In [1]:
```
#!pip install pyspark
```

Imports

In [2]:
```
%load_ext autoreload
%autoreload 2

%matplotlib inline
```

In [3]:
```
import sys
import os
# add library module to PYTHONPATH
sys.path.append(f"{os.getcwd()}/../")

import numpy as np

import pyspark
from pyspark.sql import SparkSession
from pyspark.ml.feature import StringIndexer
from pyspark.ml.feature import Imputer
from pyspark.ml import Pipeline
from pyspark.ml.classification import DecisionTreeClassifier, DecisionTreeClassificationModel
from pyspark.ml.regression import DecisionTreeRegressor, DecisionTreeRegressionModel

from pyspark.ml.feature import VectorAssembler


from dtreeviz.models.spark_decision_tree import ShadowSparkTree
from dtreeviz import trees
```

spark/data setup

In [4]:
```
spark_version = int(pyspark.__version__.split(".")[0])
```

In [5]:
```
spark_version
```

Out[5]:
```
3
```

In [6]:
```
spark = SparkSession.builder \
            .master("local[2]") \
            .appName("dtreeviz_sparkml") \
            .getOrCreate()
```

In [7]:
```
data = spark.read.csv("../data/titanic/titanic.csv", header=True, inferSchema=True)
```

In [8]:
```
data.show()
```

```
+-----------+--------+------+--------------------+------+----+-----+-----+----------------+-------+-----
+--------+
|PassengerId|Survived|Pclass|                Name|   Sex| Age|SibSp|Parch|          Ticket|   Fare|Cabin
|Embarked|
+-----------+--------+------+--------------------+------+----+-----+-----+----------------+-------+-----
+--------+
|          1|       0|     3|Braund, Mr. Owen ...|  male|22.0|    1|    0|       A/5 21171|   7.25| null
|       S|
|          2|       1|     1|Cumings, Mrs. Joh...|female|38.0|    1|    0|        PC 17599|71.2833|  C85
|       C|
|          3|       1|     3|Heikkinen, Miss. ...|female|26.0|    0|    0|STON/O2. 3101282|  7.925| null
|       S|
|          4|       1|     1|Futrelle, Mrs. Ja...|female|35.0|    1|    0|          113803|   53.1| C123
|       S|
|          5|       0|     3|Allen, Mr. Willia...|  male|35.0|    0|    0|          373450|   8.05| null
|       S|
|          6|       0|     3|    Moran, Mr. James|  male|null|    0|    0|          330877| 8.4583| null
|       Q|
|          7|       0|     1|McCarthy, Mr. Tim...|  male|54.0|    0|    0|           17463|51.8625|  E46
|       S|
|          8|       0|     3|Palsson, Master. ...|  male| 2.0|    3|    1|          349909| 21.075| null
|       S|
|          9|       1|     3|Johnson, Mrs. Osc...|female|27.0|    0|    2|          347742|11.1333| null
|       S|
|         10|       1|     2|Nasser, Mrs. Nich...|female|14.0|    1|    0|          237736|30.0708| null
|       C|
|         11|       1|     3|Sandstrom, Miss. ...|female| 4.0|    1|    1|         PP 9549|   16.7|   G6
|       S|
|         12|       1|     1|Bonnell, Miss. El...|female|58.0|    0|    0|          113783|  26.55| C103
|       S|
|         13|       0|     3|Saundercock, Mr. ...|  male|20.0|    0|    0|       A/5. 2151|   8.05| null
|       S|
|         14|       0|     3|Andersson, Mr. An...|  male|39.0|    1|    5|          347082| 31.275| null
|       S|
|         15|       0|     3|Vestrom, Miss. Hu...|female|14.0|    0|    0|          350406| 7.8542| null
|       S|
|         16|       1|     2|Hewlett, Mrs. (Ma...|female|55.0|    0|    0|          248706|   16.0| null
|       S|
|         17|       0|     3|Rice, Master. Eugene|  male| 2.0|    4|    1|          382652| 29.125| null
|       Q|
|         18|       1|     2|Williams, Mr. Cha...|  male|null|    0|    0|          244373|   13.0| null
|       S|
|         19|       0|     3|Vander Planke, Mr...|female|31.0|    1|    0|          345763|   18.0| null
|       S|
|         20|       1|     3|Masselmani, Mrs. ...|female|null|    0|    0|            2649|  7.225| null
|       C|
+-----------+--------+------+--------------------+------+----+-----+-----+----------------+-------+-----
+--------+
only showing top 20 rows
```

Classification

Prepare data and model

In [9]:

```python
features = ["Pclass", "Sex_label", "Embarked_label", "Age_mean", "SibSp", "Parch", "Fare"]
target = "Survived"

sex_label_indexer = StringIndexer(inputCol="Sex", outputCol="Sex_label", handleInvalid="keep")
embarked_label_indexer = StringIndexer(inputCol="Embarked", outputCol="Embarked_label", handleInvalid="k
age_imputer = Imputer(inputCols=["Age"], outputCols=["Age_mean"])

vector_assembler = VectorAssembler(inputCols=features, outputCol="features")
decision_tree = DecisionTreeClassifier(featuresCol="features", labelCol="Survived", maxDepth=4, seed=123
pipeline = Pipeline(stages=[sex_label_indexer, embarked_label_indexer, age_imputer, vector_assembler, de
model = pipeline.fit(data)
```

In [10]:

```python
tree_model_classifier = model.stages[4]
```

In [11]:

```python
print(tree_model_classifier.toDebugString)
```

```
DecisionTreeClassificationModel: uid=DecisionTreeClassifier_21baf501e2a6, depth=4, numNodes=17, numClass
es=2, numFeatures=7
  If (feature 1 in {0.0})
   If (feature 3 <= 3.5)
    If (feature 4 <= 2.5)
     Predict: 1.0
    Else (feature 4 > 2.5)
     Predict: 0.0
   Else (feature 3 > 3.5)
    Predict: 0.0
  Else (feature 1 not in {0.0})
   If (feature 0 <= 2.5)
    If (feature 3 <= 3.5)
     If (feature 0 <= 1.5)
      Predict: 0.0
     Else (feature 0 > 1.5)
      Predict: 1.0
    Else (feature 3 > 3.5)
     Predict: 1.0
   Else (feature 0 > 2.5)
    If (feature 6 <= 24.808349999999997)
     If (feature 2 in {1.0,2.0})
      Predict: 1.0
     Else (feature 2 not in {1.0,2.0})
      Predict: 0.0
    Else (feature 6 > 24.808349999999997)
     Predict: 0.0
```

In [12]:

```python
def _get_root_node(tree: DecisionTreeClassificationModel):
    return tree._call_java('rootNode')
```

In [13]:

```python
tree_model_classifier._call_java('rootNode').toString()
```

Out[13]:

```
'InternalNode(prediction = 0.0, impurity = 0.4730129578614428, split = org.apache.spark.ml.tree.Categori
calSplit@ca78837e)'
```

dtreeviz visualisations

In [14]:

```python
df = spark.read.parquet("../../dtreeviz/testing/testlib/models/fixtures/spark_3_0_decision_tree_classifi
```

In [15]:

```python
df.printSchema()
```

```
root
 |-- id: integer (nullable = true)
 |-- prediction: double (nullable = true)
 |-- impurity: double (nullable = true)
 |-- impurityStats: array (nullable = true)
 |    |-- element: double (containsNull = true)
 |-- rawCount: long (nullable = true)
 |-- gain: double (nullable = true)
 |-- leftChild: integer (nullable = true)
 |-- rightChild: integer (nullable = true)
 |-- split: struct (nullable = true)
 |    |-- featureIndex: integer (nullable = true)
 |    |-- leftCategoriesOrThreshold: array (nullable = true)
 |    |    |-- element: double (containsNull = true)
 |    |-- numCategories: integer (nullable = true)
```

In [16]:

```python
df.toPandas()
```

Out[16]:

	id	prediction	impurity	impurityStats	rawCount	gain	leftChild	rightChild	split
0	0	0.0	0.473013	[549.0, 342.0]	891	0.139648	1	6	(1, [0.0], 3)
1	1	0.0	0.306444	[468.0, 109.0]	577	0.018317	2	5	(3, [3.5], -1)
2	2	1.0	0.401235	[5.0, 13.0]	18	0.308642	3	4	(4, [2.5], -1)
3	3	1.0	0.000000	[0.0, 12.0]	12	-1.000000	-1	-1	(-1, [], -1)
4	4	0.0	0.277778	[5.0, 1.0]	6	-1.000000	-1	-1	(-1, [], -1)
5	5	0.0	0.284484	[463.0, 96.0]	559	-1.000000	-1	-1	(-1, [], -1)
6	6	1.0	0.382835	[81.0, 233.0]	314	0.099246	7	12	(0, [2.5], -1)
7	7	1.0	0.100277	[9.0, 161.0]	170	0.002825	8	11	(3, [3.5], -1)
8	8	1.0	0.444444	[1.0, 2.0]	3	0.444444	9	10	(0, [1.5], -1)
9	9	0.0	0.000000	[1.0, 0.0]	1	-1.000000	-1	-1	(-1, [], -1)
10	10	1.0	0.000000	[0.0, 2.0]	2	-1.000000	-1	-1	(-1, [], -1)
11	11	1.0	0.091219	[8.0, 159.0]	167	-1.000000	-1	-1	(-1, [], -1)
12	12	0.0	0.500000	[72.0, 72.0]	144	0.064858	13	16	(6, [24.808349999999997], -1)
13	13	1.0	0.487672	[51.0, 70.0]	121	0.028418	14	15	(2, [1.0, 2.0], 4)
14	14	1.0	0.412562	[16.0, 39.0]	55	-1.000000	-1	-1	(-1, [], -1)

	id	prediction	impurity	impurityStats	rawCount	gain	leftChild	rightChild	split
15	15	0.0	0.498163	[35.0, 31.0]	66	-1.000000	-1	-1	(-1, [], -1)
16	16	0.0	0.158790	[21.0, 2.0]	23	-1.000000	-1	-1	(-1, [], -1)

In [17]:

```
dataset = Pipeline(stages=[sex_label_indexer, embarked_label_indexer, age_imputer]) \
    .fit(data) \
    .transform(data) \
    .toPandas()[features + [target]]
```

In [18]:

```
spark_dtree = ShadowSparkTree(tree_model_classifier, dataset[features], dataset[target], feature_names=f
```

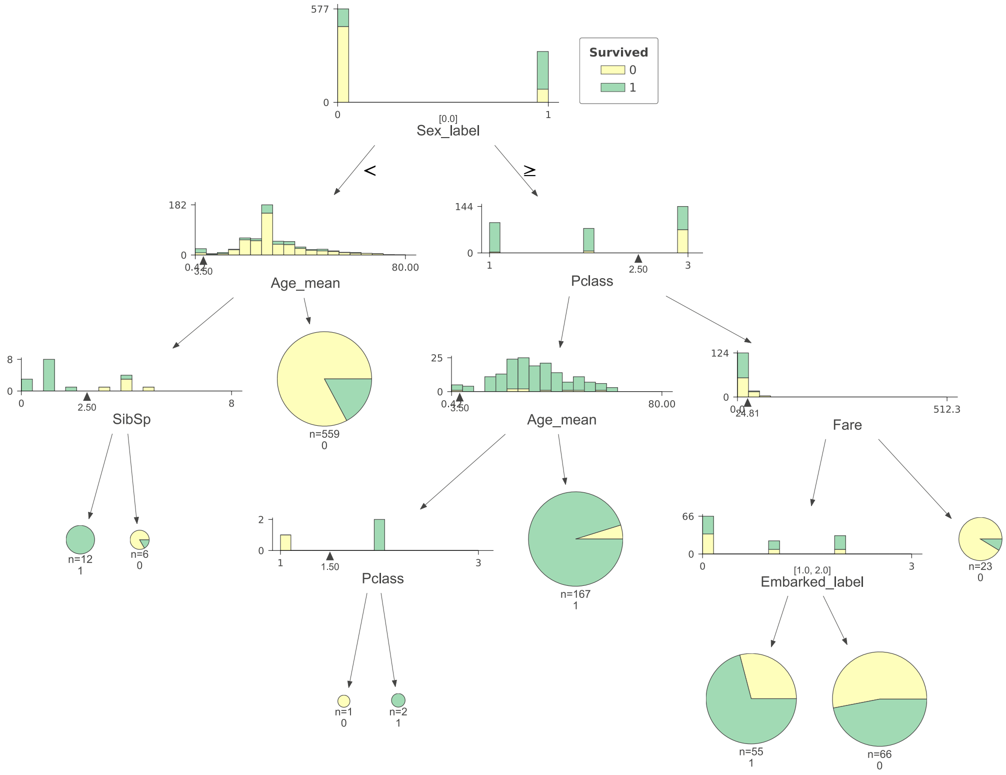
dtreeviz

In [19]:

```
trees.dtreeviz(spark_dtree, fancy=True)
```

```
/Users/parrt/opt/anaconda3/lib/python3.8/site-packages/dtreeviz-1.1.4-py3.8.egg/dtreeviz/models/spark_de
cision_tree.py:87: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is
a list-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecated. If you m
eant to do this, you must specify 'dtype=object' when creating the ndarray
  self.thresholds = np.array(node_thresholds)
```

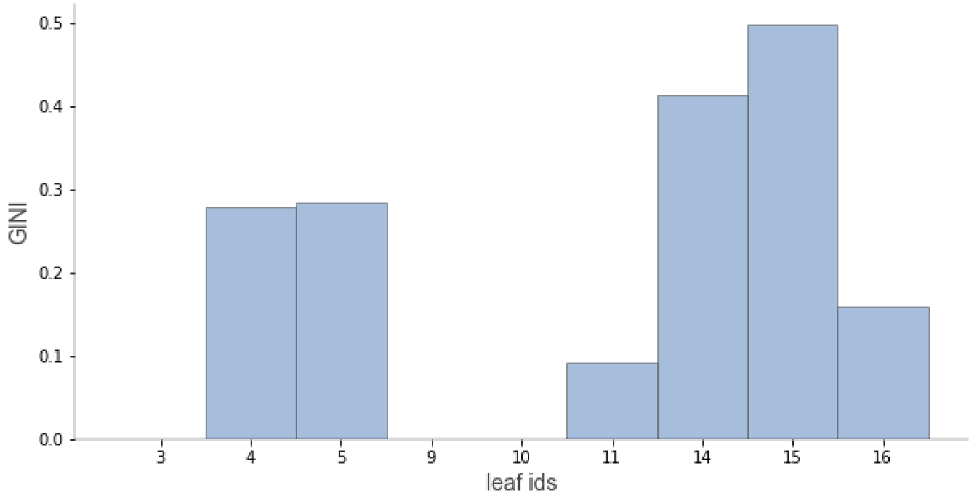
Out[19]:



viz_leaf_criterion

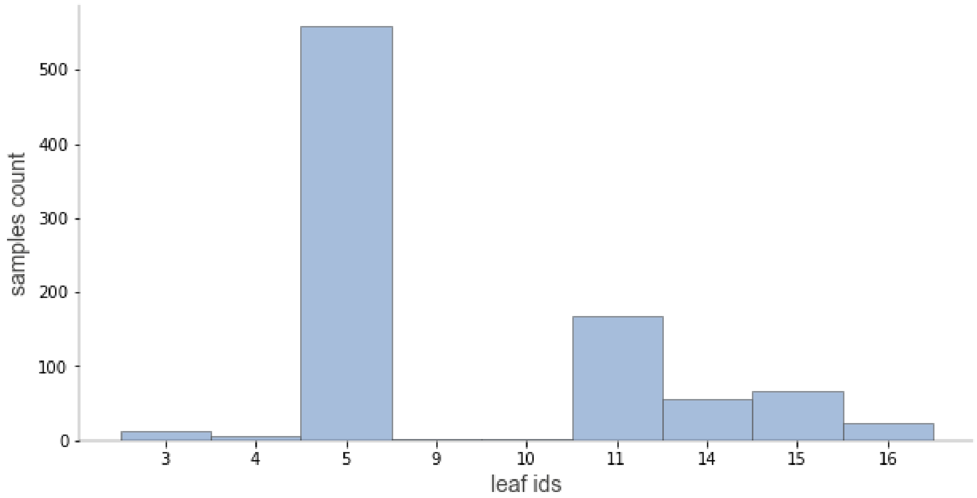
In [20]:

```
trees.viz_leaf_criterion(spark_dtree)
```



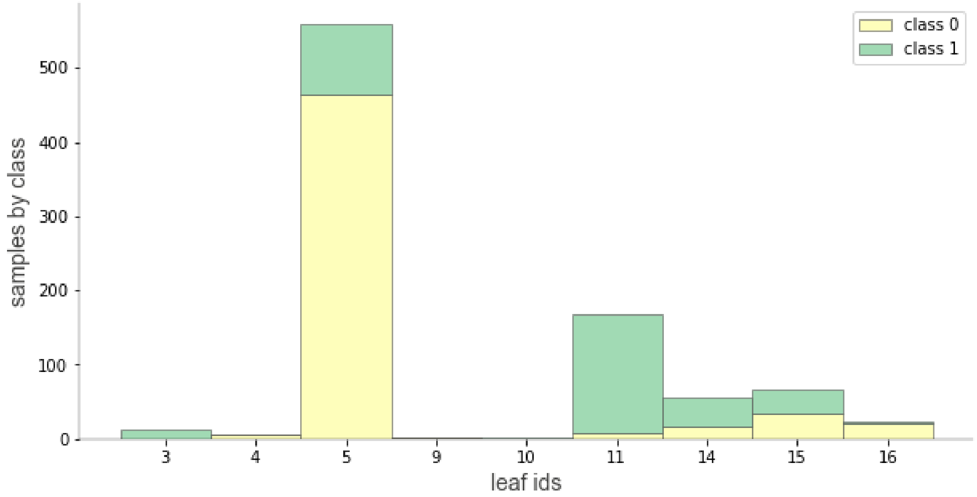
viz_leaf_samples

```
In [21]: trees.viz_leaf_samples(spark_dtree)
```



ctreeviz_leaf_samples

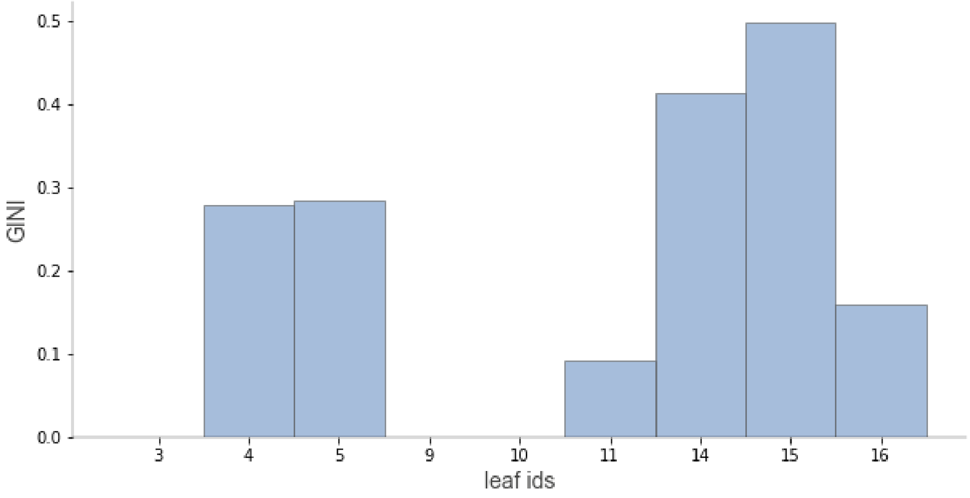
```
In [22]: trees.ctreeviz_leaf_samples(spark_dtree)
```



viz_leaf_criterion

In [23]:

```
trees.viz_leaf_criterion(spark_dtree)
```



describe_node_sample

In [24]:

```
trees.describe_node_sample(spark_dtree, node_id=10)
```

Out[24]:

	Pclass	Sex_label	Embarked_label	Age_mean	SibSp	Parch	Fare
count	2.0	2.0	2.000000	2.000000	2.0	2.000000	2.000000
mean	2.0	1.0	0.500000	2.500000	1.0	1.500000	33.789600
std	0.0	0.0	0.707107	0.707107	0.0	0.707107	11.016158
min	2.0	1.0	0.000000	2.000000	1.0	1.000000	26.000000
25%	2.0	1.0	0.250000	2.250000	1.0	1.250000	29.894800
50%	2.0	1.0	0.500000	2.500000	1.0	1.500000	33.789600
75%	2.0	1.0	0.750000	2.750000	1.0	1.750000	37.684400
max	2.0	1.0	1.000000	3.000000	1.0	2.000000	41.579200

explain_prediction_path

In [25]:

```
X = dataset[features].iloc[10]
X
```

Out[25]:

```
Pclass              3.0
Sex_label           1.0
Embarked_label      0.0
Age_mean            4.0
SibSp               1.0
Parch               1.0
Fare               16.7
Name: 10, dtype: float64
```

In [26]:

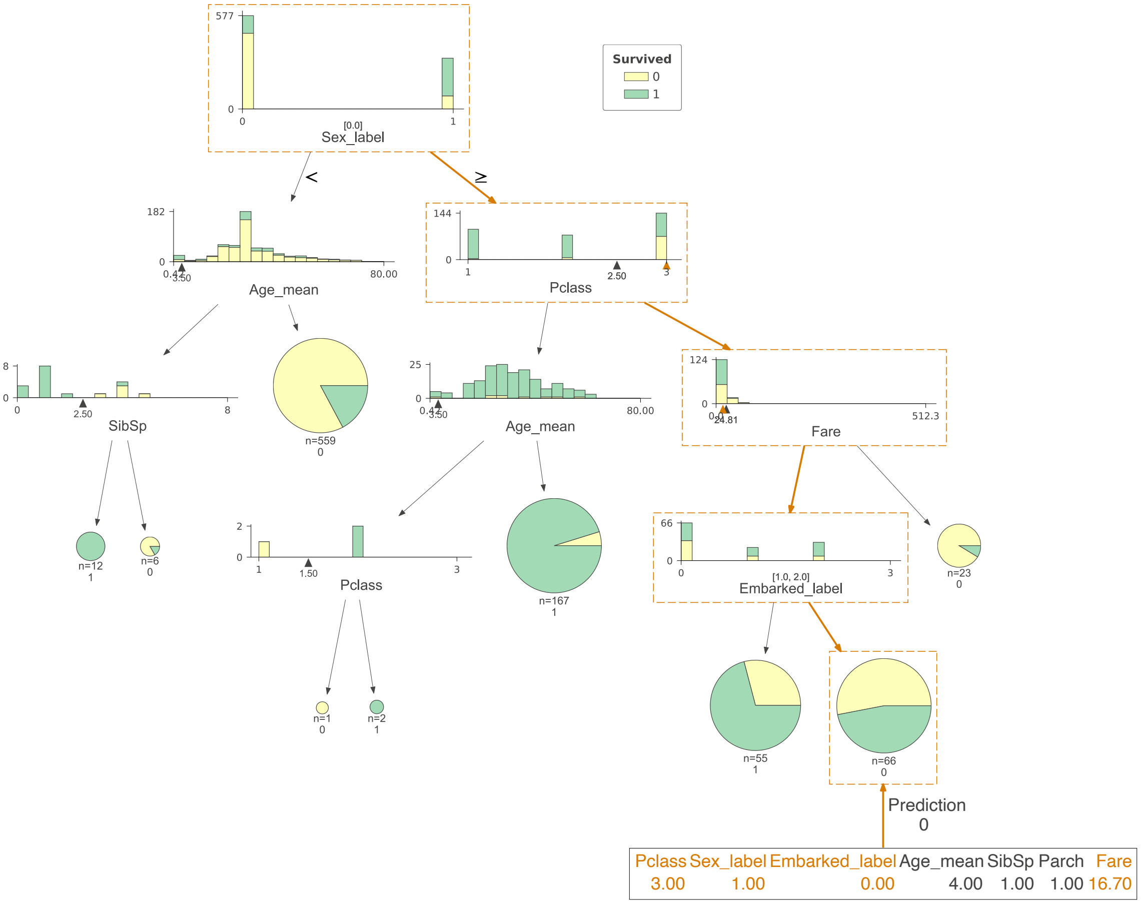
```
print(trees.explain_prediction_path(spark_dtree, X, explanation_type="plain_english"))
```

```
2.5 <= Pclass
Fare < 24.81
Sex_label in [1.0, 2.0]
Embarked_label in [0.0, 3.0]
```

In [27]:

```
trees.dtreeviz(spark_dtree, X=X)
```

Out[27]:



Regression

Prepar data and model

In [28]:

```
data = spark.read.csv("../data/titanic/titanic.csv", header=True, inferSchema=True)
```

In [29]:

```
features_reg = ["Pclass", "Sex_label", "Embarked_label", "Age_mean", "SibSp", "Parch", "Survived"]
target_reg = "Fare"
```

In [30]:

```
vector_assembler_reg = VectorAssembler(inputCols=features_reg, outputCol="features_reg")
decision_tree_reg = DecisionTreeRegressor(featuresCol="features_reg", labelCol=target_reg, maxDepth=3, s
pipeline_reg = Pipeline(stages=[sex_label_indexer, embarked_label_indexer, age_imputer, vector_assembler
model = pipeline_reg.fit(data)
```

In [31]:

```
dataset_reg = Pipeline(stages=[sex_label_indexer, embarked_label_indexer, age_imputer]) \
    .fit(data) \
    .transform(data) \
    .toPandas()[features_reg + [target_reg]]
```

In [32]:

```
dataset_reg
```

Out[32]:

	Pclass	Sex_label	Embarked_label	Age_mean	SibSp	Parch	Survived	Fare
0	3	0.0	0.0	22.000000	1	0	0	7.2500
1	1	1.0	1.0	38.000000	1	0	1	71.2833
2	3	1.0	0.0	26.000000	0	0	1	7.9250
3	1	1.0	0.0	35.000000	1	0	1	53.1000

	Pclass	Sex_label	Embarked_label	Age_mean	SibSp	Parch	Survived	Fare
4	3	0.0	0.0	35.000000	0	0	0	8.0500
...	...	...	...	...	...	...	...	...
886	2	0.0	0.0	27.000000	0	0	0	13.0000
887	1	1.0	0.0	19.000000	0	0	1	30.0000
888	3	1.0	0.0	29.699118	1	2	0	23.4500
889	1	0.0	1.0	26.000000	0	0	1	30.0000
890	3	0.0	2.0	32.000000	0	0	0	7.7500

891 rows × 8 columns

dtreeviz visualisations

In [33]:

```
tree_model_regressor = model.stages[4]
spark_dtree_reg = ShadowSparkTree(tree_model_regressor, dataset_reg[features_reg], dataset_reg[target_re
```

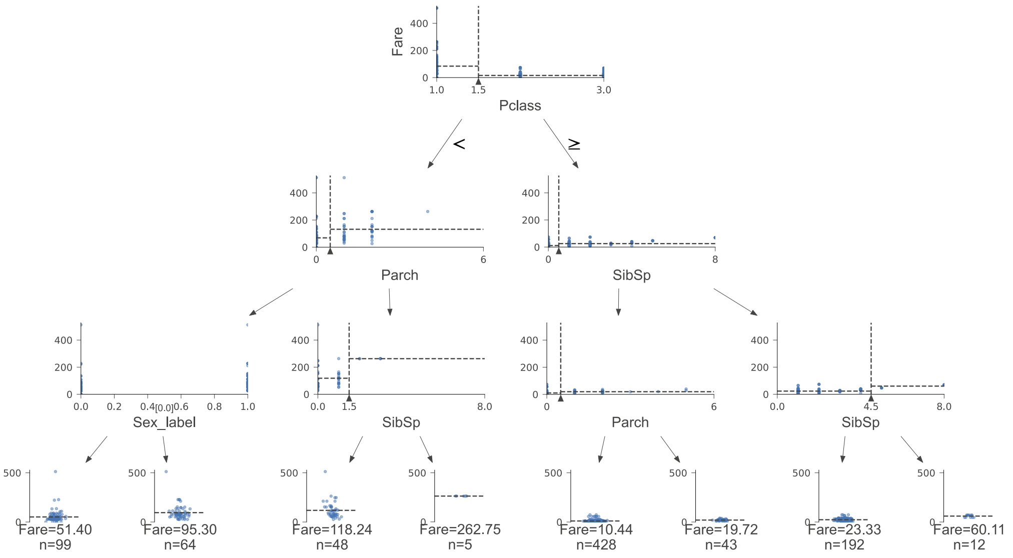
dtreeviz

In [34]:

```
trees.dtreeviz(spark_dtree_reg)
```

```
/Users/parrt/opt/anaconda3/lib/python3.8/site-packages/dtreeviz-1.1.4-py3.8.egg/dtreeviz/models/spark_de
cision_tree.py:87: VisibleDeprecationWarning: Creating an ndarray from ragged nested sequences (which is
a list-or-tuple of lists-or-tuples-or ndarrays with different lengths or shapes) is deprecated. If you m
eant to do this, you must specify 'dtype=object' when creating the ndarray
  self.thresholds = np.array(node_thresholds)
```

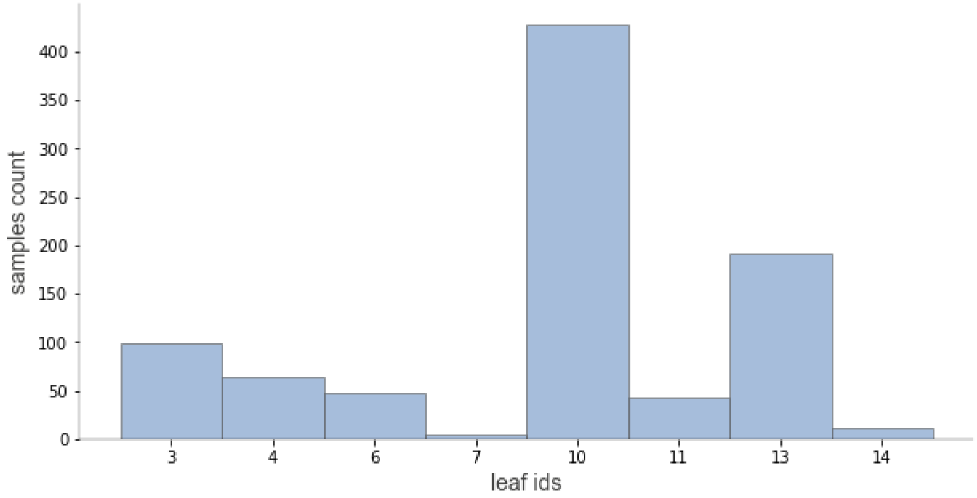
Out[34]:



viz_leaf_samples

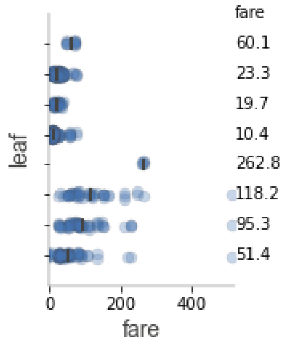
In [35]:

```
trees.viz_leaf_samples(spark_dtree_reg)
```



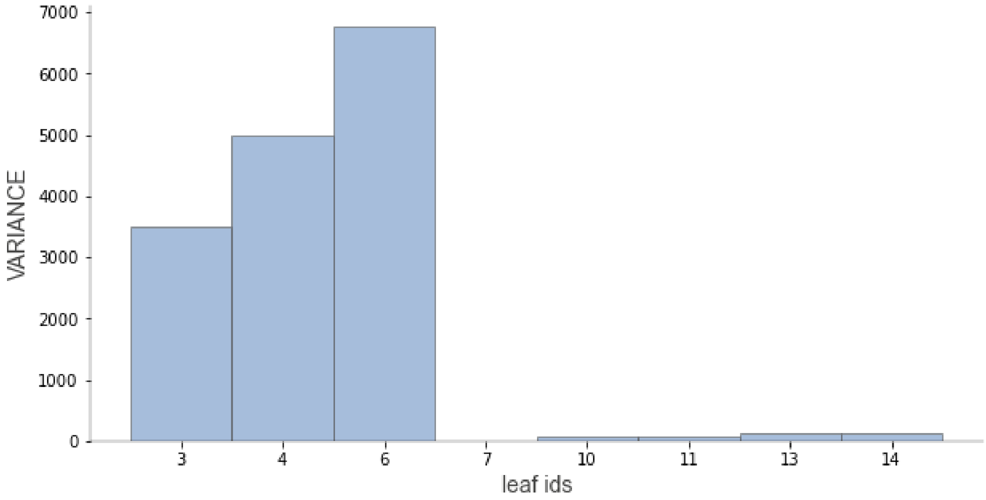
viz_leaf_target

In [36]:
```
trees.viz_leaf_target(spark_dtree_reg)
```



viz_leaf_criterion

In [37]:
```
trees.viz_leaf_criterion(spark_dtree_reg)
```



explain_prediction_path

In [38]:
```
X = dataset_reg[features_reg].iloc[3]
X
```

Out[38]:
```
Pclass               1.0
Sex_label            1.0
```

```
Embarked_label      0.0
Age_mean           35.0
SibSp               1.0
Parch               0.0
Survived            1.0
Name: 3, dtype: float64
```

In [39]:

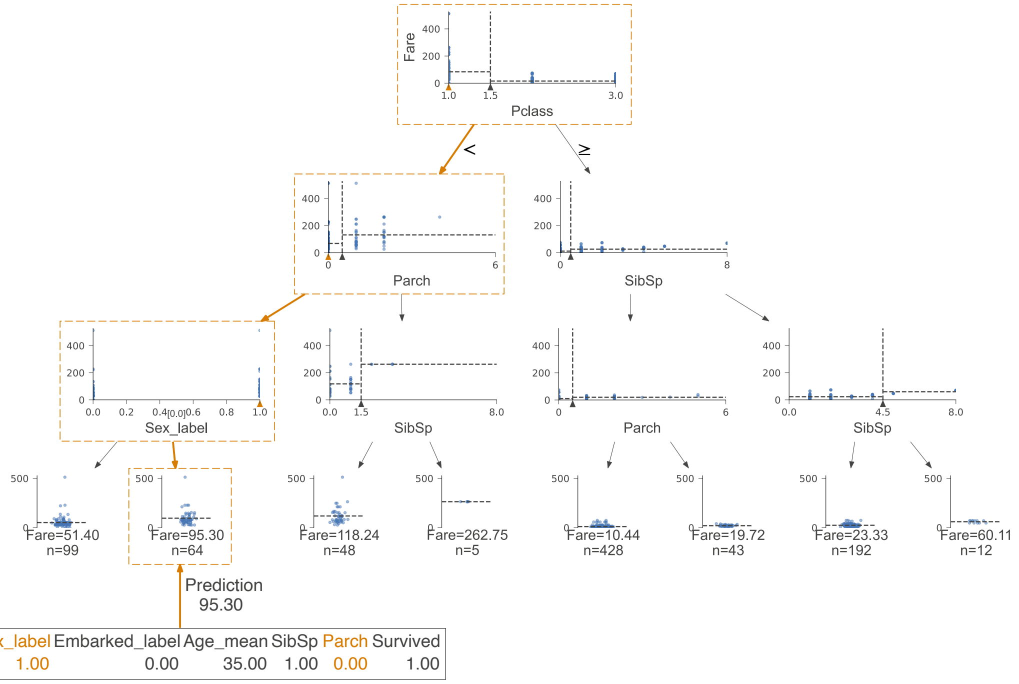
```
print(trees.explain_prediction_path(spark_dtree_reg, x = X, explanation_type="plain_english"))
```

```
Pclass < 1.5
Parch < 0.5
Sex_label in [1.0, 2.0]
```

In [40]:

```
trees.dtreeviz(spark_dtree_reg, X=X)
```

Out[40]:



Pclass	Sex_label	Embarked_label	Age_mean	SibSp	Parch	Survived
1.00	1.00	0.00	35.00	1.00	0.00	1.00