Nghia Lam

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Task 1

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decision_tree.py pendigits_training pendigits_test optimized 50:

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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= 36, feature= 7, thr= 66.47, gain=0.110097

tree= 1, node= 37, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 38, feature=14, thr= 25.49, gain=0.773333

tree= 1, node= 39, feature= 0, thr= 39.22, gain=0.203813

tree= 1, node= 40, feature= 3, thr= 96.71, gain=0.374672

tree= 1, node= 41, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 42, feature= 9, thr= 1.43, gain=0.077936

tree= 1, node= 43, feature= 6, thr= 68.14, gain=0.274080

tree= 1, node= 44, feature=14, thr= 96.08, gain=0.341335

tree= 1, node= 45, feature= 1, thr= 82.35, gain=0.324193

tree= 1, node= 46, feature= 2, thr= 88.59, gain=0.253482

tree= 1, node= 47, feature= 5, thr= 89.29, gain=0.811518

tree= 1, node= 48, feature= 8, thr= 76.47, gain=0.650022

tree= 1, node= 49, feature= 6, thr= 50.47, gain=0.757526

tree= 1, node= 50, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 51, feature= 3, thr= 87.45, gain=0.051386

tree= 1, node= 52, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 53, feature= 0, thr= 53.57, gain=0.129949

tree= 1, node= 54, feature=15, thr= 67.29, gain=0.265884

tree= 1, node= 55, feature=10, thr= 67.06, gain=0.773029

tree= 1, node= 56, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 57, feature=12, thr= 21.57, gain=0.159034

tree= 1, node= 58, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 59, feature= 5, thr= 54.41, gain=0.006884

tree= 1, node= 60, feature= 6, thr= 96.08, gain=0.024998

tree= 1, node= 61, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 62, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 63, feature= 1, thr= 3.92, gain=0.998846

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tree= 1, node= 72, feature= 5, thr= 13.35, gain=0.035341

tree= 1, node= 73, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 76, feature= 7, thr= 71.86, gain=0.496889

tree= 1, node= 77, feature=10, thr= 60.78, gain=0.864204

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tree= 1, node= 79, feature= 1, thr= 92.47, gain=0.078528

tree= 1, node= 80, feature= 5, thr= 68.63, gain=0.135036

tree= 1, node= 81, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 84, feature= 8, thr= 18.67, gain=0.368566

tree= 1, node= 85, feature= 7, thr= 73.02, gain=0.050120

tree= 1, node= 86, feature=12, thr= 55.47, gain=0.287642

tree= 1, node= 87, feature= 8, thr= 49.82, gain=0.208356

tree= 1, node= 88, feature= 1, thr= 39.18, gain=0.308576

tree= 1, node= 89, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 90, feature= 5, thr= 15.69, gain=0.106446

tree= 1, node= 91, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 92, feature= 0, thr= 78.43, gain=0.174910

tree= 1, node= 93, feature= 5, thr= 84.31, gain=0.901825

tree= 1, node= 94, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 95, feature= 6, thr= 70.59, gain=0.988057

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tree= 1, node=103, feature= 8, thr=  1.96, gain=0.027154

tree= 1, node=106, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=107, feature=14, thr=  1.96, gain=0.057144

tree= 1, node=108, feature= 4, thr= 62.75, gain=0.149994

tree= 1, node=109, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=118, feature=-1, thr= -1.00, gain=0.000000
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tree= 1, node=119, feature= 6, thr= 45.33, gain=0.097300

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tree= 1, node=126, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=145, feature=13, thr= 6.08, gain=0.024501

tree= 1, node=152, feature=13, thr= 5.10, gain=0.465185

tree= 1, node=153, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=155, feature= 7, thr= 54.53, gain=0.349184

tree= 1, node=158, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=170, feature= 9, thr= 5.61, gain=0.007149

tree= 1, node=171, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=172, feature= 6, thr= 58.29, gain=0.175730

tree= 1, node=173, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=174, feature= 0, thr= 73.33, gain=0.054012

tree= 1, node=175, feature=11, thr= 9.06, gain=0.541116

tree= 1, node=176, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=177, feature= 7, thr= 67.06, gain=0.321696

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tree= 1, node=181, feature= 0, thr= 60.78, gain=0.098830

tree= 1, node=184, feature= 9, thr= 18.55, gain=0.134335

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= 79.29, gain=0.678954

tree= 1, node=190, feature= 4, thr= 48.04, gain=0.291818

tree= 1, node=191, feature=11, thr= 39.69, gain=0.517478

tree= 1, node=206, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=290, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=291, feature= 9, thr= 88.47, gain=0.008575

tree= 1, node=304, feature= 6, thr= 67.45, gain=0.250919

tree= 1, node=305, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=310, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=311, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=345, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=349, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=351, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=354, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=355, feature= 3, thr= 88.04, gain=0.025103

tree= 1, node=362, feature= 8, thr= 24.51, gain=0.021367

tree= 1, node=363, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=368, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=369, feature=14, thr= 52.94, gain=0.111623

tree= 1, node=374, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=375, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=380, feature=-1, thr= -1.00, gain=0.000000

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= 2, thr= 45.71, gain=0.103275

tree= 1, node=582, feature= 7, thr= 17.69, gain=0.008314

tree= 1, node=583, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=608, feature= 1, thr= 81.37, gain=0.056120

tree= 1, node=609, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=696, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=697, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=710, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=711, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=724, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=725, feature=15, thr= 9.12, gain=0.021405

tree= 1, node=738, feature= 6, thr= 21.57, gain=0.053910

tree= 1, node=739, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=766, feature= 1, thr= 66.67, gain=0.077022

tree= 1, node=767, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1164, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1165, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1216, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1217, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1450, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1451, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1476, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1477, feature= 3, thr= 99.12, gain=0.041635

tree= 1, node=1532, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=1533, feature= 2, thr= 41.47, gain=0.067329

tree= 1, node=2954, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=2955, feature= 2, thr= 84.67, gain=0.016255

tree= 1, node=3066, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=3067, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=5910, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=5911, feature=-1, thr= -1.00, gain=0.000000

classification accuracy=0.8382

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decision_tree.py pendigits_training pendigits_test 1 50

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tree= 1, node= 1, feature= 4, thr= 43.14, gain=0.537612

tree= 1, node= 2, feature= 0, thr= 52.94, gain=0.343581

tree= 1, node= 3, feature=10, thr= 50.98, gain=0.464518

tree= 1, node= 4, feature= 8, thr= 58.82, gain=0.406048

tree= 1, node= 5, feature=15, thr= 52.94, gain=0.629643

tree= 1, node= 6, feature=10, thr= 24.51, gain=0.152738

tree= 1, node= 7, feature= 5, thr= 47.06, gain=0.374161

tree= 1, node= 8, feature=13, thr= 43.14, gain=0.765660

tree= 1, node= 9, feature=10, thr= 41.18, gain=0.103879

tree= 1, node= 10, feature=12, thr= 50.98, gain=0.091018

tree= 1, node= 11, feature=12, thr= 54.90, gain=0.300800

tree= 1, node= 12, feature= 2, thr= 23.53, gain=0.294131

tree= 1, node= 13, feature= 0, thr= 23.53, gain=0.375417

tree= 1, node= 14, feature= 3, thr= 31.76, gain=0.605462

tree= 1, node= 15, feature= 2, thr= 64.71, gain=0.223551

tree= 1, node= 16, feature= 3, thr= 97.06, gain=0.323831

tree= 1, node= 17, feature= 5, thr= 64.71, gain=0.084856

tree= 1, node= 18, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 19, feature=13, thr= 54.90, gain=0.999828

tree= 1, node= 20, feature= 3, thr= 93.65, gain=0.375706

tree= 1, node= 21, feature= 6, thr= 19.61, gain=0.412842

tree= 1, node= 22, feature= 7, thr= 10.06, gain=0.365467

tree= 1, node= 23, feature= 6, thr= 41.18, gain=0.527466

tree= 1, node= 24, feature= 9, thr= 45.49, gain=0.191939

tree= 1, node= 25, feature= 9, thr= 1.96, gain=0.273869

tree= 1, node= 26, feature= 9, thr= 52.94, gain=0.360555

tree= 1, node= 27, feature= 0, thr= 47.84, gain=0.355659

tree= 1, node= 28, feature= 7, thr= 40.78, gain=0.649338

tree= 1, node= 29, feature=14, thr= 1.06, gain=0.050373

tree= 1, node= 30, feature=15, thr= 21.57, gain=0.338014

tree= 1, node= 31, feature=14, thr= 1.96, gain=0.247398

tree= 1, node= 32, feature= 2, thr= 45.00, gain=0.181592

tree= 1, node= 33, feature=11, thr= 20.49, gain=0.834566

tree= 1, node= 34, feature=14, thr= 84.31, gain=0.793252

tree= 1, node= 35, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 38, feature=14, thr= 11.76, gain=0.210920

tree= 1, node= 39, feature=12, thr= 50.98, gain=0.004355

tree= 1, node= 40, feature=14, thr= 3.94, gain=0.138521

tree= 1, node= 41, feature= 0, thr= 91.71, gain=0.302876

tree= 1, node= 42, feature= 6, thr= 9.31, gain=0.029456

tree= 1, node= 43, feature=12, thr= 58.69, gain=0.112533

tree= 1, node= 44, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 45, feature=13, thr= 73.63, gain=0.100001

tree= 1, node= 46, feature= 6, thr= 1.57, gain=0.152575

tree= 1, node= 47, feature= 8, thr= 96.08, gain=0.078160

tree= 1, node= 48, feature= 4, thr= 95.61, gain=0.053562

tree= 1, node= 49, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 50, feature= 1, thr= 79.73, gain=0.398884

tree= 1, node= 51, feature=14, thr= 96.08, gain=0.286749

tree= 1, node= 52, feature=12, thr= 56.86, gain=0.409294

tree= 1, node= 53, feature= 3, thr= 88.24, gain=0.813556

tree= 1, node= 54, feature=14, thr= 94.12, gain=0.688116

tree= 1, node= 55, feature= 1, thr= 48.04, gain=0.193452

tree= 1, node= 56, feature= 6, thr= 25.49, gain=0.391244

tree= 1, node= 57, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 58, feature= 5, thr= 4.61, gain=0.215124

tree= 1, node= 59, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 60, feature= 6, thr= 86.27, gain=0.366855

tree= 1, node= 61, feature= 9, thr= 45.49, gain=0.251204

tree= 1, node= 62, feature= 2, thr= 89.02, gain=0.289558

tree= 1, node= 63, feature=12, thr= 25.49, gain=0.491294

tree= 1, node= 64, feature= 3, thr= 71.20, gain=0.458315

tree= 1, node= 65, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 66, feature=10, thr= 1.96, gain=0.426264

tree= 1, node= 67, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node= 69, feature= 6, thr= 19.76, gain=0.033843

tree= 1, node= 76, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 77, feature= 8, thr= 76.69, gain=0.026490

tree= 1, node= 78, feature= 3, thr= 29.41, gain=0.024506

tree= 1, node= 79, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 80, feature=12, thr= 34.31, gain=0.207229

tree= 1, node= 81, feature= 4, thr= 0.61, gain=0.190133

tree= 1, node= 82, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 83, feature= 5, thr= 80.24, gain=0.165727

tree= 1, node= 84, feature= 8, thr= 50.82, gain=0.355925

tree= 1, node= 85, feature= 2, thr= 53.33, gain=0.236858

tree= 1, node= 86, feature=14, thr= 17.08, gain=0.563394

tree= 1, node= 87, feature=15, thr= 0.49, gain=0.179014

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tree= 1, node= 92, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 93, feature=13, thr= 57.18, gain=0.171678

tree= 1, node= 94, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 95, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 96, feature= 3, thr= 78.47, gain=0.671344

tree= 1, node= 97, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=100, feature=11, thr= 15.37, gain=0.303883

tree= 1, node=101, feature= 2, thr= 34.43, gain=0.074792

tree= 1, node=102, feature=13, thr= 24.73, gain=0.552308

tree= 1, node=103, feature=11, thr= 37.65, gain=0.638189

tree= 1, node=104, feature= 8, thr= 69.33, gain=0.059535

tree= 1, node=105, feature=14, thr= 84.31, gain=0.533504

tree= 1, node=106, feature= 6, thr= 97.25, gain=0.086663

tree= 1, node=107, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=108, feature=10, thr= 45.10, gain=0.169633

tree= 1, node=109, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=110, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=111, feature= 0, thr= 79.61, gain=0.359183

tree= 1, node=112, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=120, feature= 0, thr= 35.29, gain=0.205118

tree= 1, node=121, feature=15, thr= 0.39, gain=0.133146

tree= 1, node=122, feature=13, thr= 9.80, gain=0.300291

tree= 1, node=123, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=124, feature=13, thr= 14.27, gain=0.404038

tree= 1, node=125, feature=15, thr= 15.69, gain=0.307107

tree= 1, node=126, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=129, feature= 9, thr= 5.18, gain=0.948410

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tree= 1, node=154, feature= 2, thr= 1.39, gain=0.145890

tree= 1, node=155, feature=15, thr= 0.37, gain=0.019846

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tree= 1, node=167, feature=11, thr= 37.43, gain=0.411529

tree= 1, node=168, feature=14, thr= 52.94, gain=0.266329

tree= 1, node=169, feature= 6, thr= 0.18, gain=0.208671

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tree= 1, node=172, feature=12, thr= 51.14, gain=0.144175

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tree= 1, node=193, feature=14, thr= 95.41, gain=0.420561

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tree= 1, node=206, feature= 2, thr= 34.43, gain=0.029442

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tree= 1, node=250, feature=14, thr= 0.02, gain=0.003726

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tree= 1, node=61583, feature=12, thr= 59.47, gain=0.029472

tree= 1, node=123164, feature= 4, thr= 52.78, gain=0.056865

tree= 1, node=123165, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=123166, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=123167, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=246328, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=246329, feature=13, thr= 1.10, gain=0.008785

tree= 1, node=492658, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=492659, feature=11, thr= 0.73, gain=0.125658

tree= 1, node=985318, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=985319, feature=-1, thr= -1.00, gain=0.000000

classification accuracy=0.7464

----

decision_tree.py pendigits_training pendigits_test 3 50

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tree= 1, node= 1, feature= 1, thr= 96.08, gain=0.369270

tree= 1, node= 2, feature= 0, thr= 1.96, gain=0.277820

tree= 1, node= 3, feature= 5, thr= 64.71, gain=0.338289

tree= 1, node= 4, feature= 3, thr= 88.24, gain=0.835136

tree= 1, node= 5, feature=15, thr= 25.49, gain=0.685246

tree= 1, node= 6, feature= 9, thr= 11.76, gain=0.683413

tree= 1, node= 7, feature= 4, thr= 50.98, gain=0.546045

tree= 1, node= 8, feature=11, thr= 68.63, gain=0.377284

tree= 1, node= 9, feature= 7, thr= 47.06, gain=0.232606

tree= 1, node= 10, feature= 7, thr= 49.02, gain=0.389654

tree= 1, node= 11, feature= 8, thr= 56.86, gain=0.554946

tree= 1, node= 12, feature= 7, thr= 6.12, gain=0.271996

tree= 1, node= 13, feature= 9, thr= 29.25, gain=0.232601

tree= 1, node= 14, feature= 0, thr= 82.35, gain=0.467554

tree= 1, node= 15, feature=12, thr= 33.33, gain=0.334577

tree= 1, node= 16, feature= 4, thr= 90.94, gain=0.043714

tree= 1, node= 17, feature= 7, thr= 41.18, gain=0.899117

tree= 1, node= 18, feature= 2, thr= 37.37, gain=0.182059

tree= 1, node= 19, feature=13, thr= 18.55, gain=0.739218

tree= 1, node= 20, feature=10, thr= 35.29, gain=0.708001

tree= 1, node= 21, feature=12, thr= 60.78, gain=0.232537

tree= 1, node= 22, feature= 9, thr= 2.67, gain=0.084641

tree= 1, node= 23, feature= 5, thr= 58.82, gain=0.670975

tree= 1, node= 24, feature=14, thr= 84.31, gain=0.558629

tree= 1, node= 25, feature=13, thr= 52.41, gain=0.384209

tree= 1, node= 26, feature=13, thr= 60.78, gain=0.886444

tree= 1, node= 27, feature=15, thr= 1.96, gain=0.568312

tree= 1, node= 28, feature= 5, thr= 82.16, gain=0.530280

tree= 1, node= 29, feature= 1, thr= 98.06, gain=0.116035

tree= 1, node= 30, feature= 6, thr= 83.18, gain=0.063951

tree= 1, node= 31, feature= 1, thr= 99.06, gain=0.049781

tree= 1, node= 32, feature= 1, thr= 76.37, gain=0.152794

tree= 1, node= 33, feature=13, thr= 33.33, gain=0.284571

tree= 1, node= 34, feature= 8, thr= 63.86, gain=0.975119

tree= 1, node= 35, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 36, feature= 6, thr= 49.71, gain=0.236064

tree= 1, node= 37, feature=14, thr= 37.25, gain=0.192726

tree= 1, node= 38, feature= 6, thr= 72.08, gain=0.065674

tree= 1, node= 39, feature=13, thr= 21.35, gain=0.070197

tree= 1, node= 40, feature=14, thr= 1.96, gain=0.024032

tree= 1, node= 41, feature=10, thr= 73.25, gain=0.403994

tree= 1, node= 42, feature= 4, thr= 58.82, gain=0.371205

tree= 1, node= 43, feature=11, thr= 47.06, gain=0.260088

tree= 1, node= 44, feature=13, thr= 79.69, gain=0.679786

tree= 1, node= 45, feature= 9, thr= 32.31, gain=0.085241

tree= 1, node= 46, feature=14, thr= 82.35, gain=0.024687

tree= 1, node= 47, feature=10, thr= 68.63, gain=0.431874

tree= 1, node= 48, feature= 4, thr= 23.53, gain=0.694084

tree= 1, node= 49, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 50, feature= 5, thr= 54.27, gain=0.048651

tree= 1, node= 51, feature= 5, thr= 45.37, gain=0.161125

tree= 1, node= 52, feature=12, thr= 70.59, gain=0.244208

tree= 1, node= 53, feature=13, thr= 91.43, gain=0.073000

tree= 1, node= 54, feature= 6, thr= 70.59, gain=0.038927

tree= 1, node= 55, feature=11, thr= 74.51, gain=0.593210

tree= 1, node= 56, feature= 2, thr= 25.10, gain=0.180102

tree= 1, node= 57, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 58, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 59, feature= 8, thr= 45.10, gain=0.708640

tree= 1, node= 60, feature= 9, thr= 33.63, gain=0.493376

tree= 1, node= 61, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 62, feature= 7, thr= 68.29, gain=0.695491

tree= 1, node= 63, feature= 3, thr= 88.24, gain=0.579572

tree= 1, node= 64, feature=15, thr= 9.80, gain=0.234967

tree= 1, node= 65, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 66, feature= 7, thr= 98.24, gain=0.207563

tree= 1, node= 67, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 68, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 69, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 72, feature= 7, thr= 33.18, gain=0.269081

tree= 1, node= 73, feature= 7, thr= 39.59, gain=0.023809

tree= 1, node= 74, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 75, feature= 2, thr= 42.71, gain=0.043930

tree= 1, node= 76, feature= 8, thr= 45.10, gain=0.612234

tree= 1, node= 77, feature=15, thr= 16.67, gain=0.446458

tree= 1, node= 78, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 79, feature=15, thr= 55.33, gain=0.191433

tree= 1, node= 80, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 81, feature= 5, thr= 81.80, gain=0.050341

tree= 1, node= 82, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 83, feature=12, thr= 57.73, gain=0.497141

tree= 1, node= 84, feature= 3, thr= 87.76, gain=0.168195

tree= 1, node= 85, feature=13, thr= 18.12, gain=0.191569

tree= 1, node= 86, feature= 2, thr= 72.55, gain=0.435324

tree= 1, node= 87, feature= 3, thr= 86.27, gain=0.072817

tree= 1, node= 88, feature=11, thr= 25.53, gain=0.084145

tree= 1, node= 89, feature=12, thr= 50.98, gain=0.562539

tree= 1, node= 90, feature= 9, thr= 19.49, gain=0.024967

tree= 1, node= 91, feature= 8, thr= 13.18, gain=0.396145

tree= 1, node= 92, feature=12, thr= 58.82, gain=0.014156

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tree= 1, node= 94, feature=15, thr= 43.18, gain=0.173740

tree= 1, node= 95, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node= 96, feature=10, thr= 38.24, gain=0.087281

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tree= 1, node=100, feature=10, thr= 7.84, gain=0.105032

tree= 1, node=101, feature= 5, thr= 61.18, gain=0.018423

tree= 1, node=102, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=103, feature= 2, thr= 39.22, gain=0.338724

tree= 1, node=104, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=105, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=106, feature=11, thr= 69.12, gain=0.362051

tree= 1, node=107, feature=12, thr= 51.29, gain=0.809182

tree= 1, node=108, feature= 0, thr= 80.39, gain=0.008746

tree= 1, node=109, feature=11, thr= 47.16, gain=0.227886

tree= 1, node=110, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=111, feature=12, thr= 73.18, gain=0.158664

tree= 1, node=112, feature= 5, thr= 69.33, gain=0.313156

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tree= 1, node=118, feature=14, thr= 67.06, gain=0.206878

tree= 1, node=119, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=120, feature=12, thr= 7.12, gain=0.029387

tree= 1, node=121, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=124, feature= 5, thr= 71.18, gain=0.131023

tree= 1, node=125, feature=12, thr= 53.06, gain=0.273054

tree= 1, node=126, feature=13, thr= 20.27, gain=0.267769

tree= 1, node=127, feature= 2, thr= 66.67, gain=0.673845

tree= 1, node=128, feature= 3, thr= 82.98, gain=0.010461

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tree= 1, node=132, feature=10, thr= 53.18, gain=0.017207

tree= 1, node=133, 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=150, feature=14, thr= 69.61, gain=0.002040

tree= 1, node=151, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=152, feature=13, thr= 9.18, gain=0.117870

tree= 1, node=153, feature= 8, thr= 53.41, gain=0.264558

tree= 1, node=154, feature= 8, thr= 71.94, gain=0.237635

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tree= 1, node=158, feature= 6, thr= 30.12, gain=0.113274

tree= 1, node=159, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=162, feature= 4, thr= 80.88, gain=0.017120

tree= 1, node=163, feature=14, thr= 94.10, gain=0.017464

tree= 1, node=166, feature= 4, thr= 66.67, gain=0.887242

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tree= 1, node=167, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=168, feature=10, thr= 66.67, gain=0.433606

tree= 1, node=169, feature=11, thr=  3.92, gain=0.272298

tree= 1, node=170, feature= 3, thr= 96.00, gain=0.224381

tree= 1, node=171, feature= 9, thr= 32.47, gain=0.367498

tree= 1, node=172, feature= 7, thr= 76.47, gain=0.367355

tree= 1, node=173, feature=13, thr=  7.33, gain=0.144205

tree= 1, node=174, feature=13, thr= 27.06, gain=0.049297

tree= 1, node=175, feature= 8, thr= 37.24, gain=0.206550

tree= 1, node=176, feature= 2, thr= 61.61, gain=0.238820

tree= 1, node=177, feature= 8, thr=  2.20, gain=0.105403

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=12, thr= 56.86, gain=0.678224

tree= 1, node=181, feature=12, thr= 64.71, gain=0.816344

tree= 1, node=182, feature=11, thr= 71.10, gain=0.555589

tree= 1, node=183, feature=13, thr= 31.37, gain=0.034968

tree= 1, node=184, feature=13, thr= 98.16, gain=0.015935

tree= 1, node=185, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=206, feature=14, thr= 96.59, gain=0.346642

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tree= 1, node=212, feature= 9, thr= 27.12, gain=0.075141

tree= 1, node=213, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=304, feature= 5, thr= 99.10, gain=0.075422

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tree= 1, node=306, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=307, feature=14, thr= 49.02, gain=0.345117

tree= 1, node=308, feature=13, thr= 7.33, gain=0.404845

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tree= 1, node=316, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=349, feature= 0, thr= 92.39, gain=0.058790

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tree= 1, node=354, feature=-1, thr= -1.00, gain=0.000000

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tree= 1, node=360, feature= 6, thr= 17.18, gain=0.163839

tree= 1, node=361, feature= 4, thr= 50.76, gain=0.199123

tree= 1, node=362, feature= 9, thr= 28.24, gain=0.059498

tree= 1, node=363, feature= 9, thr= 25.18, gain=0.026966

tree= 1, node=364, feature=-1, thr= -1.00, gain=0.000000

tree= 1, node=365, feature=12, thr= 65.06, gain=0.103275

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tree= 1, node=648, feature=11, thr= 15.24, gain=0.236504

tree= 1, node=649, feature= 8, thr= 37.10, gain=0.069195

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tree= 1, node=679, feature= 2, thr= 1.96, gain=0.455075

tree= 1, node=680, feature=15, thr= 11.27, gain=0.384150

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tree= 1, node=2735, feature=10, thr= 53.33, gain=0.093707
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tree= 1, node=3453, feature=-1, thr= -1.00, gain=0.000000

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tree= 2, node=267, feature= 0, thr= 70.35, gain=0.494491

tree= 2, node=268, feature=11, thr= 24.67, gain=0.169940

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tree= 2, node=272, feature= 7, thr= 94.35, gain=0.120681

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tree= 2, node=276, feature= 9, thr= 33.57, gain=0.233156

tree= 2, node=277, feature= 9, thr= 31.06, gain=0.589806

tree= 2, node=278, feature=11, thr= 19.59, gain=0.027382

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tree= 2, node=296, feature=11, thr= 18.14, gain=0.280387

tree= 2, node=297, feature=13, thr= 6.31, gain=0.420364

tree= 2, node=298, feature= 7, thr= 25.49, gain=0.304587

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tree= 2, node=301, feature=11, thr= 8.24, gain=0.043733

tree= 2, node=302, feature= 3, thr= 89.41, gain=0.440444

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tree= 2, node=312, feature=-1, thr= -1.00, gain=0.000000

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tree= 2, node=415, feature= 8, thr= 76.47, gain=0.833765

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tree= 2, node=438, feature=10, thr= 23.71, gain=0.191221
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tree= 3, node= 4, feature= 9, thr= 15.69, gain=0.626042

tree= 3, node= 5, feature=15, thr= 21.57, gain=0.570101

tree= 3, node= 6, feature=14, thr= 52.94, gain=0.709575

tree= 3, node= 7, feature= 1, thr= 96.67, gain=0.407898

tree= 3, node= 8, feature= 6, thr= 27.45, gain=0.721640

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tree= 3, node= 10, feature=10, thr= 39.22, gain=0.640965

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tree= 3, node= 17, feature= 9, thr= 1.18, gain=0.182486

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tree= 3, node= 28, feature= 8, thr= 56.86, gain=0.514590

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tree= 3, node= 36, feature= 6, thr= 96.08, gain=0.066486

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tree= 3, node=121, feature= 3, thr= 55.33, gain=0.074605

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tree= 3, node=1393, feature= 8, thr= 70.82, gain=0.179335

tree= 3, node=1394, feature=10, thr= 73.76, gain=0.236736

tree= 3, node=1395, feature= 1, thr= 69.12, gain=0.614248

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tree= 3, node=1407, feature= 2, thr= 89.88, gain=0.184782

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tree= 3, node=5590, feature= 7, thr= 70.49, gain=0.080615

tree= 3, node=5591, feature= 4, thr= 41.67, gain=0.642938

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tree= 3, node=11149, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=11154, feature= 6, thr= 60.47, gain=0.413817

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tree= 3, node=11183, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=11224, feature=10, thr= 97.53, gain=0.074743

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tree= 3, node=11417, feature= 3, thr= 99.02, gain=0.002190

tree= 3, node=11510, feature=12, thr= 30.18, gain=0.225352

tree= 3, node=11511, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=20426, feature=-1, thr= -1.00, gain=0.000000

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tree= 3, node=20427, feature=-1, thr= -1.00, gain=0.000000

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tree= 3, node=22322, feature= 4, thr= 21.41, gain=0.068586

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tree= 3, node=22448, feature= 1, thr= 82.12, gain=0.377497

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tree= 3, node=22518, feature= 4, thr= 69.33, gain=0.064555

tree= 3, node=22519, feature=-1, thr= -1.00, gain=0.000000

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tree= 3, node=22835, feature= 8, thr= 86.27, gain=0.114891

tree= 3, node=23020, feature=-1, thr= -1.00, gain=0.000000

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tree= 3, node=41570, feature= 1, thr= 87.24, gain=0.040777

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tree= 3, node=44618, feature=-1, thr= -1.00, gain=0.000000

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tree= 3, node=44897, feature=13, thr=  0.00, gain=0.000000

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tree= 3, node=45037, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=45670, feature= 7, thr= 37.29, gain=0.013930

tree= 3, node=45671, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=83060, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=83061, feature=-1, thr= -1.00, gain=0.000000
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tree= 3, node=83140, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=83141, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=89794, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=89795, feature= 6, thr= 68.33, gain=0.225364

tree= 3, node=91340, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=91341, feature= 3, thr=100.00, gain=0.000000

tree= 3, node=179590, feature=15, thr= 15.12, gain=0.073808

tree= 3, node=179591, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=182682, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=182683, feature= 1, thr= 70.25, gain=0.170563

tree= 3, node=359180, feature=-1, thr= -1.00, gain=0.000000

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tree= 3, node=730734, feature=-1, thr= -1.00, gain=0.000000

tree= 3, node=730735, feature=-1, thr= -1.00, gain=0.000000

classification accuracy=0.8153

Task 2

a)

$$H\left(\frac{K_1}{K}, \frac{K_2}{K}, \dots, \frac{K_N}{K}\right) = \sum_{i=1}^{N} -\frac{K_i}{K} \log_2 \frac{K_i}{K}$$
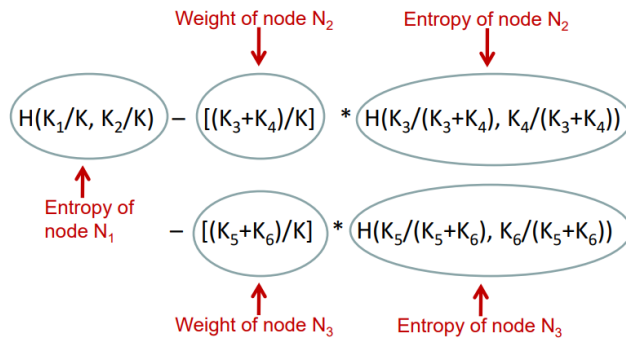
Wait: 80   Not Wait: 20
What is the initial entropy at node A?

K1 = 80, K2 = 20, K = 100
h(80/100,20/100) = -.8*log2(.8) - .2*log2(.2) = .721928

b)

weekend = 35, not weekend = 65

H(80/20) = .7219 From part a
H(20/35,15/35) = -(20/35)*log2(20/35) – (15/35)*log2(15/35) = .9852
H(60/65,5/65) = -(60/65)*log2(60/65) – (5/65)*log2(5/65) = .3912

Information Gain = H(80/20) – [35/100]*H(20/35,15/35) – [65/100]*H(60/65,5/65)
Information Gain = .7219 – [35/100]* (.9852) – [65/100]* (.3912)
Information Gain = .1228

c) Because node E leads to a leaf node Information gain would just be Entropy of class - 0 = 0.722
d) It will go to node F and it will print out will wait
e) It will end up on node H and it will print out will not wait

Task 3

Class	A	B	C
X	1	2	1
X	2	1	2
X	3	2	2
X	1	3	3
X	1	2	2
Y	2	1	1
Y	3	1	1
Y	2	2	2
Y	3	3	1
Y	2	1	1

Class X: 5
Class Y: 5
H(5/10, 5/10) = -0.5*log2(.5) - 0.5*log2(.5) = 1

Attribute A:

A1,   x = 3   y = 0 | H(3/3, 0/3) = 0
A2,   x = 1   y = 3 | H(1/4, 3/4) = 0.8113
A3,   x = 1   y = 2 | H(1/3, 2/3) = 0.9183

I(E, A) = 1 - .3(0) - .4(.8113) - .3(.9183) = .4000

Attribute B:

A1,   x = 1   y = 3 | H(1/4, 3/4) = 0.8113
A2,   x = 3   y = 1 | H(3/4, 1/4) = 0.8113
A3,   x = 1   y = 1 | H(1/2, 1/2) = 1

I(E, A) = 1 - .4(0.8113) - .4(0.8113) - .2(1) = .1510

Attribute C:

A1,   x = 1   y = 4 | H(1/5, 4/5) = 0.7219
A2,   x = 3   y = 1 | H(3/4, 1/4) = 0.8113
A3,   x = 1   y = 0 | H(1/1, 0/1) = 0

I(E, A) = 1 - .5(0.7219) - .4(0.8113) - .1(0) = 0.3145

The highest information gain is attribute A

Task 4

a) Highest entropy is 2
    H(250/1000, 250/1000, 250/1000, 250/1000) = -.25*log2(.25) -.25*log2(.25) -.25*log2(.25) - .25*log2(.25) = 2

    Lowest entropy is 0
    H(1000/1000, 0/1000, 0/1000, 0/1000) = -1*log2(1) - 0*log2(0) - 0*log2(0) - 0*log2(0) = 0

b) The lowest information gain of attribute K has the same entropy as the parent is 0, since attribute did not specify that the ratio is the same as the parent node

    Highest information gain would occur when splitting based on attribute K, thus the highest entropy would be 2

Task 5

Since the classification is based on when the home teams wins, you can flip the classification to predict who loses instead. Thus, the accuracy would go to 78%. This would guarantee a accuracy better than 68%