# PySpark for BigMart Sales

In [1]:

```python
from pyspark.sql import SparkSession
spark = SparkSession.builder.appName('Analysis-BigMart').getOrCreate()
data = spark.read.csv('train.csv', header = True, inferSchema = True)
data.printSchema()
```

```
root
 |-- Item_Identifier: string (nullable = true)
 |-- Item_Weight: double (nullable = true)
 |-- Item_Fat_Content: string (nullable = true)
 |-- Item_Visibility: double (nullable = true)
 |-- Item_Type: string (nullable = true)
 |-- Item_MRP: double (nullable = true)
 |-- Outlet_Identifier: string (nullable = true)
 |-- Outlet_Establishment_Year: integer (nullable = true)
 |-- Outlet_Size: string (nullable = true)
 |-- Outlet_Location_Type: string (nullable = true)
 |-- Outlet_Type: string (nullable = true)
 |-- Item_Outlet_Sales: double (nullable = true)
```

In [2]:

```python
data.show(5, truncate=False)
```

```
+---------------+-----------+----------------+---------------+---------------------+--------+-----------------+-------------------------+-
----------+--------------------+-----------------+-----------------+
|Item_Identifier|Item_Weight|Item_Fat_Content|Item_Visibility|Item_Type            |Item_MRP|Outlet_Identifier|Outlet_Establishment_Year|O
utlet_Size|Outlet_Location_Type|Outlet_Type      |Item_Outlet_Sales|
+---------------+-----------+----------------+---------------+---------------------+--------+-----------------+-------------------------+-
----------+--------------------+-----------------+-----------------+
|FDA15          |9.3        |Low Fat         |0.016047301    |Dairy                |249.8092|OUT049           |1999                     |M
edium     |Tier 1              |Supermarket Type1|3735.138         |
|DRC01          |5.92       |Regular         |0.019278216    |Soft Drinks          |48.2692 |OUT018           |2009                     |M
edium     |Tier 3              |Supermarket Type2|443.4228         |
|FDN15          |17.5       |Low Fat         |0.016760075    |Meat                 |141.618 |OUT049           |1999                     |M
edium     |Tier 1              |Supermarket Type1|2097.27          |
|FDX07          |19.2       |Regular         |0.0            |Fruits and Vegetables|182.095 |OUT010           |1998                     |n
ull       |Tier 3              |Grocery Store    |732.38           |
|NCD19          |8.93       |Low Fat         |0.0            |Household            |53.8614 |OUT013           |1987                     |H
igh       |Tier 3              |Supermarket Type1|994.7052         |
+---------------+-----------+----------------+---------------+---------------------+--------+-----------------+-------------------------+-
----------+--------------------+-----------------+-----------------+
only showing top 5 rows
```

In [3]:

```python
data.describe().show()
```

```
+-------+---------------+------------------+----------------+-------------------+-------------+-----------------+-----------------+-------
------------------+-----------+--------------------+-----------------+------------------+
|summary|Item_Identifier|       Item_Weight|Item_Fat_Content|    Item_Visibility|    Item_Type|         Item_MRP|Outlet_Identifier|Outlet_
Establishment_Year|Outlet_Size|Outlet_Location_Type|      Outlet_Type| Item_Outlet_Sales|
+-------+---------------+------------------+----------------+-------------------+-------------+-----------------+-----------------+-------
------------------+-----------+--------------------+-----------------+------------------+
|  count|           8523|              7060|            8523|               8523|         8523|             8523|             8523|
8523|       6113|                8523|             8523|              8523|
|   mean|           null|12.857645184136183|            null|0.06613202877895127|         null|140.9927819781768|             null|
1997.8318667135984|       null|                null|             null|2181.2889135750365|
| stddev|           null| 4.643456499186414|            null|0.05159782232113514|         null|62.27506651219047|             null|
8.371760408092667|       null|                null|             null|1706.4996157338403|
|    min|          DRA12|             4.555|              LF|                0.0| Baking Goods|            31.29|           OUT010|
1985|       High|              Tier 1|    Grocery Store|             33.29|
|    max|          NCZ54|             21.35|             reg|        0.328390948|Starchy Foods|         266.8884|           OUT049|
2009|      Small|              Tier 3|Supermarket Type3|        13086.9648|
+-------+---------------+------------------+----------------+-------------------+-------------+-----------------+-----------------+-------
------------------+-----------+--------------------+-----------------+------------------+
```

In [4]:

```
import pyspark.sql.functions as f

# null values in each column
data_agg = data.agg(*[f.count(f.when(f.isnull(c), c)).alias(c) for c in data.columns])
data_agg.show()
```

```
+---------------+-----------+----------------+---------------+---------+--------+-----------------+-------------------------+-----------+-
------------------+-----------+-----------------+
|Item_Identifier|Item_Weight|Item_Fat_Content|Item_Visibility|Item_Type|Item_MRP|Outlet_Identifier|Outlet_Establishment_Year|Outlet_Size|O
utlet_Location_Type|Outlet_Type|Item_Outlet_Sales|
+---------------+-----------+----------------+---------------+---------+--------+-----------------+-------------------------+-----------+-
------------------+-----------+-----------------+
|              0|       1463|               0|              0|        0|       0|                0|                        0|       2410|
0|          0|                0|
+---------------+-----------+----------------+---------------+---------+--------+-----------------+-------------------------+-----------+-
------------------+-----------+-----------------+
```

# Fill NA with mean and mode

In [5]:

```
data.agg({'Item_Weight': 'mean'}).show()
```

```
+------------------+
|  avg(Item_Weight)|
+------------------+
|12.857645184136183|
+------------------+
```

In [6]:

```
data = data.fillna( { 'Item_Weight':12.857645184136183 } )
```

In [7]:

```
data.groupBy('Outlet_Size').count().show()
```

```
+-----------+-----+
|Outlet_Size|count|
+-----------+-----+
|       High|  932|
|       null| 2410|
|     Medium| 2793|
|      Small| 2388|
+-----------+-----+
```

In [8]:

```
data = data.fillna( { 'Outlet_Size':'Medium' } )
```

In [9]:

```
import pyspark.sql.functions as f

# null values in each column
data_agg = data.agg(*[f.count(f.when(f.isnull(c), c)).alias(c) for c in data.columns])
data_agg.show()
```

```
+---------------+-----------+----------------+---------------+---------+--------+-----------------+-------------------------+-----------+-
------------------+-----------+-----------------+
|Item_Identifier|Item_Weight|Item_Fat_Content|Item_Visibility|Item_Type|Item_MRP|Outlet_Identifier|Outlet_Establishment_Year|Outlet_Size|O
utlet_Location_Type|Outlet_Type|Item_Outlet_Sales|
+---------------+-----------+----------------+---------------+---------+--------+-----------------+-------------------------+-----------+-
------------------+-----------+-----------------+
|              0|          0|               0|              0|        0|       0|                0|                        0|          0|
0|          0|                0|
+---------------+-----------+----------------+---------------+---------+--------+-----------------+-------------------------+-----------+-
------------------+-----------+-----------------+
```

# Label Encoding

In [10]:

```python
from pyspark.ml.feature import StringIndexer

# create object of StringIndexer class and specify input and output column
SI_Fat = StringIndexer(inputCol='Item_Fat_Content',outputCol='Item_Fat_Content_Index')
SI_Type = StringIndexer(inputCol='Item_Type',outputCol='Item_Type_Index')
SI_Size = StringIndexer(inputCol='Outlet_Size',outputCol='Outlet_Size_Index')
SI_Location = StringIndexer(inputCol='Outlet_Location_Type',outputCol='Outlet_Location_Type_Index')
SI_Out_Type = StringIndexer(inputCol='Outlet_Type',outputCol='Outlet_Type_Index')

# transform the data
data = SI_Fat.fit(data).transform(data)
data = SI_Type.fit(data).transform(data)
data = SI_Size.fit(data).transform(data)
data = SI_Location.fit(data).transform(data)
data = SI_Out_Type.fit(data).transform(data)

# view the transformed data
data.first()
```

```
Row(Item_Identifier='FDA15', Item_Weight=9.3, Item_Fat_Content='Low Fat', Item_Visibility=0.016047301, Item_Type='Dairy', Item_MRP=249.809
2, Outlet_Identifier='OUT049', Outlet_Establishment_Year=1999, Outlet_Size='Medium', Outlet_Location_Type='Tier 1', Outlet_Type='Supermark
et Type1', Item_Outlet_Sales=3735.138, Item_Fat_Content_Index=0.0, Item_Type_Index=4.0, Outlet_Size_Index=0.0, Outlet_Location_Type_Index=
2.0, Outlet_Type_Index=0.0)
```

# One Hot Encoding

In [11]:

```python
from pyspark.ml.feature import OneHotEncoder
OHE = OneHotEncoder(inputCols=['Item_Fat_Content_Index', 'Item_Type_Index', 'Outlet_Size_Index', 'Outlet_
Location_Type_Index', 'Outlet_Type_Index'],outputCols=['Item_Fat_Content_OHE', 'Item_Type_OHE', 'Outlet_S
ize_OHE', 'Outlet_Location_Type_OHE', 'Outlet_Type_OHE'])

# transform the data
data = OHE.fit(data).transform(data)
```

In [12]:

```python
data.take(1)
```

```
[Row(Item_Identifier='FDA15', Item_Weight=9.3, Item_Fat_Content='Low Fat', Item_Visibility=0.016047301, Item_Type='Dairy', Item_MRP=249.80
92, Outlet_Identifier='OUT049', Outlet_Establishment_Year=1999, Outlet_Size='Medium', Outlet_Location_Type='Tier 1', Outlet_Type='Supermar
ket Type1', Item_Outlet_Sales=3735.138, Item_Fat_Content_Index=0.0, Item_Type_Index=4.0, Outlet_Size_Index=0.0, Outlet_Location_Type_Index
=2.0, Outlet_Type_Index=0.0, Outlet_Type_OHE=SparseVector(3, {0: 1.0}), Item_Fat_Content_OHE=SparseVector(4, {0: 1.0}), Outlet_Size_OHE=Sp
arseVector(2, {0: 1.0}), Outlet_Location_Type_OHE=SparseVector(2, {}), Item_Type_OHE=SparseVector(15, {4: 1.0}))]
```

# Vectorizing into single Feature

In [13]:

```python
from pyspark.ml.feature import VectorAssembler

inputcol = ['Item_Fat_Content_Index', 'Item_Type_Index', 'Outlet_Size_Index', 'Outlet_Location_Type_Inde
x', 'Outlet_Type_Index','Item_Fat_Content_OHE', 'Item_Type_OHE', 'Outlet_Size_OHE', 'Outlet_Location_Type
_OHE', 'Outlet_Type_OHE', 'Item_Weight', 'Item_Visibility', 'Item_MRP', 'Outlet_Establishment_Year']
# specify the input and output columns of the vector assembler
assembler = VectorAssembler(inputCols=inputcol, outputCol='features')

# fill the null values
data = data.fillna(0)

# transform the data
final_data = assembler.transform(data)
```

In [14]:

```
final_data.take(1)
```

```
[Row(Item_Identifier='FDA15', Item_Weight=9.3, Item_Fat_Content='Low Fat', Item_Visibility=0.016047301, Item_Type='Dairy', Item_MRP=249.80
92, Outlet_Identifier='OUT049', Outlet_Establishment_Year=1999, Outlet_Size='Medium', Outlet_Location_Type='Tier 1', Outlet_Type='Supermar
ket Type1', Item_Outlet_Sales=3735.138, Item_Fat_Content_Index=0.0, Item_Type_Index=4.0, Outlet_Size_Index=0.0, Outlet_Location_Type_Index
=2.0, Outlet_Type_Index=0.0, Outlet_Type_OHE=SparseVector(3, {0: 1.0}), Item_Fat_Content_OHE=SparseVector(4, {0: 1.0}), Outlet_Size_OHE=Sp
arseVector(2, {0: 1.0}), Outlet_Location_Type_OHE=SparseVector(2, {}), Item_Type_OHE=SparseVector(15, {4: 1.0}), features=SparseVector(35,
{1: 4.0, 3: 2.0, 5: 1.0, 13: 1.0, 24: 1.0, 28: 1.0, 31: 9.3, 32: 0.016, 33: 249.8092, 34: 1999.0}))]
```

In [15]:

```
df_train = final_data.select(['features', 'Item_Outlet_Sales'])
```

In [16]:

```
df_train.take(1)
```

```
[Row(features=SparseVector(35, {1: 4.0, 3: 2.0, 5: 1.0, 13: 1.0, 24: 1.0, 28: 1.0, 31: 9.3, 32: 0.016, 33: 249.8092, 34: 1999.0}), Item_Ou
tlet_Sales=3735.138)]
```

In [17]:

```
df_train.show(5)
```

```
+--------------------+-----------------+
|            features|Item_Outlet_Sales|
+--------------------+-----------------+
|(35,[1,3,5,13,24,...|         3735.138|
|(35,[0,1,4,6,17,2...|         443.4228|
|(35,[1,3,5,18,24,...|          2097.27|
|(35,[0,4,6,9,24,2...|           732.38|
|(35,[1,2,5,11,26,...|         994.7052|
+--------------------+-----------------+
only showing top 5 rows
```

# Split train and test

In [18]:

```
train_df, test_df = df_train.randomSplit([0.8, 0.2])
```

# Applying various models in Pyspark Api

In [30]:

```
# Linear Regression Model
from pyspark.ml.regression import LinearRegression
from pyspark.ml.evaluation import RegressionEvaluator

lr = LinearRegression(featuresCol = 'features', labelCol='Item_Outlet_Sales', maxIter=150, regParam=0.0,
elasticNetParam=0.0)
lr_model = lr.fit(train_df)

trainingSummary = lr_model.summary
print("RMSE: %f" % trainingSummary.rootMeanSquaredError)
print("R2: %f" % trainingSummary.r2)

# Predict and Evaluate
lr_predictions = lr_model.transform(test_df)
lr_predictions.select("prediction","Item_Outlet_Sales","features").show(5)

lr_evaluator = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName="r
mse")
print("Root Mean Square Error (RMSE) on test data = %g" % lr_evaluator.evaluate(lr_predictions))

lr_evaluator_r2 = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName
="r2")
print("R Squared (R2) on test data = %g" % lr_evaluator_r2.evaluate(lr_predictions))
```

```
RMSE: 1133.476559
R2: 0.554448
+------------------+-----------------+--------------------+
|        prediction|Item_Outlet_Sales|            features|
+------------------+-----------------+--------------------+
|  729.2843759230018|         331.5684|(35,[0,1,2,3,4,6,...|
|  384.5975328735367|         425.4462|(35,[0,1,2,3,4,6,...|
| 1136.7232229275978|          945.436|(35,[0,1,2,3,4,6,...|
|-153.25180773547618|         317.5866|(35,[0,1,2,3,4,6,...|
| -30.22022594201553|         113.8518|(35,[0,1,2,3,4,6,...|
+------------------+-----------------+--------------------+
only showing top 5 rows

Root Mean Square Error (RMSE) on test data = 1106.76
R Squared (R2) on test data = 0.593892
```

In [23]:

```
#  Lasso Regression Model
lar = LinearRegression(featuresCol = 'features', labelCol='Item_Outlet_Sales', maxIter=100, regParam=0.3, elasticNetParam=1)
lar_model = lar.fit(train_df)

trainingSummary = lar_model.summary
print("RMSE: %f" % trainingSummary.rootMeanSquaredError)
print("R2: %f" % trainingSummary.r2)

# Predict and Evaluate
lar_predictions = lar_model.transform(test_df)
lar_predictions.select("prediction","Item_Outlet_Sales","features").show(5)

lar_evaluator = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName="rmse")
print("Root Mean Square Error (RMSE) on test data = %g" % lar_evaluator.evaluate(lar_predictions))

lar_evaluator_r2 = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName="r2")
print("R Squared (R2) on test data = %g" % lar_evaluator_r2.evaluate(lar_predictions))
```

```
RMSE: 1133.589738
R2: 0.554359
+------------------+-----------------+--------------------+
|        prediction|Item_Outlet_Sales|            features|
+------------------+-----------------+--------------------+
|  723.1792481893208|         331.5684|(35,[0,1,2,3,4,6,...|
| 378.63698723577545|         425.4462|(35,[0,1,2,3,4,6,...|
|  1130.646491530053|          945.436|(35,[0,1,2,3,4,6,...|
|-158.85101700072846|         317.5866|(35,[0,1,2,3,4,6,...|
| -35.82258349095355|         113.8518|(35,[0,1,2,3,4,6,...|
+------------------+-----------------+--------------------+
only showing top 5 rows

Root Mean Square Error (RMSE) on test data = 1106.86
R Squared (R2) on test data = 0.593819
```

In [26]:

```
# Decision Tree Regression Model
from pyspark.ml.regression import DecisionTreeRegressor

dt = DecisionTreeRegressor(featuresCol = 'features', labelCol='Item_Outlet_Sales', maxDepth=15, minInstan
cesPerNode=100)
dt_model = dt.fit(train_df)

# Predict and Evaluate
dt_predictions = dt_model.transform(test_df)
dt_predictions.select("prediction","Item_Outlet_Sales","features").show(5)

df_evaluator = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName="r
mse")
print("Root Mean Square Error (RMSE) on test data = %g" % df_evaluator.evaluate(dt_predictions))

df_evaluator_r2 = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName
="r2")
print("R Squared (R2) on test data = %g" % df_evaluator_r2.evaluate(dt_predictions))
```

```
+-----------------+-----------------+-------------------+
|       prediction|Item_Outlet_Sales|           features|
+-----------------+-----------------+-------------------+
|394.03078252427184|        331.5684|(35,[0,1,2,3,4,6,...|
| 283.3360183206108|        425.4462|(35,[0,1,2,3,4,6,...|
|500.69881896551715|         945.436|(35,[0,1,2,3,4,6,...|
|223.94658571428573|        317.5866|(35,[0,1,2,3,4,6,...|
| 283.3360183206108|        113.8518|(35,[0,1,2,3,4,6,...|
+-----------------+-----------------+-------------------+
only showing top 5 rows

Root Mean Square Error (RMSE) on test data = 1057.63
R Squared (R2) on test data = 0.629148
```

In [27]:

```
## GBT Regression Model
from pyspark.ml.regression import GBTRegressor

gbt = GBTRegressor(featuresCol = 'features', labelCol='Item_Outlet_Sales', maxIter=10)
# gbt = GBTRegressor(featuresCol = 'features', labelCol='Item_Outlet_Sales', maxIter=10, maxDepth=15, min
InstancesPerNode=100)
gbt_model = gbt.fit(train_df)

# Predict and Evaluate
gbt_predictions = gbt_model.transform(test_df)
gbt_predictions.select("prediction","Item_Outlet_Sales","features").show(5)

gbt_evaluator = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName=
"rmse")
print("Root Mean Square Error (RMSE) on test data = %g" % gbt_evaluator.evaluate(gbt_predictions))

gbt_evaluator_r2 = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricNam
e="r2")
print("R Squared (R2) on test data = %g" % gbt_evaluator_r2.evaluate(gbt_predictions))
```

```
+-----------------+-----------------+-------------------+
|       prediction|Item_Outlet_Sales|           features|
+-----------------+-----------------+-------------------+
|477.42167799114003|        331.5684|(35,[0,1,2,3,4,6,...|
|342.25790791842667|        425.4462|(35,[0,1,2,3,4,6,...|
| 541.6654409408936|         945.436|(35,[0,1,2,3,4,6,...|
| 245.1703909636694|        317.5866|(35,[0,1,2,3,4,6,...|
|311.27774749352017|        113.8518|(35,[0,1,2,3,4,6,...|
+-----------------+-----------------+-------------------+
only showing top 5 rows

Root Mean Square Error (RMSE) on test data = 1047.03
R Squared (R2) on test data = 0.636544
```

In [29]:

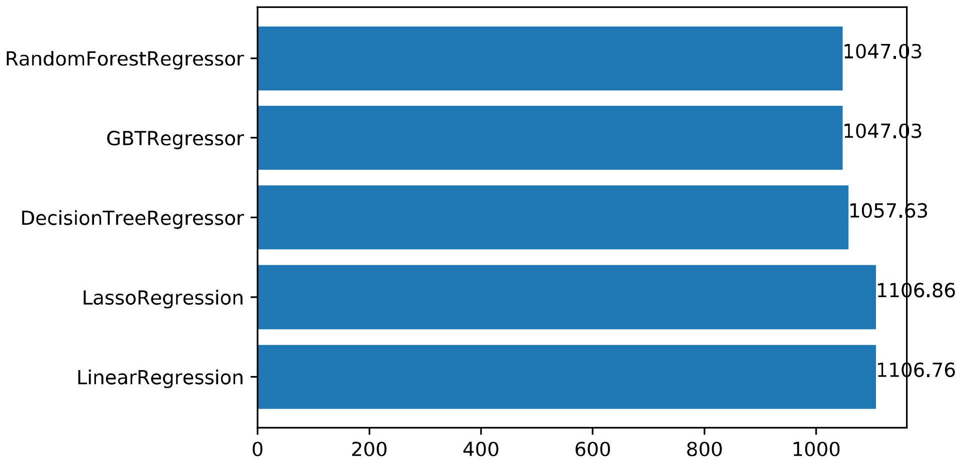
```
# RandomForest Regression Model
from pyspark.ml.tuning import CrossValidator, ParamGridBuilder
from pyspark.ml.regression import RandomForestRegressor

rf = RandomForestRegressor(featuresCol = 'features', labelCol='Item_Outlet_Sales', minInstancesPerNode=15
0)

rf_evaluator = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName="r
mse")

paramGrid = ParamGridBuilder() \
    .addGrid(rf.maxDepth, [5, 6, 10]) \
    .addGrid(rf.numTrees, [200, 400]) \
    .build()

cv = CrossValidator(estimator=rf, estimatorParamMaps=paramGrid, evaluator=rf_evaluator, numFolds=5, paral
lelism=5)

cv_model = cv.fit(train_df)

rf_predictions = cv_model.transform(test_df)
rf_predictions.select("prediction","Item_Outlet_Sales","features").show(5)

print("Root Mean Square Error (RMSE) on test data = %g" % gbt_evaluator.evaluate(gbt_predictions))

rf_evaluator_r2 = RegressionEvaluator(predictionCol="prediction", labelCol="Item_Outlet_Sales",metricName
="r2")
print("R Squared (R2) on test data = %g" % rf_evaluator_r2.evaluate(rf_predictions))
```

```
+------------------+----------------+--------------------+
|        prediction|Item_Outlet_Sales|           features|
+------------------+----------------+--------------------+
|441.65932039560516|        331.5684|(35,[0,1,2,3,4,6,...|
| 325.619648765012|        425.4462|(35,[0,1,2,3,4,6,...|
|473.97048510979783|         945.436|(35,[0,1,2,3,4,6,...|
|309.47752994468544|        317.5866|(35,[0,1,2,3,4,6,...|
|319.80938730928233|        113.8518|(35,[0,1,2,3,4,6,...|
+------------------+----------------+--------------------+
only showing top 5 rows

Root Mean Square Error (RMSE) on test data = 1047.03
R Squared (R2) on test data = 0.61196
```

# Results

In [33]:

```
import numpy as np
import matplotlib.pyplot as plt

models = ['LinearRegression', 'LassoRegression', 'DecisionTreeRegressor',
                'GBTRegressor', 'RandomForestRegressor']

data = [1106.76, 1106.86, 1057.63, 1047.03, 1047.03]

plt.barh(models, data)

for index, value in enumerate(data):
    plt.text(value, index,
             str(value))

plt.show()
```




Here we can easily see that RFR and GBT outplayed all the other models as they have least RMSE scores on test_dataset.

Improvements can be done as we can apply ANN and also can change the parameters in CrossValidations and other models' arguments as well.

We can even apply word embeddings as in case of neuralNets as well.