# 603 final code

December 1, 2021

[39]:
```
import pyspark
from pyspark.sql import SparkSession
from pyspark.sql.types import FloatType, StructType, StringType, StructField,␣
↪IntegerType
from pyspark.ml.regression import LinearRegression
from pyspark.ml.feature import VectorAssembler
import matplotlib.pyplot as plt
from matplotlib.pyplot import figure
import numpy as np
```

[40]:
```
spark = SparkSession.builder.getOrCreate()
sc = spark.sparkContext

combined_schema = StructType([
    StructField('STATION', StringType()),
    StructField('NAME', StringType()),
    StructField('LATITUDE', FloatType()),
    StructField('LONGITUDE', FloatType()),
    StructField('ELEVATION', FloatType()),
    StructField('AWND', FloatType()),
    StructField('PRCP', FloatType()),
    StructField('SNOW', FloatType()),
    StructField('SNWD', FloatType()),
    StructField('TAVG', FloatType()),
    StructField('CRASHCOUNT', IntegerType()),
    StructField('YEAR', IntegerType()),
    StructField('MONTH', IntegerType()),
    StructField('DAY', IntegerType())
])
```

[41]:
```
combinedDF = spark.read.options(header = 'True').schema(combined_schema).
↪csv('combined.csv')
combinedDF = combinedDF.drop('STATION', 'NAME', 'ELEVATION', 'LATITUDE',␣
↪'LONGITUDE')
# elevation, latitude and longitude have a large number of missing values
combinedDF.show(30)
```

```
+-----+----+----+----+----+----------+-----+---+
```

```
| AWND|PRCP|SNOW|SNWD|TAVG|CRASHCOUNT|MONTH|DAY|
+-----+----+----+----+----+----------+-----+---+
|10.74| 0.0| 0.0| 0.0|50.0|        49|    4|  1|
| 8.28| 0.0| 0.0| 0.0|40.0|        35|    4|  2|
|10.51| 0.0| 0.0| 0.0|40.0|        49|    4|  3|
| 4.25|0.04| 0.0| 0.0|37.0|        38|    4|  4|
| 8.05|0.11| 0.0| 0.0|48.0|        60|    4|  5|
| 5.59| 0.0| 0.0| 0.0|47.0|        49|    4|  6|
| 5.82| 0.0| 0.0| 0.0|50.0|        52|    4|  7|
| 4.92| 0.0| 0.0| 0.0|64.0|        64|    4|  8|
| 6.71| 0.0| 0.0| 0.0|73.0|        59|    4|  9|
| 7.61| 0.0| 0.0| 0.0|76.0|        70|    4| 10|
| 9.62| 0.0| 0.0| 0.0|72.0|        55|    4| 11|
|10.29|0.67| 0.0| 0.0|55.0|        49|    4| 12|
| 5.14| 0.0| 0.0| 0.0|54.0|        53|    4| 13|
| 5.59| 0.0| 0.0| 0.0|54.0|        58|    4| 14|
| 8.28| 0.0| 0.0| 0.0|56.0|        52|    4| 15|
| 6.04| 0.0| 0.0| 0.0|60.0|        46|    4| 16|
| 5.82| 0.0| 0.0| 0.0|65.0|        62|    4| 17|
| 9.17|0.04| 0.0| 0.0|63.0|        64|    4| 18|
| 7.83|0.79| 0.0| 0.0|66.0|        73|    4| 19|
|10.29|0.07| 0.0| 0.0|54.0|        47|    4| 20|
| 4.92| 0.0| 0.0| 0.0|47.0|        40|    4| 21|
|11.18| 0.0| 0.0| 0.0|46.0|        52|    4| 22|
| 6.26| 0.0| 0.0| 0.0|51.0|        46|    4| 23|
| 6.93| 0.0| 0.0| 0.0|56.0|        47|    4| 24|
| 7.16| 0.0| 0.0| 0.0|58.0|        65|    4| 25|
| 4.25| 0.0| 0.0| 0.0|55.0|        55|    4| 26|
| 4.47| 0.0| 0.0| 0.0|55.0|        44|    4| 27|
| 5.37| 0.0| 0.0| 0.0|57.0|        54|    4| 28|
| 7.16|0.26| 0.0| 0.0|56.0|        66|    4| 29|
| 7.83|0.22| 0.0| 0.0|56.0|        62|    4| 30|
+-----+----+----+----+----+----------+-----+---+
only showing top 30 rows
```

[42]:

```
features = combinedDF.columns

features.pop(5)

vectorAssembler = VectorAssembler(inputCols = features, outputCol = 'features')

vDF = vectorAssembler.transform(combinedDF)
vDF = vDF.select(['features', 'CRASHCOUNT'])

split = vDF.randomSplit([.8, .2], seed = 12345)
```

```
trainingData = split[0]
testData = split[1]

lr = LinearRegression(featuresCol = 'features', labelCol = 'CRASHCOUNT',␣
↪maxIter = 10, regParam = .3, elasticNetParam = .8)

lrModel = lr.fit(trainingData)
```

[43]:
```
#print('Coefficients:', str(lrModel.coefficients))

count = 0

print('Coefficients per feature:')
for item in lrModel.coefficients:
    print(features[count] + ':', item)
    count += 1
print()


trainingSummary = lrModel.summary
print('RMSE:', trainingSummary.rootMeanSquaredError)
print('R squared:', trainingSummary.r2)
```

```
Coefficients per feature:
AWND: 0.6590887741121741
PRCP: 0.0
SNOW: -1.3372764638638435
SNWD: -0.7240295709285356
TAVG: 0.17799762976077024
MONTH: 0.04447601690300508
DAY: -0.05181953403363659

RMSE: 15.65479033763715
R squared: 0.06788566821269193
```

[44]:
```
lr_predictions = lrModel.transform(testData)
lr_predictions.select('prediction', 'CRASHCOUNT', 'features').show(5, False)

from pyspark.ml.evaluation import RegressionEvaluator
lr_evaluator = RegressionEvaluator(predictionCol = 'prediction', labelCol =␣
↪'CRASHCOUNT', metricName = 'r2')
print('R squared on test data:', lr_evaluator.evaluate(lr_predictions))
testResult = lrModel.evaluate(testData)
print('RMSE on test data:', testResult.rootMeanSquaredError)
```

```
+------------------+----------+------------------------------------------------------
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```
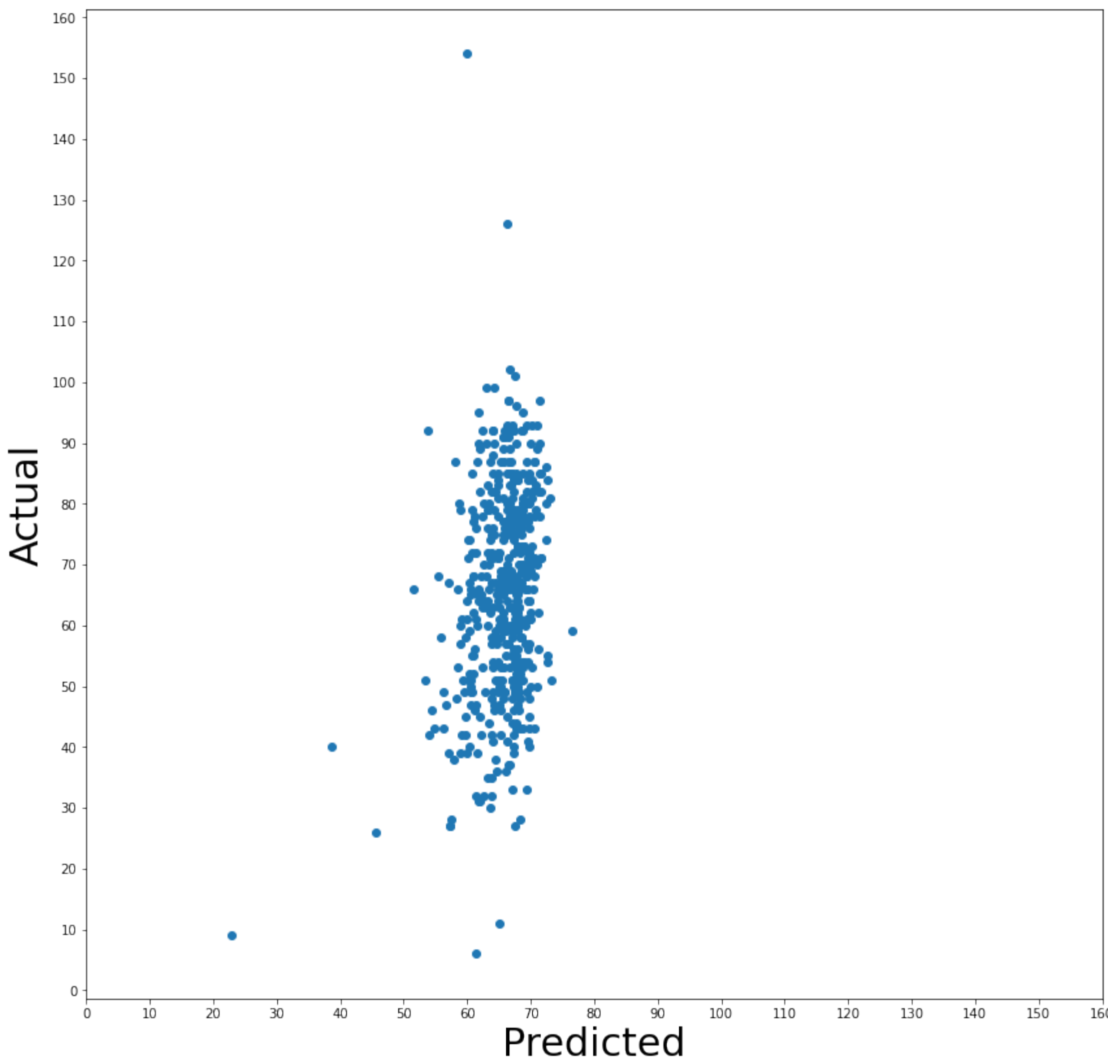

```
|prediction       |CRASHCOUNT|features
|
+-----------------+----------+----------------------------------------------------
---------------+
|60.86242379345681|55
|[0.8899999856948853,0.029999999329447746,0.0,0.0,49.0,10.0,14.0]|
|65.64618057917546|59
|[1.340000033378601,0.7599999904632568,0.0,0.0,75.0,8.0,15.0]     |
|57.05293320973557|67        |[1.5700000524520874,0.0,0.0,0.0,25.0,1.0,6.0]
|
|58.9684650252729 |57        |[1.5700000524520874,0.0,0.0,0.0,40.0,12.0,30.0]
|
|59.86519465279066|39
|[1.5700000524520874,0.07999999821186066,0.0,0.0,43.0,12.0,23.0] |
+-----------------+----------+----------------------------------------------------
---------------+
only showing top 5 rows

R squared on test data: 0.07517689841308306
RMSE on test data: 16.643762849196168
```

## 0.1 Slightly worse

[45]:
```
pdDF = lr_predictions.toPandas()
fig, ax = plt.subplots()
fig.set_size_inches(14,14)
plt.scatter(pdDF.prediction, pdDF.CRASHCOUNT)
ax.xaxis.set_ticks(np.arange(0, 170, 10))
ax.yaxis.set_ticks(np.arange(0, 170, 10))
plt.ylabel('Actual')
plt.xlabel('Predicted')
ax.xaxis.label.set_size(30)
ax.yaxis.label.set_size(30)
```




[46]:
```
trainingData.describe().show()
```

```
+-------+-----------------+
|summary|       CRASHCOUNT|
+-------+-----------------+
|  count|             1975|
|   mean|65.54886075949366|
| stddev|16.21894640101575|
|    min|                4|
|    max|              109|
+-------+-----------------+
```

[47]:
```python
from pyspark.ml.regression import DecisionTreeRegressor

dt = DecisionTreeRegressor(featuresCol ='features', labelCol = 'CRASHCOUNT')
dtModel = dt.fit(trainingData)
dtPredictions = dtModel.transform(testData)
dtEvaluator = RegressionEvaluator(
    labelCol = "CRASHCOUNT", predictionCol = "prediction", metricName = "rmse")
rmse = dtEvaluator.evaluate(dtPredictions)
print("Root Mean Squared Error (RMSE) on test data: ", rmse)
```

```
Root Mean Squared Error (RMSE) on test data:  16.805152604072795
```

[48]:
```python
dtModel.featureImportances
```

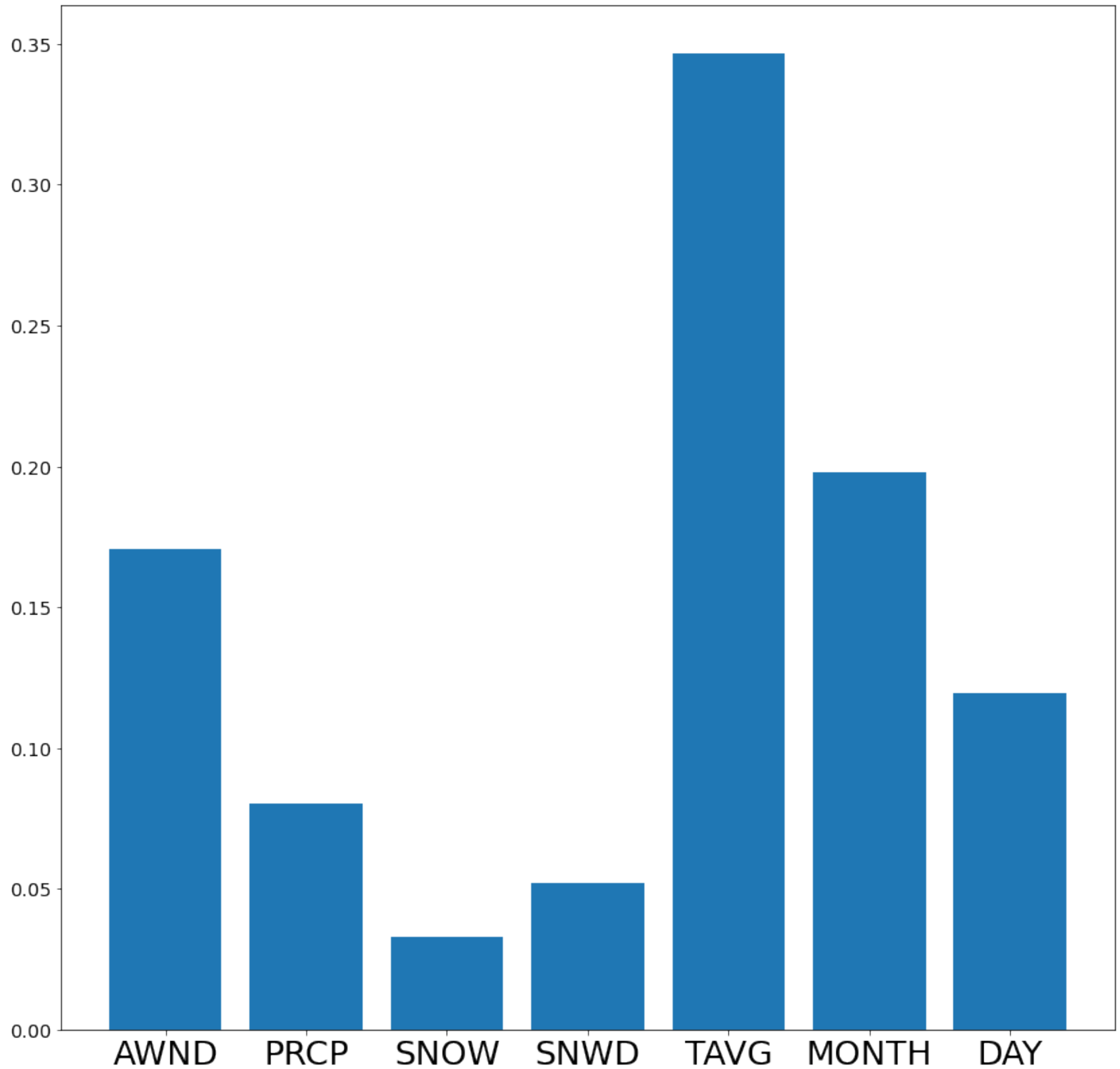
[48]:
```
SparseVector(7, {0: 0.1706, 1: 0.0803, 2: 0.0329, 3: 0.052, 4: 0.3466, 5: 0.198,
6: 0.1196})
```

[49]:
```python
features
```

[49]:
```
['AWND', 'PRCP', 'SNOW', 'SNWD', 'TAVG', 'MONTH', 'DAY']
```

[50]:
```python
fig, ax = plt.subplots()
fig.set_size_inches(14,14)
plt.bar(features, dtModel.featureImportances)
plt.xticks(fontsize=25)
plt.yticks(fontsize=14)
```

[50]:
```
(array([0.  , 0.05, 0.1 , 0.15, 0.2 , 0.25, 0.3 , 0.35, 0.4 ]),
 [Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, ''),
  Text(0, 0, '')])
```




# 1 It seems that year is by far the best predictor