Big data: architectures and data analytics

Regression algorithms

Regression algorithms

- Spark MLlib provides also a set of regression algorithms
  - E.g., Linear regression
- A regression algorithm is used to predict the value of a continuous attribute (the target attribute) by applying a model on the predictive attributes
- The model is trained on a set of training data
  - I.e., a set of data for which the value of the target attribute is know

Regression algorithms

- The regression algorithms available in Spark work only on numerical data
  - Categorical values must be mapped to integer values (i.e., numerical values)
- The input dataset must be transformed in a DataFrame of LabeledPoints
  - The label attribute is the target attribute of the regression algorithm

Linear regression and structured data

Linear regression and structured data

- Linear regression is a popular, effective and efficient regression algorithm
- The following slides show how to instantiate a linear regression algorithm in Spark an apply it
- The input dataset is a structured dataset with a fixed number of attributes
  - One attribute is the target attribute (the label)
  - The others are predictive attributes that are used to predict the value of the target attribute
  - We suppose the first column contains the target attribute

Linear regression and structured data

- Consider the following example file

```
2.0,0.0,1.1,0.1
5.0,2.0,1.0,-1.0
5.0,2.0,1.3,1.0
2.0,0.0,1.2,-0.5
```

- It contains four records
- Each record has three attributes
  - The first attribute (column) is the target attribute
  - The other attributes (columns) are predictive attributes

Linear regression and structured data: example

```
package it.polito.bigdata.spark.sparkmllib;

import org.apache.spark.api.java.*;
import org.apache.spark.sql.DataFrame;
import org.apache.spark.sql.Row;
import org.apache.spark.sql.SQLContext;
import org.apache.spark.ml.Pipeline;
import org.apache.spark.ml.PipelineModel;
import org.apache.spark.ml.PipelineStage;
import org.apache.spark.ml.regression.LinearRegression;
import org.apache.spark.mllib.regression.LabeledPoint;
import org.apache.spark.SparkConf;
```

Linear regression and structured data: example

```
public class SparkDriver {

    public static void main(String[] args) {

        String inputFileTraining;
        String inputFileTest;
        String outputPath;

        inputFileTraining=args[0];
        inputFileTest=args[1];
        outputPath=args[2];

        // Create a configuration object and set the name of the application
        SparkConf conf=new SparkConf().setAppName("MLlib - linear regression");

        // Create a Spark Context object
        JavaSparkContext sc = new JavaSparkContext(conf);
```

Linear regression and structured data: example

```
// Create an SQLContext
SQLContext sqlContext = new org.apache.spark.sql.SQLContext(sc);

// Read training data from a textual file
// Each lines has the format: target attibute,list of numerical attribute values
// E.g., 5.0,1.0,5.0,4.5,1.2
JavaRDD<String> trainingData=sc.textFile(inputFileTraining);

// Map each element (each line of the input file) a LabelPoint
JavaRDD<LabeledPoint> trainingRDD=trainingData.map(new
                                                    InputRecord());
```

Linear regression and structured data: example

```
// Prepare training data.
// We use LabeledPoint, which is a JavaBean.
// We use Spark SQL to convert RDDs of JavaBeans
// into DataFrames.
// Each data point has a set of features and a label
DataFrame training = sqlContext.createDataFrame(trainingRDD,

LabeledPoint.class).cache();
// Create a LinearRegression object.
// LogisticRegression is an Estimator that is used to
// create a classification model based on logistic regression.
LinearRegression lr = new LinearRegression();

// We can set the values of the parameters of the
// Linear Regression algorithm using the setter methods.
lr.setMaxIter(10);
lr.setRegParam(0.01);
```

Linear regression and structured data: example

```
// Define the pipeline that is used to create the logistic regression
// model on the training data
// In this case the pipeline contains one single stage/step (the model
// generation step).
Pipeline pipeline = new Pipeline()
                    .setStages(new PipelineStage[] {lr});

// Execute the pipeline on the training data to build the
// classification model
PipelineModel model = pipeline.fit(training);
```

Linear regression and structured data: example

```
// Now, the classification model can be used to predict the value of
// the target attribute of new "unlabeled" data
// Read test (unlabeled) data
JavaRDD<String> testData=sc.textFile(inputFileTest);

// Map each element (each line of the input file) a LabelPoint
JavaRDD<LabeledPoint> testRDD=testData.map(new InputRecord());

// Create the DataFrame based on the new test data
DataFrame test = sqlContext.createDataFrame(testRDD,
                                            LabeledPoint.class);
```

Linear regression and structured data: example

```
        // Make predictions on test documents using the Transformer.transform()
    method.
        // The transform will only use the 'features' columns

        // The returned DataFrame has the following schema (attributes)
        // - features: vector (values of the attributes)
        // - label: double (value of the class label)
        // - rawPrediction: vector (nullable = true)
        // - probability: vector (The i-th cell contains the probability that the
        //              current record belongs to the i-th class
        // - prediction: double (the predicted class label)

        DataFrame predictions = model.transform(test);
```

Linear regression and structured data: example

```
        // Select only the features (i.e., the value of the attributes) and
        // the predicted value of the target attribute for each record
        DataFrame predictionsDF=predictions.select("features", "prediction");

        // Save the result in an HDFS file
        JavaRDD<Row> predictionsRDD = predictionsDF.javaRDD();
        predictionsRDD.saveAsTextFile(outputPath);


        // Close the Spark Context object
        sc.close();
    }
}
```

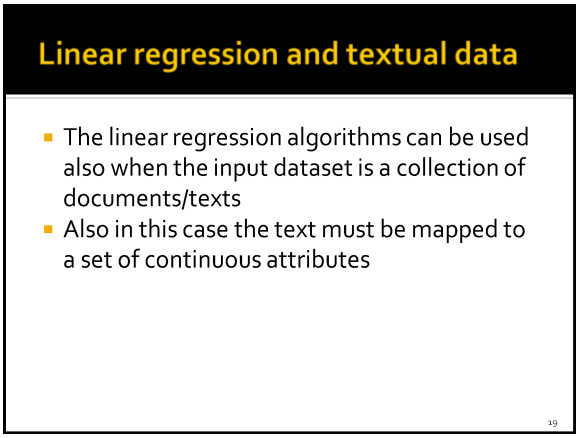
Linear regression and structured data: example

```
public class InputRecord implements Function<String, LabeledPoint> {

    public LabeledPoint call(String record) {
        String[] fields = record.split(",");

        // Fields of 0 contains the id of the class
        double classLabel = Double.parseDouble(fields[0]);

        // The other cells of fields contain the (numerical) values of the attributes
        // Create an array of doubles containing these values
        double[] attributesValues = new double[fields.length-1];

        for (int i = 0; i < fields.length-1; ++i) {
                attributesValues[i] = Double.parseDouble(fields[i+1]);
        }
```

Linear regression and structured data: example

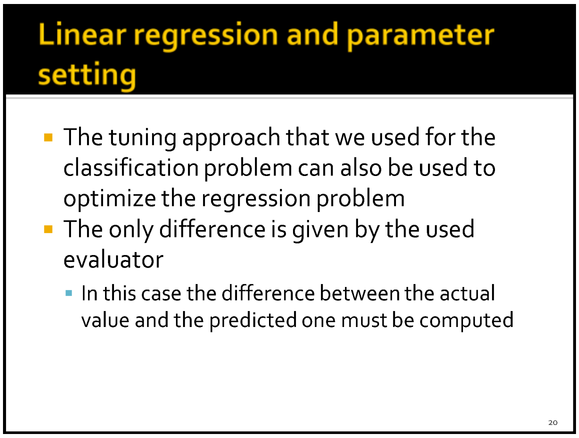
```
        // Create a dense vector based in the content of attributesValues
        Vector attrValues= Vectors.dense(attributesValues);

        // Return a new LabeledPoint
        return new LabeledPoint(classLabel, attrValues);
    }

}
```

Linear regression



Linear regression and textual data

- The linear regression algorithms can be used also when the input dataset is a collection of documents/texts
- Also in this case the text must be mapped to a set of continuous attributes



Linear regression and parameter setting

- The tuning approach that we used for the classification problem can also be used to optimize the regression problem
- The only difference is given by the used evaluator
  - In this case the difference between the actual value and the predicted one must be computed