Machine Learning Assignment -2

Decision Trees

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Output – The accuracy using the different heuristic models with varying K and L are shown below -

Dataset - 1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sl. No | L | K | Information gain | | Impurity gain | |
| Before pruning (%) | After Pruning (%) | Before pruning (%) | After Pruning (%) |
| 1 | 10 | 15 | 75.85 | 75.8 | 76.65 | 77 |
| 2 | 20 | 45 | 75.85 | 76.95 | 76.65 | 76.65 |
| 3 | 20 | 30 | 75.85 | 76.35 | 76.65 | 77.45 |
| 4 | 200 | 300 | 75.85 | 77.35 | 76.65 | 77.75 |
| 5 | 2000 | 3000 | 75.85 | 76.8 | 76.65 | 77.15 |
| 6 | 2 | 3 | 75.85 | 75.85 | 76.65 | 76.65 |
| 7 | 200 | 10 | 75.85 | 77.35 | 76.65 | 76.85 |
| 8 | 10 | 200 | 75.85 | 75.85 | 76.65 | 76.65 |
| 9 | 400 | 200 | 75.85 | 79.05 | 76.65 | 78.35 |
| 10 | 1000 | 200 | 75.85 | 77.35 | 76.65 | 77.35 |

Dataset - 2

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sl. No | L | K | Information gain | | Impurity gain | |
| Before pruning (%) | After Pruning (%) | Before pruning (%) | After Pruning (%) |
| 1 | 10 | 15 | 72.33 | 72.83 | 72.5 | 72.5 |
| 2 | 20 | 45 | 72.33 | 73 | 72.5 | 73.6 |
| 3 | 20 | 30 | 72.33 | 74 | 72.5 | 74.33 |
| 4 | 200 | 300 | 72.33 | 74.5 | 72.5 | 74 |
| 5 | 2000 | 3000 | 72.33 | 75.16 | 72.5 | 73.66 |
| 6 | 2 | 3 | 72.33 | 72.33 | 72.5 | 72.5 |
| 7 | 200 | 10 | 72.33 | 74.5 | 72.5 | 77.16 |
| 8 | 10 | 200 | 72.33 | 72.5 | 72.5 | 72.5 |
| 9 | 400 | 200 | 72.33 | 72.83 | 72.5 | 76.16 |
| 10 | 1000 | 200 | 72.33 | 75.33 | 72.5 | 73.66 |

Plot and Model Summary –

K = 10, L = 200, Print = yes

Accuracy of decision tree constructed using information gain before pruning: 72.33333333333333%

Decision tree before pruning:

XI = 0 :

| XU = 0 :

| | XQ = 0 :

| | | XF = 0 :

| | | | XO = 0 :

| | | | | XB = 0 :

| | | | | | XJ = 0 : 0

| | | | | | XJ = 1 :

| | | | | | | XG = 0 : 0

| | | | | | | XG = 1 : 1

| | | | | XB = 1 : 0

| | | | XO = 1 :

| | | | | XB = 0 :

| | | | | | XD = 0 :

| | | | | | | XM = 0 : 1

| | | | | | | XM = 1 : 0

| | | | | | XD = 1 : 0

| | | | | XB = 1 :

| | | | | | XH = 0 :

| | | | | | | XL = 0 : 1

| | | | | | | XL = 1 :

| | | | | | | | XS = 0 :

| | | | | | | | | XJ = 0 :

| | | | | | | | | | XC = 0 : 0

| | | | | | | | | | XC = 1 : 1

| | | | | | | | | XJ = 1 : 1

| | | | | | | | XS = 1 : 0

| | | | | | XH = 1 : 1

| | | XF = 1 : 0

| | XQ = 1 :

| | | XB = 0 :

| | | | XT = 0 :

| | | | | XL = 0 :

| | | | | | XR = 0 :

| | | | | | | XN = 0 :

| | | | | | | | XG = 0 : 1

| | | | | | | | XG = 1 :

| | | | | | | | | XP = 0 : 1

| | | | | | | | | XP = 1 :

| | | | | | | | | | XC = 0 :

| | | | | | | | | | | XE = 0 : 0

| | | | | | | | | | | XE = 1 : 1

| | | | | | | | | | XC = 1 : 0

| | | | | | | XN = 1 : 0

| | | | | | XR = 1 : 1

| | | | | XL = 1 :

| | | | | | XF = 0 : 0

| | | | | | XF = 1 :

| | | | | | | XC = 0 :

| | | | | | | | XH = 0 : 1

| | | | | | | | XH = 1 :

| | | | | | | | | XE = 0 : 1

| | | | | | | | | XE = 1 : 0

| | | | | | | XC = 1 :

| | | | | | | | XJ = 0 : 0

| | | | | | | | XJ = 1 :

| | | | | | | | | XK = 0 : 1

| | | | | | | | | XK = 1 :

| | | | | | | | | | XM = 0 : 1

| | | | | | | | | | XM = 1 : 0

| | | | XT = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XM = 0 :

| | | | | | | XH = 0 :

| | | | | | | | XL = 0 : 0

| | | | | | | | XL = 1 :

| | | | | | | | | XC = 0 :

| | | | | | | | | | XD = 0 : 0

| | | | | | | | | | XD = 1 : 1

| | | | | | | | | XC = 1 : 1

| | | | | | | XH = 1 : 1

| | | | | | XM = 1 : 0

| | | XB = 1 :

| | | | XO = 0 : 0

| | | | XO = 1 :

| | | | | XM = 0 :

| | | | | | XF = 0 :

| | | | | | | XP = 0 :

| | | | | | | | XL = 0 :

| | | | | | | | | XC = 0 : 1

| | | | | | | | | XC = 1 :

| | | | | | | | | | XK = 0 :

| | | | | | | | | | | XE = 0 : 0

| | | | | | | | | | | XE = 1 : 0

| | | | | | | | | | XK = 1 : 1

| | | | | | | | XL = 1 : 0

| | | | | | | XP = 1 : 1

| | | | | | XF = 1 : 0

| | | | | XM = 1 : 0

| XU = 1 :

| | XG = 0 :

| | | XS = 0 :

| | | | XB = 0 :

| | | | | XF = 0 : 0

| | | | | XF = 1 :

| | | | | | XQ = 0 : 0

| | | | | | XQ = 1 :

| | | | | | | XC = 0 : 1

| | | | | | | XC = 1 :

| | | | | | | | XH = 0 :

| | | | | | | | | XD = 0 : 0

| | | | | | | | | XD = 1 : 1

| | | | | | | | XH = 1 :

| | | | | | | | | XJ = 0 :

| | | | | | | | | | XN = 0 : 1

| | | | | | | | | | XN = 1 : 0

| | | | | | | | | XJ = 1 : 1

| | | | XB = 1 :

| | | | | XO = 0 : 0

| | | | | XO = 1 :

| | | | | | XJ = 0 :

| | | | | | | XC = 0 : 0

| | | | | | | XC = 1 :

| | | | | | | | XD = 0 : 0

| | | | | | | | XD = 1 : 1

| | | | | | XJ = 1 : 1

| | | XS = 1 :

| | | | XO = 0 : 0

| | | | XO = 1 :

| | | | | XL = 0 :

| | | | | | XN = 0 :

| | | | | | | XJ = 0 : 1

| | | | | | | XJ = 1 : 0

| | | | | | XN = 1 : 1

| | | | | XL = 1 : 0

| | XG = 1 : 0

XI = 1 :

| XK = 0 :

| | XC = 0 :

| | | XS = 0 :

| | | | XG = 0 :

| | | | | XM = 0 : 1

| | | | | XM = 1 :

| | | | | | XT = 0 : 1

| | | | | | XT = 1 :

| | | | | | | XL = 0 :

| | | | | | | | XP = 0 : 1

| | | | | | | | XP = 1 :

| | | | | | | | | XB = 0 : 1

| | | | | | | | | XB = 1 : 0

| | | | | | | XL = 1 :

| | | | | | | | XP = 0 : 0

| | | | | | | | XP = 1 :

| | | | | | | | | XQ = 0 : 1

| | | | | | | | | XQ = 1 :

| | | | | | | | | | XB = 0 : 1

| | | | | | | | | | XB = 1 : 0

| | | | XG = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XH = 0 : 0

| | | | | | XH = 1 :

| | | | | | | XL = 0 : 1

| | | | | | | XL = 1 : 0

| | | XS = 1 :

| | | | XR = 0 :

| | | | | XN = 0 : 1

| | | | | XN = 1 :

| | | | | | XH = 0 :

| | | | | | | XJ = 0 :

| | | | | | | | XM = 0 :

| | | | | | | | | XD = 0 : 0

| | | | | | | | | XD = 1 : 1

| | | | | | | | XM = 1 : 1

| | | | | | | XJ = 1 : 1

| | | | | | XH = 1 :

| | | | | | | XT = 0 : 0

| | | | | | | XT = 1 :

| | | | | | | | XF = 0 : 0

| | | | | | | | XF = 1 : 1

| | | | XR = 1 :

| | | | | XG = 0 :

| | | | | | XM = 0 :

| | | | | | | XH = 0 : 0

| | | | | | | XH = 1 :

| | | | | | | | XB = 0 : 1

| | | | | | | | XB = 1 :

| | | | | | | | | XF = 0 : 1

| | | | | | | | | XF = 1 : 0

| | | | | | XM = 1 :

| | | | | | | XD = 0 : 0

| | | | | | | XD = 1 : 1

| | | | | XG = 1 : 0

| | XC = 1 :

| | | XD = 0 :

| | | | XS = 0 :

| | | | | XF = 0 :

| | | | | | XB = 0 : 0

| | | | | | XB = 1 :

| | | | | | | XE = 0 : 0

| | | | | | | XE = 1 : 1

| | | | | XF = 1 :

| | | | | | XP = 0 : 1

| | | | | | XP = 1 :

| | | | | | | XH = 0 : 1

| | | | | | | XH = 1 :

| | | | | | | | XL = 0 :

| | | | | | | | | XJ = 0 : 1

| | | | | | | | | XJ = 1 :

| | | | | | | | | | XN = 0 : 0

| | | | | | | | | | XN = 1 : 1

| | | | | | | | XL = 1 : 0

| | | | XS = 1 :

| | | | | XJ = 0 :

| | | | | | XM = 0 : 0

| | | | | | XM = 1 :

| | | | | | | XQ = 0 :

| | | | | | | | XB = 0 : 1

| | | | | | | | XB = 1 :

| | | | | | | | | XF = 0 :

| | | | | | | | | | XH = 0 : 0

| | | | | | | | | | XH = 1 : 1

| | | | | | | | | XF = 1 : 1

| | | | | | | XQ = 1 : 0

| | | | | XJ = 1 :

| | | | | | XO = 0 :

| | | | | | | XF = 0 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 : 1

| | | | | | | XF = 1 : 1

| | | | | | XO = 1 :

| | | | | | | XR = 0 :

| | | | | | | | XB = 0 :

| | | | | | | | | XH = 0 : 0

| | | | | | | | | XH = 1 : 1

| | | | | | | | XB = 1 : 1

| | | | | | | XR = 1 : 1

| | | XD = 1 :

| | | | XF = 0 : 0

| | | | XF = 1 :

| | | | | XO = 0 : 0

| | | | | XO = 1 :

| | | | | | XP = 0 : 0

| | | | | | XP = 1 : 1

| XK = 1 :

| | XD = 0 :

| | | XT = 0 :

| | | | XF = 0 :

| | | | | XB = 0 :

| | | | | | XR = 0 : 0

| | | | | | XR = 1 :

| | | | | | | XO = 0 : 1

| | | | | | | XO = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | | | XB = 1 :

| | | | | | XO = 0 : 0

| | | | | | XO = 1 : 1

| | | | XF = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XH = 0 :

| | | | | | | XL = 0 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 :

| | | | | | | | | XG = 0 : 1

| | | | | | | | | XG = 1 : 0

| | | | | | | XL = 1 : 1

| | | | | | XH = 1 :

| | | | | | | XE = 0 : 1

| | | | | | | XE = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | XT = 1 :

| | | | XB = 0 :

| | | | | XC = 0 :

| | | | | | XM = 0 : 1

| | | | | | XM = 1 :

| | | | | | | XJ = 0 : 0

| | | | | | | XJ = 1 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 : 1

| | | | | XC = 1 :

| | | | | | XH = 0 : 1

| | | | | | XH = 1 :

| | | | | | | XL = 0 : 1

| | | | | | | XL = 1 :

| | | | | | | | XN = 0 : 1

| | | | | | | | XN = 1 : 0

| | | | XB = 1 : 0

| | XD = 1 : 0

Accuracy of decision tree constructed using information gain after pruning: 76.0%

Decision tree after pruning:

XI = 0 :

| XU = 0 :

| | XQ = 0 :

| | | XF = 0 :

| | | | XO = 0 :

| | | | | XB = 0 :

| | | | | | XJ = 0 : 0

| | | | | | XJ = 1 :

| | | | | | | XG = 0 : 0

| | | | | | | XG = 1 : 1

| | | | | XB = 1 : 0

| | | | XO = 1 :

| | | | | XB = 0 :

| | | | | | XD = 0 :

| | | | | | | XM = 0 : 1

| | | | | | | XM = 1 : 0

| | | | | | XD = 1 : 0

| | | | | XB = 1 :

| | | | | | XH = 0 :

| | | | | | | XL = 0 : 1

| | | | | | | XL = 1 :

| | | | | | | | XS = 0 :

| | | | | | | | | XJ = 0 :

| | | | | | | | | | XC = 0 : 0

| | | | | | | | | | XC = 1 : 1

| | | | | | | | | XJ = 1 : 1

| | | | | | | | XS = 1 : 0

| | | | | | XH = 1 : 1

| | | XF = 1 : 0

| | XQ = 1 :

| | | XB = 0 :

| | | | XT = 0 :

| | | | | XL = 0 :

| | | | | | XR = 0 : 1

| | | | | | XR = 1 : 1

| | | | | XL = 1 :

| | | | | | XF = 0 : 0

| | | | | | XF = 1 :

| | | | | | | XC = 0 :

| | | | | | | | XH = 0 : 1

| | | | | | | | XH = 1 :

| | | | | | | | | XE = 0 : 1

| | | | | | | | | XE = 1 : 0

| | | | | | | XC = 1 :

| | | | | | | | XJ = 0 : 0

| | | | | | | | XJ = 1 :

| | | | | | | | | XK = 0 : 1

| | | | | | | | | XK = 1 :

| | | | | | | | | | XM = 0 : 1

| | | | | | | | | | XM = 1 : 0

| | | | XT = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XM = 0 :

| | | | | | | XH = 0 :

| | | | | | | | XL = 0 : 0

| | | | | | | | XL = 1 :

| | | | | | | | | XC = 0 :

| | | | | | | | | | XD = 0 : 0

| | | | | | | | | | XD = 1 : 1

| | | | | | | | | XC = 1 : 1

| | | | | | | XH = 1 : 1

| | | | | | XM = 1 : 0

| | | XB = 1 :

| | | | XO = 0 : 0

| | | | XO = 1 :

| | | | | XM = 0 :

| | | | | | XF = 0 :

| | | | | | | XP = 0 :

| | | | | | | | XL = 0 :

| | | | | | | | | XC = 0 : 1

| | | | | | | | | XC = 1 :

| | | | | | | | | | XK = 0 :

| | | | | | | | | | | XE = 0 : 0

| | | | | | | | | | | XE = 1 : 0

| | | | | | | | | | XK = 1 : 1

| | | | | | | | XL = 1 : 0

| | | | | | | XP = 1 : 1

| | | | | | XF = 1 : 0

| | | | | XM = 1 : 0

| XU = 1 :

| | XG = 0 :

| | | XS = 0 :

| | | | XB = 0 :

| | | | | XF = 0 : 0

| | | | | XF = 1 :

| | | | | | XQ = 0 : 0

| | | | | | XQ = 1 :

| | | | | | | XC = 0 : 1

| | | | | | | XC = 1 :

| | | | | | | | XH = 0 :

| | | | | | | | | XD = 0 : 0

| | | | | | | | | XD = 1 : 1

| | | | | | | | XH = 1 :

| | | | | | | | | XJ = 0 :

| | | | | | | | | | XN = 0 : 1

| | | | | | | | | | XN = 1 : 0

| | | | | | | | | XJ = 1 : 1

| | | | XB = 1 :

| | | | | XO = 0 : 0

| | | | | XO = 1 :

| | | | | | XJ = 0 :

| | | | | | | XC = 0 : 0

| | | | | | | XC = 1 :

| | | | | | | | XD = 0 : 0

| | | | | | | | XD = 1 : 1

| | | | | | XJ = 1 : 1

| | | XS = 1 :

| | | | XO = 0 : 0

| | | | XO = 1 :

| | | | | XL = 0 :

| | | | | | XN = 0 :

| | | | | | | XJ = 0 : 1

| | | | | | | XJ = 1 : 0

| | | | | | XN = 1 : 1

| | | | | XL = 1 : 0

| | XG = 1 : 0

XI = 1 :

| XK = 0 :

| | XC = 0 :

| | | XS = 0 :

| | | | XG = 0 :

| | | | | XM = 0 : 1

| | | | | XM = 1 :

| | | | | | XT = 0 : 1

| | | | | | XT = 1 :

| | | | | | | XL = 0 :

| | | | | | | | XP = 0 : 1

| | | | | | | | XP = 1 :

| | | | | | | | | XB = 0 : 1

| | | | | | | | | XB = 1 : 0

| | | | | | | XL = 1 :

| | | | | | | | XP = 0 : 0

| | | | | | | | XP = 1 :

| | | | | | | | | XQ = 0 : 1

| | | | | | | | | XQ = 1 :

| | | | | | | | | | XB = 0 : 1

| | | | | | | | | | XB = 1 : 0

| | | | XG = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XH = 0 : 0

| | | | | | XH = 1 :

| | | | | | | XL = 0 : 1

| | | | | | | XL = 1 : 0

| | | XS = 1 :

| | | | XR = 0 : 1

| | | | XR = 1 :

| | | | | XG = 0 :

| | | | | | XM = 0 : 1

| | | | | | XM = 1 :

| | | | | | | XD = 0 : 0

| | | | | | | XD = 1 : 1

| | | | | XG = 1 : 0

| | XC = 1 :

| | | XD = 0 :

| | | | XS = 0 :

| | | | | XF = 0 :

| | | | | | XB = 0 : 0

| | | | | | XB = 1 :

| | | | | | | XE = 0 : 0

| | | | | | | XE = 1 : 1

| | | | | XF = 1 :

| | | | | | XP = 0 : 1

| | | | | | XP = 1 :

| | | | | | | XH = 0 : 1

| | | | | | | XH = 1 :

| | | | | | | | XL = 0 :

| | | | | | | | | XJ = 0 : 1

| | | | | | | | | XJ = 1 :

| | | | | | | | | | XN = 0 : 0

| | | | | | | | | | XN = 1 : 1

| | | | | | | | XL = 1 : 0

| | | | XS = 1 :

| | | | | XJ = 0 :

| | | | | | XM = 0 : 0

| | | | | | XM = 1 :

| | | | | | | XQ = 0 :

| | | | | | | | XB = 0 : 1

| | | | | | | | XB = 1 :

| | | | | | | | | XF = 0 :

| | | | | | | | | | XH = 0 : 0

| | | | | | | | | | XH = 1 : 1

| | | | | | | | | XF = 1 : 1

| | | | | | | XQ = 1 : 0

| | | | | XJ = 1 :

| | | | | | XO = 0 :

| | | | | | | XF = 0 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 : 1

| | | | | | | XF = 1 : 1

| | | | | | XO = 1 :

| | | | | | | XR = 0 :

| | | | | | | | XB = 0 :

| | | | | | | | | XH = 0 : 0

| | | | | | | | | XH = 1 : 1

| | | | | | | | XB = 1 : 1

| | | | | | | XR = 1 : 1

| | | XD = 1 :

| | | | XF = 0 : 0

| | | | XF = 1 :

| | | | | XO = 0 : 0

| | | | | XO = 1 :

| | | | | | XP = 0 : 0

| | | | | | XP = 1 : 1

| XK = 1 :

| | XD = 0 :

| | | XT = 0 :

| | | | XF = 0 :

| | | | | XB = 0 :

| | | | | | XR = 0 : 0

| | | | | | XR = 1 :

| | | | | | | XO = 0 : 1

| | | | | | | XO = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | | | XB = 1 :

| | | | | | XO = 0 : 0

| | | | | | XO = 1 : 1

| | | | XF = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XH = 0 :

| | | | | | | XL = 0 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 :

| | | | | | | | | XG = 0 : 1

| | | | | | | | | XG = 1 : 0

| | | | | | | XL = 1 : 1

| | | | | | XH = 1 :

| | | | | | | XE = 0 : 1

| | | | | | | XE = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | XT = 1 :

| | | | XB = 0 : 1

| | | | XB = 1 : 0

| | XD = 1 : 0

Accuracy of decision tree constructed using impurity gain before pruning: 72.5%

Decision tree before pruning:

XI = 0 :

| XU = 0 :

| | XQ = 0 :

| | | XF = 0 :

| | | | XO = 0 :

| | | | | XB = 0 :

| | | | | | XJ = 0 : 0

| | | | | | XJ = 1 :

| | | | | | | XG = 0 : 0

| | | | | | | XG = 1 : 1

| | | | | XB = 1 : 0

| | | | XO = 1 :

| | | | | XB = 0 :

| | | | | | XD = 0 :

| | | | | | | XM = 0 : 1

| | | | | | | XM = 1 : 0

| | | | | | XD = 1 : 0

| | | | | XB = 1 :

| | | | | | XH = 0 :

| | | | | | | XS = 0 :

| | | | | | | | XJ = 0 :

| | | | | | | | | XN = 0 : 1

| | | | | | | | | XN = 1 : 0

| | | | | | | | XJ = 1 : 1

| | | | | | | XS = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | | | | XH = 1 : 1

| | | XF = 1 : 0

| | XQ = 1 :

| | | XB = 0 :

| | | | XF = 0 :

| | | | | XG = 0 : 0

| | | | | XG = 1 :

| | | | | | XL = 0 :

| | | | | | | XS = 0 : 0

| | | | | | | XS = 1 : 1

| | | | | | XL = 1 : 0

| | | | XF = 1 :

| | | | | XT = 0 :

| | | | | | XL = 0 :

| | | | | | | XS = 0 : 1

| | | | | | | XS = 1 :

| | | | | | | | XC = 0 : 0

| | | | | | | | XC = 1 : 1

| | | | | | XL = 1 :

| | | | | | | XC = 0 :

| | | | | | | | XH = 0 : 1

| | | | | | | | XH = 1 :

| | | | | | | | | XE = 0 : 1

| | | | | | | | | XE = 1 : 0

| | | | | | | XC = 1 :

| | | | | | | | XJ = 0 : 0

| | | | | | | | XJ = 1 :

| | | | | | | | | XK = 0 : 1

| | | | | | | | | XK = 1 :

| | | | | | | | | | XM = 0 : 1

| | | | | | | | | | XM = 1 : 0

| | | | | XT = 1 :

| | | | | | XH = 0 :

| | | | | | | XO = 0 : 1

| | | | | | | XO = 1 :

| | | | | | | | XL = 0 : 0

| | | | | | | | XL = 1 :

| | | | | | | | | XC = 0 :

| | | | | | | | | | XD = 0 : 0

| | | | | | | | | | XD = 1 : 1

| | | | | | | | | XC = 1 : 1

| | | | | | XH = 1 : 1

| | | XB = 1 :

| | | | XO = 0 : 0

| | | | XO = 1 :

| | | | | XM = 0 :

| | | | | | XF = 0 :

| | | | | | | XP = 0 :

| | | | | | | | XL = 0 :

| | | | | | | | | XC = 0 : 1

| | | | | | | | | XC = 1 :

| | | | | | | | | | XK = 0 :

| | | | | | | | | | | XE = 0 : 0

| | | | | | | | | | | XE = 1 : 0

| | | | | | | | | | XK = 1 : 1

| | | | | | | | XL = 1 : 0

| | | | | | | XP = 1 : 1

| | | | | | XF = 1 : 0

| | | | | XM = 1 : 0

| XU = 1 :

| | XG = 0 :

| | | XS = 0 :

| | | | XB = 0 :

| | | | | XF = 0 : 0

| | | | | XF = 1 :

| | | | | | XQ = 0 : 0

| | | | | | XQ = 1 :

| | | | | | | XC = 0 : 1

| | | | | | | XC = 1 :

| | | | | | | | XH = 0 :

| | | | | | | | | XD = 0 : 0

| | | | | | | | | XD = 1 : 1

| | | | | | | | XH = 1 :

| | | | | | | | | XJ = 0 :

| | | | | | | | | | XN = 0 : 1

| | | | | | | | | | XN = 1 : 0

| | | | | | | | | XJ = 1 : 1

| | | | XB = 1 :

| | | | | XO = 0 : 0

| | | | | XO = 1 :

| | | | | | XJ = 0 :

| | | | | | | XC = 0 : 0

| | | | | | | XC = 1 :

| | | | | | | | XD = 0 : 0

| | | | | | | | XD = 1 : 1

| | | | | | XJ = 1 : 1

| | | XS = 1 :

| | | | XO = 0 : 0

| | | | XO = 1 :

| | | | | XL = 0 :

| | | | | | XN = 0 :

| | | | | | | XJ = 0 : 1

| | | | | | | XJ = 1 : 0

| | | | | | XN = 1 : 1

| | | | | XL = 1 : 0

| | XG = 1 : 0

XI = 1 :

| XK = 0 :

| | XC = 0 :

| | | XS = 0 :

| | | | XG = 0 :

| | | | | XM = 0 : 1

| | | | | XM = 1 :

| | | | | | XT = 0 : 1

| | | | | | XT = 1 :

| | | | | | | XL = 0 :

| | | | | | | | XP = 0 : 1

| | | | | | | | XP = 1 :

| | | | | | | | | XB = 0 : 1

| | | | | | | | | XB = 1 : 0

| | | | | | | XL = 1 :

| | | | | | | | XP = 0 : 0

| | | | | | | | XP = 1 :

| | | | | | | | | XQ = 0 : 1

| | | | | | | | | XQ = 1 :

| | | | | | | | | | XB = 0 : 1

| | | | | | | | | | XB = 1 : 0

| | | | XG = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XH = 0 : 0

| | | | | | XH = 1 :

| | | | | | | XL = 0 : 1

| | | | | | | XL = 1 : 0

| | | XS = 1 :

| | | | XR = 0 :

| | | | | XN = 0 : 1

| | | | | XN = 1 :

| | | | | | XH = 0 :

| | | | | | | XJ = 0 :

| | | | | | | | XM = 0 :

| | | | | | | | | XD = 0 : 0

| | | | | | | | | XD = 1 : 1

| | | | | | | | XM = 1 : 1

| | | | | | | XJ = 1 : 1

| | | | | | XH = 1 :

| | | | | | | XT = 0 : 0

| | | | | | | XT = 1 :

| | | | | | | | XF = 0 : 0

| | | | | | | | XF = 1 : 1

| | | | XR = 1 :

| | | | | XG = 0 :

| | | | | | XM = 0 :

| | | | | | | XH = 0 : 0

| | | | | | | XH = 1 :

| | | | | | | | XB = 0 : 1

| | | | | | | | XB = 1 :

| | | | | | | | | XF = 0 : 1

| | | | | | | | | XF = 1 : 0

| | | | | | XM = 1 :

| | | | | | | XD = 0 : 0

| | | | | | | XD = 1 : 1

| | | | | XG = 1 : 0

| | XC = 1 :

| | | XD = 0 :

| | | | XS = 0 :

| | | | | XF = 0 :

| | | | | | XB = 0 : 0

| | | | | | XB = 1 :

| | | | | | | XE = 0 : 0

| | | | | | | XE = 1 : 1

| | | | | XF = 1 :

| | | | | | XP = 0 : 1

| | | | | | XP = 1 :

| | | | | | | XH = 0 : 1

| | | | | | | XH = 1 :

| | | | | | | | XL = 0 :

| | | | | | | | | XJ = 0 : 1

| | | | | | | | | XJ = 1 :

| | | | | | | | | | XN = 0 : 0

| | | | | | | | | | XN = 1 : 1

| | | | | | | | XL = 1 : 0

| | | | XS = 1 :

| | | | | XJ = 0 :

| | | | | | XM = 0 : 0

| | | | | | XM = 1 :

| | | | | | | XQ = 0 :

| | | | | | | | XB = 0 : 1

| | | | | | | | XB = 1 :

| | | | | | | | | XF = 0 :

| | | | | | | | | | XH = 0 : 0

| | | | | | | | | | XH = 1 : 1

| | | | | | | | | XF = 1 : 1

| | | | | | | XQ = 1 : 0

| | | | | XJ = 1 :

| | | | | | XO = 0 :

| | | | | | | XF = 0 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 : 1

| | | | | | | XF = 1 : 1

| | | | | | XO = 1 :

| | | | | | | XR = 0 :

| | | | | | | | XB = 0 :

| | | | | | | | | XH = 0 : 0

| | | | | | | | | XH = 1 : 1

| | | | | | | | XB = 1 : 1

| | | | | | | XR = 1 : 1

| | | XD = 1 :

| | | | XF = 0 : 0

| | | | XF = 1 :

| | | | | XO = 0 : 0

| | | | | XO = 1 :

| | | | | | XP = 0 : 0

| | | | | | XP = 1 : 1

| XK = 1 :

| | XD = 0 :

| | | XT = 0 :

| | | | XF = 0 :

| | | | | XB = 0 :

| | | | | | XR = 0 : 0

| | | | | | XR = 1 :

| | | | | | | XO = 0 : 1

| | | | | | | XO = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | | | XB = 1 :

| | | | | | XO = 0 : 0

| | | | | | XO = 1 : 1

| | | | XF = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XH = 0 :

| | | | | | | XL = 0 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 :

| | | | | | | | | XG = 0 : 1

| | | | | | | | | XG = 1 : 0

| | | | | | | XL = 1 : 1

| | | | | | XH = 1 :

| | | | | | | XE = 0 : 1

| | | | | | | XE = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | XT = 1 :

| | | | XB = 0 :

| | | | | XC = 0 :

| | | | | | XM = 0 : 1

| | | | | | XM = 1 :

| | | | | | | XJ = 0 : 0

| | | | | | | XJ = 1 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 : 1

| | | | | XC = 1 :

| | | | | | XE = 0 :

| | | | | | | XF = 0 : 0

| | | | | | | XF = 1 : 1

| | | | | | XE = 1 :

| | | | | | | XM = 0 :

| | | | | | | | XQ = 0 : 1

| | | | | | | | XQ = 1 : 0

| | | | | | | XM = 1 : 1

| | | | XB = 1 : 0

| | XD = 1 : 0

Accuracy of decision tree constructed using impurity gain after pruning: 74.5%

Decision tree after pruning:

XI = 0 :

| XU = 0 :

| | XQ = 0 :

| | | XF = 0 :

| | | | XO = 0 :

| | | | | XB = 0 :

| | | | | | XJ = 0 : 0

| | | | | | XJ = 1 :

| | | | | | | XG = 0 : 0

| | | | | | | XG = 1 : 1

| | | | | XB = 1 : 0

| | | | XO = 1 :

| | | | | XB = 0 :

| | | | | | XD = 0 :

| | | | | | | XM = 0 : 1

| | | | | | | XM = 1 : 0

| | | | | | XD = 1 : 0

| | | | | XB = 1 :

| | | | | | XH = 0 :

| | | | | | | XS = 0 : 1

| | | | | | | XS = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | | | | XH = 1 : 1

| | | XF = 1 : 0

| | XQ = 1 :

| | | XB = 0 :

| | | | XF = 0 :

| | | | | XG = 0 : 0

| | | | | XG = 1 :

| | | | | | XL = 0 :

| | | | | | | XS = 0 : 0

| | | | | | | XS = 1 : 1

| | | | | | XL = 1 : 0

| | | | XF = 1 : 1

| | | XB = 1 :

| | | | XO = 0 : 0

| | | | XO = 1 :

| | | | | XM = 0 :

| | | | | | XF = 0 :

| | | | | | | XP = 0 :

| | | | | | | | XL = 0 :

| | | | | | | | | XC = 0 : 1

| | | | | | | | | XC = 1 :

| | | | | | | | | | XK = 0 :

| | | | | | | | | | | XE = 0 : 0

| | | | | | | | | | | XE = 1 : 0

| | | | | | | | | | XK = 1 : 1

| | | | | | | | XL = 1 : 0

| | | | | | | XP = 1 : 1

| | | | | | XF = 1 : 0

| | | | | XM = 1 : 0

| XU = 1 :

| | XG = 0 :

| | | XS = 0 :

| | | | XB = 0 :

| | | | | XF = 0 : 0

| | | | | XF = 1 :

| | | | | | XQ = 0 : 0

| | | | | | XQ = 1 :

| | | | | | | XC = 0 : 1

| | | | | | | XC = 1 :

| | | | | | | | XH = 0 :

| | | | | | | | | XD = 0 : 0

| | | | | | | | | XD = 1 : 1

| | | | | | | | XH = 1 :

| | | | | | | | | XJ = 0 :

| | | | | | | | | | XN = 0 : 1

| | | | | | | | | | XN = 1 : 0

| | | | | | | | | XJ = 1 : 1

| | | | XB = 1 :

| | | | | XO = 0 : 0

| | | | | XO = 1 :

| | | | | | XJ = 0 :

| | | | | | | XC = 0 : 0

| | | | | | | XC = 1 :

| | | | | | | | XD = 0 : 0

| | | | | | | | XD = 1 : 1

| | | | | | XJ = 1 : 1

| | | XS = 1 :

| | | | XO = 0 : 0

| | | | XO = 1 :

| | | | | XL = 0 :

| | | | | | XN = 0 :

| | | | | | | XJ = 0 : 1

| | | | | | | XJ = 1 : 0

| | | | | | XN = 1 : 1

| | | | | XL = 1 : 0

| | XG = 1 : 0

XI = 1 :

| XK = 0 :

| | XC = 0 :

| | | XS = 0 :

| | | | XG = 0 :

| | | | | XM = 0 : 1

| | | | | XM = 1 :

| | | | | | XT = 0 : 1

| | | | | | XT = 1 :

| | | | | | | XL = 0 :

| | | | | | | | XP = 0 : 1

| | | | | | | | XP = 1 :

| | | | | | | | | XB = 0 : 1

| | | | | | | | | XB = 1 : 0

| | | | | | | XL = 1 :

| | | | | | | | XP = 0 : 0

| | | | | | | | XP = 1 :

| | | | | | | | | XQ = 0 : 1

| | | | | | | | | XQ = 1 :

| | | | | | | | | | XB = 0 : 1

| | | | | | | | | | XB = 1 : 0

| | | | XG = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XH = 0 : 0

| | | | | | XH = 1 :

| | | | | | | XL = 0 : 1

| | | | | | | XL = 1 : 0

| | | XS = 1 :

| | | | XR = 0 :

| | | | | XN = 0 : 1

| | | | | XN = 1 :

| | | | | | XH = 0 :

| | | | | | | XJ = 0 :

| | | | | | | | XM = 0 : 0

| | | | | | | | XM = 1 : 1

| | | | | | | XJ = 1 : 1

| | | | | | XH = 1 :

| | | | | | | XT = 0 : 0

| | | | | | | XT = 1 :

| | | | | | | | XF = 0 : 0

| | | | | | | | XF = 1 : 1

| | | | XR = 1 :

| | | | | XG = 0 :

| | | | | | XM = 0 : 1

| | | | | | XM = 1 :

| | | | | | | XD = 0 : 0

| | | | | | | XD = 1 : 1

| | | | | XG = 1 : 0

| | XC = 1 :

| | | XD = 0 :

| | | | XS = 0 :

| | | | | XF = 0 :

| | | | | | XB = 0 : 0

| | | | | | XB = 1 :

| | | | | | | XE = 0 : 0

| | | | | | | XE = 1 : 1

| | | | | XF = 1 :

| | | | | | XP = 0 : 1

| | | | | | XP = 1 :

| | | | | | | XH = 0 : 1

| | | | | | | XH = 1 :

| | | | | | | | XL = 0 :

| | | | | | | | | XJ = 0 : 1

| | | | | | | | | XJ = 1 :

| | | | | | | | | | XN = 0 : 0

| | | | | | | | | | XN = 1 : 1

| | | | | | | | XL = 1 : 0

| | | | XS = 1 :

| | | | | XJ = 0 :

| | | | | | XM = 0 : 0

| | | | | | XM = 1 :

| | | | | | | XQ = 0 :

| | | | | | | | XB = 0 : 1

| | | | | | | | XB = 1 :

| | | | | | | | | XF = 0 : 1

| | | | | | | | | XF = 1 : 1

| | | | | | | XQ = 1 : 0

| | | | | XJ = 1 :

| | | | | | XO = 0 :

| | | | | | | XF = 0 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 : 1

| | | | | | | XF = 1 : 1

| | | | | | XO = 1 :

| | | | | | | XR = 0 :

| | | | | | | | XB = 0 :

| | | | | | | | | XH = 0 : 0

| | | | | | | | | XH = 1 : 1

| | | | | | | | XB = 1 : 1

| | | | | | | XR = 1 : 1

| | | XD = 1 :

| | | | XF = 0 : 0

| | | | XF = 1 :

| | | | | XO = 0 : 0

| | | | | XO = 1 :

| | | | | | XP = 0 : 0

| | | | | | XP = 1 : 1

| XK = 1 :

| | XD = 0 :

| | | XT = 0 :

| | | | XF = 0 :

| | | | | XB = 0 :

| | | | | | XR = 0 : 0

| | | | | | XR = 1 :

| | | | | | | XO = 0 : 1

| | | | | | | XO = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | | | XB = 1 :

| | | | | | XO = 0 : 0

| | | | | | XO = 1 : 1

| | | | XF = 1 :

| | | | | XO = 0 : 1

| | | | | XO = 1 :

| | | | | | XH = 0 :

| | | | | | | XL = 0 :

| | | | | | | | XE = 0 : 0

| | | | | | | | XE = 1 :

| | | | | | | | | XG = 0 : 1

| | | | | | | | | XG = 1 : 0

| | | | | | | XL = 1 : 1

| | | | | | XH = 1 :

| | | | | | | XE = 0 : 1

| | | | | | | XE = 1 :

| | | | | | | | XL = 0 : 1

| | | | | | | | XL = 1 : 0

| | | XT = 1 :

| | | | XB = 0 : 1

| | | | XB = 1 : 0

| | XD = 1 : 0