification.kNN_IS.kNN_IS
import utils.keel.KeelParser
import scala.collection.mutable.ListBuffer
```

# kNN-IS: Read



```
val converter = new KeelParser(sc, "/home/hadoop/datasets/susy.header")

val train = sc.textFile("/home/hadoop/datasets/susy-10k-tra.data", 10).
            map(line => converter.parserToLabeledPoint(line)).persist

val test = sc.textFile("/home/hadoop/datasets/susy-10k-tst.data", 10).
            map(line => converter.parserToLabeledPoint(line)).persist
```

# kNN-IS: Param.



```
val k = 5
val dist = 2 //euclidean
val numClass = converter.getNumClassFromHeader()
val numFeatures = converter.getNumFeaturesFromHeader()
val numPartitionMap = 10
val numReduces = 2
val numIterations = 1
val maxWeight = 5

val knn = kNN_IS.setup(train, test, k, dist, numClass, numFeatures,
numPartitionMap, numReduces, numIterations, maxWeight)
```

# kNN-IS: Classify



```
val predictions = knn.predict(sc)

val metrics = new MulticlassMetrics(predictions)
val precision = metrics.precision
val cm = metrics.confusionMatrix

val binaryMetrics = new BinaryClassificationMetrics(predictions)
val AUC = binaryMetrics.areaUnderROC
```


# INSTALLING AND RUNNING SPARK



Jesús Maillo (jesusmh@decsai.ugr.es)