databricksHW_07

DSCI 417 – Homework 07

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```
import pandas as pd
import matplotlib.pyplot as plt

from pyspark.sql.functions import col, expr

from pyspark.sql import SparkSession
from pyspark.ml.feature import VectorAssembler, StringIndexer
from pyspark.ml.classification import DecisionTreeClassifier
from pyspark.ml.evaluation import MulticlassClassificationEvaluator
from pyspark.ml import Pipeline
from pyspark.ml.tuning import CrossValidator, ParamGridBuilder

spark = SparkSession.builder.getOrCreate()
```

Problem 1: Decision Tree Classification

```
+----+----+----+----+----+-----------+
|  x0|  x1|  x2|  x3|  x4| prediction|  Leaf Node
+----+----+----+----+----+-----------+  ---------
| 3.7| 5.6| 3.6| 2.0| 1.0|        0.0|          3
| 8.2| 4.2| 2.1| 2.0| 0.0|        0.0|          7
| 5.4| 3.9| 4.9| 1.0| 1.0|        1.0|          6
| 2.8| 6.1| 8.1| 0.0| 0.0|        2.0|          2
+----+----+----+----+----+-----------+
```

Problem 2: Random Forest Classification

Tree Model 1 Prediction: 0.0
Tree Model 2 Prediction: 0.0
Tree Model 3 Prediction: 1.0
Random Forest Prediction: 0.0

Problem 3: Load and Process Stroke Data

```
stroke_schema = 'gender STRING, age DOUBLE, hypertension INTEGER, heart_disease INTEGER, ever_married STRING, work_type STRING, residence_type STRING,
avg_glucose_level DOUBLE, bmi DOUBLE, smoking_status STRING, stroke INTEGER'

stroke_df = spark.read.option('header', True).schema(stroke_schema).csv('/FileStore/tables/stroke_data.csv')

stroke_df.printSchema()
```

```
root
 |-- gender: string (nullable = true)
```

```
 |-- age: double (nullable = true)
 |-- hypertension: integer (nullable = true)
 |-- heart_disease: integer (nullable = true)
 |-- ever_married: string (nullable = true)
 |-- work_type: string (nullable = true)
 |-- residence_type: string (nullable = true)
 |-- avg_glucose_level: double (nullable = true)
 |-- bmi: double (nullable = true)
 |-- smoking_status: string (nullable = true)
 |-- stroke: integer (nullable = true)
```

```
num_features = ['age', 'avg_glucose_level', 'bmi']
cat_features = [c for c in stroke_df.columns[:-1] if c not in num_features]

ix_features = [c + '_ix' for c in cat_features]

indexer = StringIndexer(inputCols=cat_features, outputCols=ix_features)

assembler = VectorAssembler(inputCols=num_features + ix_features, outputCol='features')


pipeline = Pipeline(stages=[indexer, assembler]).fit(stroke_df)
train = pipeline.transform(stroke_df)

train.persist()
train.select(['features', 'stroke']).show(10, truncate=False)
```

```
+----------------------------------------------+------+
|features                                      |stroke|
+----------------------------------------------+------+
|(10,[0,1,2,6],[13.0,77.63,31.7,1.0])          |0     |
|[10.0,84.02,18.7,1.0,0.0,0.0,1.0,3.0,1.0,0.0] |0     |
|[82.0,88.6,32.5,0.0,0.0,1.0,0.0,1.0,1.0,1.0]  |0     |
|[3.0,57.33,16.8,0.0,0.0,0.0,1.0,3.0,0.0,1.0]  |0     |
```

```
|[65.0,220.52,37.2,0.0,0.0,0.0,0.0,1.0,1.0,3.0]|0     |
|(10,[0,1,2,7,8],[65.0,100.65,31.0,1.0,1.0])   |1     |
|[65.0,56.64,28.4,1.0,0.0,0.0,0.0,0.0,1.0,2.0] |1     |
|(10,[0,1,2,8],[28.0,64.64,22.1,1.0])          |0     |
|(10,[0,1,2,7,9],[80.0,84.86,29.3,2.0,1.0])    |0     |
|(10,[0,1,2,3,9],[78.0,60.22,29.7,1.0,2.0])    |0     |
+----------------------------------------------+------+
only showing top 10 rows
```

Problem 4: Hyperparameter Tuning for Decision Trees

```
accuracy_eval = MulticlassClassificationEvaluator(predictionCol='prediction', labelCol='stroke', metricName='accuracy')

dtree = DecisionTreeClassifier(featuresCol='features', labelCol='stroke', seed=1)

param_grid = (ParamGridBuilder()
              .addGrid(dtree.maxDepth, range(2,18,2))
              .addGrid(dtree.minInstancesPerNode, [4, 8, 16, 32])
             ).build()

cv = CrossValidator(estimator=dtree, estimatorParamMaps=param_grid, numFolds=5, evaluator=accuracy_eval, seed=1, parallelism=6)

cv_model = cv.fit(train)

MLlib will automatically track trials in MLflow. After your tuning fit() call has completed, view the MLflow UI to see logged runs.
```

```
model = cv_model.bestModel
maxDepth = model.getMaxDepth()
minInstancesPerNode = model.getMinInstancesPerNode()

print('Max CV Score:   ', round(max(cv_model.avgMetrics),4))
print('Optimal Depth:  ', maxDepth)
print('Optimal MinInst:', minInstancesPerNode)
```

```
Max CV Score:    0.7895
Optimal Depth:   6
Optimal MinInst: 16
```

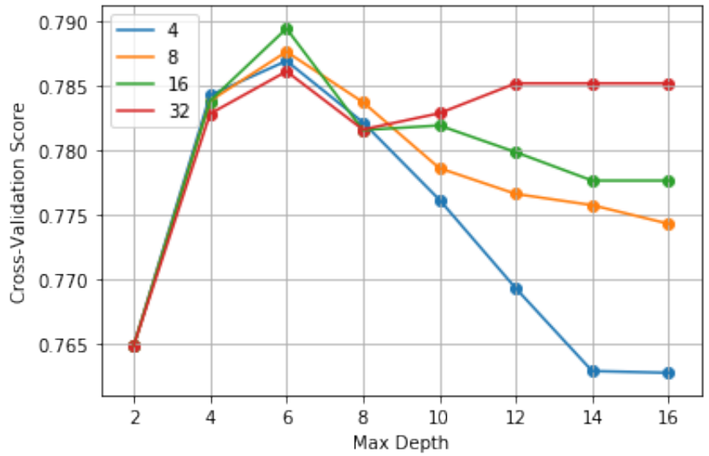
```
model_params = cv_model.getEstimatorParamMaps()

dt_cv_summary_list = []
for param_set, acc in zip(model_params, cv_model.avgMetrics):
    new_set = list(param_set.values()) + [acc]
    dt_cv_summary_list.append(new_set)

cv_summary = pd.DataFrame(dt_cv_summary_list, columns=['maxDepth', 'minInst', 'acc'])

for mi in cv_summary.minInst.unique():
    sel = cv_summary.minInst == mi
    plt.plot(cv_summary.maxDepth[sel], cv_summary.acc[sel], label=mi)
    plt.scatter(cv_summary.maxDepth[sel], cv_summary.acc[sel])

plt.legend()
plt.grid()
plt.xticks(range(2,18,2))
plt.xlabel('Max Depth')
plt.ylabel('Cross-Validation Score')
plt.show()
```



Problem 5: Structure of Final Model

```
print(model.toDebugString)
```

```
DecisionTreeClassificationModel: uid=DecisionTreeClassifier_a1082be60bd0, depth=6, numNodes=53, numClasses=2, numFeatures=10
  If (feature 0 <= 56.5)
   If (feature 5 in {1.0})
    If (feature 9 in {3.0})
     Predict: 0.0
    Else (feature 9 not in {3.0})
     If (feature 4 in {1.0})
      Predict: 1.0
     Else (feature 4 not in {1.0})
      If (feature 2 <= 27.15)
       Predict: 1.0
      Else (feature 2 > 27.15)
       If (feature 3 in {1.0})
```

```
       Predict: 0.0
      Else (feature 3 not in {1.0})
       Predict: 1.0
  Else (feature 5 not in {1.0})
   If (feature 0 <= 43.5)
    If (feature 4 in {1.0})
     If (feature 2 <= 28.15)
      Predict: 1.0
```

```
features = num_features + cat_features
print(features)
```

```
['age', 'avg_glucose_level', 'bmi', 'gender', 'hypertension', 'heart_disease', 'ever_married', 'work_type', 'residence_type', 'smoking_status']
```

First Feature Used in Tree: age

Features Unused in Tree: ever_married, work_type, residence_type

```
pd.DataFrame({'feature':features, 'importance':model.featureImportances})
```

Out[10]:

	feature	importance
0	age	0.780537
1	avg_glucose_level	0.064422
2	bmi	0.022221
3	gender	0.004708
4	hypertension	0.030844
5	heart_disease	0.088194
6	ever_married	0.000000
7	work_type	0.000000
8	residence_type	0.000000
9	smoking_status	0.009074

Problem 6: Applying the Model to New Data

```
new_data_values = [
    ['Female', 42.0, 1, 0, 'No',  'Private',       'Urban', 182.1, 26.8, 'smokes'         ],
    ['Female', 64.0, 1, 1, 'Yes', 'Self-employed', 'Rural', 171.5, 32.5, 'formerly smoked'],
    ['Male',   37.0, 0, 0, 'Yes', 'Private',       'Rural', 79.2,  18.4, 'Unknown'        ],
    ['Male',   72.0, 0, 1, 'No',  'Govt_job',      'Urban', 125.7, 19.4, 'never smoked'   ]
]

new_data_schema = 'gender STRING, age DOUBLE, hypertension INTEGER, heart_disease INTEGER, ever_married STRING, work_type STRING, residence_type STRING,
avg_glucose_level DOUBLE, bmi DOUBLE, smoking_status STRING'

new_data = spark.createDataFrame(new_data_values, schema=new_data_schema)

new_data.show()
```

gender	age	hypertension	heart_disease	ever_married	work_type	residence_type	avg_glucose_level	bmi	smoking_status
Female	42.0	1	0	No	Private	Urban	182.1	26.8	smokes
Female	64.0	1	1	Yes	Self-employed	Rural	171.5	32.5	formerly smoked
Male	37.0	0	0	Yes	Private	Rural	79.2	18.4	Unknown
Male	72.0	0	1	No	Govt_job	Urban	125.7	19.4	never smoked

probability	prediction
[0.3125,0.6875]	1.0
[0.3755020080321285,0.6244979919678715]	1.0
[0.9767441860465116,0.023255813953488372]	0.0
[0.3755020080321285,0.6244979919678715]	1.0