HW5

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Task 1

optimized

data.txt

```
tree= 1, node=  1, feature=15, thr= 21.57, gain=0.621424
tree= 1, node=  2, feature= 4, thr= 41.18, gain=0.587628
tree= 1, node=  3, feature=13, thr= 58.82, gain=0.697235
tree= 1, node=  4, feature= 9, thr= 15.69, gain=0.670083
tree= 1, node=  5, feature=10, thr= 39.22, gain=0.629044
tree= 1, node=  6, feature= 0, thr= 35.29, gain=0.712500
tree= 1, node=  7, feature= 8, thr= 56.86, gain=0.814218
tree= 1, node=  8, feature=14, thr= 60.78, gain=0.475710
tree= 1, node=  9, feature= 5, thr= 64.71, gain=0.620325
tree= 1, node= 10, feature=14, thr= 37.25, gain=0.224713
tree= 1, node= 11, feature= 3, thr= 90.20, gain=0.686759
tree= 1, node= 12, feature=14, thr= 37.25, gain=0.281171
tree= 1, node= 13, feature=10, thr= 29.41, gain=0.584898
tree= 1, node= 14, feature=14, thr= 96.08, gain=0.737506
tree= 1, node= 15, feature= 7, thr= 24.33, gain=0.205385
tree= 1, node= 16, feature= 1, thr= 73.53, gain=0.027989
tree= 1, node= 17, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 18, feature=15, thr=  0.41, gain=0.188928
tree= 1, node= 19, feature= 9, thr= 60.47, gain=0.530651
tree= 1, node= 20, feature=12, thr= 30.06, gain=0.640257
tree= 1, node= 21, feature= 8, thr= 34.59, gain=0.140904
tree= 1, node= 22, feature= 6, thr= 72.55, gain=0.509615
tree= 1, node= 23, feature= 7, thr= 77.10, gain=0.409412
tree= 1, node= 24, feature= 1, thr= 84.51, gain=0.550957
tree= 1, node= 25, feature=13, thr= 14.78, gain=0.131381
tree= 1, node= 26, feature=15, thr= 31.18, gain=0.222560
tree= 1, node= 27, feature= 9, thr= 19.61, gain=0.464511
tree= 1, node= 28, feature=11, thr= 31.67, gain=0.157508
tree= 1, node= 29, feature=13, thr= 71.06, gain=0.344859
tree= 1, node= 30, feature= 2, thr= 54.90, gain=0.092930
tree= 1, node= 31, feature= 9, thr= 58.82, gain=0.918296
tree= 1, node= 32, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 33, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 34, feature= 7, thr= 66.47, gain=0.110097
tree= 1, node= 35, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node= 36, feature=14, thr= 25.49, gain=0.773333
tree= 1, node= 37, feature= 0, thr= 39.22, gain=0.203813
tree= 1, node= 38, feature= 3, thr= 96.71, gain=0.374672
tree= 1, node= 39, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 40, feature= 9, thr=  1.43, gain=0.077936
tree= 1, node= 41, feature= 6, thr= 68.14, gain=0.274080
tree= 1, node= 42, feature=14, thr= 96.08, gain=0.341335
tree= 1, node= 43, feature= 1, thr= 82.35, gain=0.324193
tree= 1, node= 44, feature= 2, thr= 88.59, gain=0.253482
tree= 1, node= 45, feature= 5, thr= 89.29, gain=0.811518
tree= 1, node= 46, feature= 8, thr= 76.47, gain=0.650022
tree= 1, node= 47, feature= 6, thr= 50.47, gain=0.757526
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tree= 1, node= 49, feature= 3, thr= 87.45, gain=0.051386
tree= 1, node= 50, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 51, feature= 0, thr= 53.57, gain=0.129949
tree= 1, node= 52, feature=15, thr= 67.29, gain=0.265884
tree= 1, node= 53, feature=10, thr= 67.06, gain=0.773029
tree= 1, node= 54, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node= 61, feature= 1, thr=  3.92, gain=0.998846
tree= 1, node= 62, feature= 5, thr= 13.35, gain=0.035341
tree= 1, node= 63, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 64, feature= 7, thr= 71.86, gain=0.496889
tree= 1, node= 65, feature=10, thr= 60.78, gain=0.864204
tree= 1, node= 66, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 67, feature= 1, thr= 92.47, gain=0.078528
tree= 1, node= 68, feature= 5, thr= 68.63, gain=0.135036
tree= 1, node= 69, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 70, feature= 8, thr= 18.67, gain=0.368566
tree= 1, node= 71, feature= 7, thr= 73.02, gain=0.050120
tree= 1, node= 72, feature=12, thr= 55.47, gain=0.287642
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tree= 1, node= 90, feature= 4, thr= 62.75, gain=0.149994
tree= 1, node= 91, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 92, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node= 93, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=119, feature=11, thr=  9.06, gain=0.541116
tree= 1, node=120, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=121, feature= 7, thr= 67.06, gain=0.321696
tree= 1, node=122, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=123, feature= 0, thr= 60.78, gain=0.098830
tree= 1, node=124, feature= 9, thr= 18.55, gain=0.134335
tree= 1, node=125, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=126, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=127, feature= 1, thr= 79.29, gain=0.678954
tree= 1, node=128, feature= 4, thr= 48.04, gain=0.291818
tree= 1, node=129, feature=11, thr= 39.69, gain=0.517478
tree= 1, node=130, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=149, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=150, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=151, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=153, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=156, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=157, feature= 3, thr= 89.02, gain=0.028237
tree= 1, node=158, feature= 8, thr= 24.51, gain=0.021367
tree= 1, node=159, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=160, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=161, feature=14, thr= 52.94, gain=0.111623
tree= 1, node=162, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=164, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=166, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=167, feature= 2, thr= 45.71, gain=0.103275
tree= 1, node=168, feature= 7, thr= 17.69, gain=0.008314
tree= 1, node=169, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=170, feature= 1, thr= 81.37, gain=0.056120
tree= 1, node=171, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=172, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=176, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=177, feature=15, thr=  9.12, gain=0.021405
tree= 1, node=178, feature= 6, thr= 21.57, gain=0.053910
tree= 1, node=179, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=180, feature= 1, thr= 66.67, gain=0.077022
tree= 1, node=181, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=182, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=183, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=184, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=185, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=186, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=187, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=188, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=189, feature= 3, thr= 99.12, gain=0.041635
tree= 1, node=190, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=191, feature= 2, thr= 41.47, gain=0.067329
tree= 1, node=192, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=193, feature= 2, thr= 86.33, gain=0.018695
tree= 1, node=194, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=195, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=196, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=197, feature=-1, thr= -1.00, gain=0.000000
classification accuracy=0.8382
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randomized

```
tree= 1, node=  1, feature=11, thr= 35.29, gain=0.466267
tree= 1, node=  2, feature= 4, thr= 45.10, gain=0.525995
tree= 1, node=  3, feature= 4, thr= 35.29, gain=0.579050
tree= 1, node=  4, feature=13, thr=  8.33, gain=0.712979
tree= 1, node=  5, feature= 1, thr= 79.73, gain=0.228608
tree= 1, node=  6, feature= 6, thr=  9.80, gain=0.081891
tree= 1, node=  7, feature=15, thr= 68.63, gain=0.725088
tree= 1, node=  8, feature=13, thr=  0.16, gain=0.233468
tree= 1, node=  9, feature= 5, thr= 63.02, gain=0.200975
tree= 1, node= 10, feature= 0, thr= 74.51, gain=0.083994
tree= 1, node= 11, feature= 3, thr= 94.22, gain=0.217031
tree= 1, node= 12, feature=12, thr= 56.16, gain=0.271621
tree= 1, node= 13, feature=14, thr= 50.98, gain=0.334705
tree= 1, node= 14, feature= 7, thr= 60.78, gain=0.406972
tree= 1, node= 15, feature=14, thr= 88.24, gain=0.895108
tree= 1, node= 16, feature= 9, thr= 60.59, gain=0.349127
tree= 1, node= 17, feature= 2, thr= 43.14, gain=0.687160
tree= 1, node= 18, feature= 2, thr= 19.53, gain=0.106781
tree= 1, node= 19, feature= 9, thr= 29.57, gain=0.216972
tree= 1, node= 20, feature= 4, thr= 87.29, gain=0.124331
tree= 1, node= 21, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 22, feature=12, thr= 72.55, gain=0.544897
tree= 1, node= 23, feature=15, thr= 17.12, gain=0.806056
tree= 1, node= 24, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 25, feature= 0, thr= 43.14, gain=0.113316
tree= 1, node= 26, feature= 8, thr= 56.86, gain=0.149521
tree= 1, node= 27, feature=13, thr= 54.43, gain=0.396916
tree= 1, node= 28, feature= 3, thr= 56.86, gain=0.872888
tree= 1, node= 29, feature=13, thr= 17.04, gain=0.307837
tree= 1, node= 30, feature= 2, thr= 41.18, gain=0.087139
tree= 1, node= 31, feature= 1, thr= 85.18, gain=0.013515
tree= 1, node= 32, feature=10, thr= 43.14, gain=0.576291
tree= 1, node= 33, feature=12, thr= 42.76, gain=0.061507
tree= 1, node= 34, feature= 6, thr= 63.33, gain=0.184930
tree= 1, node= 35, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 36, feature= 1, thr= 99.06, gain=0.596212
tree= 1, node= 37, feature= 8, thr= 37.25, gain=0.040753
tree= 1, node= 38, feature= 3, thr= 99.12, gain=0.246690
tree= 1, node= 39, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 40, feature= 2, thr= 41.18, gain=0.154757
tree= 1, node= 41, feature= 5, thr= 99.27, gain=0.316606
tree= 1, node= 42, feature=10, thr= 68.63, gain=0.773969
tree= 1, node= 43, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 44, feature= 1, thr= 90.20, gain=0.063093
tree= 1, node= 45, feature= 9, thr= 25.88, gain=0.149629
tree= 1, node= 46, feature= 3, thr= 67.65, gain=0.451623
tree= 1, node= 47, feature=11, thr= 57.61, gain=0.341525
tree= 1, node= 48, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 49, feature=10, thr= 92.16, gain=0.162458
tree= 1, node= 50, feature= 5, thr= 68.24, gain=0.458984
tree= 1, node= 51, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 52, feature= 3, thr= 15.10, gain=0.171663
tree= 1, node= 53, feature=12, thr= 61.02, gain=0.464025
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tree= 1, node= 54, feature=13, thr=  6.33, gain=0.205162
tree= 1, node= 55, feature= 9, thr= 72.47, gain=0.069214
tree= 1, node= 56, feature= 7, thr=  6.18, gain=0.238826
tree= 1, node= 57, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 58, feature= 3, thr= 81.61, gain=0.136571
tree= 1, node= 59, feature=15, thr= 99.29, gain=0.002308
tree= 1, node= 60, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 61, feature= 8, thr= 83.76, gain=0.200388
tree= 1, node= 62, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 63, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 64, feature= 2, thr= 27.82, gain=0.236365
tree= 1, node= 65, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 66, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node= 67, feature=12, thr= 82.98, gain=0.437709
tree= 1, node= 68, feature= 2, thr= 47.18, gain=0.156983
tree= 1, node= 69, feature= 9, thr=  7.53, gain=0.235687
tree= 1, node= 70, feature=14, thr= 60.78, gain=0.619111
tree= 1, node= 71, feature= 7, thr= 32.53, gain=0.129734
tree= 1, node= 72, feature= 9, thr= 37.69, gain=0.334509
tree= 1, node= 73, feature=14, thr= 74.51, gain=0.575713
tree= 1, node= 74, feature= 4, thr= 96.24, gain=0.133920
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tree= 1, node= 78, feature= 0, thr= 66.67, gain=0.129902
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tree= 1, node= 84, feature= 7, thr= 50.04, gain=0.450067
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tree= 1, node= 86, feature=15, thr=  1.96, gain=0.924521
tree= 1, node= 87, feature=13, thr= 52.94, gain=0.634223
tree= 1, node= 88, feature= 7, thr= 63.71, gain=0.101500
tree= 1, node= 89, feature= 3, thr= 94.24, gain=0.086283
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tree= 1, node= 91, feature= 7, thr=  9.25, gain=0.042791
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tree= 1, node= 94, feature= 6, thr= 66.67, gain=0.053860
tree= 1, node= 95, feature= 8, thr= 58.82, gain=0.407930
tree= 1, node= 96, feature= 3, thr= 95.00, gain=0.448589
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tree= 1, node=108, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=109, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=110, feature= 5, thr= 56.12, gain=0.108514
```

```
tree= 1, node=111, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=112, feature= 2, thr= 52.94, gain=0.039855
tree= 1, node=113, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=114, feature= 8, thr= 55.59, gain=0.080136
tree= 1, node=115, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=116, feature= 7, thr= 24.04, gain=0.174551
tree= 1, node=117, feature=15, thr= 48.53, gain=0.711432
tree= 1, node=118, feature= 6, thr= 42.75, gain=0.087885
tree= 1, node=119, feature= 7, thr= 63.18, gain=0.240071
tree= 1, node=120, feature= 4, thr= 69.31, gain=0.443297
tree= 1, node=121, feature= 3, thr= 99.22, gain=0.242405
tree= 1, node=122, feature= 1, thr= 68.96, gain=0.141659
tree= 1, node=123, feature=15, thr= 25.53, gain=0.710094
tree= 1, node=124, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=125, feature= 0, thr= 30.08, gain=0.090455
tree= 1, node=126, feature=15, thr= 49.02, gain=0.629249
tree= 1, node=127, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=128, feature= 5, thr= 73.00, gain=0.143011
tree= 1, node=129, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=130, feature=14, thr= 45.10, gain=0.901124
tree= 1, node=131, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=132, feature=13, thr=  0.24, gain=0.149175
tree= 1, node=133, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=134, feature=10, thr=  1.29, gain=0.029725
tree= 1, node=135, feature= 9, thr= 10.37, gain=0.092138
tree= 1, node=136, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=137, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=138, feature= 5, thr= 44.55, gain=0.214128
tree= 1, node=139, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=140, feature= 7, thr= 67.45, gain=0.607801
tree= 1, node=141, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=142, feature=13, thr= 21.00, gain=0.473225
tree= 1, node=143, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=144, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=145, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=146, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=147, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=148, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=149, feature= 8, thr= 47.06, gain=0.083906
tree= 1, node=150, feature= 7, thr= 94.35, gain=0.247524
tree= 1, node=151, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=152, feature= 6, thr= 70.59, gain=0.379937
tree= 1, node=153, feature=12, thr= 52.78, gain=0.172178
tree= 1, node=154, feature= 7, thr= 99.47, gain=0.110441
tree= 1, node=155, feature= 6, thr= 94.12, gain=0.374643
tree= 1, node=156, feature=12, thr= 72.65, gain=0.042147
tree= 1, node=157, feature= 9, thr= 75.04, gain=0.130977
tree= 1, node=158, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=159, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=160, feature= 4, thr= 56.08, gain=0.035169
tree= 1, node=161, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=162, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=163, feature= 8, thr= 62.61, gain=0.120393
tree= 1, node=164, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=165, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=166, feature=12, thr= 88.24, gain=0.290595
tree= 1, node=167, feature=-1, thr= -1.00, gain=0.000000
```

```
tree= 1, node=168, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=169, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=170, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=171, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=172, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=173, feature=11, thr=  0.65, gain=0.018436
tree= 1, node=174, feature= 8, thr= 19.00, gain=0.111910
tree= 1, node=175, feature= 2, thr= 34.57, gain=0.071466
tree= 1, node=176, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=177, feature=11, thr=  3.43, gain=0.194907
tree= 1, node=178, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=179, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=180, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=181, feature= 5, thr= 85.75, gain=0.191114
tree= 1, node=182, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=183, feature= 6, thr= 55.02, gain=0.182523
tree= 1, node=184, feature= 5, thr= 77.24, gain=0.091179
tree= 1, node=185, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=186, feature= 4, thr= 92.24, gain=0.112812
tree= 1, node=187, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=188, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=189, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=190, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=191, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=192, feature= 8, thr= 63.76, gain=0.073177
tree= 1, node=193, feature= 7, thr= 53.65, gain=0.036491
tree= 1, node=194, feature= 6, thr= 51.06, gain=0.379190
tree= 1, node=195, feature= 8, thr= 60.78, gain=0.630990
tree= 1, node=196, feature= 5, thr= 68.71, gain=0.086705
tree= 1, node=197, feature= 1, thr= 87.06, gain=0.034561
tree= 1, node=198, feature= 2, thr= 71.37, gain=0.514666
tree= 1, node=199, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=200, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=201, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=202, feature=11, thr= 51.06, gain=0.158543
tree= 1, node=203, feature= 0, thr= 59.76, gain=0.133941
tree= 1, node=204, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=205, feature= 4, thr=  0.25, gain=0.141833
tree= 1, node=206, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=207, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=208, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=209, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=210, feature= 5, thr= 79.14, gain=0.169700
tree= 1, node=211, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=212, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=213, feature= 9, thr= 72.18, gain=0.341121
tree= 1, node=214, feature= 7, thr= 79.12, gain=0.046109
tree= 1, node=215, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=216, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=217, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=218, feature= 9, thr= 88.35, gain=0.078484
tree= 1, node=219, feature= 9, thr= 77.24, gain=0.059931
tree= 1, node=220, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=221, feature= 8, thr= 58.82, gain=0.391854
tree= 1, node=222, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=223, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=224, feature=-1, thr= -1.00, gain=0.000000
```

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tree= 1, node=225, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=226, feature= 9, thr=  0.12, gain=0.008724
tree= 1, node=227, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=228, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=229, feature= 2, thr= 55.86, gain=0.018107
tree= 1, node=230, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=231, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=232, feature= 5, thr= 99.35, gain=0.148599
tree= 1, node=233, feature=13, thr= 21.57, gain=0.515947
tree= 1, node=234, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=235, feature= 5, thr= 92.02, gain=0.062620
tree= 1, node=236, feature=15, thr= 34.29, gain=0.142194
tree= 1, node=237, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=238, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=239, feature= 2, thr= 58.71, gain=0.133145
tree= 1, node=240, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=241, feature=15, thr=  6.12, gain=0.297313
tree= 1, node=242, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=243, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=244, feature= 8, thr= 37.12, gain=0.160804
tree= 1, node=245, feature=14, thr=  0.88, gain=0.004867
tree= 1, node=246, feature=10, thr=  0.69, gain=0.010300
tree= 1, node=247, feature= 9, thr= 16.45, gain=0.135303
tree= 1, node=248, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=249, feature= 9, thr= 46.71, gain=0.604633
tree= 1, node=250, feature= 6, thr= 29.00, gain=0.217051
tree= 1, node=251, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=252, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=253, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=254, feature=14, thr= 31.37, gain=0.217507
tree= 1, node=255, feature= 8, thr=  6.75, gain=0.169075
tree= 1, node=256, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=257, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=258, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=259, feature=10, thr= 37.10, gain=0.042251
tree= 1, node=260, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=261, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=262, feature= 9, thr= 62.75, gain=0.841291
tree= 1, node=263, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=264, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=265, feature= 7, thr= 95.06, gain=0.391063
tree= 1, node=266, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=267, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=268, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=269, feature= 3, thr= 76.37, gain=0.335206
tree= 1, node=270, feature= 5, thr= 93.53, gain=0.206917
tree= 1, node=271, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=272, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=273, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=274, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=275, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=276, feature=12, thr= 65.76, gain=0.063937
tree= 1, node=277, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=278, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=279, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=280, feature= 3, thr=100.00, gain=0.000000
tree= 1, node=281, feature=-1, thr= -1.00, gain=0.000000
```

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tree= 1, node=282, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=283, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=284, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=285, feature=11, thr= 26.18, gain=0.115802
tree= 1, node=286, feature= 9, thr=  5.02, gain=0.144473
tree= 1, node=287, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=288, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=289, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=290, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=291, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=292, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=293, feature=10, thr= 99.14, gain=0.098534
tree= 1, node=294, feature=10, thr= 85.47, gain=0.009295
tree= 1, node=295, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=296, feature= 5, thr= 74.08, gain=0.017552
tree= 1, node=297, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=298, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=299, feature= 7, thr= 58.31, gain=0.038113
tree= 1, node=300, feature= 9, thr= 27.06, gain=0.175109
tree= 1, node=301, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=302, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=303, feature=10, thr= 29.41, gain=0.859953
tree= 1, node=304, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=305, feature= 0, thr=  8.47, gain=0.288011
tree= 1, node=306, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=307, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=308, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=309, feature= 7, thr= 23.86, gain=0.042517
tree= 1, node=310, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=311, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=312, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=313, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=314, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=315, feature= 3, thr= 85.33, gain=0.125103
tree= 1, node=316, feature= 7, thr= 97.02, gain=0.057693
tree= 1, node=317, feature= 2, thr= 30.55, gain=0.389630
tree= 1, node=318, feature= 2, thr= 50.12, gain=0.008009
tree= 1, node=319, feature=10, thr= 90.20, gain=0.162211
tree= 1, node=320, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=321, feature=12, thr= 49.29, gain=0.046275
tree= 1, node=322, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=323, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=324, feature= 3, thr=100.00, gain=0.000000
tree= 1, node=325, feature= 2, thr= 81.63, gain=0.075491
tree= 1, node=326, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=327, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=328, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=329, feature= 9, thr= 56.29, gain=0.134028
tree= 1, node=330, feature= 5, thr= 67.10, gain=0.018531
tree= 1, node=331, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=332, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=333, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=334, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=335, feature=10, thr= 29.41, gain=0.289986
tree= 1, node=336, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=337, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=338, feature=-1, thr= -1.00, gain=0.000000
```

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tree= 1, node=339, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=340, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=341, feature=15, thr=  0.00, gain=0.000000
tree= 1, node=342, feature=14, thr= 47.06, gain=0.036415
tree= 1, node=343, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=344, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=345, feature= 4, thr= 94.31, gain=0.135448
tree= 1, node=346, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=347, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=348, feature= 7, thr= 26.10, gain=0.263815
tree= 1, node=349, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=350, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=351, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=352, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=353, feature=15, thr= 32.84, gain=0.356191
tree= 1, node=354, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=355, feature= 0, thr= 54.84, gain=0.066136
tree= 1, node=356, feature=12, thr= 35.92, gain=0.103275
tree= 1, node=357, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=358, feature= 1, thr= 86.08, gain=0.014859
tree= 1, node=359, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=360, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=361, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=362, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=363, feature=14, thr=  0.27, gain=0.001909
tree= 1, node=364, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=365, feature= 2, thr= 36.24, gain=0.020133
tree= 1, node=366, feature= 6, thr=  7.84, gain=0.182455
tree= 1, node=367, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=368, feature=12, thr= 62.90, gain=0.012316
tree= 1, node=369, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=370, feature=11, thr= 18.20, gain=0.010269
tree= 1, node=371, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=372, feature= 4, thr= 67.18, gain=0.025345
tree= 1, node=373, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=374, feature= 9, thr=  4.02, gain=0.024275
tree= 1, node=375, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=376, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=377, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=378, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=379, feature=15, thr=  5.33, gain=0.015690
tree= 1, node=380, feature= 9, thr= 37.18, gain=0.040162
tree= 1, node=381, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=382, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=383, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=384, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=385, feature= 8, thr= 82.67, gain=0.089600
tree= 1, node=386, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=387, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=388, feature=11, thr= 17.12, gain=0.053474
tree= 1, node=389, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=390, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=391, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=392, feature= 6, thr= 39.45, gain=0.285419
tree= 1, node=393, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=394, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=395, feature=-1, thr= -1.00, gain=0.000000
```

```
tree= 1, node=396, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=397, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=398, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=399, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=400, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=401, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=402, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=403, feature=-1, thr= -1.00, gain=0.000000
classification accuracy=0.6944
```

forest3

```
tree= 1, node=  1, feature= 0, thr= 52.94, gain=0.321120
tree= 1, node=  2, feature=13, thr= 58.82, gain=0.639754
tree= 1, node=  3, feature=15, thr= 49.02, gain=0.604175
tree= 1, node=  4, feature=10, thr= 52.94, gain=0.576431
tree= 1, node=  5, feature= 5, thr= 28.53, gain=0.271499
tree= 1, node=  6, feature=15, thr=  0.96, gain=0.428072
tree= 1, node=  7, feature= 6, thr= 37.25, gain=0.290059
tree= 1, node=  8, feature=12, thr= 47.06, gain=0.268717
tree= 1, node=  9, feature= 0, thr=  1.02, gain=0.400228
tree= 1, node= 10, feature=14, thr= 86.27, gain=0.559245
tree= 1, node= 11, feature= 3, thr= 69.33, gain=0.318324
tree= 1, node= 12, feature= 9, thr= 49.02, gain=0.511165
tree= 1, node= 13, feature= 8, thr= 72.55, gain=0.525372
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tree= 1, node= 17, feature= 0, thr=  2.04, gain=0.177917
tree= 1, node= 18, feature= 2, thr= 21.57, gain=0.097121
tree= 1, node= 19, feature=14, thr=  3.92, gain=0.710378
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tree= 1, node= 25, feature=13, thr= 18.82, gain=0.251127
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tree= 1, node= 31, feature= 6, thr= 57.45, gain=0.142826
tree= 1, node= 32, feature=13, thr= 26.16, gain=0.498766
tree= 1, node= 33, feature= 1, thr= 85.55, gain=0.448934
tree= 1, node= 34, feature= 4, thr= 67.22, gain=0.089943
tree= 1, node= 35, feature= 2, thr= 39.12, gain=0.080546
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tree= 1, node= 37, feature=10, thr= 97.24, gain=0.456282
tree= 1, node= 38, feature= 9, thr= 55.73, gain=0.394265
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tree= 1, node= 50, feature= 9, thr= 25.49, gain=0.369963
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tree= 1, node= 53, feature= 0, thr= 61.29, gain=0.091993
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tree= 1, node= 63, feature=11, thr= 50.04, gain=0.064820
tree= 1, node= 64, feature= 3, thr= 95.24, gain=0.080129
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tree= 1, node= 72, feature= 3, thr= 96.08, gain=0.152981
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tree= 1, node=115, feature= 9, thr=  0.96, gain=0.711949
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tree= 1, node=223, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=224, feature=11, thr= 21.04, gain=0.096003
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tree= 1, node=322, feature= 7, thr= 39.39, gain=0.278670
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tree= 1, node=324, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=325, feature= 0, thr= 51.04, gain=0.110581
tree= 1, node=326, feature= 1, thr= 89.02, gain=0.000620
tree= 1, node=327, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=328, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=329, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=330, feature= 7, thr= 29.02, gain=0.050445
tree= 1, node=331, feature=14, thr= 13.53, gain=0.019462
tree= 1, node=332, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=333, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=334, feature= 6, thr= 71.37, gain=0.139233
tree= 1, node=335, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=336, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=337, feature= 6, thr= 48.24, gain=0.023489
tree= 1, node=338, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=339, feature= 7, thr= 58.69, gain=0.276584
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tree= 1, node=343, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=344, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=345, feature=10, thr= 94.12, gain=0.047237
tree= 1, node=346, feature=14, thr= 98.96, gain=0.030029
tree= 1, node=347, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=356, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=360, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=361, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=362, feature=12, thr= 43.06, gain=0.090544
tree= 1, node=363, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=384, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=385, feature= 1, thr= 98.14, gain=0.020799
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tree= 1, node=389, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=390, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=393, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=394, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=395, feature=13, thr= 36.41, gain=0.062760
```

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tree= 1, node=404, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=408, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=409, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=420, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=421, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=422, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=423, feature= 4, thr= 87.65, gain=0.028026
tree= 1, node=424, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=425, feature=10, thr=  0.90, gain=0.021706
tree= 1, node=426, feature=-1, thr= -1.00, gain=0.000000
tree= 1, node=427, feature= 8, thr= 18.43, gain=0.285761
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tree= 2, node=  3, feature= 1, thr= 76.47, gain=0.294116
tree= 2, node=  4, feature=15, thr=  0.02, gain=0.050731
tree= 2, node=  5, feature= 1, thr= 98.25, gain=0.442021
tree= 2, node=  6, feature=11, thr= 35.29, gain=0.473644
tree= 2, node=  7, feature=11, thr= 37.25, gain=0.568447
tree= 2, node=  8, feature= 3, thr= 98.08, gain=0.263606
tree= 2, node=  9, feature=-1, thr= -1.00, gain=0.000000
tree= 2, node= 10, feature= 1, thr= 79.24, gain=0.134450
tree= 2, node= 11, feature=15, thr= 67.33, gain=0.440282
tree= 2, node= 12, feature= 4, thr= 39.22, gain=0.306365
tree= 2, node= 13, feature= 5, thr= 52.94, gain=0.731120
tree= 2, node= 14, feature= 0, thr= 35.29, gain=0.407454
tree= 2, node= 15, feature=13, thr= 60.78, gain=0.890141
```

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tree= 2, node= 16, feature=14, thr= 27.45, gain=0.400219
tree= 2, node= 17, feature= 0, thr= 54.90, gain=0.567984
tree= 2, node= 18, feature=12, thr= 70.59, gain=0.263434
tree= 2, node= 19, feature= 0, thr= 47.06, gain=0.227530
tree= 2, node= 20, feature= 3, thr= 68.29, gain=0.091721
tree= 2, node= 21, feature= 9, thr= 22.06, gain=0.685663
tree= 2, node= 22, feature= 4, thr= 24.47, gain=0.399128
tree= 2, node= 23, feature=10, thr= 39.22, gain=0.559089
tree= 2, node= 24, feature= 1, thr=  4.47, gain=0.480723
tree= 2, node= 25, feature=11, thr= 53.29, gain=0.036226
tree= 2, node= 26, feature= 5, thr= 74.27, gain=0.090095
tree= 2, node= 27, feature= 6, thr= 49.22, gain=0.258678
tree= 2, node= 28, feature=10, thr= 50.98, gain=0.212410
tree= 2, node= 29, feature=13, thr= 99.24, gain=0.080939
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tree= 2, node= 32, feature=13, thr= 18.43, gain=0.877962
tree= 2, node= 33, feature= 0, thr= 99.12, gain=0.297328
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tree= 2, node= 72, feature=15, thr= 59.65, gain=0.898337
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tree= 2, node= 85, feature=14, thr=  0.82, gain=0.006781
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tree= 2, node= 87, feature= 1, thr= 65.43, gain=0.047387
tree= 2, node= 88, feature=10, thr= 65.49, gain=0.135116
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tree= 2, node= 93, feature= 7, thr= 52.59, gain=0.062466
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tree= 2, node=129, feature=-1, thr= -1.00, gain=0.000000
```

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tree= 2, node=130, feature=12, thr= 56.00, gain=0.076507
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tree= 2, node=145, feature= 3, thr= 99.06, gain=0.041739
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tree= 2, node=147, feature= 1, thr= 98.20, gain=0.096727
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tree= 2, node=173, feature=-1, thr= -1.00, gain=0.000000
tree= 2, node=174, feature=-1, thr= -1.00, gain=0.000000
tree= 2, node=175, feature=14, thr= 95.69, gain=0.019795
tree= 2, node=176, feature=-1, thr= -1.00, gain=0.000000
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tree= 2, node=183, feature= 8, thr= 19.29, gain=0.690916
tree= 2, node=184, feature=15, thr= 55.53, gain=0.254596
tree= 2, node=185, feature=11, thr= 15.27, gain=0.036163
tree= 2, node=186, feature= 8, thr= 65.88, gain=0.105591
```

```
tree= 2, node=187, feature=-1, thr= -1.00, gain=0.000000
tree= 2, node=188, feature=-1, thr= -1.00, gain=0.000000
tree= 2, node=189, feature= 2, thr= 63.41, gain=0.062116
tree= 2, node=190, feature= 1, thr= 74.35, gain=0.080388
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tree= 2, node=197, feature=-1, thr= -1.00, gain=0.000000
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tree= 2, node=199, feature=-1, thr= -1.00, gain=0.000000
tree= 2, node=200, feature=-1, thr= -1.00, gain=0.000000
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tree= 2, node=202, feature= 7, thr= 55.80, gain=0.127290
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tree= 2, node=216, feature=-1, thr= -1.00, gain=0.000000
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tree= 2, node=223, feature= 8, thr= 88.02, gain=0.076465
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tree= 2, node=228, feature= 9, thr= 88.47, gain=0.013140
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tree= 2, node=233, feature=14, thr=  1.80, gain=0.302327
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tree= 2, node=242, feature= 8, thr= 35.29, gain=0.212001
tree= 2, node=243, feature=-1, thr= -1.00, gain=0.000000
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tree= 2, node=307, feature=15, thr= 60.47, gain=0.055863
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tree= 3, node= 11, feature= 6, thr= 68.63, gain=0.158005
tree= 3, node= 12, feature= 1, thr= 89.02, gain=0.281091
tree= 3, node= 13, feature= 6, thr= 74.51, gain=0.410632
tree= 3, node= 14, feature= 9, thr= 56.86, gain=0.482827
tree= 3, node= 15, feature= 2, thr= 25.49, gain=0.157902
tree= 3, node= 16, feature= 0, thr= 60.78, gain=0.230597
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tree= 3, node= 17, feature= 8, thr= 54.90, gain=0.705469
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tree= 3, node= 72, feature= 6, thr= 17.65, gain=0.445384
tree= 3, node= 73, feature= 2, thr= 19.06, gain=0.296882
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tree= 3, node=351, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=352, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=353, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=354, feature= 3, thr= 92.63, gain=0.359454
tree= 3, node=355, feature=15, thr=  6.18, gain=0.015912
tree= 3, node=356, feature= 4, thr= 98.12, gain=0.132811
tree= 3, node=357, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=358, feature=-1, thr= -1.00, gain=0.000000
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tree= 3, node=359, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=360, feature= 0, thr= 14.12, gain=0.411691
tree= 3, node=361, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=362, feature= 8, thr= 46.88, gain=0.058337
tree= 3, node=363, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=364, feature=10, thr= 18.67, gain=0.044445
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tree= 3, node=366, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=367, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=368, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=369, feature= 3, thr= 99.06, gain=0.058192
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tree= 3, node=371, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=372, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=373, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=374, feature=-1, thr= -1.00, gain=0.000000
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tree= 3, node=377, feature= 5, thr= 53.08, gain=0.017026
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tree= 3, node=380, feature=13, thr= 52.31, gain=0.056220
tree= 3, node=381, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=382, feature= 3, thr= 73.53, gain=0.021324
tree= 3, node=383, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=384, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=385, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=386, feature= 1, thr= 70.39, gain=0.191131
tree= 3, node=387, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=388, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=389, feature= 6, thr= 56.63, gain=0.469945
tree= 3, node=390, feature= 2, thr= 85.88, gain=0.059706
tree= 3, node=391, feature=13, thr=  0.18, gain=0.000436
tree= 3, node=392, feature=14, thr= 20.69, gain=0.034519
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tree= 3, node=396, feature=-1, thr= -1.00, gain=0.000000
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tree= 3, node=401, feature=10, thr= 28.94, gain=0.330291
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tree= 3, node=406, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=407, feature= 5, thr= 54.37, gain=0.006809
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tree= 3, node=409, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=410, feature= 9, thr= 47.06, gain=0.189914
tree= 3, node=411, feature= 1, thr= 93.31, gain=0.184544
tree= 3, node=412, feature= 0, thr= 70.59, gain=0.041437
tree= 3, node=413, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=414, feature=12, thr= 59.20, gain=0.067855
tree= 3, node=415, feature=-1, thr= -1.00, gain=0.000000
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tree= 3, node=416, feature=-1, thr= -1.00, gain=0.000000
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tree= 3, node=418, feature=11, thr=  3.59, gain=0.022967
tree= 3, node=419, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=420, feature=12, thr= 32.98, gain=0.597426
tree= 3, node=421, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=422, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=423, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=424, feature= 9, thr=  1.57, gain=0.121480
tree= 3, node=425, feature=-1, thr= -1.00, gain=0.000000
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tree= 3, node=428, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=429, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=430, feature=10, thr= 76.29, gain=0.058732
tree= 3, node=431, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=432, feature=14, thr=  0.02, gain=0.000039
tree= 3, node=433, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=434, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=435, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=436, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=437, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=438, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=439, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=440, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=441, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=442, feature= 0, thr= 63.41, gain=0.028092
tree= 3, node=443, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=444, feature=-1, thr= -1.00, gain=0.000000
tree= 3, node=445, feature=-1, thr= -1.00, gain=0.000000
classification accuracy=0.8399
```

Task 2

a)

$E = -\frac{80}{100}log_2(\frac{80}{100}) - \frac{20}{100}log_2(\frac{20}{100}) = 0.72192$

b)

$E = -\frac{80}{100}log_2(\frac{80}{100}) - \frac{20}{100}log_2(\frac{20}{100}) = 0.72192$

$E_1 = -\frac{20}{35}log_2(\frac{20}{35}) - \frac{15}{35}log_2(\frac{15}{35}) = 0.985232$

$E_2 = -\frac{5}{65}log_2(\frac{5}{65}) - \frac{60}{65}log_2(\frac{60}{65}) = 0.391268$

$I(E,0) = E - \frac{35}{100}E_1 - \frac{65}{100}E_2 = 0.12276$

c)

The information gain for Node E is 0 since all examples at Node E will already be of the same class,ie yes for the weekend, so there is no information gain.

d)

They will end up at Node F.
The decision is to wait.

e)

They will end up at Node H.
The decision is to not wait.

Task 3

Calculated using choose_attribute function in decision_tree.py:
$E = 1$ since even distribution of classes at root node. Information gain of attribute A:
$E_1 = -\frac{3}{3}log_2(\frac{3}{3}) = 0$

$E_2 = -\frac{1}{4}log_2(\frac{1}{4}) - \frac{3}{4}log_2(\frac{3}{4}) = 0.8113$

$E_3 = -\frac{1}{3}log_2(\frac{1}{3}) - \frac{2}{3}log_2(\frac{2}{3}) = 0.9183$

$I(E,0) = E - \frac{3}{10}E_1 - \frac{4}{10}E_2 - \frac{3}{10}E_3 = 0.3999$

Information gain of attribute B:
$E_1 = -\frac{1}{4}log_2(\frac{1}{4}) - \frac{3}{4}log_2(\frac{3}{4}) = 0.8113$

$E_2 = -\frac{3}{4}log_2(\frac{3}{4}) - \frac{1}{4}log_2(\frac{1}{4}) = 0.8113$

$E_3 = -\frac{1}{2}log_2(\frac{1}{2}) - \frac{1}{2}log_2(\frac{1}{2}) = 1$

$I(E,0) = E - \frac{4}{10}E_1 - \frac{4}{10}E_2 - \frac{2}{10}E_3 = 0.1509$

Information gain of attribute C:
$E_1 = -\frac{1}{5}log_2(\frac{1}{5}) - \frac{4}{5}log_2(\frac{4}{5}) = 0.7219$

$E_2 = -\frac{3}{4}log_2(\frac{3}{4}) - \frac{1}{4}log_2(\frac{1}{4}) = 0.8113$

$E_3 = -1 * log_2(1) - 0 * log_2(0) = 0$

$I(E,0) = E - \frac{5}{10}E_1 - \frac{4}{10}E_2 - \frac{1}{10}E_3 = 0.3145$

A has the highest information gain at the root node.

Task 4

a)

Highest Value: each class has 250 objects
$E = \frac{-250}{1000}log_2(\frac{250}{1000}) * 4 = 2$

Lowest Value: only one class
$E = \frac{-1000}{1000}log_2(\frac{1000}{1000}) - 0 * log_2(0) - 0 * log_2(0) - 0 * log_2(0) = 0$

b)

Highest Value: 2
Occurs if parent is evenly split and each child only contains one class.

Lowest Value: 0
Occurs if parent is evenly split and each child is evenly split as well.

Task 5

We could create a forest of decision trees that have nodes that maximize the information gain at each node, and take the average of the forest outputs as the output of the classifier. This could allow us to increase the accuracy of the classifier, however we cannot guarantee a classification accuracy of 60%.