# Apply HS to decision tree algorithm

# max\_depth=2

# sklearn

The binary tree structure has 7 nodes and has the following tree structure:

node=0 is a split node with weights 506: go to node 1 if X[:, 5] rm <= 6.940999984741211 else to node 4.

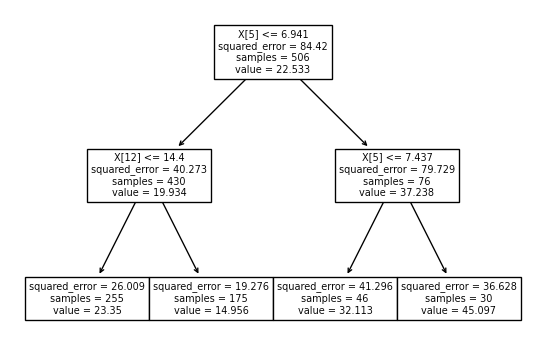
node=1 is a split node with weights 430: go to node 2 if X[:, 12] lstat <= 14.400000095367432 else to node 3.

node=2 is a leaf node.

node=3 is a leaf node.

node=4 is a split node with weights 76: go to node 5 if X[:, 5] rm <= 7.437000036239624 else to node 6.

node=5 is a leaf node.

node=6 is a leaf node.

# ours

{'rm <= 6.941

with num of samples 506 and current y 22.532806324110677':

[{'lstat <= 14.399999999999999

with num of samples 430 and current y 19.933720930232557':

[23.349803921568625, 14.956000000000001]},

{'rm <= 7.436999999999999

with num of samples 76 and current y 37.238157894736844':

[32.11304347826087, 45.09666666666667]}]}

Mse: 25.69946745212606

# After applying HS

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> Decision Tree with Hierarchical Shrinkage

> Prediction is made by looking at the value in the appropriate leaf of the tree

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|--- feature\_5 <= 6.94

| |--- feature\_12 <= 14.40

| | |--- value: [23.32]

| |--- feature\_12 > 14.40

| | |--- value: [15.12]

|--- feature\_5 > 6.94

| |--- feature\_5 <= 7.44

| | |--- value: [32.42]

| |--- feature\_5 > 7.44

| | |--- value: [43.90]

Lambda = 10.0

Mse = 25.803078052769635

Calculate by hands:

23.322535543739914 = 22.532806324110677+(19.933720930232557-22.532806324110677)/(1+10/506)+(23.349803921568625-19.933720930232557)/(1+10/430)

# after adjusting our codes

{'rm <= 6.941 with num of samples 506 and current y 22.532806324110677 and above y {0: [0, 506, 22.532806324110677]}':

[{'lstat <= 14.399999999999999 with num of samples 430 and current y 19.933720930232557 and above y {0: [0, 506, 22.532806324110677], 1:[1, 430, 19.933720930232557] }':

[23.349803921568625, 14.956000000000001]},

{'rm <= 7.436999999999999 with num of samples 76 and current y 37.238157894736844 and above y {0: [0, 506, 22.532806324110677], 1: [1, 430, 19.933720930232557], 2: [2, 255, 23.349803921568625], 3: [2, 175, 14.956000000000001], 4: [1, 76, 37.238157894736844]}':

[32.11304347826087, 45.09666666666667]}]}

# Applying HS to our codes

Mse: 25.803078052769635

{'rm <= 6.941 with num of samples 506 and current y 22.532806324110677 and above y {0: [0, 506, 22.532806324110677]}':

[{'lstat <= 14.399999999999999 with num of samples 430 and current y 19.933720930232557 and above y {0: [0, 506, 22.532806324110677], 1: [1, 430, 19.933720930232557]}':

[23.322535543739914, 15.119499893116032]},

{'rm <= 7.436999999999999 with num of samples 76 and current y 37.238157894736844 and above y {0: [0, 506, 22.532806324110677], 1: [1, 430, 19.933720930232557], 2: [2, 255, 23.322535543739914], 3: [2, 175, 15.119499893116032], 4: [1, 76, 37.238157894736844]}':

[32.42399958152113, 43.89789914336812]}]}

# Find out why mse differs so much after adjustment

K=None

{'rm node 0 <= 6.941':

[{'lstat node1 <= 14.399999999999999': [

{'dis node2 <= 1.3848500000000001':

[45.58, node3 -> 4/5

{'rm node6 <= 6.543':

[21.62974358974359 node7, 27.427272727272722 node8]

}

]

},

{'crim node9 <= 6.99237':

[{'nox node10 <= 0.531':

[20.020833333333332 node11, 16.238961038961037 node12]},

{'nox node13 <= 0.6695':

[15.505555555555556 node14, 10.844642857142858 node15]}

]

}]

},

{'rm node16 <= 7.436999999999999': [

{'lstat nox node17 <= 11.455 <= 0.6590000092983246 ':

[{'lstat dis node18 <= 5.4399999999999995 <= 1.8859500288963318 ':

[35.36363636363636 node19, 31.3421052631579 node20]

},

20.740000000000002]},

{'ptratio node24 <= 15.4':

[{'rm <= 7.864':

[46.1, 49.85]},

{'ptratio <= 17.6':

[44.728571428571435, 38.885714285714286]}]

}]

}]

}

K=0

Depth=7

{'rm node0 X[:, 5] <= 6.941':

[{'lstat node1 X[:, 12] <= 14.399999999999999':

[{'dis node2 X[:, 7] <= 1.3848500000000001':

[{'b <= 339.985': node3 X[:, 0] <= 10.591700077056885

[27.9 node4, 50.0 node5]},

{'rm node6 X[:, 5] <= 6.543':

[{'lstat node7 X[:, 12] <= 7.57':

[{'tax node8 X[:, 9] <= 222.5':

[28.7 node9,

{'indus node10 X[:, 2] <= 5.48':

[23.01 node11, 24.55652 node12]}

]

},

{'tax node13 X[:, 9] <= 208.0':

[{'lstat <= 13.565000000000001': node14 X[:, 0] <= 0.069

[32.9node15, 22.9 node16]},

{'rm node17 X[:, 5] <= 6.0775':

[19.997 node18, 21.6588 node19]}

]

}

]

},

{'tax <= 269.0':

[{'ptratio <= 17.85':

[{'b <= 393.40999999999997':

[30.4, 33.019999999999996]},

{'rm <= 6.605499999999999':

[30.8, 27.7]}]}, {'nox <= 0.526': [{'nox <= 0.436': [24.563636363636363, 28.5]}, {'ptratio <= 17.1': [26.35, 22.642857142857142]}]}]}]}]}, {'crim <= 6.99237': [{'nox <= 0.531': [{'dis <= 5.57015': [{'age <= 88.55': [{'b <= 385.375': [24.049999999999997, 22.424999999999997]}, {'rm <= 5.9055': [19.575, 20.933333333333334]}]}, {'crim <= 0.15729500000000002': [{'ptratio <= 15.6': [27.1, 19.6]}, {'age <= 89.65': [18.35, 15.475]}]}]}, {'lstat <= 18.885': [{'age <= 85.2': [{'lstat <= 15.235': [17.94, 20.457142857142856]}, {'tax <= 291.5': [20.549999999999997, 16.170270270270276]}]}, {'age <= 97.2': [{'ptratio <= 19.7': [16.750000000000004, 13.957142857142859]}, {'crim <= 0.22863': [7.55, 13.744444444444445]}]}]}]}, {'nox <= 0.6054999999999999': [{'crim <= 12.66115': [{'age <= 78.35': [10.95, {'dis <= 1.7537000000000003': [17.2, 14.133333333333335]}]}, {'dis <= 1.4965000000000002': [27.5, {'b <= 289.855': [17.13333333333333, 19.6]}]}]}, {'lstat <= 19.645': [{'crim <= 12.223600000000001': [{'chas = 0.0': [14.453846153846154, 17.8]}, {'crim <= 14.1671': [12.2, 10.25]}]}, {'nox <= 0.675': [{'lstat <= 22.509999999999998': [11.466666666666667, 13.12857142857143]}, {'crim <= 13.240200000000002': [10.460000000000003, 8.052631578947368]}]}]}]}]}]}, {'rm <= 7.436999999999999': [{'nox <= 0.659': [{'dis <= 1.88595': [{'chas = 0.0': [41.3, 50.0]}, {'nox <= 0.4885': [{'age <= 11.95': [29.3, {'lstat <= 5.4399999999999995': [35.30625, 33.18888888888889]}]}, {'rm <= 7.121': [{'nox <= 0.5934999999999999': [25.580000000000002, 30.25]}, {'dis <= 2.0044500000000003': [36.25, 31.919999999999998]}]}]}]}, {'age <= 94.9': [10.4, 16.4]}]}, {'b <= 361.925': [21.9, {'ptratio <= 14.8': [{'rm <= 7.7059999999999995': [{'lstat <= 2.42': [50.0, {'age <= 34.15': [42.3, 43.3]}]}, {'lstat <= 3.755': [50.0, {'crim <= 0.54924': [48.65, 50.0]}]}]}, {'b <= 385.48': [{'crim <= 0.3234': [{'dis <= 3.1347500000000004': [44.8, 46.35]}, 49.15]}, {'crim <= 0.06095': [{'zn <= 10.0': [50.0, 44.7]}, {'age <= 44.349999999999994': [43.3, 38.6]}]}]}]}]}]}]}

3.0223585198593192